



PAKISTAN AIRPORTS AUTHORITY (PAA)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu

Volume-II (Technical Specifications)



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SECTION 0010 - GENERAL REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

All civil, structural, architectural, mechanical, electrical, plumbing, fire protection, ICT, and specialist aviation systems as specified herein and shown on Contract Drawings, including all temporary works, testing, commissioning, and rectification of defects. The Contractor shall notify all subcontractors of the provisions of the Conditions of Contract. All Work shall be executed in accordance with these Specifications; inconsistencies shall be referred to the Engineer.

1.02 REFERENCES AND APPLICABLE CODES

A. In the absence of other contractually required standards, all work and materials shall conform to the following codes and standards. Where the Pakistan Building Code (BCP) requires a higher standard, the BCP shall govern.

Reference Standards

Abbreviation	Organization
AASHTO	American Association of State Highway & Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASA	American Standard Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BCP	Building Code of Pakistan
BSI / BSICP	British Standards Institute / Code of Practice
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
NFPA	National Fire Protection Association
PCA	Portland Cement Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
PSI / PSQCA	Pakistan Standards Institute / Standards & Quality Control Authority
UBC	Uniform Building Code
UPC	Uniform Plumbing Code

1.02.1 Technical Parameters

PARAMETER	REQUIREMENT
Seismic Zone	BCP Zone-4; Z=0.4. SMRF detailing for ATCT tower shaft minimum.

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Maximum Ambient Temperature (Equipment Qualification)	+50 °C — equipment qualification envelope; refer also to Section 0740 for CNS equipment and Section 0710 and Section 0720 for HVAC summer design
Minimum Ambient Temperature (Equipment Qualification)	–25 °C — equipment qualification envelope. For HVAC and envelope sizing, the design winter dry-bulb temperature shall be taken as –18 °C (99.6 % winter design value) per the HVAC Basis of Design. For CNS and electronic equipment, refer also to Section 0740 §1.3.
Maximum Humidity	90% RH
Snow Load on Roof	50 lbs/ft ²
Wind Load	Per ASCE 7 at 2,230 m AMSL; glazing/cladding to resist calculated pressures
Building Envelope U-Value	Below 0.45 W/m ² K for all opaque elements
Glazing	Double- or triple-glazed units minimum
UV Resistance	All exposed finishes/sealants/polymers: UV-resistant, high-altitude rated
Air Density Correction	0.79 × sea-level density factor at 2,230 m AMSL (HVAC/generators)

1.03 CODES, STANDARDS, AND CERTIFICATES

- A. The Contractor shall maintain on site current editions of all codes and standards referenced herein, manufacturer catalogues, and published recommendations for all products used.
- B. The Contractor shall provide the Engineer with manufacturer's or supplier's certificates of compliance for all products required to meet a specific code or standard.

1.04 UNITS OF MEASUREMENT

- A. The International System of Units (SI) shall be used throughout the Project unless otherwise specified in the Contract Documents.

1.05 MANUFACTURER'S RECOMMENDATIONS

- A. Installation, testing, and commissioning of manufactured items shall comply with manufacturer's recommended procedures or as approved by the Engineer.

1.06 EXISTING CONDITIONS

- A. Drawings and information pertaining to existing conditions are provided for reference only. Neither the Employer nor the Engineer warrants their accuracy or completeness.

1.07 PROTECTION AND PRECAUTIONS

- A. The Contractor and all subcontractors shall protect existing structures, roads, pavements, and other infrastructure. All damage caused by the Contractor's operations shall be repaired at the Contractor's expense.
- B. The Contractor shall maintain unobstructed airside and landside traffic flow at all times and shall provide warning signs, warning lamps, and barricades as required.
- C. The Air Traffic Control cabin shall be constructed and finished such that the controller shall have a 360° unobstructed view of both runway thresholds, the apron and the airfield movement areas. No plant, antenna, parapet ornament, light fixture, refrigerant line or any other obstruction shall be located within the line-of-sight cone defined on the architectural drawings.

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Any rooftop equipment shall be located outside this cone and coordinated with the Engineer before installation.

D. Refer also to Section 0750 — Airport Operational Safety Requirements — for additional construction-phase requirements applicable inside the operational area of the aerodrome.

1.08 SETTING OUT OF WORK

1.08. A General

1. Verify layout information shown on Drawings against property surveys and existing benchmarks before commencing layout. Locate and protect all existing benchmarks and control points.
2. Do not change or relocate benchmarks without prior written approval of the Engineer.
3. Promptly report lost or destroyed reference points to the Engineer. Replacements shall be based on original survey control.
4. Establish and maintain permanent benchmarks as directed by the Engineer. Record benchmark data on Project Record Documents.

1.08. B Existing Utilities and Facilities

1. Prior to site work, investigate and verify the location of all underground utilities, equipment, and construction. Record findings on the relevant plan.
2. Verify invert elevations at sanitary, storm, water, electrical, communications, hydrant refueling, airfield lighting, and firefighting utility connection points.

1.08.C Performance

1. Establish benchmarks and markers from property survey lines and levels. Calculate and measure dimensions within tolerances; do not scale Drawings.
2. Maintain a Surveyor's Log of all survey work. Record deviations and advise the Engineer when deviations exceed tolerances.

1.08.D Site Works

1. Prior to Substantial Completion, prepare a final property survey plan signed by the Contractor certifying that principal metes, bounds, lines, and levels are accurately positioned.

1.09 SEQUENCE OF CONSTRUCTION

A. Skardu International Airport is an operational facility. Site possession will be phased to maintain airport operations throughout the construction period. Security clearance of all staff and equipment shall be obtained by Contractor at their own cost per CAA/ASF rules.

B. The Contractor shall submit a proposed sequence of construction including demolition, relocation, rehabilitation, and new construction for Engineer/Employer approval.

C. The Contractor shall give not less than four (4) weeks' prior written notice when requiring possession of any section or portion of the site.

D. The Contractor shall account for weather and site conditions and shall ensure no disturbance to airport operations results from construction activities. The Contractor shall not be entitled to any claim whatsoever on account of disruption caused by weather conditions. The Contractor is expected to plan and sequence the activities according to the prevailing weather pattern of the Skardu to ensure timely completion of the project.

1.10 LINES AND LEVELS

A. The Engineer has established survey control points. The Contractor shall verify these and shall be responsible for maintaining required locations, lines, and levels throughout execution of the Work.

1.11 PARTIAL POSSESSION

A. The Employer may take possession of or use any portion of the Work deemed suitable for use. Such use does not constitute final acceptance and does not relieve the Contractor of contract obligations.

B. If partial use increases costs or delays remaining Work, the Contractor may be entitled to an equitable adjustment.

C. If a portion proves unsatisfactory due to the Contractor's non-compliance, the Employer may continue use until corrective action is completed, not to exceed twelve (12) months unless mutually agreed in writing.

1.12 EXISTING SERVICES

A. The Contractor shall locate, identify, and protect all wiring, cables, ducts, and pipework within or adjoining the site by careful excavation under QC supervision. The Contractor shall reinstate all exploratory excavations.

B. The Contractor assumes full responsibility for the safety of existing service lines and utility structures. Any damage shall be repaired immediately at the Contractor's cost with prompt notification to the Engineer and relevant authorities.

C. Existing services intended to remain in operation shall be safeguarded, protected from damage, and supported throughout construction.

1.13 PLANT AND EQUIPMENT

A. The Contractor shall submit a detailed equipment list including type, manufacturer, model, identification number, and year of manufacture for Engineer review. All listed equipment shall be on site, inspected, and approved by the Engineer before use.

1.14 CONSTRUCTION AREA AND ACCESS

A. The Contractor shall confine operations to areas made available by the Employer and shall fence such areas accordingly. Access roads, storage areas, and haul routes shall be arranged by the Contractor at his own cost, subject to Engineer approval.

B. Security clearance and police verification of all staff shall be the Contractor's responsibility at their own cost.

1.15 STORAGE AND HANDLING

A. The Employer will provide available space within or near the site for storage of plant, equipment, and materials and for the Contractor's temporary offices. Where space is insufficient, the Contractor shall arrange alternative storage at his own cost.

B. Temporary installations shall not conflict with or interfere with permanent installations, services, or airport operations.

1.16 TESTING LABORATORY AND TESTING

A. Testing shall be performed by an approved testing agency proposed by the Contractor at no extra cost to the Employer, unless otherwise specified. The Engineer may require all testing to be conducted under his direct supervision.

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- B. Where an adequate materials testing laboratory is not available nearby, the Contractor shall provide and maintain one in the vicinity of his camp, equipped with all necessary facilities.
- C. The Contractor shall supply and maintain all testing equipment, apparatus, gauges, and instruments in sufficient quantities for all specified tests. Valid calibration certificates shall be provided.
- D. The Contractor shall maintain complete records of all quality tests and submit them to the Engineer. All testing shall conform to applicable standards and codes.

1.17 QUALITY CONTROL

- A. The Contractor shall submit a Construction Management and Quality Control Plan to the Engineer for approval, including methods, standard formats for approvals, material submittals, shop drawings, testing, and labor/equipment information.
- B. Approval of the QC Plan by the Engineer does not relieve the Contractor of responsibility under the Contract.
- C. The Engineer reserves the right to inspect all parts of the Work. The Contractor shall provide adequate qualified supervision and full access for the Engineer's inspection and measurement.
- D. If the Engineer determines that progress is insufficient to meet the Contract schedule, the Contractor shall work overtime or in shifts at no additional cost to the Employer.

1.18 BAR BENDING SCHEDULE

- A. The Contractor shall prepare reinforcement bar bending schedules with all drawing details and submit three (3) copies to the Engineer for approval.

PART 2 – SUBMITTALS

2.01 DRAWINGS

2.01.A Bidding Drawing

Drawings in Volume IV are for bidding purposes only and shall not be used as fabrication or construction documents. They may be used for preliminary material ordering subject to revision upon issue of construction drawings.

2.01.B Drawings Issued for Construction (IFC)

After Contract Award, Bidding Drawings are replaced by IFC Drawings, issued by the Engineer within 14 days from the date of commencement date, which form the basis for all shop, fabrication, erection, and installation drawings. The Contractor shall prepare and maintain a schedule of required IFC drawings and submit it to the Engineer immediately following approval of the Construction Programme.

2.01.C Study of Drawings

The Contractor shall study all IFC Drawings promptly upon receipt and immediately notify the Engineer of any errors or discrepancies.

2.01.D Copies

Drawings will be issued to the Contractor free of charge per the provisions of the Conditions of Contract.

2.02 CONTRACTOR-FURNISHED DRAWINGS AND SUBMITTALS

2.02.A Shop Drawings

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The Contractor shall prepare and submit all shop, fabrication, erection, installation, placement, and layout drawings required for the Work. Submittals shall include three (3) hard copies and one (1) soft copy (CAD + PDF). Combined services coordination drawings for all utilities shall also be submitted.

2.02.B Lift and Placement Drawings

Not less than thirty (30) calendar days prior to commencing any concrete lift or placement, the Contractor shall submit lift placement drawings showing all recesses, openings, embedded parts, and reinforcement for Engineer approval.

2.02.C Construction Plant Layout Drawings

Three (3) prints showing the layout of all principal construction plant, offices, storage areas, yards, and unloading facilities shall be submitted to the Engineer for review.

2.03 SUBMISSION AND REVIEW PROCEDURE

- A. The Contractor shall prepare and submit material submittals in accordance with the Technical Specifications, the Contract Documents, and the procedures set forth herein. All submittals shall demonstrate full compliance with the specified requirements prior to submission.

For each material item identified and defined in the Technical Specifications, the Engineer shall not grant approval to more than three (3) material submittals in total. Once three (3) approvals have been issued for a given material item, no further submittal for that material shall be entertained or processed by the Engineer, unless otherwise directed by the Employer in writing.

Rejected material submittals shall not be counted toward the limit of three (3) approvals specified under Clause B above. The Contractor may resubmit a revised material submittal following rejection, provided the resubmission fully addresses the Engineer's stated reasons for rejection. The total number of submission attempts, whether approved or rejected, shall however not exceed five (5) per material item, after which the Contractor shall revert to the material explicitly specified in the Technical Specifications without substitution.

- B. Three (3) hard copies and one (1) soft copy (PDF and CAD) of each drawing and material submittal shall be submitted via transmittal form with Submittal/Transmittal number and revision numbers.
- C. The Engineer will return submittals within fourteen days (14) calendar days marked 'Approved', 'Approved/Except as Noted', or 'Revise and Resubmit'. The 14-day period commences upon receipt at the Engineer's office.
- D. Upon 'Approved' or 'Approved/Except as Noted' status, the Contractor shall furnish three (3) prints plus one (1) soft copy (CAD and PDF) to the Engineer.
- E. Subcontractor submittals shall be routed through the Contractor.
- F. Approval of drawings by the Engineer does not constitute a complete design check and does not relieve the Contractor of his obligations to meet all specification requirements or ensure the correctness and fit of his drawings.
- G. Out-of-sequence or bulk-submitted documents shall not be subject to the standard 14-day review period; associated delays shall be attributed to the Contractor.

2.04 SUBMISSION REQUIREMENTS

- A. The Contractor shall schedule all submissions to arrive at the Engineer's office at least thirty (30) days before the reviewed submittals are required.

- B. Each transmittal letter shall include:

- Date and project title/number
- Contractor's name and address

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- Submittal/Drawing numbers and revision numbers
- Notification of deviations from Contract Documents
- Reference to trade/discipline, specification number, and BOQ number
- Other pertinent data

2.05 RESUBMISSION REQUIREMENTS

- A. Shop Drawings: Revise as required and resubmit per initial submittal requirements. Cloud all revisions for identification.
- B. Product Data and Samples: Submit new data and samples as required. Resubmit within seven (7) days of receipt of Engineer's comments.

2.06 AS-BUILT DRAWINGS

- A. The Contractor shall maintain on site one current copy of all Drawings and approved samples, together with applicable codes and standards.
- B. The Contractor and all subcontractors shall maintain a separate marked-up set of drawings recording all deviations from the Contract Documents as work progresses.
- C. At completion, the Contractor shall furnish six (6) hard copies and two (2) electronic copies (CAD and PDF) of all As-Built Drawings to the Engineer at the Contractor's expense.

2.07 PRODUCT DATA

- A. Standard schematic drawings shall be modified to show only project-applicable information. Catalogue sheets and literature shall be clearly marked to identify pertinent materials, models, dimensions, and clearances.

2.08 SAMPLES

- A. The Contractor shall furnish all samples as directed or specified, with reasonable promptness at their own cost.
- B. Duplicate final approved samples shall be provided: one for the Engineer's office and one for the site.
- C. Each sample shall be labeled with material name and quality, manufacturer's name, project name, Contractor's name, submission date, and applicable Specification article number.
- D. Manufacturer's installation directions shall accompany each sample. All transportation costs are the Contractor's responsibility.
- E. Samples shall be of adequate size and number to permit proper evaluation. Samples shall show the maximum expected range of variation; materials exceeding the approved range shall not be used.
- F. A sample room of not less than 30 m² shall be provided for the exclusive use of the Engineer.

PART 3 – EXECUTION

3.01 ACCIDENT PREVENTION AND PROTECTIVE EQUIPMENT

- A. The Contractor shall comply with and enforce the highest international standards of safety and accident prevention in conformance with applicable Pakistani laws and ordinances.
- B. All workers and staff shall be provided with and required to use safety helmets, boots, gloves, and other appropriate PPE all at the Contractor's cost.
- C. Barriers, fences, warning signs (in English and Urdu), and lighting shall be provided and maintained in clean, legible condition at the Contractor's cost.

3.02 TEMPORARY FACILITIES

A. The Contractor shall provide, erect, maintain, alter as necessary, and remove on completion all temporary facilities and services. The Contractor's temporary site office shall be available within one month of site handover.

3.02.A Temporary Roads

The Contractor shall construct and maintain temporary access roads as required, per Engineer's instructions. Dust suppression by watering shall be provided as directed. Access routes shall be kept free of debris at all times.

3.02.B Temporary Water Supply

The Contractor shall supply adequate potable and construction water for all trades. He shall arrange and pay for installation, maintenance, and removal of the water service and all consumption costs. When the permanent system is operational, it may be used for construction with Engineer and Employer written approval.

3.02.C Temporary Electricity

The Contractor shall arrange, install, operate, and remove a temporary electrical service at his cost for all trades. Where a local grid connection is unavailable or insufficient, the Contractor shall provide his own supply. Temporary wiring shall meet governing code requirements. At completion, temporary services shall be removed and replaced by permanent systems upon written approval of Engineer and Employer.

3.02. D Waste Disposal

The Contractor shall provide temporary measures to dispose of chemicals, fuels, waste, and other materials without site or environmental pollution. Disposal areas shall be as directed by the local authority and approved by the Engineer. Unauthorized dumping shall be remediated by the Contractor at his cost.

3.02. E Fire Protection

Adequate fire protection (extinguishers, fire buckets, water barrels) shall be distributed throughout the site and temporary structures. Flammable liquids shall be stored in Engineer-approved safety containers, not within buildings. Torch-cutting and welding require Engineer approval and a chemical extinguisher on location. The Contractor shall comply with Civil Defence and HSE manual of PAA.

3.03 CONSTRUCTION PROGRAMME AND SCHEDULE

A. The Contractor shall prepare a detailed Construction Programme (Master Programme) using an approved CPM scheduling software (Primavera P6 or MS Project 2019 or later). The programme shall be submitted in editable native format together with a PDF copy and six (6) hardcopy plots within twenty-eight (28) days of the Notice to Proceed. The programme shall represent the full 24-month construction duration .

B. The Master Programme shall include, as a minimum: (i) work breakdown structure to Level 4 (Project — Phase — Discipline — Activity); (ii) start and finish dates for every activity; (iii) logical interdependencies (Finish-to-Start, Start-to-Start, Finish-to-Finish with leads and lags as applicable); (iv) resource loading by trade and by quantity; (v) cost loading aligned with the BOQ for the purpose of progress payment certification; (vi) critical path clearly highlighted; (vii) twenty (20) key project milestones not later than those listed; (viii) procurement schedule for all long-lead items, in particular CNS equipment, HVAC chillers and cooling towers, transformers and switchgear, lifts, and ARFF equipment; (ix) airside coordination calendar (NOTAM windows, ASF pass procurement, OLS-penetrating operations, navigation-aid coordination periods); (x) testing and commissioning sub-schedule covering MEP, ELV, CNS

and integrated-systems tests; (xi) handover sub-schedule with as-built, O&M and training deliverables; and (xii) Defect Liability Period commencement and milestones.

C. Within fourteen (14) days of Engineer's approval, the Master Programme shall be baselined. No change to the baseline shall be made except by written Engineer's instruction or by an approved variation. The Contractor shall maintain a Baseline copy and a Current copy.

D. The Master Programme shall be updated by the Contractor on a monthly basis and submitted with the Monthly Progress Report. The update shall show actual start and finish dates, percent complete and remaining duration for every activity, and shall recompute the critical path. Any activity forecasting a slippage of more than five (5) working days against the Baseline shall be highlighted with an attached Recovery Plan describing the corrective measures, resource mobilisation, and revised forecast finish.

E. Three-Week Look-Ahead programmes shall be issued by the Contractor every Sunday for the forthcoming three weeks, identifying the activities to be executed, the inspections required, the materials required on site, and the labour and plant deployment. Look-Ahead programmes shall be tabled at the weekly Site Progress Meeting.

F. The Master Programme shall recognise the cold-climate constraints applicable to Skardu. External concrete works, external paving, external waterproofing and external finishing activities shall not be planned for the four-month winter period (typically December through March) when daytime ambient temperatures may fall below -5°C and night-time below -18°C , except under the specific cold-weather provisions of Sections 0150, 0340 and 0330 with prior Engineer approval. The dry-in milestone (building envelope weather-tight, roofing and external glazing complete) shall be achieved before the onset of the first winter falling within the construction period.

G. The Master Programme shall further recognise the operational constraints of an active aerodrome, in particular: (i) crane operations and other OLS-penetrating activities shall be planned within agreed NOTAM windows per Section 0750 2.1; (ii) hot work near fuel installations and works within 300 m of operational navigation aids shall be planned to discrete coordination periods with the Aerodrome Operator/ ATC of Skardu Airport; and (iii) all flight-inspection requirements for CNS equipment shall be agreed with the Aerodrome Operator / PAA and shall be programmed not later than 30 days before the Reliability Trial.

B. Delay impact assessment shall use the Window Time Analysis retrospective method or another method approved by the Engineer.

3.04 NOTIFICATION TO ENGINEER

A. The Engineer's Representative shall receive daily written notification of the nature and location of the following day's Work to enable inspection and measurement. The Engineer may require longer advance notice for specific operations.

3.05 NIGHT WORK

A. Night work shall be carried out with lighting from sunset to sunrise as directed by the Engineer. No work shall be performed when, in the Engineer's opinion, weather conditions preclude proper protection of the Work. The Night work shall be subject to approval from the relevant authority, i.e., ASF, PAF, and PAA.

3.06 COORDINATION WITH OTHER CONTRACTORS

A. The Contractor shall coordinate with all other contractors on site and ensure all embedded components (pipes, bases, etc.) are accurately and timely installed. Written sign-off from the authorized representative of other contractors shall be obtained before concreting or compaction.

B. Losses or rework resulting from the Contractor's negligence in coordination are at the Contractor's cost. Coordination costs are deemed included in the Contract rates.

3.07 MONTHLY PROGRESS REPORTS AND PHOTOGRAPHS

A. The Contractor shall submit monthly progress reports on Engineer-approved forms, plotting actual progress against the approved programme for all contract activities.

B. Commencing after the first month and continuing monthly, the Contractor shall submit progress photographs to the Engineer's Representative.

C. The Contractor shall also submit two (2) copies of a Daily Activity Report to the Engineer's Site Office, including manpower and equipment deployed and expediting status of materials.

3.08 PHOTOGRAPHS

A. From commencement of Work, the Contractor shall provide photographic documentation from positions selected by the Engineer. Each print shall be not less than 297 mm × 210 mm and shall bear a printed description, serial number, and date.

B. Time-lapse photography shall be provided by the Contractor using a specialist photographer and equipment, producing a 3-5 minute construction video from fixed positions at regular intervals. All photography is subject to Employer and security agency approval; confidentiality of images shall be maintained. Complete records shall be submitted to the Employer at Contract completion.

3.09 HEALTH, SAFETY, AND ENVIRONMENTAL REQUIREMENTS

A. The Contractor shall provide all required PPE for Employer, Engineer, Contractor, subcontractor personnel, and visitors throughout the Contract. Minimum requirements include helmets, safety shoes, gloves, harnesses, and respiratory protection.

B. A qualified HSE Engineer shall be deployed at the site during all working hours. HSE requirements shall be integrated into the Project Execution Plan from project commencement.

C. The Contractor shall provide adequate first aid equipment and trained first aid personnel on site during all working hours.

D. All HSE facility costs shall be borne by the Contractor until issuance of the Final Payment Certificate; these costs are deemed included in the Contract rates.

3.10 SURVEY INSTRUMENTS

A. The Contractor shall provide and maintain all survey instruments, equipment, and materials necessary to perform and verify survey work at all times. Equipment shall include but not be limited to:

- Electronic Total Station
- Electronic Data Recorder
- Disto Laser Meter
- Precision Level and Invert Staff
- Automatic Levels and Power Level
- Compass, steel tape, and ranging poles
- GPS and related equipment

3.11 INSPECTION AND TEST REPORTS

A. All equipment and materials are subject to inspection by the Engineer at any time. Acceptance or waiver of inspection does not relieve the Contractor of contractual responsibility.

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B. The Contractor shall provide certified true copies of test reports for all materials in manufactured and fabricated equipment, demonstrating compliance with applicable specifications and codes.

3.12 FACTORY ACCEPTANCE TESTING (FAT)

A. Where FAT is specified, equipment shall be inspected and tested at the point of manufacture by one (1) representative of the Employer and one (1) representative of the Engineer before packing and dispatch.

B. The Contractor shall arrange all facilities, travel, visas, accommodation, and boarding for Employer/Engineer representatives at the Contractor's cost.

C. The Contractor shall provide daily allowances (in cash before departure) as follows, calculated including day of departure and day of arrival back to city of deployment:

Inspection Location	Daily Allowance per Person
Foreign inspection	USD 250 per day
Local (outside city of deployment)	PKR 20,000 per day

D. Test procedures/protocols shall be submitted for Engineer approval at least three (3) weeks before the scheduled inspection date. All relevant submittals and shop drawings shall be approved prior to commencement of production.

3.13 RESTORATION AND CLEANING

A. The Contractor at its own cost, shall perform regular cleaning throughout the Contract and shall remove all rubbish and excess materials upon completion. All temporary construction facilities, foundations, stockpiles, and waste shall be obliterated unless directed otherwise. The site and Works shall be left clean and ready for immediate use and occupation.

3.14 PROTECTION OF WORKS

A. The Contractor shall cover and protect the Works from weather and damage as necessary. Dust sheets, barriers, and guard rails shall be provided and removed upon completion. Warning signs, lamps, and barricades shall be maintained at all dangerous locations.

3.15 PRODUCT QUALITY AND HANDLING

A. Suppliers shall have been engaged in the business of manufacturing, fabricating, installing, and/or servicing the required work for not less than five (5) years. The Engineer may request:

- List of similar installations with project description, scope, and completion date
- Complete technical literature and performance data
- List of service records within Pakistan
- Location of service office capable of maintaining the installation
- Availability of a local representative in Pakistan

B. Installation, fabrication, and testing shall be performed by trained and experienced workmen. No allowance will be made for lack of skill. The Contractor shall protect all materials before, during, and after installation; damage shall be repaired immediately at no additional cost to the Employer.

PART 4 – EMPLOYER AND ENGINEER FACILITIES

4.01 ENGINEER'S SITE OFFICE

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Within thirty (30) days of Contract signing or Notice to Commence (whichever is earlier), the Contractor shall supply, construct, erect, and fully commission pre-engineered/pre-fabricated insulated structures / building complete in all respects, ready for use for the Engineer's Site Office at a location designated by the Engineer as per provided design / drawings. All costs shall be borne by the Contractor. The Engineer's office shall at minimum consist of the following:

Unit	Size	Description	Qty
Office Rooms	Equivalent to 30 m ²	Pre-fabricated insulated structure, individual electrical sockets, individual distribution boards, air-conditioned (heating and cooling), backup generator connection	3
Engineer's Representative Office	Equivalent to 30 m ²	Pre-fabricated insulated structure, attached toilet, backup generator connection, full furnishings (executive desk, chairs, filing cabinets, shelving)	1
Toilet Block	Equivalent to 20 m ²	Pre-fabricated insulated structure, six (6) toilet cubicles with all sanitary accessories, soakage pits, mechanical ventilation	1
Records Room	Equivalent to 30 m ²	Pre-fabricated insulated structure, air-conditioned, backup generator connection, shelving and storage systems	1

B. Minimum furniture for Engineer's offices:

Item	Quantity
Wooden office table 4' × 6' with filing rack and drawers	6
Officer's revolving chairs	6
Wooden visitor chairs with arms	18
Wooden table 3' × 5' with revolving chair, 2 visitor chairs, side and full-height racks	20
Steel filing cabinet (standard size)	10

C. The Contractor shall undertake grading and landscaping of the area around site offices, supply all office consumables and stationery, POL for generators, hire two (2) office boys, provide cleaning and security staff, supply drinking water dispensers, potable water, power, five (5) landline telephone connections, and internet.

D. All facilities shall be maintained by the Contractor until issuance of the Defect Liability Certificate. All the facilities and equipment provided under this clause shall become the property of the Employer and shall be handed over in serviceable condition.

4.02 ENGINEER'S OFFICE EQUIPMENT

A. The following new equipment shall be provided within thirty (30) days of Contract signing and maintained, including consumables, until the Defect Liability Certificate:

Description	Qty
Laptop – Intel Core Ultra 7 / Intel Core i7 (14th Generation or later), minimum 16 GB DDR5 RAM, 1 TB NVMe SSD, 15.6" FHD IPS Display, Wi-Fi 6E, Bluetooth, HD Webcam, Windows 11 Pro, carrying bag (HP/Dell/Lenovo or approved equivalent)Laptop – Core i7, 11th Gen, 8 GB RAM, 512 GB SSD, 15.6" FHD, and Official Microsoft Office Software (HP/Dell or approved equivalent)	03
All-in-One Desktop Computer – Intel Core Ultra 7 / Intel Core i7 (14th Generation or later), minimum 16 GB DDR5 RAM, 1 TB NVMe SSD, integrated graphics, minimum 27-inch Full HD (1920 × 1080) anti-glare display, integrated webcam, speakers and microphone, wireless keyboard and mouse, Gigabit Ethernet, Wi-Fi 6E, Bluetooth, Windows 11 Pro (HP/Dell/Lenovo or approved equivalent)Desktop Computer – Core i7, 11th Gen, 4 GB RAM, 1 TB HDD, with monitor, keyboard, mouse, and Microsoft Office Software (HP/Dell or approved equivalent)	04
Laser MFP (copier/scanner/printer) – HP MFP M725 or approved equivalent	02
Laser Printer – HP LaserJet Pro M402dn or latest model or approved equivalent	02
Color Laser Printer – HP CP5225 or latest model or approved equivalent	01
Large Format Plotter / Technical Printer – Capable of printing engineering drawings, maps and architectural plans up to A0 size (36-inch width minimum), color printing, minimum print resolution 2400 × 1200 dpi, roll-feed and sheet-feed support, network connectivity (Ethernet/Wi-Fi), compatible with AutoCAD, GIS and PDF workflows, complete with stand and starter ink set (HP DesignJet, Canon imagePROGRAF, Epson SureColor or approved equivalent)	01

B. All equipment / computers and laptops shall be networked to the printers. Equipment becomes the Employer's property upon issuance of Defect Liability Certificate and shall be handed over in serviceable condition.

4.03 ENGINEER'S TRANSPORT

A. The Contractor shall provide the following brand-new vehicles with drivers within thirty (30) days of Contract signing:

Vehicle	Qty
Honda BR-V i-VTEC S (CVT) (Brand New)	01
Toyota Hilux Revo Rocco (Brand New)	01

B. The Contractor shall bear all costs for registration, taxes/duties, comprehensive insurance, fuel (250 liters per month per vehicle), maintenance at authorized service centers, and drivers' pay until issuance of the Defects Liability Certificate. Specified vehicles shall continue until the issuance of Defect Liability Certificate. Thereafter, vehicles become the Employer's property.

4.04 ENGINEER'S ACCOMMODATION

A. The Contractor shall, at its own cost and responsibility, provide fully furnished residential accommodation for the Engineer's personnel for the entire duration of the Contract up to and including issuance of the Defect Liability Certificate. The accommodation shall be provided in either of the following options, subject to the Employer's approval:

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Option A:

One (01) fully furnished house comprising not less than ten (10) bedrooms with attached bathrooms, along with one (1) living/sitting/TV room, one (1) dining room, one (1) kitchen, and one (1) store room.

Option B:

Two (02) fully furnished houses, each comprising not less than five (05) bedrooms with attached bathrooms per house. Under this option, at least one (1) house shall additionally include one (1) living/sitting/TV room, one (1) dining room, one (1) kitchen, and one (1) store room.

All accommodation shall be located within reasonable proximity to the Project Site, as approved by the Employer. The Contractor shall be fully responsible for all costs, charges, and liabilities relating to the accommodation, including but not limited to rent, utilities, and operational services. This shall include electricity, gas, potable water, internet services, and uninterrupted power supply through 24-hour generator backup along with fuel (POL) costs or solar system backup. No additional reimbursement shall be admissible on any account whatsoever.

B. All accommodation provided under Sub-clause 4.04A shall be fully furnished, operational, and maintained in habitable condition at all times. As a minimum requirement, each house shall include the following:

- One (01) 72-inch LED television for the living room;
- One (01) 2.0-ton inverter type air conditioner for the living room;
- One (01) 2.0-ton inverter type air conditioner for the dining room;
- One (01) sofa set (minimum thirteen-seater) for the living room;
- One (01) dining table with seating capacity for at least twelve (12) persons;
- One (01) double bed set per bedroom, including wardrobes/cupboards, dressing table, foam, bed sheets, pillows complete in all respect;
- One (01) large refrigerator at least 15cft;
- One (01) deep freezer;
- One (01) automatic washing machine;
- Television connectivity (cable/satellite) in all rooms.

All equipment shall be new or in “as-new” condition and shall be subject to inspection and acceptance by the Employer.

C. The Contractor shall deploy and maintain adequate trained support staff for housekeeping, catering, maintenance, and security services, including but not limited to cooks, cleaners/sweepers, helpers, and security guards.

Such personnel shall be available on a 24-hour basis as required to ensure cleanliness, safety, and proper functioning of the accommodation facilities.

The Employer reserves the right to inspect, approve, reject, or require replacement of any accommodation, furnishing, equipment, or services that do not comply with these Employer's Requirements. Any non-compliance shall be rectified by the Contractor at its own cost within a timeframe specified by the Employer.

4.05 EMPLOYER'S SITE OFFICE

Within thirty (30) days of Contract signing or Notice to Commence (whichever is earlier), the Contractor shall supply, construct, erect, and fully commission pre-engineered/pre-fabricated insulated structures / building complete in all respects, ready for use for the Employer's Site Office at a location designated

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by the Engineer as per provided design / drawings. All costs shall be borne by the Contractor. The Employer's office shall at minimum consist of the following

Unit	Description
General Office Rooms	Pre-fabricated insulated structures, air-conditioned, individual electrical sockets and distribution boards, fully furnished (desks, chairs, filing cabinets, computers, printers)
Project Director Office	Pre-fabricated insulated structures, air-conditioned, individual electrical sockets and distribution boards, fully furnished (desks, chairs, filing cabinets, computers, printers)
Conference Room	Pre-fabricated insulated structure with: three (3) 1.5-ton reversible ACs; conference table for 30 persons; 30 executive revolving chairs; 10 low-back chairs; 85-inch QLED screen; multimedia system; video-link; executive bathroom; kitchenette; generator connection. The Conference shall also be equipment with Audio-Video IP Conference System including but not limited to HD camera, microphone array, LED connectivity, decoder, static IP CIR connection, complete AV integration
Toilet Block	Pre-fabricated insulated structure, six (6) toilet cubicles with all sanitary accessories, soakage pits, mechanical ventilation
Record Room	Pre-fabricated insulated structure, air-conditioned, backup generator connection, shelving and storage systems

B. Furniture for Employer's offices:

Item	Quantity
Wooden office table 4' × 6' with filing rack and drawers	6
Officer's revolving chairs	6
Seven Seater Sofa Set	1
Wooden visitor chairs with arms	20
Wooden table 3' × 5' with revolving chair and side/rear racks	12
Steel filing cabinet (standard size)	2

C. The Contractor shall provide cleaning staff, security, drinking water, potable water for sanitation, power, internet, and landline telephone connections with all utility bills paid. All facilities shall be maintained until the Defect Liability Certificate. All facilities shall be maintained by the Contractor until issuance of the Defect Liability Certificate. All the facilities and equipment provided under this clause shall becomes the property of the Employer and shall be handed over in serviceable condition.

4.06 EMPLOYER'S OFFICE EQUIPMENT

Description	Qty
Laptop – Intel Core Ultra 7 / Intel Core i7 (14th Generation or later), minimum 16 GB DDR5 RAM, 1 TB NVMe SSD, 15.6" FHD IPS Display, Wi-Fi 6E, Bluetooth, HD Webcam, Windows 11 Pro with Official Microsoft Office Software carrying bag (HP/Dell/Lenovo or approved equivalent)	05
All-in-One Desktop Computer – Intel Core Ultra 7 / Intel Core i7 (14th Generation or later), minimum 16 GB DDR5 RAM, 1 TB NVMe SSD, integrated graphics, minimum 27-inch Full HD (1920 × 1080) anti-glare display, integrated webcam, speakers and microphone, wireless keyboard and mouse, Gigabit Ethernet, Wi-Fi 6E, Bluetooth, Windows 11 Pro with Official Microsoft Office Software (HP/Dell/Lenovo or approved equivalent)	05
Laser MFP (copier/scanner/printer) – HP MFP M725 or latest approved equivalent; networked to all computers	02
Color Printer A3 – Epson L1800 or latest approved equivalent	01
Heavy Duty Duplex Scanner with Autofeed System – High-volume production scanner, minimum 50 ppm / 100 ipm duplex scanning, 100-sheet automatic document feeder (ADF), daily duty cycle ≥ 8,000 pages, support for mixed media and cardstock, USB 3.0 connectivity (built-in or optional Ethernet), TWAIN/ISIS drivers. (Epson DS-870 or Ricoh fi-8150 or approved equivalent)	02
Photocopier Machine with A4/A3 Copy Capability – Latest generation digital copiermonochrome (as required), minimum 45 ppm A4 copy/print speed, A3 copy / print capability, dual-sided automatic document feeder, network ready, scan to email/folder, duplex printing, 7-inch or larger touch panel. (Canon imageRUNNER ADVANCE DX C5850, Ricoh IM C4510, Xerox AltaLink C8245, or approved equivalent)	01

All equipment becomes the Employer's property upon issuance of the Defects Liability Certificate and shall be handed over in serviceable condition.

4.07 EMPLOYER'S TRANSPORT

Vehicle	Qty
BYD Shark 6 DMO AWD Premium	01
Changan Oshan X7 Future Sense 7-Seat	01
Honda BR-V i-VTEC S (CVT)	01

All costs including registration, taxes/duties, insurance, fuel (250 liter per vehicle per month), maintenance, and drivers' pay are the Contractor's responsibility until the issuance of Defect Liability Certificate. Vehicles become the Employer's property thereafter.

4.08 EMPLOYER'S ACCOMMODATION

A. The Contractor shall, at its own cost and responsibility, provide fully furnished residential accommodation for the Employer's personnel for the entire duration of the Contract up to and including issuance of the Defect Liability Certificate. The accommodation shall fully comply with the requirements specified under Clauses 4.04(A), 4.04(B), and 4.04(C), which shall be deemed to form an integral part of and be fully applicable to the accommodation to be provided under this Clause.

4.09 PENALTIES FOR NON-COMPLIANCE OR DELAYED PROVISION OF FACILITIES

- A. In case of non-provision, partial provision, or delayed provision of any facility required under the Contract, the following penalties shall be imposed. The penalties shall apply without prejudice to any other rights or remedies available to the Employer under the Contract:

Sr. No.	Description of Default	Time Allowed	Penalty / Fine
1	Non-provision of Engineer's / Employer's Site Office in accordance with Clauses 4.01 and 4.05, including any substantial part thereof or associated equipment	Within 30 days from issuance of Notice to Commence (NTC)	PKR 1,000,000 per month or part thereof of delay
2	Non-provision of Engineer's / Employer's Office Equipment in accordance with Clauses 4.02 and 4.06, including any individual item or component including subsequent replacement / repair.	Within 30 days from issuance of NTC	PKR 50,000 per month per item or component not provided
3	Non-provision of Engineer's / Employer's Transport in accordance with Clauses 4.03 and 4.07, including any vehicle or unit	Within 30 days from issuance of NTC	PKR 500,000 per month per vehicle not provided
4	Non-provision of Engineer's / Employer's Accommodation in accordance with Clauses 4.04 and 4.08, including any part thereof	Within 30 days from issuance of NTC	PKR 500,000 per month or part thereof of non-compliance
5	Non-availability or interruption of utilities (electricity, gas, internet) for Engineer's or Employer's office	Within 30 days from issuance of NTC / Interruption for more than one day	PKR 100,000 per month or part thereof
6	Failure to pay utility charges for Employer's accommodation	Within 30 days from issuance of NTC / interruption for more than one day / expiry of due date of utility company	PKR 100,000 per month or part thereof
7	Failure to provide required support staff including peons, security staff, cook, drivers and cleaning staff as per Contract requirements	Within 30 days from issuance of NTC / absence of any of the staff for more than 7 days.	PKR 5,000 per day per person not provided

PART 5 – ADMINISTRATIVE REQUIREMENTS

5.01 PERMITS

A. The Contractor shall secure and pay for all required approvals, permits, and inspections from governmental or other controlling agencies before commencing any Work. Official records of permits shall be turned over to the Engineer/Employer. No reimbursement will be made.

5.02 FAA ADVISORY CIRCULARS

A. In the event of any contradiction between the Drawings and Specifications and FAA Advisory Circular Nos. AC 150/5370-10H, AC 150/5320-6G, and AC 150/5380-6C, the more stringent requirement shall govern as determined by the Engineer, with no financial implications to the Employer. Measurement and payment clauses of respective specification sections shall remain unchanged.

5.03 WARRANTIES

A. The Contractor shall provide equipment warranties as specified in the relevant specification sections. Warranty periods commence from the effective date of the Taking Over Certificate. Warranties shall be endorsed in the Employer's name, with an undertaking from the OEM and local representative to provide warranty services to the Employer.

5.04 MEASUREMENT & PAYMENT OF WORK

The cost of providing and maintenance of above facilities during the construction period and Defects Liability Period shall not be paid separately to the Contractor and all costs shall be deemed to have been included by the Contractor in rates/ amounts of other items of BOQ.

If the aforementioned facilities are not provided within the time specified above, then the Contractor shall bear all expenses, such as rents incurred by the Engineer/ Employer due to the failure of the Contractor to complete and handover the said facilities and any of their fittings, furniture, equipment and associated hiring of staff/ drivers etc.

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0020 - DIVERSION AND TRAFFIC CONTROL PLAN

PART 1 – GENERAL

1.01 SUMMARY

The Contractor shall be responsible to provide a comprehensive traffic control plan for the safety of vehicular and pedestrian traffic during construction. Shop drawing for this purpose shall be submitted to the Engineer for approval. The Traffic Control Devices shall comprise but not be limited to Barricades/Fences, Cones, Warning Signs, Warning Lights etc. The Contractor will specify the number and details of the traffic control devices he intends to use in the traffic control plan. Items that should be considered in preparing traffic control plans include but not limited to the following:

- (a) The Contractor shall construct detour roads as per approved road pavement section.
- (b) Detour alignment and surface that will allow traffic to pass smoothly around the work zones. The surface of the travelled way, whether located within the construction area or on a detour, should be maintained in a condition that will permit the safe movement of traffic at a reasonable speed.
- (c) Adequate tapers are needed for lane drops or at locations where traffic must be shifted laterally.
- (d) Adequate traffic control devices and pavement markings for complete day and night effectiveness must be provided, including specification of temporary marking materials that can be removed when traffic lane patterns change.
- (e) Roadway illumination and warning lights should be used where required. Steady burning lights are used to delineate a continuous travel path through or around a work zone. The very short "on" time of flashing lights does not enable motorists to focus on the light and make a depth perception estimate. The use of flashers is limited to mark single hazards, marking the start of a section using steady burn lights, and for use with traffic control signs.
- (f) The location of cones, delineators, drums, barriers, or barricades, as means of channelizing traffic, should be detailed in the traffic control plans when special conditions exist or it not shown in the standard plans.
- (g) If not provided for in the specifications, requirements regarding the removal of signs and markings from the job site, when they are no longer needed, should be noted on the traffic control plans.

PART 2 – SUBMITTALS

2.01 SHOP DRAWINGS

The Contractor shall prepare and submit a comprehensive Traffic Control Plan shop drawing to the Engineer for approval prior to commencement of any work that affects vehicular or pedestrian traffic. The plan shall detail all traffic control devices, their locations, and the sequence of implementation.

PART 3 – EXECUTION

3.01 IMPLEMENTATION

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The Contractor shall implement the approved Traffic Control Plan throughout the duration of construction. All traffic control devices shall be installed, maintained, and removed in accordance with the approved plan and as directed by the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0030 - CONTRACTOR'S CAMP

PART 1 – GENERAL

1.01 SCOPE

The work to be done under this item consists of construction, erection, installation and maintenance of the Contractor's Project Site Offices or main camp and the Contractor's sub-camps or temporary camps, if any, and shall include all offices, shops, warehouses, and other operational buildings; all housing and related facilities including accommodations for the Contractor's personnel. Contractor's Camp may not be located within project site.

1.02 GENERAL

The location of the Contractor's camps, including all buildings, utilities and facilities thereof, and of the camps or establishments of all persons/parties in the vicinity operating or associated with the Contractor shall be subject to approval of the Engineer.

The work to be done under this item will terminate upon the issuance of the Taking over Certificate. However, if directed by the Engineer or the Employer, the Contractor shall continue such work to the extent required by the Contractor's personnel during the Defects Liability Period or until the certification of the final Bill by the Engineer. No compensation shall be paid for the continued operation and maintenance of the Contractor's Camps during the extended Period.

Upon completion of the Works, or at such time within the Defects Liability Period as directed by the Engineer, the Contractor shall remove all buildings, utilities and other facilities from the Site and restore all camp areas to a neat and clean condition. The Employer may opt to retain any or all of the above-mentioned facilities for his use after the completion of the works, in which case the Contractor shall have no claim on these facilities.

Contractor shall protect the environmental interests and HSE (Health, Safety & Environmental) regulations at camp and works sites during execution of the contractual work.

1.03 CODES AND STANDARDS

The construction, operation and maintenance of all camps of the Contractor shall comply with all applicable provisions of current Pakistan Labour Camp Rules.

PART 2 – SUBMITTALS

2.01 SUBMITTALS

The Contractor shall submit to the Engineer for approval the following prior to establishment of camp facilities:

- A. Proposed location and layout plan of the Contractor's camp, sub-camps, and all associated facilities.
- B. Details of all buildings, utilities, and services proposed for the camp.
- C. HSE plan for camp operations.

PART 3 – EXECUTION

3.01 MAINTENANCE

The Contractor shall furnish, make arrangements for, and carry out proper and adequate maintenance of the Contractor's Camp areas at such camp to provide a neat, well-kept camp in all respects with pleasant and healthy surroundings and conditions for all occupants of

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their camp. The Contractor's camp shall be kept clean, well-graded, free from undergrowth and bushes, and adequately drained. Roads and streets shall be kept in good condition. All utilities shall be adequately and properly operated and maintained to provide services and conditions meeting the requirements of these specifications in all respects.

Adequately equipped and properly staffed portable first aid stations or dispensaries shall be provided by the Contractor at camps and other strategic locations to administer first aid treatment at any time required and free of charge to all persons on the Site, including employees of the Engineer and the Employer.

All the facilities developed by the Contractor for his personnel shall be well ventilated and in line with the extreme weather conditions of Skardu. In any case, a steel structure without insulation will not be allowed for office/residential accommodation of the Contractor's Staff. Access of Employer/Engineer to Contractor Camp shall be ensured all times.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0040 - STAKE-OUT SURVEY

PART 1 – GENERAL

1.01 SCOPE

The work to be done under this item the Contractor shall make the stakeout survey for construction purposes with competently qualified men, consistent with the current practices. The work shall proceed immediately upon the award of the Contract and shall be expeditiously progressed to completion in a manner and at a rate satisfactory to the Engineer. The Contractor shall keep the Engineer fully informed as to the progress of the stakeout survey. The scope of this section of specifications is covered by detailed specifications as laid down herein.

PART 2 – PRODUCTS

2.01 MATERIAL AND EQUIPMENT

All instruments, equipment, stakes and other material necessary to perform all work shall be calibrated and provided by the Contractor. These instruments and equipment shall be available to Engineer at all times for the purpose of checking the work of the Contract.

All stakes used shall be of a type approved by the Engineer, clearly and permanently marked so as to be legible at all times. It shall be the Contractor's responsibility to maintain these stakes in their proper position and location at all times. Any existing stakes or markers defining property lines and survey monuments which may be disturbed during construction shall be properly tied into fixed reference point before being disturbed and accurately reset in their proper position upon completion of the work.

PART 3 – EXECUTION

3.01 CONSTRUCTION

The Contractor shall trim trees, bushes and other interfering objects, not consistent with the plan, from survey lines in advance of all survey work to permit accurate and unimpeded work by his stake-out survey crews and the Engineer's survey crews. The Contractor shall mark/locate/identify all features/facilities which require to be dismantle and obtain approval of the Engineer before proceeding with the dismantling/relocation activities. The exact position of all work shall be established from control points, which are shown on the plans or modified by the Engineer. Any error, apparent discrepancy in or absence of data shown or required for accurately accomplishing the stakeout survey shall be referred to the Engineer for interpretation or furnishing when such is observed or required.

The Contractor shall be responsible for the accuracy of his work and shall maintain all reference points, stakes, etc. throughout the life of the Contract. Damaged, destroyed, or inaccessible reference points, benchmarks or stakes shall be replaced by the Contractor. Existing or new control points that will be or are destroyed during construction shall be re-established and all reference ties recorded thereon shall be furnished to the Engineer. All stakeout survey work shall be referenced to the centrelines shown on the Plans. All computations necessary to establish the exact position of the work from control points shall be made and preserved by the Contractor. All computations, survey notes and other records necessary to accomplish the work shall be kept neatly and made available to the Engineer upon request and furnished to the Employer upon Contract completion.

The Engineer may check all, or any portion of the stakeout survey work or notes made by the Contractor and any necessary correction to the work shall be immediately made. Such checking by the Engineer shall not relieve the Contractor of any of his responsibilities for the accuracy or completeness of his work.

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Reference points, base lines, stakes and benchmarks for borrow pits shall be established by the Contractor.

All required right-of-way and easement limits shall be established, staked and referenced by the Contractor concurrent with the construction stakeout survey.

The Contractor shall place at least two offset stakes or references at each centre lines station and at such intermediate stations as the Engineer may direct. From computations and measurements made by the Contractor, these stakes shall be clearly marked with the correct centre line, station number, offset and cut or fill so as to permit the establishment of the true centre line location during construction. He shall locate and place all cut, fill, slope, line grade or other stakes and points as the Engineer may direct to be necessary for the proper progress of the work.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0050 - CLEARING AND GRUBBING

PART 1-GENERAL

1.1 Scope

Clearing and grubbing shall consist of clearing the designated area of all trees, down timber, snags, bush, other vegetation, rubbish and all other objectionable material, and shall include grubbing stumps, roots, and matted roots, and disposal of all spoil material resulting from the clearing and grubbing. It shall also include the removal and disposal of structures that protrude, encroach upon, or otherwise obstruct the work, except when otherwise provided for on the plans or directed by the Engineer to be saved. The scope of this section of specifications is covered with detailed specifications laid down herein.

PART 2-LIMIT OF AREA

The Engineer will define the limit of areas where clearing and grubbing is to be done. Normally it will include all land within the right of way and all other construction area including ditches, detours, minor road crossings and other areas shown on the plans or as specified or as directed by the Engineer. The Engineer will designate the fences, structures and debris and trees and bushes to be cleared where grubbing is not required. It shall not include clearing and grubbing of borrow or other pit areas from which material is secured. It shall include the leveling or removal of all bunds or mounds within the right of way unless otherwise directed by the Engineer.

PART 3-PRODUCTS

Not used

PART 4-EXECUTION

4.1 Grubbing and Cutting

All roots and stumps within the limits of the site shall be grubbed and excavated unless otherwise specified or approved by the Engineer.

4.2 Disposal

The Contractor shall be responsible for disposal of any materials not required at site within specified time after cutting and filling unless otherwise approved. All wood and bushes shall be disposed of within fifteen (15) days after cutting or falling unless otherwise approved. No tree trunks, stumps, debris or other objectionable material shall be left within Site unless approved in writing by the Engineer. The location of disposal areas shall be within the Contract limits of the project or as approved in writing by the Engineer and shall be acquired by the Contractor at his own expense. All materials whatsoever designate as reusable shall be stockpiled or stored safely by the Contractor at approved locations and shall remain the property of the Employer.

4.4 Protection and Restoration

The Contractor shall prevent all damage to pipes, conduits, wires, cables or structures above or below ground. No land monuments, property markers, or official datum points shall be damaged or removed until the Engineer has witnessed or otherwise referred their location and approved their removal. The Contractor shall so control his operations as to prevent damage to trees and shrubs, which are to be preserved. Protection may include fences and boards lashed to trees to prevent damage from machine operations. The Contractor shall protect the environmental interests / conditions of the areas of camp and work site. The existing covered or open benchmarks should be relocated as directed by the Engineer. In the event that anything specified herein to be saved and protected is damaged by the Contractor; such damages shall immediately be repaired or

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replaced by the Contractor at his own cost to the satisfaction of the Engineer. All areas cleared and grubbed must be approved by the Engineer or Engineer's Representative before the start of cleaning operations.

PART 5- MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0060 - STRIPPING OF TOPSOIL

PART 1-GENERAL

1.1 Scope

The work under this section of the specifications shall consist of furnishing all plant, labor and equipment and performing all operations in connection with stripping of topsoil, removal and disposal of unsuitable and surplus material in accordance with the specification and the lines, grades and levels as shown on the drawings or as directed by the Engineer.

PART 2-PRODUCT

Not used

PART 3-EXECUTION

The Contractor shall jointly survey the area marked on the drawings or designated by the Engineer and prepare the survey drawings showing pre-work levels and cross-section and submit to the Engineer for approval prior to the start of any stripping of top soil up to the depth as shown on drawings or mentioned on BoQ. Any area that shall be stripped to thickness more than the specified thickness shall be approved by the Engineer prior to the start of the work. All related drawings shall be submitted for the approval of the Engineer before stripping operations are started. Approval of the Engineer for further stripping shall be required before proceeding for further stripping if required.

All suitable material from stripping of top soil shall be transported to and placed in fill areas or stock piled as directed by the Engineer. All material declared by the Engineer as unsuitable or surplus shall be removed and disposed of in areas as designated by the Engineer.

Over stripping, unless otherwise directed, shall not be acceptable, and the Contractor shall backfill to the required levels and grades and compact to 90% of maximum dry density as determined by ASTM D 1557 at his own expense. Stripping will not be carried out on areas where rock is exposed on the surface.

The finished grade surface shall be smooth and even, and the tolerance from the required grade shall not be more than 25mm.

Stripping of topsoil beyond the depth of 300 mm shall be treated as excavation and shall not be considered as stripping.

Space created after stripping up to the required depth shall be filled with the material as directed by the Engineer and shall be dealt with separately under the relevant item.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0070 - DEMOLISHING & DISMANTLING WORKS

PART 1 – GENERAL

1.01 SCOPE

The work covered by this Section of the Specifications consists of furnishing all plant, labour, equipment, appliances and performing all operations in connection with demolition/dismantling and removal of existing structures, sheds, asphalt road, pavement, kerbs, medians, foundations, stone pitching, approaches/platforms, buildings, boundary walls, trees, plants, removal of services with accessories and embankments, stone ballast, sub base and base course, plain & reinforced concrete and brick/concrete/block masonry structures within and around the proposed construction area for the New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu, including disposal of demolished/dismantled and removed material to designated places or handing over of useable material to Employer. Whole work shall be done in accordance with these specifications and as directed by the Engineer.

1.02 GENERAL REQUIREMENTS

- A.** The work includes demolition, salvage of identified items and materials, and removal of resulting rubbish and debris. Rubbish and debris shall be removed, unless otherwise directed. Materials that cannot be removed daily shall be stored in areas specified by the Engineer. In the interest of conservation, salvage shall be pursued to the maximum extent possible. The usable/salvaged material shall become the property of the Employer.
- B.** Dismantling works including demolition/dismantling of existing pavement, structures, facilities, redundant utility network and manholes (as identified by the Engineer) at any depth & level, stacking of useable material its handing over to Employer and disposal of debris/unused/demolished/removed materials, including loading, unloading and transporting complete in all respect to designated places and up to any lead or as directed by the Engineer. The works shall require to be carried out with reference to the requirements of the particular sections of specifications listed below and without damaging all operational existing utility network/services connections and ensuring uninterrupted airport operations and safe movement within Skardu International Airport during construction of the New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities:

Section 0050 – Clearing and Grubbing

Section 0060 – Stripping of Soil

Section 0070 – Dismantling Works

Contractor shall conduct a pre-work survey of the entire proposed construction area for the ATCT, Fire Station and Allied Facilities and shall submit program for carrying the works specified here for approval of the Engineer prior to execution.

- C.** All existing structures and utilities obstructing the construction shall be demolished/relocated as directed by the Engineer. For further details and extent of demolition & dismantling works refer to drawings.

PART 2 – SUBMITTALS

2.01 SUBMITTALS

The procedures proposed for the accomplishment of the work shall be submitted for Engineer review prior to commencement.

The procedures shall provide for safe conduct of the work, including procedures and methods to provide necessary supports, lateral bracing and shoring when required, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. The procedures shall include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations.

PART 3 – EXECUTION

3.01 DUST CONTROL

The amount of dust resulting from demolition shall be controlled using construction safety cloths to prevent the spread of dust to occupied portions of the construction site and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it could result in, or create, hazardous or objectionable conditions such as ice, flooding and pollution.

3.02 PROTECTION

3.02. A Protection of Personnel

During the demolition work the Contractor shall continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area.

3.02. B Protection of Buildings to be Demolished / Dismantled

Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, may be allowed to remain standing without additional bracing, shoring, or lateral support until demolished. The Contractor shall ensure that no elements determined to be unstable are left unsupported and shall be responsible for placing and securing bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

3.02.C Protection of Existing Property

Before beginning any demolition work, the Contractor shall survey the site and examine the drawings and specifications to determine the extent of the work. The Contractor shall take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the User; any damaged items shall be repaired or replaced as approved by the Engineer. The Contractor shall coordinate the work of this section with all other works and shall construct and maintain shoring, bracing, and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

3.02. D Protection From the Weather

The usable and salvageable materials shall be protected from the weather at all times until handing over to the Employer.

The Contractor shall also prevent ingress of rain water/surface runoff or water from any source into excavation/dismantled area.

3.02. E Protection of Trees

Trees within the project site which might be damaged during demolition and which are indicated to be left in place shall be protected by a 1.83 m high fence. The fence shall be securely erected a minimum of 1.5 m from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the work under this contract shall be replaced in kind or as approved by the Engineer.

3.03 BURNING

The use of burning at the project site for the disposal of refuse and debris shall not be permitted.

3.04 USE OF EXPLOSIVES

Use of explosives shall not be permitted.

3.05 PROCEDURES

- A. The Engineer will define the limits where demolition/dismantling and removal activity is to be done and shall approve the procedures/methods to be adopted by the Contractor. The Contractor shall layout the boundaries/limits for Engineer's checking and approval before commencing dismantling work.
- B. Whole work shall be performed in an orderly manner and the Contractor shall take all necessary precautions and expedients to prevent damages to the adjacent structures, installed equipment/machinery, pipes, conduits, any other installation etc. Any damage caused to the structures and installations due to negligence of the Contractor during demolition/dismantled and removal operations shall be repaired/replaced by the Contractor at his cost and to the satisfaction of the Engineer.

3.06 DEMOLITION OF SHEDS, STRUCTURES, ROADS, PAVEMENTS, MASONRY WORKS, BUILDINGS AND PLAIN/REINFORCED CONCRETE

The Contractor shall demolish sheds, structures, road/pavements, masonry/flooring works, stone pitching, buildings, utilities/networks and plain/reinforced concrete works to the line and depth as shown on the Drawings or as directed by the Engineer within the construction area for the New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport. Explosives shall not be used to remove the plain and reinforced cement concrete or any other material whatsoever. Mechanically operated breakers, concrete saws, chipping hammers or other methods as approved by the Engineer shall be employed for cutting. Care shall be taken that existing services and structures are not damaged. It shall be the responsibility of the Contractor to replace at his cost any service, pavement/PQC and structure damaged by the Contractor due to his negligence during cutting operations or thereafter until the whole of areas are restored to original condition.

3.07 CLEARANCE OF GREEN AREA

The bushes/plants in existing green area shall be cleared off up to the roots and the surface shall smoothen and cleared from all debris and any organic material before receiving new layer after approval of the Engineer.

3.08 SHIFTING / TRANSPLANTING OF EXISTING VEGETATION

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Any existing trees, shrubs or plants within the ATCT, Fire Station and Allied Facilities construction area that are identified by the Engineer for retention or transplanting shall be carefully uprooted and shifted to locations as shown in drawings or as approved by the Engineer, with due care to preserve their root systems and ensure their survival.

3.09 REMOVAL OF EXISTING SERVICES / UTILITIES

The Contractor shall mark all the services/utilities falling within the ROW. After getting approval from the Engineer, the Contractor shall remove all such services/utilities as per the requirement/specifications of the relevant department whose utilities/services are being removed/shifted.

3.10 CLEAN UP

Debris and rubbish shall be removed from site. Debris shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

All debris materials resulting from demolition/dismantling works shall be disposed off to places designated by the Engineer in the manner of disposition required and directed by the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0075 - LEVELLING AND GRADING

01. SCOPE

- 1.1 The work to be done under this section of the specifications consists of performing all earth work required for levelling & grading the area in accordance with required levels, elevations and grades shown on the Drawing/Plans or as established by the Engineer. The work to be done by the Contractor shall include performing the required cutting to line, levels, grade and filling the area to the desired levels and grades; providing and transporting labour, excavating, grading, levelling, and watering and all incidental operations required in performing the work as specified herein.
- 1.2 Levelling and grading work shall be performed after completing the clearing and grubbing.
- 1.3 During the progress of the works, if by reason of delay, effects of bad weather; rainfall, or from any cause whatsoever, any levels, grades or profiles of the area are changed, the Contractor shall, at his own cost, be liable to bring the area to the required levels and profiles as shown on the Drawings or as directed by the Engineer.
- 1.4 Prior to commencement of work the Contractor shall submit for approval of the Engineer complete proposal with regard to methodology to be adopted for cut and fill for levelling and grading works contractor should give due consideration to the site configuration and the required levels and lines shown on the drawing.

02. APPLICABLE STANDARDS

- 2.1 Materials, construction and testing shall comply with the following codes and standards:

ASTM D 422	Particle size analysis
ASTM D 423 & 424	Test for liquid & Plastic Limit
ASTM D 1556, 1557 & 2167	Compaction

03. GENERAL

- 3.1 The Contractor shall submit, a detailed list of plant and equipment which he shall undertake to bring to the site and to carry out the work. The list shall satisfy the Engineer as to type, size and quantity.
- 3.2 The Contractor shall jointly survey the Project area marked on the drawings or any area designated by the Engineer and prepare the survey drawings showing pre work levels of natural ground profile and cross-sections and submit to the Engineer for approval prior to start of any leveling and grading operation. Clearing grubbing shall be done in accordance with the provision of related specification section.
- 3.3 Existing utilities which are to remain in service or to be relocated and to remain in service until relocation, are to be determined by the Contractor.
- 3.4 The select material from cut/excavations shall be transported to and placed in fill areas or stockpiled at locations designated by the Engineer.

04. SITE PREPARATION

- 4.1 The Contractor shall set out the works and shall be responsible for true and perfect setting out of the same and for correctness of the positions, levels, dimensions and alignments of all parts thereof. If at any time any error in this respect shall appear during the progress of the works, the Contractor shall at his own expense rectify such error.
- 4.2 The Contractor shall construct and maintain accurate bench marks so that the lines and levels can be easily checked by the Engineer.
- 4.3 Levelling and grading of the designated area shall be done by means of levelling equipment and grading machines. The Contractor shall be responsible for the required construction and stability of the grades in conformity with the Drawings/Plans or as determined by the Engineer.

05. CUT

5.1 Classifications of Cut

No classification shall be made of any material excavated/ cut as to its class, nature, origin or condition. The excavation will be unclassified as being carried out in all kinds of subsurface material including soil and rock.

Blasting will be permitted only when proper precautions are taken for the safety of all persons, the work, and the property. All damage done to the work or property shall be repaired at the Contractor's expense. All operations of the Contractor in connection with the transportation, storage, and use of explosives shall conform to all state and local regulations and explosive manufacturers' instructions, with applicable approved permits reviewed by the Engineer. Any approval given, however, will not relieve the Contractor of his/ her responsibility in blasting operations.

In each distinct blasting area, where pertinent factors affecting blast vibrations and their effects in the area remain the same, the Contractor shall submit a blasting plan of the initial blasts to the Engineer for approval. This plan must consist of holes size, depth, spacing, one delay period, depth of rock and depth of overburden if any. The maximum explosive charge weights per delay included in the plan shall not be increased without the approval of the Engineer.

The Contractor shall keep a record of each blast fired – its date, time and location; the amount of explosives used, maximum explosive charge weight per delay period and where necessary, seismograph records identified by instrument number and location.

The Contractor shall build, maintain and operate all berms, channels, flumes, sumps and other temporary diversion and protection works needed to divert the surface water through or around the required excavation.

Prior to commencement of the work, the Contractor shall furnish the Engineer for review and comments with complete plans and sketches for diverting surface water, if any.

Submission for review and comments of the required plans and sketches and any approval from Engineer shall not relieve the Contractor of any of his/ her duties and obligations under the Contract.

5.2 Tolerance

The surface shall be of smoothness that will not vary more than 50mm from true grade as shown on drawings and decided by the Engineer.

5.3 Extra Cut/Excavation

In the event the Contractor cuts/excavates any area to a level lower than the required, he shall re-instate such areas to the required density levels and grades. No extra payment will be made to the Contractor on this account.

06. FILL

6.1 Fill Materials

Areas requiring filling shall be filled with select material obtained from the required cut / excavations. The fill material shall be free from objectionable material and to the satisfaction of the Engineer. The gaps between the rock fragments shall be filled with finer material. The earthwork by rock fragments should be kept at lower part of the fill and size of these fragments shall not be larger than 0.06 cu.m. The location of rock fragment dumping shall be subject to the approval of the Engineer.

The Contractor shall not place fill material during periods of rain.

6.2 Haul

All hauling will be considered a necessary and incidental part of the work.

6.3 Tolerances

Finished surface shall be smooth and even and shall not vary more than 50 mm from elevations/ true grade as shown on drawings.

07. QUALITY CONTROL

Field inspection will be carried out jointly by the contractor and the Engineer. Contractor shall facilitate the inspection and the performance of tests and bear all costs thereof. A copy of all test shall be submitted to the Engineer for approval. Tests shall be performed for each type of the material encountered during excavation in accordance with ASTM D-422 for selecting the material at various fill locations.

08. MEASUREMENT AND PAYMENT

8.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the undermentioned works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective item of the Bills of Quantities.

8.1.1 Any fill with approved material necessitated by over cut/excavation due to fault or convenience of the contractor.

8.1.2 Stock piling of the cut/excavated select material at approved locations within project boundary and transporting back the same to places requiring fill.

8.1.3 Laboratory and field tests stipulated in these specifications.

8.1.4 Disposal of surplus cut material within 05 kilometers free haulage limit along the most direct route from the boundary of the project.

8.1.5 Transporting approved select fill material from within the project boundary.

8.1.6 Levelling, grading and spreading of cut & fill of soil/rock.

8.2 **Levelling and Grading by 'Cutting'**

8.2.1 Measurement

Measurement of acceptably completed works of levelling and grading by cutting will be made on the basis of net actual volume of 'cut' as per BOQ in accordance with the line level and grade shown on the drawings or as directed by the Engineer.

Quantities of cutting shall be calculated / measured for payment purposes from the pre-work levels and the levels shown on the drawings.

8.2.2 Payment

Payment will be made for acceptable measured quantity as provided above of levelling and grading in 'cut' on the basis of unit rate as per BOQ quoted in the Bill of Quantities and shall constitute full compensation of all the works related to the item.

8.3 **Levelling & Grading by 'Filling'**

8.3.1 Measurement

Measurement of acceptably completed works of levelling and grading by 'Filling' will be made on the basis of net actual volume as per BOQ of compacted 'Fill' in accordance with the lines levels and grade as shown on the drawings as directed by the Engineer.

Quantities of 'Filling' shall be calculated / measured for payment purposes from the pre-work levels and the levels shown on the drawings.

8.3.2 Payment

Payment will be made for acceptable measured quantity of levelling and grading in 'Filling' on the basis of unit rate as per BOQ quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

SECTION 0080 - LANDSCAPING

PART 1 -SCOPE

The work covered by this section of the specifications consists of furnishing all plant, labour, equipment appliances, materials and performing all operations in connection with the preparation, placing and final grading of all top soil, furnishing and planting all new trees, lawn, shrubs / creepers and plant material shown on the Drawings and or specified herein and ensuring protection of all existing trees and plantation.

PART 2- APPLICABLE CODES & STANDARDS

A. AASHTO (American Association of State Highway and Transportation Officials)

1. AASHTO T 99 – Standard Method of Test for Moisture Density Relations of Soils.

B. ASTM International:

ASTM A 36/A 36M-05: Specification for Carbon Structural Steel

ASTM A 48/A 48M-03: Specification for Gray Iron Castings

ASTM A 641/A 641 M-03: Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM C 602-95a (Reapproved 2001): Specification for Agricultural Liming Materials

ASTM D 448-03a: Classification for Sizes of Aggregate for Road and Bridge Construction

ASTM D 5268-02: Specification for Topsoil Used for Landscaping Purposes

PART 3-DEFINITIONS

- i. **Backfill:** The earth used to replace or the act of replacing earth in an excavation.
- ii. **Bagged Stock:** Healthy, vigorous, well-rooted plants grown in polythene plastic bags, with a well-established root system reaching sides of container and maintaining a firm ball when removed from bags.
- iii. **Balled and Burlapped Stock:** Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth specified herein for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball.
- iv. **Balled and Potted Stock:** Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth specified herein for type and size of plant required.
- v. **Bare-Root Stock:** Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread specified herein for type and size of plant required.
- vi. **Container-Grown Stock:** Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized as specified herein for type and size of plant required.
- vii. **Duff Layer:** The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- viii. **Fertilizers; Chemical fertilizers:** Shall be approved granular fertilizers. Fertilizer may be single element or compound, normal or slow-release compound fertilizers. They shall be stored in waterproof sealed bags under shelter away from water and direct sunlight. Samples shall be submitted to, and approved by the Landscape Architect, before use in the Works.
- ix. **Finish Grade:** Elevation of finished surface of soil mix.
- x. **Geo-membrane Liner:** A high-density polyethylene liner used a separator between the growing containers and the surface ground to prevent plant root penetration.

- xi. **Green area:** Areas of grassy lawn with or without groundcover.
- xii. **Imported grass:** Grass developed in nursery for garden areas like "Korean Grass" (Zoysia/Matrella).
- xiii. **Local grass:** Indigenous grass variety like "khabbal grass" (Bermuda grass/Cynodon dactylon).
- xiv. **Manufactured Topsoil:** Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic manure to produce topsoil or soil mix. Organic Compost; Organic compost shall be an organic vegetable compost produced through a horticultural or industrial composting process. Compost is to be clean, decomposed, smell free, and free of any debris, refuse, clay or visible fungus. A sample and test data is to be submitted for approval before use. All compost is to be sterilized before being packed for transport. Any odorous materials delivered to site will be rejected. Any vermin resulting from use of organic compost will have to be controlled by the Contractor within 12 hours.
- xv. **Mulches:** Mulches shall be an approved friable-composted organic material, mulching material free from soluble salts or toxic materials and resistant to rapid decay.
- xvi. **Organic fertilizers (Farmyard manure):** Shall be organic products such as organic liquid fertilizer, pellets or granules manufactured primarily from organic materials. These products are to be from accredited sources and technical data indicating sources of origin and manufacturing process must be submitted and approved before use. Animal by-products must be sterilized before being packed for transport and odorous materials used on site will be rejected.
- xvii. **Pesticide:** A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- xviii. **Pests:** Living organisms that occurs where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- xix. **Planting Area:** Areas to be planted.
- xx. **Plant; Plants; Plant Material:** These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- xxi. **Project Nursery:** Site procured and maintained for pre-growing of plant materials before transport and installation to the Project Site.
- xxii. **Project Site:** Site of final installation of planting materials.
- xxiii. **Root Flare:** Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- xxiv. **Sand/Silt/Sweet Soil:** Sand/Silt/Sweet Soil shall be clean, coarse, well graded material mostly quarried from natural river side, free from soluble salts included natural mineral. Particles shall range in size so that 80-100% passes the 1mm sieve and 0-50% passes the 250 micron sieve.
- xxv. **Soil mix:** Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers (Natural Manure) to produce a soil mixture best for plant growth.
- xxvi. **Soil Conditioner:** Soil Conditioner shall be Peat Moss, organic compost composted rice hulls or other approved fibrous organic matter suitable for mixing with topsoil to make a friable growing medium for plants. It shall be resistant to rapid decay, free from soluble salts (below 900ppm), pH 6-7, free from large lumps or debris.
- xxvii. **Source Nursery:** Nursery where plant materials will be procured from.
- xxviii. **Stem Girdling Roots:** Roots that encircle the stems (trunks) of trees below the soil surface.

- xxix. Surface Soil:** Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- xxx. Watering:** After planting of all plants are to be thoroughly watered using enough water to soak the ground all around the rootball known to be watering.

PART 4 - MATERIALS

4.1 Topsoil

- 4.1.1 Topsoil shall be provided from approved source, it shall be typical sterile, sandy soil obtained from well-drained areas and possessing characteristics of representative soils in the project vicinity that produce vigorous plant growth. The topsoil shall be free of subsoil, brush, organic materials, objectionable weeds, clods, shale, large stones, stumps, roots or other material 13 mm (1/2") in diameter or more, or any substance which might be harmful to plant growth or be a hindrance to grading, planting and maintenance operations. The topsoil shall be subject to approval by the Engineer.
- 4.1.2 Careful supervision of excavation, hauling and stockpiling of topsoil is required to avoid contamination with unapproved soils, any soil furnished which does not meet the foregoing requirements and analysis for use as topsoil shall be rejected by the Engineer who may require it to be hauled off-site for disposal at no cost to the Employer.
- 4.1.3 The Engineer shall have the option to test topsoil and planting mix at any time for conformance to the specifications. Any discrepancies or deficiencies found as a result of these tests shall be corrected by the Contractor at no additional expense to the Employer. Should such test reveal that material does not meet specification requirements, expenses for testing and necessary subsequent testing shall be borne by the Contractor.
- 4.1.4 Organic Compost; Organic compost shall be an organic vegetable compost produced thorough a horticultural or industrial composting process. Compost is to be clean, decomposed, smell free, and free of any debris, refuse, clay or visible fungus. A sample and test data is to be submitted for approval before use. All compost is to be sterilized before being packed for transport. Any odorous materials delivered to site will be rejected. Any vermin resulting from use of organic compost will have to be controlled by the Contractor within 12 hours.
- 4.1.5 Sand/Silt /Sweet soil; Sand/silt/Sweet soil shall be clean, coarse, well graded material mostly quarried form natural river side , free from soluble salts included natural mineral. Particles shall range in size so that 80-100% passes the 1mm sieve and 0-50% passes the 250 micron sieve.

Sweet Soil is an old fashioned term used to describe lime rich soil, that has a high level of alkaline and a low level of acid. The pH of 4 indicates slightly alkaline soil and the pH of 6 indicates soil that is very alkaline.
- 4.1.6 Fertilizers; Chemical fertilizers; shall be approved granular fertilizers. Fertilizer may be single element or compound, normal or slow release compound fertilizers. They shall be stored in waterproof sealed bags under shelter away from water and direct sunlight. Samples shall be submitted to, and approved by the Engineer, before use in the Works.
- 4.1.7 Organic fertilizers (Farm yard manure); shall be organic products such as organic liquid fertilizer, pellets or granules manufactured primarily from organic materials. These products are to be from accredited sources and technical data indicating sources of origin and

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manufacturing process must be submitted and approved before use. Animal by-products must be sterilized before being packed for transport and odorous materials used on site will be rejected.

- 4.1.8. Mulches; Mulches shall be an approved friable-composted organic material .mulching material free from soluble salts or toxic materials and resistant to rapid decay.
- 4.1.9. Soil Conditioner: Soil Conditioner shall be Peat Moss, organic compost composted rice hulls or other approved fibrous organic matter suitable for mixing with topsoil to make a friable growing medium for plants. It shall be resistant to rapid decay, free from soluble salts (below 900ppm), pH 6-7, free from large lumps or debris.
- 4.1.10 WATERING; after planting of all plants are to be thoroughly watered using enough water to soak the ground all around the rootball known to be watering.

PART 5- SUBMITTALS

Product Data: For each type of product indicated, including soils.

- 5.1 Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
- 5.2 Pesticides and Herbicides: Include product label and Manufacturer's application instructions specific to the Project.
- 5.3 Plant Photographs: Include colour photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
- 5.4 Samples for Verification: For each of the following:
 - 5.4.1 Trees and Shrubs: Three samples of each variety and size delivered to the site for review. Maintain approved samples on-site as a standard for comparison.
 - 5.4.2 Topsoil, Sand, Soil Conditioner and Organic Mulch: 1-liter volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of colour, texture, and organic makeup.
 - 5.4.3 Light Weight Aggregate and Mineral Mulch: 1.0 kg of each light weight aggregate and mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on the site; provide an accurate indication of colour, texture, and makeup of the material.

PART 6- EXECUTION

6.1 Design & Details

Any discrepancies in the design subject to execution hurdles and alteration required shall be reported to the Engineer for further instructions. Contractor shall have to work only after due approval of the modification.

6.2 Landscape Site Preparation

The landscape site shall be free of any construction debris or wild vegetation. It shall be responsibility of the Contractor to ensure that the site is in working condition as per instruction of the Engineer. The Contractor shall also ensure proper grading of the landscape site in terms of aesthetics as well as drainage providing mounts and with a gentle slope towards natural drainage direction. All rubbles and debris if any and dispose it of in the suitable location possibly in low lying areas as identified by the Contractor and approved by the Engineer.

6.3 Soil Testing

The soil to be used as Top Soil (Good Soil/earth) for all plantation works shall be primarily imported fertile soil from agriculture fields off the site.

The Contractor shall get the soil test report and could meet the requirement for additives and soil conditioner to maintain pH value of the soil between 7.0 - 7.5 before plantation works. Also after every 6 months or as required on poor performance of the plantation shall accordingly get the soil tested and measures taken for maintaining the pH value within acceptable range. Also Contractor shall undertake treatment for soil conditioning during the entire maintenance period.

6.4 Manpower Employment

Contractor shall employ qualified & experienced garden supervisors and adequate number of gardeners to maintain the quality of garden and tree plantation. A senior supervisor/well trained Horticulturist with experience of relevant & similar work shall be deputed at site.

6.5 Disposal of Waste-General Cleanliness of Landscape Site

The arrangement of transport for disposal of waste, shifting of plants, etc. has to be made by the Contractor. The generated waste shall be disposed off within 48 hrs of generation or as instructed.

6.6 Provision for Water

The Contractor shall arrange and provide water for irrigation of landscape areas as follows.

6.6.1 Trees and Shrubs

Annually 40 irrigates;
Maximum in summer (once in a week).
Minimum in winter (once in a fortnightly).
Minimum water requirement of each plant is 4 (four) gallons per irrigation.

6.6.2 For Lawns flood irrigation shall be provided @ 25 ltrs /m²/weekly or appropriate requirement of watering should be provided by the Contractor to keep the lawns green.

Wherever irrigation tap connection is not available, watering should be done with water tankers or appropriate methodology. The maintenance of tankers or any appropriate system shall be integral responsibility of the Contractor to meet the watering requirements of the Trees, shrubs and lawns under any circumstances.

6.7 Electricity:

It shall be Contractor's responsibility to make arrangement for Diesel Generator set(s) to meet its requirement. The use of electricity if provided by the Employer shall be on chargeable basis. The Contractor shall install electricity meter and shall pay for the metered readings as per the rates settled with the Employer.

6.8 Maintenance

The Contractor shall adhere to the maintenance schedule. During the maintenance period of all the plants, Contractor shall be responsible for any replacement towards mortality and the trees or the area of the plantation under shrubs/creepers/ground covers etc. Plant shall be in healthy condition during the inspection conducted by the Engineer.

Contractor shall maintain record of maintenance & operations on site and submit daily report for all the areas certified for virtual completion of the work. The Contractor shall take note of the observations of the Engineer or his representative/Horticulturist and seek compliance of the same at the earliest before nearest schedule to avoid any penalty as per penalty terms.

6.9 Reports

The Contractor shall submit daily report on the deployment details as well as work planned for the day to the Engineer in prescribed format. All instructions and activities shall be recorded as per the desired format. Any problem or hindrance shall be brought to notice in the daily report along with evidence in form of photographs.

6.10 Nursery Set-up

The Contractor shall be required to set-up. Nursery having good micro-climate to store the supply of the plants.

In case of propagation of the plants in the nursery, the same shall be used on site only.

Laboratory should also be provided by the Contractor.

6.11 Vermi-Composts

Contractor shall mandatorily have Vermi-Composting System developed at appropriate location where all the pruning wastes, organic wastes shall be dumped with weeds, weed seeds or bulbs, stones etc., mix it well in the soil in the ratio (6:1), level as per grade.(point of unloading 0-50m). The process shall require approval of the Engineer and periodic maintenance of the activity. Approval of Engineer prior to dispatch of material for use on site is must.

PART 7- PLANT LOCATIONS

Tree, shrub & ground covers shall to be laid out in accordance with the Drawings.

Layout of bed outlines shall be staked out on the ground and the trees shrubs and ground covers shall be placed in locations as shown on the Drawings. The Engineer will inspect the locations of the bed outline and plants in the field, will direct the Contractor in adjusting the bed outline and the plants to their exact position before planting begins. The Contractor shall give the Engineer 15 day notice before the inspection and planting layout date.

7.1 Planting Pits for Trees and Shrubs & Ground Covers

Excavation for planting shall include plant pits and planting beds. The minimum depths of plant pits or beds shall be measured from finished grade level as per the drawings.

Plant beds and pits shall be tested for drainage before planting by filling with water twice in succession. Conditions permitting the retention of water in planting beds or pits for more than 24 hours shall be brought to the attention of the Engineer.

If rock, underground construction obstructions, tree roots or other obstructions are encountered in the excavation of plant pits, alternate locations may be selected by the Engineer.

The Contractor shall review the applicable Drawings and shall be familiar with the alignment of utility lines, ducts and buried cables existing in the area. The Contractor shall field check the location of utilities shown on the Drawings before any installation of material or plants. The Contractor shall be responsible for all damage resulting from any neglect or failure to comply with this requirement.

Following excavation of the planting pits (as per Table I to V), the pits shall be back filled with the soil mixture as specified. Three days prior to planting, the pit shall then be filled with water for consolidation of the soil.

PART 8- TREES & SHRUB PLANTATION

8.1 Supply of Trees & Shrub

8.1.1 Physical Condition

All plant materials shall be healthy, sound, vigorous with good foliage, Plants supplied shall be conforming to the names listed on the plant list. No plant materials will be accepted if branches are damaged or broken. All material must be protected from the sun and weather until planted

8.1.2 Health of Trees

All plant materials shall be free from plant diseases, insect pests, or their eggs, and shall have healthy well-developed root systems. Plant material shall be well formed and shaped true to type and free from disease, insect and defect such as knots, windburn, sun-cold, injuries, abrasion or disfigurement.

8.1.3 Specification of Trees

The specification of the material in terms of height, stem size mentioned in the BOQ's shall only be acceptable for plantation works. In case of non-availability of the particular species or the planting material, the alternate species may be approved by the Engineer.

8.2 Planting of Trees & Shrubs

8.2.1 Pit Size

Minimum Pit Size for all trees should be as per drawings.

8.2.2 Soil Preparation-Preparation of tree pits:

60% of the soil which has been obtained after digging shall be used for backfilling. 20% shall be approved silt/sweet earth 20% natural organic manures or (farm yard manure) as per Table-I.

8.2.3 Planting of trees

Planting of trees shall be done by stacking / propping to protect the trees from wind. Plants shall be irrigated on need basis. The Contractor shall maintain the tree basins free of weeds by regular hoeing.

Planting the tree with root ball in the pit (tin grown / poly bag grown) after removing carefully and without disturbing the root. Pressing the soil firmly around the tree planted. Preparing the basin around the tree and watering after staking and tying. The plant shall be well maintained, disease free, well trimmed at the time of handing over.

In case of death of the plant the Contractor shall replace the same with well grown healthy plant of similar size.

8.2.4 Insecticides Spray

All the planting materials shall be periodically examined for termite, pest and insect attacks or plant disease. Appropriate measure (i.e. application of liquid manures/ growth regulators/ pesticides as per need, weeding regularly so as to keep the plant healthy all the time) shall be undertaken for entire period of the contract and also during entire defect liability period/maintenance period.

8.2.5 Watering Arrangement

The Contractor shall make basin around trees and shrubs with material of precast fair face concrete Curbing or in pebbles/ random stone. Tools and Tackles/Hose-pipes, tractor mounted Water Tankers or as required all arrangement for water distribution and watering equipments/manpower shall be managed by the Contractor for watering the trees & shrubs.

Table – I: Trees and Shrubs:	
	Ornamental trees and shrubs shall be planted in pits of size 600 x 600 x 600 mm ft having cylindrical shape.
	60% of the soil which has been obtained after digging shall be used for backfilling 20% shall be used rotten leaves mould and 20% natural organic manures or (farm yard manure)
	Plant shall be spaced as per drawings for different areas as mentioned in the drawings.

	• A grove (bunch of plants) shall be usually consisting of 3 to 5 plants in a circular / conical shape. The shrubs used for continuous planting in a row shall be spaced as per drawings.
	• Annually 40 irrigates: – Maximum in summer (once in a week). – Minimum in winter (once in a fortnightly). – Minimum water requirement of each plant is 4 (four) gallons per irrigation.

8.2.6 Handing Over of Trees & Shrubs

- Name tag for Trees

All trees planting shall have plastic/metal name Tag with name of the relevant species well placed on trees with good visual characteristics. In case of row plantation of similar species, the same can be repeated at definite intervals i.e. at every 5th tree from the start.

PART 9- GROUND COVERS PLANTATION

9.1 Supply of Ground Covers

9.1.1 Physical Condition

All plant materials shall be healthy, sound, vigorous with good foliage, and free from plant diseases, insect pests, or their eggs, and shall have healthy well-developed root systems. Plants supplied shall be conforming to the names listed on the plant list. No plant materials will be accepted if branches are damaged or broken. All material must be protected from the sun and weather until planted.

9.1.2 Health of Ground Cover

Plant material shall be well formed and shaped true to type and free from disease, insect and defect such as knots, windburn, sun-cold, injuries, abrasion or disfigurement.

9.1.3 Specification of Ground Cover

The species should be in appropriate specification in terms of height & Foliage as provided in drawings schedule.

9.2 Planting of Ground Covers

9.2.1 Pits

Depth should be minimum 300x300x300mm exclusive of the top 50mm where top edge is defined for watering and flooding as per Table II.

9.2.2 Soil Preparation

Dig and remove all weeds, debris, rubbles, and stones from surface soil level to be maintained in due course. The 60% of the soil which has been obtained after digging shall be used for backfilling. 20% shall be approved silt/sweet earth and 20% natural organic manure or (farm yard manure).

9.2.3 Planting

Planting Ground cover - Planting of ground cover plants in the ground prepared earlier by filling garden soil and manure. Preparing a pit of require size in the ground. Planting the ground cover plant root ball in the pit after removing carefully and without disturbing the root ball. Pressing the soil firmly around the plant Preparing the basin around the plant in precast fair face concrete Curbing or in pebbles/ random stone for proper watering as mention Drawings. Maintenance of ground cover up to two months by regular watering and attending the inter-cultivation practices such as weeding, raking, gap filling, trimming and pruning etc. The ground cover should be well maintained, disease free, well-trimmed at the time of handing over. In case of death of the plant the contractor shall replace the same with equally well grown healthy plant.

9.2.4 Insecticides

All the planting materials shall be periodically examined for termite attacks or plant disease and appropriate measure (application of liquid manures/ growth regulators/ pesticides as per need, weeding regularly so as to keep the plant healthy all the time) shall be undertaken for entire period of the Contract.

9.2.5 Watering Requirements

Tools and Tackles/Hose-pipes, tractor mounted Water Tankers or as required shall be managed by the Contractor for watering the plants.

Table – II: Ground Covers	
	In situation where planting of ground covers is required such as slopes and some open spaces, it shall be done with species, which trail along the ground such as petunia, asparagus officialus, climbing rose etc.
	The spacing between ground covers plants shall be 900 x 900 mm in length/row.
	The pits to be dug for these plants shall be of size 300 x 300 x 300 mm.
	Irrigation and rest of the maintenance operation shall be carried out as per Table-I.

9.3 Handing Over of Ground Corus

Name Plate for Ground Cover

The ground cover planting shall be provided with Name Plate to specify the type of ground cover planted as per the bed and in case of longer beds at appropriate intervals so that the same can be identified at distant observations.

9.4 Maintenance of Ground cover

For details refer Specification Section 0501 Operation and maintenance of Landscaping

PART 10- LAWNS

10.1 Supply of Lawns

10.1.1 Specification of Lawns

Plant material shall be well formed and shaped true to type and free from disease, insect and defect such as knots, windburn, sun-cold, injuries, abrasion or disfigurement.

Supply and planting of lawn: Planting of lawn grass (for imported , Dhaka and local grass) as per drawing without disturbing the desired gradient including its leveling and maintaining (forking, mowing, weeding, fertilizer application). Contractor has to make his own arrangement for the water.

10.2 Planting of Lawns

10.2.1 Soil Preparation

The Contractor shall be responsible for the preparation of the lawn areas and planting of the lawn.

The soil shall be "trenched or ploughed" 300 mm (12") deep over the entire surface. Should the soil be unsuitable, it shall be removed upto 300 mm and replaced with Sweet soil/Silt.

All stones in excess of 25 mm (1") in diameter and all rubbish materials shall be removed. Contractor shall not spread sweet soil in muddy state.

Top 300 mm depth the soil shall be essentially good earth mixed with 1/3 of decomposed Farm yard manure.

The lawn bed shall be fine graded to remove all ridges and depressions.

Surface irregularities resulting from this or other operations shall be leveled to prevent depressions. Grades shall be adjusted to assure that the grade, after natural settlement and light rolling, will be 25 mm to 40mm below adjoining grade of any paved areas.

Rolling shall be done in two directions at right angles to each other. The roller shall be hand roller weighing not more than 200 pounds nor less than 150 pounds. Rolling shall be in such a manner so as to eliminate the necessity for walking on the finished grade.

Extreme care shall be taken during planting to ensure that no change shall occur in the finished grade.

10.2.2 Planting

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Dibbling of grass: Fine level the soil, apply thin layer of sand Vermi compost mixture of 25mm thickness and dibble the grass at 75mm distance. Roll the lawn after planting. Irrigate the lawn regularly. Remove weeds on periodical basis. Nurture the lawn with organic, bio-insecticides, parasites, predators to protect the lawn from pest and disease. Mow the lawn regularly and maintain the grass at 50 mm height. Trim all the edges after mowing; keep the edges with trees, shrubbery and flower beds clean.

The sweet soil surface shall be moistening with a fine spray immediately before planting.

The lawn shall be planted according to acceptable local standard practice in order to ensure a completely healthy grass cover.

10.2.3 Insecticides

Required at the time of Plantation or as per maintenance schedule.

10.2.4 Watering Requirements

Planting areas shall be maintained by watering, weed eradication, cutting, trimming, repair of all erosion, settlement restacking and reseeding where required establishing a uniform, knitted turf. Initial watering of lawns shall be at 2 day intervals for a period of 18 days from time of planting. At each watering, it shall be applied through flood irrigation.

Watering shall continue after the 18 day period, considering the provision of water according to annual irrigation procedure as previously mentioned, as necessary to maintain turf in a thriving condition. After the grass has matured, all of the areas which fail to show a uniform strand of grass for any reason whatsoever shall be planted repeatedly until all areas are covered with a satisfactory growth of grass.

The equipment necessary to carry out lawn maintenance work shall include but not be limited to: typical large manual/motorized lawn-mowers as used in parks, small manual lawn-mowers for grass cutting in confined area, shovels, rakes, lawn rollers, sprinklers and hoses, trimming shears and wheel barrows.

At the time of the first cutting and at subsequent cuttings, the mower blades shall be set at a minimum height of 50 mm (2"). Grass shall be cut first when it reaches a height of 100 mm (4"). Regular cutting shall be done as per Table-III, IV & V.

On areas of steep slope, place straw to completely cover newly planted area.

Final grading shall be carried out only after a 12 week establishment period. The Contractor shall allow for rolling after a further 3 month period if instructed to do so by the Engineer.

Tools and Tackles/Hose-pipes, tractor mounted Water Tankers etc. as required to be managed by the Contractor for watering as per Table-III, IV & V.

10.2.5 Plant Replacements

Dead plants/lawn patches shall be removed and replaced by the Contractor with healthy seedlings of the same species during the following planting season. Bare lawn or weed infested patches should be replanted by retrenching the area to a depth of 300 mm (12") and

repeating the procedures for newly made lawns replacement materials, adjustment or maintenance of lawns shall be done at no additional cost to the Employer.

Table – III: Imported grass (Korean Grass/Zoysia/Matrella)

	• Deep plowing shall be carried out at least two times.
	• The area shall be cleared of from bushes etc.
	• Farm yard Manure and Sand/Silt/Sweet Soil shall be added to the soil with the following ratio: - 2,000 cft. Sand/silt/sweet soil required for one acre. - 1,000 cft. Farm yard manure for one acre.
	• Area should be leveled and compacted upto desired level given proper slopes to the natural drainage or as specified and shown in the drawings.
	• Korean Grass shall be arranged from local nurseries.
	• Dibbling of Grass shall be carried out in specified areas.
	• Spacing of grass plants shall be kept as 75 x 75 mm in the soil.
	• Irrigation shall be carried out by flood irrigation method which shall be done according to the weather conditions.
	• Generally, during summer weekly irrigation is to be done and during winter the same shall be done fortnightly which approx. 50mm deep.
	• Weeding should also be done regularly at least 2 times in a year or as directed by the Engineer.
	• Machine mowing shall be carried out regularly at least fortnightly to keep the lawn in good condition and shape.

Table – IV: Dhaka Grass (Bent Grass /Agrostis Stolonisera)

	• Deep plowing shall be carried out at least two times.
	• The area shall be cleaned from bushes etc.
	• Farm yard manure should be added to the soil with the following ratio: – 500 cft. Farm yard manure for one acre.
	• Area should be leveled, compacted upto desired level and given its slope to natural drainage or as specified and shown on the drawings.
	• Dibbling of local grass shall be carried out in specified areas.

	• Spacing of grass plants shall be kept as 75 x 75mm in the soil.
	• Irrigation shall be carried out by flood irrigation method which shall be done according to the weather conditions.
	• Generally, during summer weekly flood irrigation 50mm deep is to be done and during winter the same shall be done fortnightly.
	• Weeding should also be done regularly at least 2 times in a year or as directed by the Engineer.
	• Machine mowing shall be carried out regularly at least fortnightly to keep the lawn in good condition and shape.

10.2.6 Handing Over of Lawns

The lawn areas should be considered fit once the lawns have settled and the surface starts showing the lawn effect.

10.2.7 Maintenance of Lawns

Lawns should be maintained by regular watering, weeding, replacing dead Spots, applying pesticides etc. so as to grow them vigorously.

Lawns should be regularly mowed and maintained as good green carpet till the final completion of the maintenance period or as per the maintenance schedule.

PART 11- PLANTING PRACTICES-APPLICATION

11.1 STAKING & SUPPORTS

11.1.1 General

- Stakes shall always be used when planting trees and tall shrubs as indicated in the drawings.
- Stakes shall be poles, bamboo or equal and shall be appropriate to the size of the plant to be supported.

11.1.2 Single Staking

Plants in the field need supports at least for initial part of their life, till it is fully established with self supporting trunk / stem girth. The Contractor shall select proper stakes and fix them aesthetically as well as purposefully. Stakes shall be made of straight wooden sticks and tied to the plant with strings or which should hold it and have flexibility to allow the stem growth freely. The stakes shall be dug deep enough to hold itself on its own, but shall not harm the roots of the plants.

11.1.3 Climber Wires

Climber wire for training climbing plants against walls shall be approved lightweight PVC coated wire mesh, fixed at 600mm intervals to GI screw eyes. The climbing plants shall be trained through the wire mesh with the shoots directed upwards and tied.

PART 12- DISEASE CONTROL

The Contractor shall take all necessary precaution to prevent eradicate any outbreak of disease or insect attack.

PART 13- DISEASE CONTROL

13.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective item (s) of the Bill of Quantities.

- 13.1.1 Excavation of trenches to required depth and width of trees, shrubs and ground covers trending or ploughing of existing ground upto 300 mm thick for planting of lawns.
- 13.1.2 Scarifying soil at the bottom of the trench and adding and mixing equal amount of prepared soil.
- 13.1.3 Providing watering for landscaping works.
- 13.1.4 Preparation of soil mix, puddle and setting plants, shrubs, vines and ground cover.
- 13.1.5 Compaction of Berms for plants, trees and ground covers.
- 13.1.6 Guying and stacking propping with bamboo tripod material.
- 13.1.7 Providing and placing fertilizer in trees, shrubs, ground cover and lawn grass, disucide sprays, pesticides application as required.
- 13.1.8 Seeds for turf lawn grass and trees. Temporary fencing, barriers, signs and other works required for proper maintenance.
- 13.1.9 Providing and replacement of dead trees, shrubs, ground cover and lawn grass
- 13.1.10 Restoration, cleanup and maintenance of tress, plants, ground covers and lawn grass.
- 13.1.11 Scarifying, disposal of surplus material, filling where extra excavated by Contractor's error or convenience, Bed preparation, seeding mowing & watering the plants, shrubs, lawn grasses.
- 13.1.12 Gravel mulch as specified on the drawings.
- 13.1.13 Providing plant photographs in specified format for approval.
- 13.1.14 Samples of plants/trees/shrubs.
- 13.1.15 Testing of materials/soils.
- 13.1.16 Disposal of general waste.

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13.1.17 Name plate for trees/shrubs ground cover

13.2 **Planting**

13.2.1 Measurement

Measurement of acceptably completed works of Planting of trees will be made on the basis of unit number of tree provided, planted and lay in position as shown on the Drawings or as directed by the Engineer.

13.2.2 Payment

Payment will be made for acceptable measured quantity of planting of trees on the basis number quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

13.3 **Sand/Silt/Sweet Earth and organic backfill**

13.3.1 Measurement

Measurement of acceptably completed works of Sand/Silt/Sweet Soil / earth will be made on the basis of actual volume in cubic meter of compacted backfill/fill provided and placed in position in accordance with the lines, levels and grade as shown on the drawings or as directed by the Engineer.

13.3.2 Payment

Payment will be made for acceptable measured quantities of Sand/Silt/Sweet Soil on the basis of unit rate per cubic meter quoted in the Bills of Quantities and shall constitute full compensation for all the works related to the item.

13.4 **Korean Grass & Synthetic Turf (Grass)**

13.4.1 Measurement

Measurement of acceptably development of Korean Grass & Synthetic Turf (Grass) will be made on the basis of actual area in square meter of korean grass provided, planted and laid in position as shown on the Drawings or as directed by the Engineer.

13.4.2 Payment

Payment will be made for acceptable measured development of Korean Grass & Synthetic Turf (Grass) on the basis of unit rate per square meter quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

SECTION 0100 - EARTHWORKS

PART 1 – GENERAL

1.1 SCOPE

The work under this section of the specifications consists of furnishing all plant, labor, equipment, appliances and materials and in performing all operations for excavation, backfilling, construction of embankments and disposal of unsuitable and surplus excavated material as required in accordance with this section of specifications, the applicable drawings and subject to terms and conditions of the Contract.

PART 2 – APPLICABLE STANDARDS

Materials, construction and testing shall comply with the following latest versions of codes and standards:

ASTM C 136	Sieve Analysis of Fine and Coarse Aggregate
ASTM D 422	Particle Size Analysis of Soils
ASTM D 596	Water Analyses
ASTM D1556	Density and Unit Weight of Soil In-place by the Sand Cone Method
ASTM D1557	Moisture-Density Relation of Soils Using 4.5kg Rammer and 457mm Drop
ASTM D1883	Test Method for California Bearing Ratio (CBR) of Laboratory Compacted Soils
ASTM D 2167	Density of Soil In-place by the Rubber-Balloon Method
ASTM D 2216	Moisture content of soil
ASTM D 4253	Test Method for Maximum Index Density and Unit Weight of Soils
ASTM D 4254	Test Method for Minimum Index Density and Unit Weight of Soils
ASTM D 4318	Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soil

PART 3 – GENERAL

- i. The Contractor shall acquaint himself with the nature of the ground, existing structures and subsurface materials (soil / rock) which will be encountered during excavation or earthworks. The Employer does not guarantee or warrant in any way that the materials to be found in the excavation will be similar in nature to that of any samples which may have been exhibited or indicated in the Geo-Investigation Report, Drawings or any other documents or to material obtained from boring or trial holes. Shared with the Contractor upon his request, the Contractor shall be deemed to have made local and independent inquiries, and shall take whole risk of the nature of the subsurface materials (soil / rock) to be excavated or penetrated and the Contractor shall not be entitled to receive an extra or additional payment nor to be relieved from any of his obligations by reasons of the nature of such ground and subsurface material.
- ii. The Contractor shall submit a detailed list of plant and equipment which he shall undertake to bring to the site and to carry out the work. The list shall satisfy the Engineer as to type, size and quantity of various plant and equipment, the Contractor has planned to bring at site. The Contractor shall place on the site of the work all of the equipment listed and all subsequent equipment required for approval of the detailed program of work and such equipment which may be directed by the Engineer. All equipment which is proposed to be used on the work shall be sufficient size and in such mechanical condition as to meet requirement of work and produce a satisfactory quality of work. In no case shall the Contractor remove from the site the plant and equipment without the written approval of the Engineer. The Contractor shall supply all plant and equipment necessary for the construction of each phase of the work and it must be on site, inspected and approved by the Engineer. If after use of the equipment the Engineer determines that the work provided does not meet the Contract requirement, the equipment

shall be changed and the deficient work shall be removed and corrected as directed by the Engineer.

- iii. All suitable materials from stripping of top soil and excavation shall be used unless otherwise declared unsuitable by the Engineer. The suitable material shall be used in permanent works if it complies with the requirements as specified for the respective works in drawings and specifications.
- iv. The Contractor shall jointly survey the area marked for pavements, utilities, service lines, buildings or other structures or any area designated by the Engineer and prepare the survey drawings showing natural ground profile and cross-section and submit to the Engineer for approval prior to start of any earthwork operation.

All suitable material from excavations shall be transported to and placed in fill areas or stockpiled at locations designated by the Engineer. Materials from excavation and stripping shall be stockpiled separately.

Existing utilities which are to remain in service or to be relocated and to remain in service until relocation are to be located and determined by the Contractor. They shall be safeguarded and protected from damage irrespective if they are shown on the As-Built drawings of earlier works or otherwise.

If any existing service lines, utilities and utility structures which are to remain in service are uncovered or encountered during the operations, shall be safe guarded, protected from damage and supported as directed by the Engineer.

- v. All excavations, cut and fills shall be constructed to the lines, levels and gradients specified with any necessary allowance for consolidation, settlement and drainage so that at the end of the Defect Liability Period the ground shall be at the required lines, levels and gradients. During the course of the Contract and during the Defect Liability Period any damage or defects in cuts and fills, in structures and other works, caused by slips, falls of wash-ins or any other ground movement due to the Contractor's negligence shall be made good by the Contractor at his own cost.

PART 4 – SITE PREPARATION

- i. The Contractor shall set out the works and shall be responsible for true and perfect setting out of the same and for correctness of the positions, levels, dimensions and alignments of all parts thereof. If at any time any error in this respect shall appear during the progress of the works, the Contractor shall at his own expense rectify such error, to the satisfaction of the Engineer.

The Contractor shall construct and maintain accurate bench marks so that the Lines and Levels can be easily checked by the Engineer. The Contractor shall construct and maintain such temporary drains in addition to those shown on the plans, as will adequately drain areas during construction.

The Contractor shall perform a joint survey with the Engineer's Representative, of the area where earth work is required, plot the ground levels on the drawings and obtain approval from the Engineer before starting the earth work and shall supply a copy to the Employer duly checked, signed and authenticated by the Engineer before start of work.

PART 5 – EXCAVATION

- i. No classification shall be made of any material excavated / cut as to its class, nature, origin or condition. The excavation will be unclassified as being carried out in all kinds of subsurface material including soil and rock.
- ii. Blasting will not be permitted and other means if mechanical excavation shall be used.
- iii. The excavation wherever required will be carried out below ground water level by dewatering the area.

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The Contractor shall build, maintain and operate all berms, channels, flumes, sumps and other temporary diversion and protective works needed to divert the surface water through or around the required excavation. All excavation shall be dewatered and kept free of standing water, water seeping from the sides and bottom of excavation above, the free level. The Contractor shall furnish, install, operate and maintain all drains, sumps, pumps and other equipment needed to dewater the excavation areas. Dewatering methods that cause a loss of fines from the bottom and slopes of the excavation will not be permitted.

Prior to commencement of the work, the Contractor shall furnish the Engineer for review and comments with complete plans and sketches for diverting surface water if any and dewatering of the required excavation.

- iv. Submission for review and comments of the required plans and sketches and any approval from Engineer shall not relieve the Contractor of any of his duties and obligations under the contract.

PART 6 – EMBANKMENT CONSTRUCTION

6.1 GENERAL REQUIREMENTS

It shall consist of construction of select embankment for paved areas (i.e. runways, taxiways, aprons, shoulders and overruns) and common embankment for unpaved, areas including graded strip. Only approved material shall be used in the construction of embankments.

All embankment construction shall be made to the lines, levels, profiles and grades as shown on the drawings or established by the Engineer. During progress of the work it may be found necessary or desirable by the Engineer to vary the levels, elevations and grades from those shown on the drawings, the Contractor shall perform the embankment construction to the revised grades, levels, elevation as established by the Engineer.

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a working platform shall be first established, consisting of a blanket of fill material placed on the water logged area. The thickness of the working platform shall be about 0.5 meters unless directed otherwise by the Engineer and the width shall be that of the embankment. The placement and compaction of the working platform shall be performed by use of light equipment as directed by the Engineer. No density requirements are specified for the working platform, however, subsequent layers above shall be compacted to densities specified in the relevant items. For over moist clayey silts and silty clay which restrict the compaction of subsequent layers to the required degree of compaction, the Engineer may also instruct for scarifying the soil and let it dry to control moisture in such soils. If the Engineer decides that situation cannot be controlled with this method he can instruct for further removal of such soil upto a depth of maximum 600mm for repeating the process of reduction in moisture.

Benching of sufficient width for slope stability and movement of equipment and machinery shall be carried out for embankment formation in areas of steep slopes.

6.2 SELECT EMBANKMENT

The select embankment shall be constructed under all paved areas. The area shall be prepared (after stripping of top soil) by scarifying the surface to a minimum depth of 150 mm and compacting it to densities mentioned in subsection 6.2.2.

6.2.1 Material

The suitable subsurface material obtained from excavation (except top soil) shall be used in the construction of select embankment or as directed by the Engineer. CBR of material shall not be less than seven (07) percent or as directed by the Engineer, determined in accordance with ASTM D1883. CBR value shall be obtained corresponding to the degree of compaction required for the corresponding layer. At-least one test per 1000 cum of selected embankment material shall be

conducted. Material of embankment shall also have a Plasticity Index of more than six (6) when determined as per ASTM D4318-17 or as directed by the Engineer. If the material obtained from required excavation does not fulfill the requirement, the material shall be thoroughly mixed with sand of approved gradation at a rate of 80% material obtained from required excavation with 20% sand to achieve required plasticity index unless instructed otherwise by the Engineer.

6.2.2 Formation of Embankment

Before placing and compacting the fill material the ground shall be scarified to a depth of 150 mm and compacted to a dry density of 90% as per laboratory compaction test method ASTM D1557. The moisture content of soil during compaction of scarified layer and successive layers shall be within $\pm 2\%$ of optimum moisture content before rolling to obtain the desired density results.

Embankment shall be formed in successive horizontal layers of not more than 200 mm in loose depth for the full width of the cross-section, unless otherwise approved by the Engineer.

The material placed in layers and the subgrade scarified shall be compacted to the density specified below:

Table 1: Required Compaction in Different Depths for Different Materials

Depth (mm) Below Subgrade Level Cohesive Soil	Depth (mm) Below Subgrade Level Non-Cohesive Soil	% of Max. Dry Density (ASTM D1557) Cohesive Soil	% of Max. Dry Density (ASTM D1557) Non-Cohesive Soil
0 to 300	0 to 600	95%	100%
300 to 750	600 to 1000	93%	95%
Over 750	Over 1000	90%	90%

The maximum density of sand (granular material, if used) shall also be determined as per ASTM D4253 and for other material ASTM D1557 shall be used. The Engineer can instruct for determination of maximum density by both methods and in that case the higher of the two values obtained from ASTM D1557 and ASTM D4253 shall be used to check the relative compaction of the in-place material. If the soil used for embankment contains the coarse grained particle (more than 30% retained on 3/4 inch sieve) then density and moisture tests shall be conducted as per ASHTO T180 Method D and the test frequency shall remain the same.

The moisture content of the material should be controlled to within $\pm 2\%$ of the optimum moisture content. In order to achieve a uniform moisture content throughout, the wetting and drying of the material, and manipulation shall be required when deemed necessary.

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less than 1% of the layer thickness. When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding 50% of the thickness of the layer being placed.

6.3 COMMON EMBANKMENT

6.3.1 Material

The area requiring common embankment, i.e. graded strip, and other unpaved areas shall be constructed from the excavated soil and rock. The top soil obtained from stripping may be used at deeper level with the approval of the Engineer.

6.3.2 Formation of Embankment

Before placing and compacting the fill material the ground shall be scarified to a depth of 150 mm and compacted to a dry density of 90% as per laboratory compaction test method ASTM D1557. The

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moisture content of soil during compaction of scarified layer and successive layers shall be within $\pm 2\%$ of optimum moisture content before rolling to obtain the desired density results. The successive horizontal layers shall be formed in loose depth (200mm) for the full width of the cross section unless otherwise approved by the Engineer. Each layer will be compacted to dry density of 90% as per laboratory compaction test method ASTM D 1557.

The layer thicknesses and compaction requirements shall be the same as specified under 'Select Embankment' for embankment formed by rock fragments.

No rock larger than 80mm in any dimension shall be placed in top three hundred (300) mm of embankment unless allowed by the Engineer.

PART 7 – TOLERANCE FOR EXCAVATION, FILL AND BACKFILL

7.1 SUBGRADE

In those areas upon which a sub-base or base course or lean concrete is to be placed, the top of the subgrade shall be of such smoothness that when tested with a 5.0 m straight edge applied parallel and at right angles to the centerline, it shall not show any deviation in excess of 50 mm. The tolerance in elevation range between 0 to -25 mm. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing material; reshaping; and re-compacting by sprinkling and rolling.

On graded strips (safety areas) intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 30 mm from true grade. The finished surface of the subgrade shall range between 0mm to -25mm from the grade line elevations and cross sections shown on the drawings.

7.2 SELECT EMBANKMENT AND COMMON EMBANKMENT

The grade surface of each layer excluding subgrade, shall be smooth and even and tolerance from required grade shall not be more than 20 mm.

PART 8 – QUALITY CONTROL

A testing program and required forms of all the tests shall be submitted by the Contractor. Tests shall be performed by the Contractor to ensure compliance with the specifications as required. A copy of all test reports shall be submitted to the Engineer for approval. The test shall be performed in accordance with the following test procedures and frequency of testing.

Prior to construction of embankment, classification and compaction tests shall be carried out on stock-piled material obtained from stripping of top soil and excavated subsurface material (soil & rock) and improved soil obtained after mixing of sand with material obtained from required excavation. The tests shall be carried out as per ASTM 422, ASTM D4318 and ASTM D 1557 and all the test reports shall comprise of comprehensive data and calculations used in the test with specific mentioning of testing code / standard. A family of laboratory compaction curves as per ASTM D 1557 representing typical material shall be developed for the fill / backfill material.

The frequency of classification tests shall be for every 1000 Cu.m of fill material. The Engineer may alter the frequency of testing depending on the type of material and variation encountered at site.

The field density tests shall be performed as per ASTM D 1556 or ASTM D 2167. The frequency of testing shall be as under:

Sieve Size	Percentage Passing
No. 4 (4.75mm)	100
No. 2 (2mm)	85 – 100
No. 40	30 – 60
No. 200	10 – 20 (non plastic)

8.1 SELECT EMBANKMENT

Area requiring 90% to 93% compaction – one test in every 350 Sq.m area in each layer

Area requiring 95% & 100% compaction – one test in every 250 Sq.m area in each layer

8.2 COMMON EMBANKMENT

Area requiring 90% compaction – one test in every 750 Sq.m area

For 100% compaction the average of four tests performed in a lot of four adjacent tests are required to be greater than the required compaction and not more than one test be 1.8% less than required percentage of compaction. For the required compaction of 95% to 90% compaction, following are the tolerance in the compaction requirement:

Percentage Compaction	One test in a lot of four adjacent tests not less than
95%	93.5%
90%	89.5%

PART 9 – EARTH WORK FOR STRUCTURES, STORM WATER DRAINS & CULVERTS

9.1 EXCAVATION

Excavation, including dewatering where required, for building/related structures, culverts, storm water drains etc. shall conform to the elevations and dimensions as shown on the drawings and extend to a sufficient distance to permit placing and removal of concrete formwork or other construction.

When determined by the Engineer to be insufficiently firm, excavation bottoms shall be further excavated to reach firm ground or backfilled with suitable material as per the requirements given in section 6.2 of the specifications and compacted to 95% of maximum dry density as per ASTM D-1557.

All excavations in foundations shall be taken as 150 mm above the final excavation elevations shown on the drawings and the last 150 mm shall be trimmed carefully to a smooth surface. Immediately after trimming to final elevation, subsequent layer if engineered fill or a layer of blinding concrete shall be placed to thickness shown on the drawings.

9.2 FILL AND BACKFILL FOR STRUCTURES, SERVICES TRENCHES, STORM WATER DRAINS & CULVERTS

- After completion of foundation footings, foundation walls and other construction below the elevation of the final grades and prior to start of back-filling, forms shall be removed and the excavation shall be cleaned of trash and debris.
- The backfilling/fill shall include filling under the floors where shown or required and around the foundations.
- The backfilling/fill shall include loading, unloading transporting, placing, stacking, spread of earth, watering, rolling, ramming and compaction etc. complete as specified herein.
- Filling in and around the foundations or under floors shall be placed in 200mm loose layers and compacted at optimum moisture content by mechanical means or other means as approved by the Engineer.
- Material for backfilling shall be as approved by the Engineer and compacted to produce in-situ dry density not less than 95% of the maximum dry density as achieved by compaction test as per ASTM D-1557 for filling around the foundation, trenches in paved sections of pavements and culverts and all other areas except for trenches backfilled in non-traffic areas.
- All care shall be exercised by the Contractor not to disturb works executed in the trenches.

9.3 SELECT FILL UNDER FOUNDATIONS

The select fill must be well graded granular material. The fines (i.e. particles passing no. 200 sieve) in select fill material should be non-plastic and fines should not be more than 15%. It shall be placed and compacted in layers appropriate to the type and size of compaction equipment, to at least 75% of the relative density determined as per ASTM D-4253 or 95% modified maximum dry density determined as per ASTM D-1557.

The moisture content of the select fill material shall be controlled to within + 2% of the optimum moisture content. The compaction of the select fill material shall be verified by appropriate field testing prior to the placement of foundation.

The gradation of the compacted select fill material is listed in the following table:

Sieve Size	Percent Passing
1" (25 mm)	100
3/4" (19 mm)	75 – 100
No. 4 (4.75 mm)	55 – 100
No. 10 (2 mm)	40 – 100
No. 40 (0.425 mm)	20 – 50
No. 200 (0.075 mm)	5 – 15 (non-plastic)

9.4 SAND CUSHION IN SERVICE TRENCHES

Gradation of the compacted sand cushion / sand surround shall be as under and compacted to degree of compaction based on the location of trenches i.e. in traffic /non traffic area.

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PART 10 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0120 - STONE SOLING

PART 1 – SCOPE

The work under this section of specifications consists of furnishing all plant, labour, equipment, appliances, materials and performance of all operations required in connection with the construction of stone soling for the Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu, in strict accordance with the specifications and Drawings and/or as directed by the Engineer.

PART 2 – MATERIAL

Material shall be of approved quality, it shall be comprised of strong hard durable stone of the approved size free from impurities, quarry sap, dust, dirt and solubility characteristics. The stone shall be obtained from approved quarries and shall be sound, free from laminations and weak cleavages.

PART 3 – QUALITY CONTROL

The quality of material used in stone soling shall conform to the following.

- Maximum Los Angeles Abrasion value 35% determined as per ASTM C-535-16 or ASTM C-131-06 whichever is applicable.
- Soundness 5 cycles with sodium sulphate 10% determined as per ASTM C-88-18.
- Specific Gravity shall be not less than 2.65 determined as per ASTM C-127-15.
- Water Absorption shall not be more than 1.5%

PART 4 – CONSTRUCTION

4.1 Preparation of Sub-grade (Substrate)

Sub-grade shall be formed of suitable materials free of clods, sod, roots, stumps, brush or other objectionable material. Sub-grade material shall be placed in successive layers not exceeding 6 inch in thickness and each layer shall be thoroughly compacted at optimum moisture content.

Compaction shall be done by approved methods consistent with the soil/material to be compacted.

The maximum dry weight density of the sub-grade shall not be less than 95% of Modified density determined as per ASTM D1557.

4.2 Stone Ballast / Brick Ballast Soling

The Stone Ballast / Brick Ballast (if allowed by the Engineer) shall be well graded and broken hard of 2" mesh obtained from an approved quarry. The soling stone shall be 50mm in size from an approved quarry.

The stone shall be laid and packed to even grades and well rolled using vibratory roller/plate compactor to a consolidated thickness of not less than 6 inch or as shown on the Drawings.

The whole of the surface of the compacted stone ballast soling will be blinded with murum or any other approved gritty material/ stone dust (Khaka). After the interstices have been filled with smaller size crushed stone, so as to effectively fill in the voids and crevices, soling area may be watered, if necessary and again thoroughly rolled with the same roller to produce a smooth and even surface free from irregularities. true to line and level.

Care is to be taken to avoid any damage to existing structures, mains or pipes while rolling operation is in progress. In places inaccessible for a roller, compaction shall be done by hand tampers weighing not less than 20 lb. or power reamers as directed by the Engineer.

PART 5- MEASUREMENT AND PAYMENT

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No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0130 - TERMITE CONTROL TREATMENT

PART 1 – SCOPE

The scope of work for anti-termite treatment includes injecting insecticide into the sides and bottom of the foundation trenches, spraying it on stockpiled backfill material, and injecting it into the floor subgrade of the building. The scope also covers the treatment of all woodwork with insecticides before installation in position.

PART 2 – MATERIAL

- 2.1 An emulsible concentrate insecticide shall be used for dilution with water, specially formulated to prevent infestation by termites. Fuel oil will not be permitted as a diluent. Provide a working solution of the following chemical element and concentrations.
BIFLEX with Bifenthrin Tech 25.1% or approved equivalent.
- 2.2 All mixing shall be done at site and mixing proportion of insecticide with water shall be in accordance with the approved manufacturer's recommendations and shall be verified by the Engineer.
- 2.3 Pure turpentine shall be used for dilution of insecticide, in approved proportion for application to woodwork.

PART 3 – QUALITY ASSURANCE

- 3.1 In addition to the requirements of these specifications, comply with manufacturer's instructions and recommendations for the work, including preparation of substrate and application of insecticide.
- 3.2 A professional operator shall be engaged who shall have license in accordance with regulations of governing authorities for application of soil treatment solution.

PART 4 – EXTENT OF APPLICATION

- 4.1 Insecticide solution shall be applied with approved pressure spraying equipment maintaining a pressure of 150 psi to all applications to, on or in earth.
- 4.2 Soil treatment shall begin after all work of preparation of earth prior to installation of concrete has been done. After application, no additional earth moving or work upon sub grade should be done. No covering of earth or concrete should be applied over soil treatment until at least 24 hours after treatment has been made.
- 4.3 Insecticide solution should not be applied during wet weather, or when the earth surface is excessively moist. Application should be made to all areas beneath concrete slabs-on-grade, including sidewalks and paving abutting buildings for distance of at least 3 meters beyond building line. Solution shall be applied in amounts of not less than 5 lit./ square meter. or 5 lit./10.76 square feet. of area. If applied over material predominantly gravel or sand, application shall not be less than 7 lit./ square meter or 7 lit./10.76 square feet of area. Insecticide shall penetrate to a depth of 1-inch minimum in porous earth at bottom and 2 inch to 3 inch at sides of excavations.
- 4.4 Sides of foundation excavations, grade beam, and similar areas shall be treated with solution at a rate of 0.5 lit per square feet upon inner sides of such excavations, and at all locations where concrete slabs for platforms and similar work abut the building. Similar treatment shall be made at all locations where expansion joints, control joints, column bases and similar work occur at or below grade slabs.
- 4.5 In the areas of application signs shall be fixed to show that soil treatment has been applied. Such signs shall be removed when areas are covered by other construction.

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- 4.6 Care shall be exercised to ensure that no marks or damage occurs to the finished structure as a result of the work under this section.
- 4.7 All woodwork for the entire project is to be insecticide or treated (before application of solignum). Insecticide shall be sprayed on all surfaces of all the wooden work including but not limited to door frames, blocking, furring, planks, boards etc. before installation. Spraying is to be done at site, after delivery and before installation. No spraying shall be necessary after field sawing, jointing or installation of such material.

PART 5 – STANDARDS

All methods of termite protection used herein shall be in accordance with the standard practices of National Pest Control Association, U.S.A and the British Wood Preserving Association.

PART 6 – SAMPLES AND TESTS

The Contractor shall supply samples of all the materials to be used for insecticide control for approval of the Engineer and testing in accordance with the specified standards. Rejected materials shall be removed from the site immediately.

PART 7 – GUARANTEE

The Contractor is to guarantee that the building shall be free from termites (white ants), wood bores and other pests, which cause damage to wood or other organic material for 10 years from the date of acceptance of the building.

In the event of any damage caused within the guaranteed period, the Contractor shall replace at his own cost such damaged material, finishes affected and suitably preserve and treat the entire premises with the best method known to the trade to prevent the spreading of termites.

PART 8 - MEASUREMENT AND PAYMENT

8.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost there of shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

- 8.1.1 Termite control treatment on wood works.
- 8.1.2 Turpentine & Water required for mixing insecticide solution.
- 8.1.3 Transportation of material and storage at site.
- 8.1.4 Anti-termite treatment on stock piled backfill material.
- 8.1.5 Termite control treatment to vertical surfaces.
- 8.2 Termite Control Treatment
- 8.2.1 Measurement

Measurement of acceptably completed works of termite control treatment will be made on the basis of number of square meter of plinth area treated of ground /upper floor by measuring the two dimensions (length & breadth) of treated area. No separate measurement will be made for the vertical or horizontal surfaces of the foundations.

8.2.2 Payment

8.2.2.1 Payment will be made for acceptable measured quantity of termite control treatment on the basis of unit rate per square meter of plinth area treated for ground /upper floor quoted in the Bills of Quantities & shall constitute full compensation for all the works related to the item.

8.2.2.2 For "Termite Proofing", the rate is for the unit plinth area (measured along the outside of the external walls at DPC or peripheral plinth beam level irrespective of the number of storeys in the building) and covers the followings operations:

- i. Treatment of bed and sides of excavated foundation trenches.
- ii. Treatment of backfill.
- iii. Treatment of filled up earth.
- iv. Treatment of timber to be used.
- v. Treatment of surrounding areas within 3 meters of the building.
- vi. Any other operation which the specialized firm may deem necessary in context to their guaranteed obligations.

SECTION 0140 - FORMWORK

PART 1 – SCOPE

The work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the design, supply and installation of formwork for the purpose of containing concrete during placement and consolidation in the required shape and form.

PART 2 – GENERAL

It shall be the responsibility of the Contractor to perform the work by engaging well trained and experienced staff.

APPLICABLE CODES AND STANDARDS

The latest edition of following ACI, ASTM, Pakistan & British Standard are relevant to these specifications wherever applicable:

2.1 ACI (American Concrete Institute)

- ACI 301 Specifications for Structural Concrete.
- ACI 318 Building Code Requirements for Structural Concrete
- ACI 347 Guide to Formwork to Concrete (ANSI A145.1)

2.2 APA (Engineered Wood Association)

- EWA High Density Overlay Concrete Form, Class 1
- EWA Structural 1, Exterior Quality, Class 1
- EWA Plastic Overlay Plywood Forms

2.3 ANSI (American National Standard Institute)

- NBS PSI Voluntary Product Standard, Structural Plywood (ANSI-A199.1)

Latest editions of the codes/standards shall be used in all cases.

PART 3 – MATERIALS

The Contractor shall use the following materials for different purposes as stated below:

3.1 Timber: Form framing, sheathing and shoring.

3.2 Plywood: Form sheathing and panels.

3.3 Steel

- Heavy forms and false work
- Column and joint forms
- Permanent forms
- Welding of permanent forms

3.4 Form Ties, Anchors and Hangers: For securing formwork against placing loads and pressures.

3.5 Coatings: Facilitate form removal.

3.6 Steel Joints: For formwork support.

3.7 Steel frame shoring: For formwork support.

PART 4 – DELIVERY AND STORAGE

4.1 Delivery

The delivery of formwork components shall be made in a manner so as not to cause damage.

4.2 Storage

Form work should be stored, after cleaning and preparing for re-use, if used before in such a manner that access to all different component is available.

Form work component which can be affected by weathering shall be stored in appropriate building or under covers and shade.

PART 5 – WORKMANSHIP

- 5.1 Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.
Where required details and locations of special forms to be used are set out on the drawings. The Engineer may reject any formwork in any part of the work which has been constructed with a non-approved formwork. Approval of form work by the Engineer shall be one of these conditions to be fulfilled before concreting. The Engineer may reject any concreting where it does not conform to the approved model.
- 5.2 Earth cuts shall not be used as forms for vertical surfaces of reinforced concrete work unless required as such or permitted by the Engineer.
- 5.3 Formwork shall be of timber, steel, plywood, proprietary building boards and such special materials, as may be approved by the Engineer, which give the required finish and shape to the surface of concrete. Wooden formwork shall be free from loose knots and shall be well seasoned.
- 5.4 The formwork shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete.
The design and engineering of the formwork, as well as its construction, shall be the responsibility of the Contractor. Where necessary, to maintain the specified tolerances, the formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads.
The Contractor shall establish and maintain, in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used as references for checking upon tolerances.
Requirements for 'facing materials' are given in Clause 8, Section 0140 relevant to 'Finishing of Formed Surfaces.'
- 5.6 Where natural plywood-form-finish, grout-cleaned-finish, smooth-rubbed-finish, scrubbed-finish, or sand-floated-finish is required, forms shall be smooth (faced with plywood, liner sheets, or prefabricated panels) and true to line, in order that the surfaces produced will require little dressing to arrive at true surfaces. Where any as-cast finish is required, no dressing shall be permitted in the finishing operation.
- 5.7 Where as-cast surfaces, including natural plywood-form-finish are specified, the panels of material against which concrete is cast shall be orderly in arrangement, with joints between panels planned in approved relation to openings, building corners, and other architectural features.
- 5.8 Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall provide for locating form ties, where possible, within the joints so that patches of tie holes will not fall within the panel areas.
- 5.9 Forms shall not be re-used if there is any evidence of surface wear and tear or defect which would impair the quality of the surface finish. Forms shall be thoroughly cleaned and properly coated before re-use.

- 5.10 Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Unless otherwise specified in the Contract documents chamfer strips shall be placed in the corners of forms to produce beveled edges on permanently exposed surfaces. Interior corners on such surfaces and the edges of formed joints will not require beveling unless required by the Contract documents.
- 5.11 Positive means such as wedges or jacks for accurate adjustment and for proper removal of shores and struts shall be provided and all settlement shall be monitored during concrete placing operation. Forms shall be securely braced against lateral deflections.
- 5.12 Where concreting of thin members is required to be carried out within formwork of considerable depth, temporary openings in the sides of the formwork shall be provided where necessary to facilitate the placing and consolidation of concrete. Small temporary openings shall also be provided at the bottom of the formwork for columns, walls and deep beams to permit the cleaning out of debris and observation immediately before concrete is deposited.
- 5.13 Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. After the ends or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than twice the diameter or twice the minimum dimension of the tie from the formed faces of concrete to be permanently exposed to view and in no case shall this distance be less than 20mm. When the formed face of the concrete is not to be permanently exposed to view form ties may be cut off flush with the formed surfaces.
- Through bolts may be permitted provided that they are greased to allow for easy withdrawal and the holes subsequently made good. Through bolts are not to be used on water-retaining structures.
- 5.14 At construction joints contact surface of the form sheathing for flush surfaces exposed to view shall overlap the hardened concrete in the previous placement by no less than 25mm. The forms shall be held against the hardened concrete to prevent offsets or loss of mortar at the construction joint so as to maintain a true surface.
- 5.15 Wood forms for wall opening shall be constructed to facilitate loosening, if necessary, to counteract swelling of the forms.
- 5.16 Wedges used for final adjustment of the forms prior to concrete placement shall be fastened in position after the final check.
- 5.17 Formwork shall be so anchored to shores or to other supporting surfaces or members that upward or lateral movement of any part of the formwork system during concrete placement will not occur.
- 5.18 Runways or planks for moving labour and equipment shall be provided with struts or legs and shall be supported directly on the formwork or upon the structural member without resting on the reinforcing steel.
- 5.19 All surfaces of forms and embedded materials shall be cleaned of any accumulated mortar or grout from previous concreting and of all other foreign material before placing fresh concrete.
- 5.20 Forms shall be sufficiently tight to prevent leakage of grout or cement paste. Board forms having joints opened by shrinkage of the wood shall be removed and replaced. Plywood and other wood surfaces not subject to shrinkage shall be sealed against absorption of moisture from the concrete by either (1) a field applied, approved form oil or sealer, or (2) a factory applied non-absorptive liner. When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Excess coating material shall not be allowed to stand in puddles in the forms nor allowed to come in contact with the concrete against which fresh concrete will be placed. Care shall be taken that such approved composition is kept out of contact with the reinforcement. Where as-cast finishes are required, materials,

which will impart a stain to the concrete, shall not be applied to the form surfaces. Where the finished surface is required to be painted, the material applied to form surfaces shall be compatible with the type of paint to be used.

- 5.21 For reinforced concrete, under no circumstances shall forms be struck until the concrete attains strength of at least twice the stress to which the concrete may be exposed at the time of striking.

The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions, and cured under conditions of temperature and moisture similar to those obtaining in the work. Where possible, the formwork should be left for longer time as it would assist the curing.

In normal circumstances (generally where temperature are above 20° C and where ordinary cement is used) forms may be struck after expiry of the following periods:

- Walls, Columns & Vertical Sides of Beams & slab	48 Hours or as may be decided by the Engineer
- Beams Soffits	14 Days (shores or props left under)
- Removal of shores or props to Slabs	14 Days (Spanning up to 4 meters) 16 Days (Spanning up to 5 meters) 18 Days (Spanning up to 6 meters)

For rapid hardening cement 3/7 of the above period will be sufficient in all cases except vertical sides of slabs, beams and columns which should be retained for a minimum of 24 hours.

The number of shores or props, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab and beams, as the case may be.

Proper allowance shall be made for the decrease in rate of hardening of concrete in cold weather and the above minimum duration must be increased when the mean daily temperature is below 20° C.

- 5.22 When repair of surface defects or finishing is required at an early age, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.
- 5.23 Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or treatment required on such sloping surfaces shall be performed at once and be followed by the specified curing.
- 5.24 Wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.
- 5.25 All formwork shall be removed without such shock or vibration as would damage the reinforced concrete. Before the top plank and struts are removed, the concrete surface shall be exposed where necessary in order to ascertain that the concrete has sufficiently hardened. Proper precautions shall be taken to allow for the decrease in the rate of hardening that occurs with all cement in the cold weather.
- 5.26 When reshoring or repropping is permitted or required, the operations shall be planned in advance and shall be subject to approval. While reshoring is underway no live loads shall be permitted on the new construction.

In no case during reshoring shall concrete in beams, slab, columns or any other structural member be subjected to combined dead and construction loads in excess of the load permitted by the Engineer for the developed concrete strength at the time of reshoring.

Reshores shall be placed as soon as practicable after stripping operations are complete but in no case later than the end of working day on which stripping occurs.

Reshores shall be tightened to carry their required loads without overstressing the construction. Reshores shall remain in place at least until tests representative of the concrete being supported have reached the specified strength.

- 5.27 Floors supporting props or shores under newly placed concrete shall have their original supporting props or shores left in place or shall be reshored. The reshoring system shall have a capacity sufficient to resist the anticipated loads and, in all cases, shall have a capacity equal to at least one half the capacity of the shoring system above. The reshores shall be located directly under a shore position above unless other locations are permitted.

The reshoring or re-propping shall extend over a sufficient number of storeys to distribute the weight of newly placed concrete, forms and live loads in such a manner that the design superimposed loads of the floors supporting shores or props are not exceeded.

- 5.28 It is generally desirable to give forms for reinforced concrete an upward camber to ensure that the beams or slabs (specially cantilever slabs) do not have a sag when they have taken up their deflection, but this should not be done unless permitted by the Engineer.
- 5.29 No loads, other than man and light plant required in connection with the actual work in hand, shall be allowed on suspended floors until 28 days after concreting where ordinary Portland Cement is used and 14 days when rapid hardening Portland Cement is used.
- 5.30 Prior to placing concrete, all forms shall be inspected and all debris and extraneous matter removed. The form oil or release agent shall not react with concrete to affect the strength, nor shall it give any colour. It shall be applied in such a manner as not to contaminate the reinforcement and other fixtures to be embedded in concrete.
- 5.31 For formwork of PQC pavements refer Section 0140 of these specifications.
- 5.32 Forms for fairfaced concrete and pre-cast elements shall be of such type that all the surfaces of concrete once removed from the forms shall be free of all surface blemishes, discoloration, pin holes, edges drop-off and proper beveled surfaces are achieved.

PART 06 - FORMWORK TOLERANCES

Formwork shall be designed, erected, and removed in strict compliance with ACI 347 and the following requirements:

Tolerances for concrete formed surfaces:

- Variation in cross-sectional dimensions: -6 mm / +12 mm
- Variation in floor level (slab soffit): ± 10 mm
- Variation from plumb for column and wall faces: 6 mm per 3 m height, 25 mm maximum

At high-altitude low temperatures (below +5°C at Skardu), stripping times shall be doubled unless accelerated curing with heated water or steam is employed and approved by the Engineer. No formwork shall be struck without prior approval of the Engineer in writing.

Exposed concrete formwork shall use high-quality form-ply or steel to produce a smooth, blemish-free finish. Release agent: approved non-staining, non-reactive type applied uniformly to all form surfaces before placing reinforcement

PART 7 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0145 - REINFORCEMENT

PART 1 - GENERAL

1.01 SCOPE

1.01.1 The work under this section of specification consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with the supply, transporting, cutting, bending and placing steel reinforcement, welded wire-fabric, dowels, tie-bars and assemblies in concrete structures, pavement or elsewhere, as shown in the drawings, as specified herein and as required by the site conditions or as directed by the Engineer.

1.02 APPLICABLE STANDARDS

1.02.1 Latest editions of the following Pakistan, British and ASTM Standards are relevant to these specifications wherever applicable.

Pakistan Standards:

- PS: 2031 – Metallic Materials – Bent Test
- PS 607 – Steel and Steel Product - General technical delivery requirement for steel
- PS 1879 – Deformed and Plain Billet Steel Bars for concrete Reinforcement
- PS 1612 – Steel for the reinforcement of concrete – weldable reinforcement

British Standards:

- BS 4449 – Specifications for Carbon steel bars for reinforcement of concrete
- BS 8666 – Specifications for Scheduling, dimensioning, Bending and Cutting of Steel reinforcement for concrete

ASTM Standards:

- ASTM A615 – Standard specification for deformed and plain Carbon-Steel bars for concrete reinforcement
- ASTM A1064 – Standard Specification for Carbon-Steel wire and welded wire reinforcement, plain and deformed, for concrete

ACI Codes:

- ACI 315 – Details and Detailing of Concrete Reinforcement (ACI Publication SP-66)
- ACI 318 – Building Code Requirements for Structural Concrete

1.02.2 In addition to the above, the latest editions of other Pakistan Standards, British standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other standard as may be specified by the Engineer for Special Material and construction are also relevant.

1.03 SUBMITTALS

1.03.1 Bar Bending Schedules

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The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and shall obtain approval of the Engineer before proceeding with the work. The Engineer's approval, however, will not relieve the Contractor of his responsibility in this regard.

1.03.2 Certificates of Compliance

The Contractor shall submit certificates of compliance from the manufacturer stating that the supplied reinforcement conforms to the Specifications.

1.04 QUALITY ASSURANCE

1.04.1 Wherever and as directed by the Engineer, conformance of the supplied reinforcing bars with the specifications shall be demonstrated by the Contractor through laboratory tests, in accordance with the relevant standards. If the results of such tests show that the sample does not meet with the specifications, the whole consignment shall be rejected and removed from the site at the Contractor's cost.

1.05 DELIVERY, STORAGE AND HANDLING

1.05.1 Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged. Each bar or bundle of bars shall be identified by marks as per relevant ASTM standard.

1.05.2 Storage

A. The method of storage shall be approved by the Engineer.

B. Reinforcing bars shall be stored in racks or platforms above the surface of ground and shall be protected free from scaling, rusting, oiling, coatings, damage, contamination and structural defects prior to placement in works.

C. Bars of different diameters and grades of steel reinforcement shall be kept separately.

1.05.3 Reinforcement

Materials for reinforcing steel, welded wire fabric, dowels and tie bars, refer relevant specification.

Column Design Schedule

Member	Reinforcement Requirement
Column C1 (24" × 36")	As = 10.60 in ² ; ρ = 1.23%; ASTM A615 Gr 60; Mu = 192 ft-k; Pu = 223k — SAFE
Column C2 (24" × 36")	As = 21.99 in ² ; ρ = 2.55%; SMRF detailing required; multiple load combos — SAFE
Column C3 (30" dia circular)	As = 14.14 in ² ; ρ = 2.00%; Mu = 148 ft-k; Pu = 358k — SAFE
Column C4 (18" × 18")	As = 3.53 in ² ; ρ = 1.09% — SAFE

Beam Design Schedule

Member	Reinforcement Requirement
Plinth Beam PB1 (18" × 24")	Top: 5-#6; Bottom: 5-#6; Stirrups #3 @ 4" c/c supports, 9" c/c mid-span; V = 47k, M = 144 ft-k — SAFE

Plinth Beam PB2 (18" × 30")	Top: 6-#6; Bottom: 6-#6; Stirrups #3 @ 4" c/c supports; V = 42k, M = 140 ft-k — SAFE
Beam B1 — Transfer Beam (21" × 45")	Top: 15-#8; Bottom: 15-#8; Stirrups #3 4-legged @ 3.5" c/c; V = 280k, M = 1,942 ft-k — SAFE
Beam B1-a (21" × 24")	Top: 8-#8; Bottom: 4-#8; Stirrups #3 2-legged @ 4" c/c; V = 75k, M = 519 ft-k — SAFE
Beam B2 (18" × 30")	Top: 6-#8; Bottom: 6-#8; Stirrups #3 @ 4" c/c; V = 92k, M = 499 ft-k — SAFE
Beam B3 (18" × 24")	Top: 5-#8; Bottom: 5-#8; Stirrups #3 @ 4" c/c; V = 67k, M = 276 ft-k — SAFE
Beam B4 (12" × 24")	Top: 5-#6; Bottom: 3-#6; Stirrups #3 @ 4" c/c; V = 52k, M = 171 ft-k — SAFE
Beam B5 (18" × 30")	Top: 10-#8; Bottom: 6-#8; Stirrups #3 4-legged @ 4" c/c; V = 150k, M = 793 ft-k — SAFE
Beam B6 (10" × 24")	Top: 3-#6; Bottom: 3-#6; Stirrups #3 @ 4" c/c; V = 15k, M = 114 ft-k — SAFE

Slab Design Schedule

Slab	Thickness / Reinforcement
S1 — Two-Way (24.5' × 29')	t = 7"; Short span: #4@4" neg, #4@6" pos; Long span: #4@5" neg, #4@8" pos; f'c = 3,000 psi — SAFE
S2 — Two-Way (18.5' × 24.25')	t = 6"; Short span: #4@3.5" neg; Long span: per calc; f'c = 3,000 psi — SAFE
Typical slab thickness	7 inches (175 mm) for two-way spanning slabs per ETABS model

PART 2 - PRODUCTS

2.01 REINFORCING STEEL

2.01.1 General

Reinforcement shall be obtained only from manufacturers approved by the Engineer. Each consignment of reinforcement steel shall be accompanied by the manufacturer's certificate or shall refer to a previous certificate, if the consignment is from the same batch, showing that the reinforcement steel complies with the specified requirement. Reinforcement shall be free from all loose or flaky rust and mill scale or coating, and any other substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not be used.

2.01.2 Reinforcing Bars

Unless otherwise specified, all reinforcing bars shall comply with the requirements of ASTM A706 for deformed and plain carbon steel bars hot rolled from new stock billet steel bars and shall have minimum yield strengths of 60,000 psi. Alternatively, ASTM A615 Grade 60 steel with minimum specified yield strength of 60,000 psi (420MPa) and meeting the following limitations can be used:

A. Actual minimum yield strength shall not be less than 60,000 psi (420 MPa) and actual maximum yield strength shall not exceed 78,000 psi (540 MPa).

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B. Ratio of actual tensile strength to actual yield strength shall not be less than 1.25.

2.02 SPACERS AND SUPPORTS

2.02.1 Spacers and supports shall be approved standard products of types best suited for the purpose.

2.03 WELDING MATERIALS

2.03.1 The bars shall not be welded, unless prior approval of the Engineer is obtained in writing. If permitted, welding shall be done in accordance with the latest edition of AWS D 1.4 with proper selection of procedure and filler material according to the chemical composition of the bars being welded together.

PART 3 - EXECUTION

3.01 FABRICATION AND BENDING

3.01.1 Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer.

3.01.2 The cutting tolerance for all reinforcing bars shall be 20 mm.

3.01.3 Fabricating tolerance shall be as per ACI - 315.

3.01.4 Reinforcement shall not be bent or straightened in a manner that will injure the material. No bars shall be bent twice in the same place, nor shall they be straightened after bending. Unless permitted by the Engineer, reinforcement shall not be bent after being partially embedded in hardened concrete.

3.01.5 No splice of reinforcement shall be made except as approved by the Engineer.

3.01.6 Welding of reinforcement shall not be done unless permitted and approved by the Engineer.

3.02 PLACING AND INSTALLATION

3.02.1 Reinforcement shall be accurately placed as shown in drawings and secured against displacement by using 16 gauge steel wire ties or suitable clips at intersections and supported from the formwork by using concrete, metal or plastic chairs, spacers or hangers of an approved pattern.

3.02.2 Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than one part of cement to two parts of sand. Where the concrete surface will be exposed to the weather in the finished structure, the portions of all accessories in contact with the form work shall be galvanized or shall be made of plastic.

3.02.3 Placing tolerances shall be as per ACI-318 & 117.

3.02.4 Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be subject to approval of the Engineer.

3.02.5 Vertical bars in columns shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all column dowels.

3.02.6 Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete where the exposed part is to be built into later concrete.

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3.02.7 No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer.

3.02.8 All detailing shall be done as per ACI standards ACI-315, ACI-318 & ACI-350R, as and where required.

3.02.9 Standard or actual unit weight whichever is lesser shall be used for calculation of weights.

PART 4 - MEASUREMENT AND PAYMENT

4.1 General

Except otherwise specified herein or elsewhere in the Contract Documents no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bills of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bills of Quantities.

A. Providing and installing chairs, supports, hooks, spacers, binding wires, corrosion protection sleeves, wire cage or basket for tie bars and dowels and laps not shown on drawings including wastage and rolling margin.

B. Testing of mild steel, deformed steel, welded wire fabric, dowels, tie bars and assemblies.

4.2 Reinforcing Bars

MEASUREMENT:

A. Measurement for acceptably completed works of reinforcement shall be made by weight in metric tonne according to bar bending schedules approved by the Engineer.

PAYMENT:

B. Payment will be made for acceptable measured quantity of reinforcement provided and placed in position on the basis of unit rate per metric tonne quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

SECTION 0150 - CONCRETE WORKS

PART 1 GENERAL

1.1 Scope

The work under this section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply, manufacture, transporting, placing, consolidating, finishing and curing of plain and reinforced concrete for pavements and other structures as shown on the drawings, as specified herein and as required by the site conditions or as directed by the Engineer, for a complete job. Reinforcement does not form part of this section.

1.2 Applicable Codes and Standards

The latest edition of following ACI, ASTM, FAA & British Standard are relevant to these specifications wherever applicable:

1.2.1 American Concrete Institute (ACI)

Sr. No.	ACI Code	Description
1	ACI 117	Standard Specification for Tolerances for Concrete Construction and Materials
2	ACI 201.2R	Guide to Durable Concrete
3	ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavy Weight and Mass Concrete
4	ACI 214R	Evaluation of Strength Test Results of Concrete
5	ACI 301	Specifications for Structural Concrete
6	ACI 303.1	Standard Specification for Cast-In-Place, Architectural Concrete
7	ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
8	ACI 305R	Hot Weather Concreting
9	ACI 308R	Guide to Curing Concrete
10	ACI 309R	Guide for Consolidation of Concrete
11	ACI 315	Details and Detailing of Concrete Reinforcement
12	ACI 318	Building Code Requirements for Structural Concrete
13	ACI 347	Guide to Formwork for Concrete

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14	ACI 350R	Code Requirement for Environmental Engineering Concrete Structures and Commentary
15	ACI 351.1R	Grouting between Foundation and Bases for Support of Equipment & Machinery
16	ACI 544.1R	State-of-the-Art Report on Fiber Reinforced Concrete

1.2.2 American Society for Testing and Materials (ASTM)

Sr. No.	ASTM Code	Description
1	ASTM A499	Hot-Rolled Rail Carbon Steel Bars and Shapes
2	ASTM A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
3	ASTM A675	Steel Bars and Bar Size Shapes, Carbon, Hot-Rolled, Special Quality, Subject to Mechanical Property Requirements
4	ASTM A996/A996M	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
5	ASTM A1064/A1064M	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
6	ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
7	ASTM C33	Standard Specification for Concrete Aggregates
8	ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
9	ASTM C40	Standard Test Method for Organic Impurities in Fine Aggregate for Concrete
10	ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
11	ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third Point Loading)
12	ASTM C87	Standard Test Method for Effect of Organic Impurities in Fine Aggregates on Strength of Mortar
13	ASTM C88	Standard Test Method for Soundness of Aggregates by use of Sodium Sulphate and Magnesium Sulphate

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14	ASTM C94	Standard Specification for Ready-Mixed Concrete
15	ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2 in or 50 mm cube specimen)
16	ASTM C117	Standard Test Method for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing
17	ASTM C123	Standard Test Method for Lightweight Particles in Aggregates
18	ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
19	ASTM C289	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates
20	ASTM C293	Standard Test Method for Flexural Strength of Concrete (using simple beam with center Point Loading)
21	ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
22	ASTM C321	Standard Test Method for Bond Strength of Chemical Resistant Mortars
23	ASTM C330	Standard Specification for Lightweight Aggregates for Structural Concrete
24	ASTM C332	Standard Specification for Lightweight Aggregates for Insulating Concrete
25	ASTM C348	Standard Test Method for Flexural Strength of Hydraulic Cement Mortars
26	ASTM C494	Standard Specification for Chemical Admixtures for Concrete
27	ASTM C535	Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine
28	ASTM C595	Standard Specification for Blended Hydraulic Cements
29	ASTM C596	Standard Test Method for Drying, Shrinkage of Mortar Containing Hydraulic Cement
30	ASTM C685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
31	ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

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32	ASTM C989	Standard Specification for Slag Cement for use in Concrete and Mortars
33	ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
34	ASTM C1399	Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete
35	ASTM D75	Standard Practice for Sampling Aggregates
36	ASTM D512	Standard Test Methods for Chloride Ion in Water
37	ASTM D516	Standard Test Methods for Sulphate Ion in Water
38	ASTM D596	Standard Guide for Reporting Results of Analysis of Water
39	ASTM D1411	Standard Test Method for Water-Soluble Chlorides Present as Admixtures in Graded Aggregate Road Mixes

1.2.3 CRD US Army Corps of Engineers

- i. CE CRD C119 Method of Test for Flat and Elongated Particles in Coarse Aggregate
- ii. CE CRD C400 Requirements for Water for Use in Mixing and Curing Concrete
- iii. CE CRD C513 Specifications for Rubber Water stops
- iv. CE CRD C572 Specifications for Polyvinyl Chloride Water stops
- v. FF-MM-9650 Epoxy Resin Grout

1.2.4 British Standard (BS)

- i. BS EN 197-1 Cement Composition, Specification and Conformity Criteria for Common Cements
- ii. BS EN 932-6 Test for General Properties of Aggregates Definition of Repeatability and Reproducibility
- iii. BS ISO 3310-2 Test Sieves – Technical Requirement and Testing – Part 2: Test Sieves of Perforated Metal Plate
- iv. BS EN 1008 Mixing Water for Concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
- v. BS EN 1992-1 Design of Concrete Structures – General Rules and Rules for Buildings

1.2.5 Federal Aviation Administration (FAA)

- i. Advisory Circular 150/5320-6G
- ii. Advisory Circular 150/5370-10H
- iii. Advisory Circular 150/5380-6C

In addition, the latest editions of other ACI, ASTM, FAA & BS and other Standards as may be specified by the Engineer for Special Materials and construction are also relevant.

1.3 Submittals

All submittals shall be in accordance with the schedule of submittals prepared by the Contractor and approved by the Engineer.

1.4 Proposed Mix Designs

The Contractor shall submit proposed designs for trial design batches for each grade, class or strength of concrete along with samples of proposed material.

The Contractor shall submit proposed final mix designs for each grade of concrete at least 28 calendar days before the date planned for the start of concrete placement, along with samples of proposed materials which differ from those submitted previously, and reports of successful 3, 7, 14 and 28 calendar day strength tests, for Engineer's approval.

PART 2-PRODUCTS

2.1 Material

2.1.1 Cement

1. Cement shall be fresh and of approved origin and manufacture. It shall be one of the following as may be specified by the Engineer or type of Cement as shown on the drawings and/or BoQ.
 - a) Ordinary Portland Cement (low alkali) complying with the requirements of BS EN197-1 or ASTM C150 (Type-I).
 - b) Ordinary Portland Cement Type II (low alkali) complying with the requirements of ASTM C-150.
 - c) Sulphate Resistant Portland Cement (low alkali) complying with the requirements of BS-4027 or ASTM C-150 (Type V).
 - d) Ordinary Portland Cement Type III High Early Strength Cement (Rapid Hardening)
 - e) Portland Blast-Furnace Slag Cement shall conform to BS EN 197-1 or to ASTM C-595. Slag shall consist of finely ground granulated iron blast-furnace slag and shall conform to ASTM C-989 Grade 80, 100, or 120. The proportioning of OPC and Portland Blast Furnace Slag material shall be in the ratio of 60 OPC to 40 Slag or as approved by the Engineer.
 - f) Modified cements (low alkali) as per the requirements of drawings and specifications.
2. Cement shall be tested and allowed to use after receiving satisfactory test reports from reputable laboratory.
3. Unless otherwise specified, ordinary Portland Cement complying with the requirements of BS EN197-1 or ASTM C150 (Type-I) shall be used.
4. The Contractor shall supply to the Engineer at fortnightly intervals, reports of tests for conformance with the relevant specified standard in respect of the samples of cement from the work-site. These tests shall be carried out in a laboratory approved by the Engineer.
5. Only one brand of each type of cement shall be used for concrete in any individual member of the structure. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed.
6. There shall be sufficient cement at site to ensure that each section of work is completed without interruption.
7. Cement reclaimed from cleaning of bags or from leaky containers and silos shall not be used.
8. The Contractor shall provide and erect (at his cost) in a suitable plain, dry, well ventilated, weather-proof and water proof shed of sufficient capacity to store the cement. Storage shall be done in a manner that cement bags stored first shall be used first and only then the next batch of cement shall be used.
9. The cement shall be used as soon as possible after delivery, cement which the Engineer consider has become stale or unsuitable through absorption of moisture from the

atmosphere or otherwise, shall be rejected and removed immediately from the site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or permitting access of the atmosphere prior to opening of the container at the time of concrete mixing shall be rejected and removed immediately from the site at the Contractor's expense.

10. Low Alkali cements shall only be used for manufacturing of concrete. Only cements, containing less than 0.6%0.6% equivalent alkali or cements that can demonstrate a positive reduction in the expansion created by alkali-silica reactions shall be used. Total Alkalis (Na_2O & K_2O) of the cement secured for the production of concrete shall be verified in accordance with ASTM C114.
11. Mixing of different type and brand of cement shall not be permitted.

2.1.2 Aggregates

The sources of supply of all fine and coarse aggregates shall be subject to the approval of the Engineer.

Aggregates shall conform with ASTM C33 (including applicable ASTM Documents referenced therein) and as specified elsewhere in the Contract. Coarse aggregates shall be well graded from fine to coarse within the prescribed limits of this specification. Fine aggregate shall consist of natural sand, manufactured sand or combination of the two and shall be composed of clean, hard, and durable spherical or cubical particles. Coarse aggregate shall consist of crushed or uncrushed gravel, crushed stone, or a combination thereof and shall be clean, hard, uncoated particles of maximum nominal size as specified for each grade of concrete.

All fine and coarse aggregates shall be clean and free from clay, loam, silt and other deleterious matter. If required, the Engineer reserves the right to have them washed by the Contractor at no additional expense. Coarse and fine aggregates shall be delivered and stored separately at site. Aggregates shall not be stored on muddy ground or where they are likely to become dirty or contaminated. The materials shall be stockpiled for a period before use for at least a day so as to drain nearly to constant moisture content. The grading of the coarse and fine aggregates shall be tested at least once for every 100 tonnes supplied, to ensure that grading is uniform and same as that of the samples used in preliminary tests.

When tested as per BS EN 933 the sulphate content of aggregates shall not exceed 0.40 percent by weight for each individual source of coarse and fine aggregate. The chloride content of aggregates shall not exceed 0.05 percent by weight for each source of coarse and fine aggregate. The total sulphate content of concrete shall not exceed 4.0 percent by weight of the cement. The total chloride content of concrete from all sources shall not exceed 0.40 percent by weight of the cement.

Petrographic analysis of aggregates should be carried out initially for each source and periodically as directed by the Engineer.

Aggregates, when tested in accordance with CRD C119 shall contain no more than 8 percent by weight of thin, flat and elongated particles.

The specific gravities and absorption of aggregates shall be identified in accordance with ASTM C127 and ASTM C128.

Prior to initial use of each source of aggregate, all the specified tests shall be performed on aggregates to verify compliance with those specifications.

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The Fineness Modulus of fine aggregate (sand) shall be not less than 2.6 nor more than 3.1. In at least four out of five successive test samples, the modulus shall vary by not more than 0.20 from the moving average for the last five tests. The gradation of the coarse aggregate will be suitable if the results of four out of the last five consecutive tests comply with the gradation requirements.

Aggregates shall be tested for deleterious reactivity with alkalis in the cement, which may cause excessive expansion of the concrete. Tests of coarse and fine aggregates shall be made in accordance with ASTM C1260. If the expansion of the coarse and/or fine aggregates test specimen, tested in accordance with the ASTM C1260, does not exceed 0.10% at 16 days from casting, then the coarse and fine aggregates shall be accepted.

Prior to the initial use of each source of aggregates, certified tests shall be performed on aggregates to verify compliance with these specifications and submitted for the Engineer's review and approval.

Gradation of coarse aggregates for concrete shall conform to the gradations given in Table-4.

The gradation of combined coarse and fine aggregates shall be within the grading limit specified in Table-5.

The Contractor shall furnish certified test reports for aggregate tests listed in Table-6, Quality Tests.

2.1.3 Water

Only potable water from the sources approved by the Engineer shall be used. The Contractor shall supply sufficient water for all purposes, including mixing the concrete, curing and cleaning plant and tools. Performance requirements for mixing water shall conform to ASTM C1602.

In case of doubt, the Engineer will require that concrete mixed with water proposed to be used should be tested to have a compressive strength not less than 90% of the strength of concrete mixed with distilled water.

2.1.4 Concrete Patching Compound

Use an approved epoxy-resin compound applied according to manufacturer's instructions. Compound shall be paintable material which produces no evidence of bleeding and which, after final set, shall not be affected by high humidity and moisture. Epoxy-resin compound shall comply with FS-MM-G-650, Type 1, Grade C.

2.1.5 Additives

All additives shall be from a manufacturer approved by the Engineer.

Air Entraining Admixtures shall conform to ASTM C260. Other admixtures for water reducing, retarding, accelerating shall conform to ASTM C494.

2.1.6 Vapor Barrier

Geotextile fabric conforming to AASHTO M-288, Class-1.

2.1.7 Grout

- i. Damp Pack Bedding Grout: Mix of one part Portland cement and 2 parts of fine aggregate proportioned by weight and not more than 4 gal. (17 liters) of water per bag of cement.
- ii. Pre-mixed, Non-Shrink, Non-Metallic Grout: "Masterflow 713" manufactured by Master Builders, "Euco-N.S." manufactured by the Euclid Chemical Company or other approved equivalent.

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iii. Pre-mixed, Non-Shrink, Metallic Grout: "Embeco 636" manufactured by Master Builders, "Firmix" manufactured by the Euclid Chemical Company or approved equivalent.

2.1.8 Waterproofing Admixture

Crystalline Water Proofing Admixture Bitocrete C-16 from Schomburg Germany or approved equivalent as specified in or as shown in drawings.

2.1.9 Corrosion Inhibiting Admixture

Migrating Corrosion Inhibiting admixture shall be used for reinforced concrete works as specified in the drawings and BOQ. Preparation and proportions shall be according to the manufacture's recommendations and ACI 212. The migrating corrosion inhibitor should be organic amine-carboxylate based and applied at a fixed low dosage rate according to ACI 212 and as per manufacturer recommendations, and should have the following qualities:

- i. Meet the requirements of ASTM C1582 when tested as per ASTM G109 from 3rd party independent accredited lab and shall meet or exceed the requirements of ASTM C1582.
- ii. Must meet the requirements of BS 8443
- iii. Be proven effective when tested in accordance to ASTM G109 for a testing period not less than 3 years and proven effective in modified cracked beam testing.
- iv. Protect both anodic and cathodic components of the corrosion cell.
- v. The manufacturer shall be ISO 9001 and ISO 14001 certified for the design and manufacturing of corrosion protection systems and concrete protection products with valid certificate.

The contractor must submit a certificate of supply for each concrete pour with corrosion inhibitor and must mention the following:

- i. Batch numbers and expiry dates of the material
- ii. Company Stamp and its authorized representative signature

2.1.10 Cover Material for Curing

Curing material shall conform to the following:

- i. Impervious Sheeting: ASTM C171, type optional, except that polyethylene sheeting shall be 0.1mm0.1mm minimum thickness, white opaque. Where the work is exposed to high winds the impervious sheeting shall not be used.
- ii. Burlap: Cloth made of jute or kenaf shall conform with AASHTO M182 and shall weigh a minimum 0.3kg/m.
- iii. Liquid Membrane Forming Compound: ASTM C309, Type 2.

2.1.11 Joint Fillers

ASTM D1751, preformed, resilient bituminous type or ASTM D1752, preformed sponge rubber.

2.1.12 Joint Sealants

ASTM D7116 for PQC Pavements, ASTM D6690 for joints between flexible shoulder pavement & PQC, ASTM C920 for joints in building.

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2.1.13 Waterstops

Provide flat, dumbbell type or center bulb type water stops at construction joints where shown. Web thickness not less than 5mm for units up to 125mm wide, and not less than 10mm for widths over 125mm. Provide polyvinyl chloride (PVC) water stops complying with US Corps of Engineers Specification CRD-C-572 or ASTM D-412 or ASTM D-638 of approved manufacturer.

2.1.14 Epoxy Resin

ASTM C881, type, Grade 3, Class C.

Bond Breaking Tape shall conform to ASTM D789.

2.1.15 Formwork

i. Formwork for Concrete Pavement

If the concrete is to be laid in panels which require forms, they shall be made of steel of an approved section, with a base width of at least two hundred and fifty (250) millimeters and the depth shall be equal to the thickness of the pavement at the edge as shown on the plans. The forms shall be staked with steel stakes, and stakes shall be of a length approved by the Engineer. Each section of forms shall have a stake pocket at each end and at intervals of not more than one and one-half (1.5) meters between ends. The stake pockets shall have approved devices for locking the form to the steel stakes. Each section of forms shall always be straight and free from bends and warps. No section shall show a variation greater than three (3) millimeter in three (3) meters from a true plane surface on the top of the form, and the inside face shall not vary more than six (6) millimeters from a plane surface.

Before placing forms, the underlying base shall be to the required grade, and shall be firm and compact. The forms shall have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than three (3) millimeters from the proper elevation.

Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement especially, dowels. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Dowels shall be protected from damage during removal of forms and subsequently from traffic until concrete for adjacent panels are casted. All the damaged dowels shall be replaced without any financial implication as per the procedure approved by the Engineer using epoxy bond material for fixing the dowels.

Pavement, which in the opinion of the Engineer, is damaged due to the careless removal of forms shall be repaired by the Contractor, as directed by the Engineer, at the Contractor's own expense.

Forms shall be thoroughly cleaned and oiled each time they are used.

When pavement is placed adjoining existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true, uniform surface, of sufficient width to accommodate the wheels of the finishing equipment, if necessary to obtain proper smoothness of the pavement.

ii. Formwork for Structures

Material, workmanship etc. of formwork for structures, refer relevant specification.

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2.1.16 Reinforcement

Materials for reinforcing steel, welded wire fabric, dowels and tie bars, refer relevant specification.

Column Design Schedule

Member	Reinforcement Requirement
Column C1 (24" × 36")	As = 10.60 in ² ; ρ = 1.23%; ASTM A615 Gr 60; Mu = 192 ft-k; Pu = 223k — SAFE
Column C2 (24" × 36")	As = 21.99 in ² ; ρ = 2.55%; SMRF detailing required; multiple load combos — SAFE
Column C3 (30" dia circular)	As = 14.14 in ² ; ρ = 2.00%; Mu = 148 ft-k; Pu = 358k — SAFE
Column C4 (18" × 18")	As = 3.53 in ² ; ρ = 1.09% — SAFE

Beam Design Schedule

Member	Reinforcement Requirement
Plinth Beam PB1 (18" × 24")	Top: 5-#6; Bottom: 5-#6; Stirrups #3 @ 4" c/c supports, 9" c/c mid-span; V = 47k, M = 144 ft-k — SAFE
Plinth Beam PB2 (18" × 30")	Top: 6-#6; Bottom: 6-#6; Stirrups #3 @ 4" c/c supports; V = 42k, M = 140 ft-k — SAFE
Beam B1 — Transfer Beam (21" × 45")	Top: 15-#8; Bottom: 15-#8; Stirrups #3 4-legged @ 3.5" c/c; V = 280k, M = 1,942 ft-k — SAFE
Beam B1-a (21" × 24")	Top: 8-#8; Bottom: 4-#8; Stirrups #3 2-legged @ 4" c/c; V = 75k, M = 519 ft-k — SAFE
Beam B2 (18" × 30")	Top: 6-#8; Bottom: 6-#8; Stirrups #3 @ 4" c/c; V = 92k, M = 499 ft-k — SAFE
Beam B3 (18" × 24")	Top: 5-#8; Bottom: 5-#8; Stirrups #3 @ 4" c/c; V = 67k, M = 276 ft-k — SAFE
Beam B4 (12" × 24")	Top: 5-#6; Bottom: 3-#6; Stirrups #3 @ 4" c/c; V = 52k, M = 171 ft-k — SAFE
Beam B5 (18" × 30")	Top: 10-#8; Bottom: 6-#8; Stirrups #3 4-legged @ 4" c/c; V = 150k, M = 793 ft-k — SAFE
Beam B6 (10" × 24")	Top: 3-#6; Bottom: 3-#6; Stirrups #3 @ 4" c/c; V = 15k, M = 114 ft-k — SAFE

Slab Design Schedule

Slab	Thickness / Reinforcement
S1 — Two-Way (24.5' × 29')	t = 7"; Short span: #4@4" neg, #4@6" pos; Long span: #4@5" neg, #4@8" pos; f'c = 3,000 psi — SAFE
S2 — Two-Way (18.5' × 24.25')	t = 6"; Short span: #4@3.5" neg; Long span: per calc; f'c = 3,000 psi — SAFE
Typical slab thickness	7 inches (175 mm) for two-way spanning slabs per ETABS model

2.1.17 Fibre Reinforced Concrete

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Concrete shall be treated with polypropylene synthetic reinforcing fibers (Duracete or approved equivalent) when indicated on the drawings or as otherwise specified by the Engineer in accordance with the fiber manufacturer's recommendations.

- a. Synthetic reinforcing fibers shall be manufactured from virgin polypropylene.
- b. The dosage rate shall be 1.8kg/cu.m (3.0 Lb/Cu yd) of concrete.
- c. Fiber supplier shall provide technical assistance, if required.
- d. All fibers must meet or exceed the standards and specifications set forth in ACI 544, Fiber Reinforced Concrete.
- e. Listed below are the minimum properties of the polypropylene fibers for use. All fibers must meet or exceed the characteristics described in ACI-544, IR, Table 1.1, Fiber Reinforced Concrete.
 1. Tensile Strength: 58,000 psi (minimum)
 2. Elongation at break: 12% (minimum)
 3. Fiber: 100% Fibrillated / Monofilament Polypropylene (as per site requirement)
 4. Lengths: As per requirement/drawings
 5. Absorption: Nil
 6. Specific gravity: 0.9
 7. Ignition point: 593 °C
 8. Melting point: 160-170 °C
 9. Heat & UV stabilization: Long term
 10. Thermal conductivity: Low
 11. Electrical conductivity: Low
 12. Salt resistance: High
 13. Acid resistance: High
 14. Alkali resistance: 100% (alkali proof)

2.1.18 Bond Breaker Tapes

Bond breaking tape or separating material that is a flexible, non-shrinkable, non-absorbing, non-staining, and non-reacting adhesive-backed tape. The material shall have a melting point at least 5°F 3°C greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch (3 mm) wider than the nominal width of the joint and shall not bond to the joint sealant.

If required Contractor can use Backer Rod instead of debonding tape or in combination which shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant in accordance with ASTM D5249. The backer-rod material shall be 25%±5% larger in diameter than the nominal width of the joint.

2.1.19 Cold-Weather and Hot-Weather Concreting Requirements

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Cold-weather concreting (mandatory provision for Skardu winter season applicable when ambient temperature < +5°C):

- (a) Concrete shall not be placed on frozen ground. Frozen ground shall be thawed and covered before any placement.
- (b) Fresh concrete temperature at point of delivery: maintained between +10°C and +25°C.
- (c) Heating of mixing water and aggregates is permitted.
- (d) Concrete shall be protected with insulated blankets or heated enclosures for a minimum curing period of 7 days for 4,500 psi concrete.
- (e) No calcium chloride accelerating admixture shall be used.

Hot-weather concreting (when ambient temperature exceeds +30°C): Fresh concrete temperature shall not exceed +35°C at point of delivery. Ice may be substituted for part of the mixing water. Additional retarding admixture may be used with Engineer approval.

2.2 Material Testing

2.2.1 Samples and Testing

Samples from stock on the site or suppliers shall be taken by the Contractor in presence of the Engineer. Furnish tests and certificates as specified.

Test	Standard
Compressive Strength (cylinders)	ASTM C39
Slump Test	ASTM C143
Air Content	ASTM C231
Temperature at Delivery	ASTM C1064

2.2.2 Cement

Sampled cement shall be tested by a testing laboratory. Certified copies of laboratory test reports shall be furnished for each lot of cement and shall include all test data, results and certification that the sampling and testing procedures are in conformance with the Specifications for approval. No cement shall be used until test results are satisfactory. Cement that has been stored for longer periods after being tested shall be re-tested before use. Cement found unsatisfactory under test shall be immediately removed from the construction site or supplier stock.

2.2.3 Aggregates

Aggregate sampling shall conform to ASTM D75. Aggregates shall be sampled and tested by a testing laboratory. No aggregate shall be used until all the tests mentioned in these specifications are conducted, reported and found satisfactory to the Engineer.

Table 4: Quality Tests for Aggregates

Material	Test	Requirement	Test Designation
Coarse	Abrasion	Loss 40% max	ASTM C131
Coarse	Absorption	2.0% max	ASTM C127

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Material	Test	Requirement	Test Designation
Coarse	Clay Lumps	1.0% max	ASTM C142
Coarse	Surface Coating	0.5% max	ASTM C117
Coarse and Fine	Soundness	Loss 10% max	ASTM C88
Coarse and Fine	Sieve	As specified	ASTM C136
Fine	Absorption	4.0% max	ASTM C128
Coarse	Cleaness	75% min	CALIF 227
Fine	Sand equivalent	70% min	CALIF 217

2.2.4 Water

Water analysis shall be performed in accordance with ASTM D596, and the report shall be submitted for Engineer's approval. Any change in source of water shall be intimated to the Engineer, and specified testing shall be done as directed by the Engineer. Water shall conform to ASTM C1602 or BS 3148.

2.2.5 Admixtures

Sampling and testing of all admixtures used in concrete mix shall be in accordance with the standard procedure recommended by an approved testing laboratory. No admixture shall be used until test results are satisfactory and approved.

2.2.6 Concrete

i. Compressive Strength

Specimens shall be tested in accordance with ASTM C39 or ACI 214. Test specimens shall be evaluated for each grade of concrete specified in conformance with ACI 318, chapter "Concrete Quality". The standard age of concrete for tests shall be 3, 7, 14 and 28 calendar days.

ii. Flexural Strength

The flexural strength of concrete for pavement quality concrete shall be 4.5 MPa at 28 days as per ASTM C78. Samples shall be secured in accordance with ASTM C172. Test specimens shall be made and cured in accordance with ASTM C31.

iii. Slump and Entrained Air

Slump test and entrained air tests shall be performed in the field under the supervision of the Engineer. Slump test shall conform to ASTM C143 and entrained air content shall be determined in accordance with ASTM C231 or C173 as applicable.

iv. Concrete removed for the Structure

When the results of the strength test of the specimen indicate deficiency in specified requirements or where there is other evidence that the quality of concrete is below specified requirements, cores shall

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be obtained through drilling and tested in conformance with ASTM C-42 at the Contractor's expense. If a deficiency is discovered, the Contractor may be allowed to make load test, at his expense, and results shall be evaluated in conformance with ACI 318, Chapter 20. Otherwise, concrete shall be removed / demolished at the Contractor's risk and cost.

v. Coefficient of Thermal Expansion of Concrete

For determining Coefficient of Thermal Expansion of Concrete exclusively for pavement quality concrete, four (4) test specimens shall be fabricated from a single batch of concrete to be tested as per AASHTO T 336 initially for field qualification and during regular production of each type of pavement quality concrete, similar number of specimen shall be produced and tested for determining Coefficient of Thermal Expansion of Concrete for every 1000 Cu.m of concrete.

The coefficient of thermal expansion must not exceed 6.0 micro strain / °F. During production, test the coefficient of thermal expansion of the concrete at a frequency of 1 test for each 1,000 Cu.m of paving or concrete pouring but not less than 1 test for a project with less than 1,000 Cu.m of concrete.

2.3 Frequency of Testing

i. All the tests on cement shall be performed initially for approval and afterwards on every ten (10) tonnes of cement arrived at site.

ii. The following tests shall be performed on aggregates and water initially for approval and weekly thereafter:

- a. Aggregates ASTM C33
- b. Soundness ASTM C88
- c. Specific Gravity ASTM C127
- d. Absorption ASTM C128
- e. Abrasion ASTM C131
- f. Gradation ASTM C136
- g. Sand Equivalent ASTM C217
- h. Cleanness ASTM C227
- i. Alkali-Silica Reactivity ASTM C1260
- j. Elongation CRD C119
- k. Chloride Sulphate tons ASTM D512
- l. Water Analysis ASTM D596

All the test reports to be submitted for the works covered under these specifications, shall contain comprehensive data and calculations used in the test with specific mentioning of testing code / standard for that particular testing.

iii. The following tests shall be performed initially for approval and thereafter as mentioned hereunder:

- a) Concrete Compressive Strength

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Three sets of specimens for each 125 Cu.m of each grade of concrete placed or at least three sets for each grade per work shift. Compressive strength of each grade of concrete shall be tested as per ASTM C39.

b) Flexural Strength

Three sets of specimens for each 250 Cu.m of concrete placed or at least three sets per work shift. The concrete shall be sampled in accordance with ASTM C172. Flexural strength specimens shall be made in accordance with ASTM C31 and tested in accordance with ASTM C78.

c) Concrete Sulphate and Chloride Content

Sulphate (SO_3) Content, Chloride Content and pH value: One test per month for each grade of concrete. Broken laboratory specimens from strength tests shall be used for hardened concrete Sulphate, Chloride content and pH Value tests.

iv. The following tests shall be performed at the discharge point for each truck load of concrete delivered or at delivery point, as determined by the Engineer.

- a) Slump ASTM C143
- b) Air Content ASTM C173 or C231

PART 3-EXECUTION

3.1 Submission Requirements

3.1.1 Procedures

Following procedures shall be submitted to the Engineer:

Both hot and cold weather concreting procedures shall be submitted to the Engineer by Contractor regardless of the need for the immediate implementation of such not less than two weeks before beginning the work. Procedures shall include requirements for insulation, enclosures and the like. Finishing procedures and timing and duration of curing shall be described.

Contractor's construction procedures shall be computer word processed procedure and shall include description, charts and diagrams as applicable and necessary, to fully explain the subject procedures, methods and equipment operation in order to allow effective review by the Engineer, assist the Testing Agency's evaluation of the work, and to allow Contractor's personnel to perform work in full conformance to the Contract Stipulations.

iii. Protection of concrete against injury due to mechanical contact and construction operation.

iv. Protection of work by other trades.

v. Any other document demonstrating manufacturing, delivering, transportation and protection of concrete.

3.1.2 Placement Schedule

Submit a placement schedule for approval prior to start of concrete placement operations. Daily concrete pour schedules shall be submitted 24 hours in advance of planned pours.

3.1.3 Formwork

Submit for approval copies of manufacturer's data and installation instructions for proprietary materials including form coatings, manufactured form systems, ties and accessories.

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3.1.4 Certificates of Compliance

Submit certificates of compliance covering cement types, reinforcement, grout materials, additives, sealants, soft board, patch repair materials, epoxy-resin materials etc. The certificates of compliance shall include the material or product manufacturer's statements that supplied items conform to Specifications.

3.1.5 Testing Programme

Submit test programme for all specified requirements along with the testing schedule for approval of the Engineer.

3.1.6 Test Reports

Submit test reports showing the result of required tests and compliance with specified standards and codes, for approval. Test reports shall be certified by the Contractor and the Testing Agency.

3.1.7 Samples

Submit to the Engineer for acceptance prior to purchase, fabrication or delivery, samples of materials for his approval.

Substitute products materials or fixtures proposed by the Contractor shall be submitted as samples for approval. The samples shall be accompanied by detailed information about materials.

3.1.8 Shop Drawings

Shop drawings shall be submitted to the Engineer for approval in accordance with the requirements of the Contract Documents and as specified herein under:

- i. Shop drawings furnished for this section shall conform to the best standards of the construction industry. Shop drawings shall be prepared under the supervision of competent engineering personnel. Prior to submittal, the Contractor shall check each shop drawing for compliance with the requirements of the Contract Documents. As evidence of conformance with this requirement, each shop drawing shall bear the seal and the self-written signature of Contractor's registered Professional Engineer.
- ii. Shop drawings shall include plans, elevations, sections and complete details to describe clearly, at an ample scale for all works to be provided. Drawings shall be accurately dimensioned, where applicable, and shall be noted clearly.
- iii. Work of Other Trades: Show in the shop drawings, and the names shown, holes required for passage of work of other sections through Cast-In-Place Concrete Work. Prepare and submit to the Engineer field work drawings for holes not shown in shop drawings.
- iv. Submit shop drawings for curved and radial concrete formwork and identify the formwork materials proposed for use.
- v. Construction Joint, Expansion Joint and contraction Joint Drawings: Show all joints given in the drawings, specified herein, and required by Contractor to provide for the sequence of pouring. Submit in sufficient time to allow the orderly detailing of reinforcing steel. Reinforcement shop drawings shall be prepared in conformance with the accepted Construction Joint, Expansion Joint and contraction Joint Drawings. Measures to control cracks e.g. shrinkage strips, admixture as per relevant ACI codes shall be shown on the drawings.

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vi. Reinforcing Steel, including Welded Wire Fabric (WWF), shall be detailed in strict accordance with the methods and procedures provided in "ACI Detailing Manual". Reinforcing steel drawings shall be submitted simultaneously with related shop drawings. Prepare shop drawings which provide for reinforcement, including dowels, properly positioned in all concrete work, so that material can be properly cut, bent and placed. Form not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully given in shop drawings. Reinforcing steel drawings shall show, to scale, all concrete work including pits, kerbs, trenches, pads, equipment bases, steps, slopes, radii, curves, openings, holes, block-outs and the like. Provide schedules and details showing placing sequences, bending, lengths and locations of all reinforcement.

vii. Detailing: All reinforcing steel shall be detailed in strict compliance with ACI 318 and ACI 315.

3.1.9 Coordination Drawings

The Contractor shall submit coordinated drawings of the following:

All sleeve locations, whether round or of other shape, penetrating exterior and interior walls, pits, slabs, beams, other structural systems and pavements.

The position of all embedded items required to receive the work of other trade, including details needed to assure correct placement of both the embedded items and the reinforcing steel.

The Contractor shall coordinate and crosscheck for accuracy, completeness and correct relationship to the work of other sections, each shop drawing prepared for the work of this section, including each shop drawing prepared by nominated subcontractors. Contractor's check shall include a verification of strict compliance with the Contract Documents and shall be performed prior to submission of each shop drawing for review by the Engineer. The Contractor shall certify the co-ordination, accuracy, and Contract compliance of each shop drawing by a written statement placed in each drawing and attested by the responsible person in charge of the work for Contractor. The personally inscribed initials of the person(s) preparing each drawing as well as the detailing agency's supervisor and chief checker shall be included in the title block or similar prominent location.

3.1.10 Mill Test Reports

Furnish the Engineer with certified mill test report for cement and for steel reinforcement, including bars, welded wire fabric, dowels, anchors and splices for approval.

3.1.11 Name of Manufacturers/Suppliers

Submit for acceptance by the Engineer:

- i. Aggregates
- ii. Ready mix concrete
- iii. Reinforcing bars
- iv. Welded steel wire fabric
- v. Concrete accessories
- vi. Cement
- vii. Admixture

- viii. Joint filler
- ix. Joint sealants
- x. Water stops
- xi. Membrane curing, sealing, hardening compound
- xii. Bonding compound
- xiii. Form oil
- xiv. Anchors
- xv. Concrete repair mortars

3.2 Nominal Concrete Mixes

- i. The cement, fine aggregate and the coarse aggregate shall be weighed separately. The proportions of cement to fine aggregate and coarse aggregate shall be adjusted as per ACI 211 & ACI 318 so as to provide the concrete of the required crushing strength when tested as set out in Table 3.
- ii. The Contractor shall regulate and arrange mixing of the ingredients for the designed mix of the concrete by weight-batching.

iii. Water/Cement Ratio

The quantity of water used shall be just sufficient to produce a dense concrete of the specified strength. For all exterior exposed work and foundations, the water/cement ratio shall not exceed 0.45, allowance being made for any water in the fine and coarse aggregates.

iv. Workability

Admixtures may be used where necessary to achieve required workability, with the Engineer's approval. For concrete pavements, the mix determined shall be workable concrete having a slump between 13mm13mm and 50mm50mm, as determined by ASTM C143. For other structures the concrete shall be proportioned and produced to have a slump of 75mm75mm or less if consolidation is to be by vibration, and 125mm125mm or less if consolidation is to be by methods other than vibration.

3.3 Strength Requirements for Concrete and Gradation of Aggregate

Strength requirements for concrete are given below:

Table 1: Strength of Different Classes of Concrete

Compressive Strength (MPa)	Approx. Grade (M)	Typical Uses
31 MPa	M30–M35	Heavy-duty RCC, piling works (bored cast-in-situ piles, pile caps)
28 MPa	M25–M30	RCC slabs, beams, columns, rafts
25 MPa	M25	General structural concrete

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21 MPa	M20	Footings, slabs, residential structures
17 MPa	M15	PCC, blinding concrete
14 MPa	M10–M15	Lean concrete, leveling course
10 MPa	M10	Non-structural works, pathways
7 MPa	M7.5	Sub-base, temporary works
5 MPa	M5	Very lean concrete, filler layers

Table 2: Gradation of Concrete Aggregates

Particle Size Square Openings (Equivalent U.S. Sieve Designation)	Percentage by Weight Passing
63.0 mm (2 1/2 in.)	-
50.0 mm (2 in.)	-
37.5 mm (1 1/2 in.)	-
25.0 mm (1 in.)	100
19.0 mm (3/4 in.)	90 - 100
12.5 mm (1/2 in.)	25 - 60
9.5 mm (3/8 in.)	20 - 55
5.0 mm (No.4)	0 - 10
2.36 mm (No.8)	0 - 5
1.18 mm (No.16)	-
0.60 mm (No.30)	-
0.30 mm (No.50)	-
0.15 mm (No.100)	-

Table 3: Gradation of Combined Course and Fine Aggregates for Concrete

Particle Size Square Openings (Equivalent U.S. Sieve Designation)	Percentage by Weight Passing
63.0 mm (2 1/2 in.)	100
50.0 mm (2 in.)	90 - 100

Particle Size Square Openings (Equivalent U.S. Sieve Designation)	Percentage by Weight Passing
37.5 mm (1 1/2 in.)	70 - 90
25.0 mm (1 in.)	50 - 75
19.0 mm (3/8 in.)	45 - 70
12.5 mm (1/2 in.)	-
9.5 mm (3/8 in.)	38 - 55
5.0 mm (No.4)	30 - 45
2.36 mm (No. 8)	22 - 35
1.18 mm (No. 16)	15 - 27
0.60 mm (No. 30)	10 - 18
0.30 mm (No. 50)	4 - 10
0.15 mm (No. 100)	1 - 3
0.075 mm (No. 200)	0 - 2

The flexural strength of concrete for pavement quality concrete shall be 4.5 MPa at 28 days as per ASTM C78 with minimum cement content of 340kg340kg of cement per Cu.m of concrete. The flexural strength requirement is the governing factor, excess cement if any used to achieve the required flexural strength shall not be payable.

i. The Contractor shall adopt all necessary measures as per ACI201.2, like proper grading of aggregates, control of water cement ratio and cement content, proper compaction and curing, to achieve dense and durable concrete.

ii. The Contractor shall submit mix design by weight for each class, strength or grade of concrete at least 45 calendar days before any placement of concrete, along with samples of the proposed materials. Manufacture 12 nos. test cylinders 300mm×150mm300mm×150mm or beams for flexural strength in accordance with ASTM C-31 and in accordance with the mix design batching by weight and test 3 cylinders or beams each at 3, 7, 14 and 28 days in the presence of Engineer's Representative, in accordance with ASTM C-39 / ASTM C 78 and submit all relevant data and results of tests for approval of the Engineer. The Contractor shall obtain approval from the Engineer in writing for each mix design before producing the actual concrete for the works.

iii. The Contractor is required to submit the 3rd3rd, 7th7th and 14th14th day strength test results soon after its availability but not later than 3 days from the date on which tests are to be conducted for review of the Engineer.

PART 4-BATCHING, MIXING AND DELIVERY

4.1 Batching

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All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement may be taken as 50kg.

Aggregates shall be batched by weight; due allowance being made for water content. Aggregates may be batched by volume only with the prior permission of the Engineer. The apparatus for weight batching may be as integral part of the mixer or a separate unit of a type approved by the Engineer. It shall be accurate within 2% and shall be checked for accuracy at least once a week.

The quantity of additives shall be as prescribed by the manufacturer or as directed by the Engineer.

4.2 Mixing

The concrete shall be mixed in an approved batch mixer. It shall be fitted with the manufacturer's plate stating the rates, capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device.

Mixing shall continue for the period recommended by the mixer manufacturer or until there is apparently a uniform distribution of the materials and the mass is uniform in colour, whichever period is longer. However, minimum mixing time shall not be less than 1-1/2 minutes.

If it is desired to use a mixing period of less than 1-1/2 minutes, the Engineer's approval shall be obtained in writing.

Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added.

The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixing blades shall be replaced when they have lost 10 percent of their original height.

Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be re-tempered but shall be discarded.

4.3 Transporting

The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent segregation or loss of or addition to ingredients. It shall be deposited as nearly as practicable in its final position so as to avoid re-handling or flowing. All skips vehicles, or containers used for transporting the concrete shall be thoroughly clean.

During hot or cold weather, concrete shall be transported in deep containers, on account of their ratios of surface area to mass, which reduces the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

a) Batching

The Contractor shall submit to the Engineer for review the plans and capacity of the concrete batching plant and delivery equipment, which shall comply with ASTM C-94.

The Contractor shall furnish test certificates for the scales and metering devices before producing concrete and at least every six weeks thereafter.

b) Accuracy of Plant Batching

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Cement measured by weight in individual batchers shall be within +1.0 percent of the desired intermediate and final weights in cumulative batchers. The minimum batching accuracy shall be +0.3 percent of scale capacity for small loads below 30 percent of scale capacity.

Aggregate measured by weight in individual batchers shall be within +2.0 percent of the desired weight, or within +1.0 percent of the desired intermediate and final weights in cumulative batchers; but in either case, the minimum batching accuracy shall be +0.3 percent of scale capacity for small loads below 15 percent and 30 percent of scale capacity, respectively.

Water measured by volume or by weight shall be within +1.0 percent of the desired amount.

Liquid admixtures measured by volume or by weight shall be within +1.0 percent of the desired amount.

Compensation for changes of moisture content in fine and coarse aggregate shall be made by devices which shall correct the batch water and the weight of the affected aggregate simultaneously without changing the batch setting.

c) Mixing and Delivery

Concrete shall be mixed completely in the batching plant. Records shall be kept of water added in normal batching.

Concrete shall be transported to the point of discharge in agitator-mixer trucks, or by other approved means.

Trip tickets shall be provided for each delivery. The tickets shall show the designation of the materials in each batch, measured weight or volume of materials, methods of cooling concrete, class of concrete, batch number, mixer number, batch volume, date and time water was added to the mix, time of discharge from the mixer, and delivery truck number.

When it is necessary to add water to the agitator-mixer, it shall be done in accordance with ASTM C94 and recorded.

PART 5-CONCRETE FOR PAVEMENT

The base upon which the concrete pavement is laid shall have been constructed or prepared under other relevant section of the specifications and shall be smooth, compacted and true to the grade and cross-section shown on the drawing and shall be maintained throughout the period of placing concrete pavement.

To prevent flow of cement slurry from concrete, geotextile fabric conforming to AASHTO M-288 Type-I as vapor barrier, as per relevant section of specifications shall be placed on cement treated base course or lean concrete, prior to placing of concrete.

Pavement concrete can be cast within the forms or preferably concrete paver or should be used for laying the concrete subject to demonstration of suitability of the adopted methodology and ensuring quality of the works. Concrete laying methodology shall be approved.

5.1 Formwork

Before placing forms or laying of concrete through mechanical pavers, the underlying base shall be to the required grade, and shall be firm and compact. The forms shall have full bearing upon the Cement Treated Base-course or lean concrete throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported

during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than three (3) mm from the proper elevation.

5.2 Placing Reinforcement

All pavement reinforcement shall be placed as shown on the drawings. All reinforcement required by the works shall be held in proper position by sufficient number of metal bar supports or chairs as approved by the Engineer. The dowels may be installed mechanically by means of equipment and methods approved by the Engineer. The satisfactory placement of the dowels shall depend upon the ability of the mechanical device to place the dowels in their true position. The Engineer may require, when satisfactory placement is not obtained by mechanical means, that the dowels be installed ahead of placing the concrete and that they be securely staked and tied if necessary to hold them in their exact position. The use of removable devices, supporting the bars from the forms, will not be permitted.

If it is observed during the construction that dowels are not placed / installed perpendicular to the vertical face of the PQC if not inserted properly Contractor may suggest post work anchorage of dowels with epoxy without any financial implication.

5.3 Placing Concrete

5.3.1 General

Concrete within Forms: The concrete shall be deposited on the base course or concrete in successive batches for the full width between forms and in a manner which will require as little re-handling as possible. Spreading shall be done by an approved mechanical spreader in a manner that will prevent segregation and separation of the materials. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances. The amount of material deposited shall be sufficiently in excess of that required to form the pavement to the required cross section after consolidation in order to provide a roll of concrete ahead of the front screed of the finishing machine for the full length of the screed.

When concrete is placed adjoining a previously constructed lane of pavement and when mechanical equipment will be operated upon the existing lane of pavement, the concrete shall be at least 7 days old and at a flexural strength approved by the Engineer. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after 3 days, if approved by the Engineer.

Concrete shall be thoroughly consolidated against and along the full length and on both sides of all expansion joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than fifteen (15) seconds in any one location.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly. Damage to joint assemblies caused by dumped concrete shall be repaired immediately, as directed by the Engineer, at the Contractor's expense.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by methods approved by the Engineer.

Placement of concrete ahead of the initial spreader strike-off shall not be more than fifteen (15) minutes ahead of final spreader strike-off. If concrete is placed in one (1) layer only, the placement of concrete shall not be more than twenty (20) minutes ahead of the spreader strike-off.

5.3.2 Slip-form Construction

The concrete shall be distributed uniformly into final position by a self-propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms.

The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 225mm. The spacing of internal units shall be uniform and shall not exceed 450mm. The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be within 8000 to 12000 cycles per minute and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least 300mm. The frequency of vibration or amplitude shall vary proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible. And all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

Dowels shall be inserted or placed during the laying of concrete by using hydraulic mechanism which pushes them into concrete when its workable. Any other method can be used with the prior approval of the Engineer.

5.3.3 Works in Extreme Weather

Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 4°C and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 2°C. When concreting is authorized during cold weather, the Engineer may require the aggregates to be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials. Unless otherwise authorized, the temperature of the mixed concrete shall not be less than 10°C at the time of placement in the forms.

If the air temperature is 2°C or less at the time of placing concrete, the Engineer may require the water and/or the aggregate to be heated to not less than 21°C nor more than 66°C. Concrete shall neither be placed on frozen sub-grade nor frozen aggregates be used in the concrete.

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During periods of warm weather when the maximum daily air temperature exceeds 30°C, the following precautions should be taken. The forms and/or the underlying material shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 32°C. The aggregates and/or mixing water shall be cooled as required.

5.4 Joints

5.4.1 General

Joints shall be constructed exactly in accordance with the details shown on the plans and the Specifications and with the best of workmanship.

5.4.2 Expansion Joints

Expansion joints shall be of the type and dimensions and of the spacing shown on the plans. Joint filler shall be of pre-molded compressible material according to ASTM D1751 or ASTM D1752, and joint sealant material shall be according to ASTM D7116.

The entire joint assembly shall be of a type designated on the plans and shall be installed in such a position that the centreline of the joint assembly is perpendicular to the centerline of the pavement slab and the dowels lie parallel to the centerline of the slab. Finished joints shall not deviate more than six (6) millimeters in the horizontal alignment from a straight line. No plugs of concrete shall be permitted anywhere within the expansion space.

One-half of the length of each dowel bar shall be painted, and then thoroughly coated with hard grease, or lubricant as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.

An expansion cap of the dimensions shown on the plans shall be placed on the greased end of each dowel. The greased ends shall be free to slide in the dowel holder and shall extend in the direction as indicated on the plans. Any excess grease on the dowel holder shall be removed.

The joint shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure that the joint and the dowel bars will remain in their proper position after the concreting and finishing operations are completed.

The paver or finishing machine shall be operated in a manner that will prevent displacement of the joint. If for any reason it is necessary to straighten a joint, any depressions caused by this operation shall immediately be filled with fresh concrete, re-spaded and brought to the original crown in advance of the longitudinal finishers. Any fluid laitance or mortar caused by this operation shall be removed and replaced with fresh concrete.

As the paver or finishing machine approaches the joint on the first trip, the excess concrete shall be shoveled ahead and the tamper and each screed, in turn, shall be lifted over the joint. On the second trip of the finishing machine, the screed may be operated over the joint.

5.4.3 Contraction Joints

Contraction joints shall be of the type and dimensions and at the spacing shown on the plans. Sawed contraction joints shall be cut by means of an approved concrete saw. The joints shall not be sawed until the concrete has hardened to the extent that tearing and raveling is precluded.

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All joints shall be sawed during the initial curing period as described in subsection 4.5.10 of these specifications and the sawing shall begin before the pavement starts shrinking and before uncontrolled cracking takes place.

Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints. In no case shall the pavement be left overnight without having the joints sawed.

The joints shall be sawed at the depth, spacing, and lines shown on the plans. Guidelines or devices approved by the Engineer shall be provided to ensure cutting the joint in a straight line and perpendicular to the centerline of the pavement.

The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut, and before filling with joint sealant.

A string line shall be stretched between the pavement forms along the centerline of the joint.

Each dowel shall be painted and thoroughly coated with hard grease, or lubricant, in accordance with the directions shown on the plans or as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.

The entire joint assembly shall be an approved type and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the centerline of the pavement and the dowels lie parallel to the pavement surface parallel to the centerline of the pavement.

The greased ends of the dowels shall be placed in the direction as indicated on the plans and shall be free to slide in the dowel holder. Any excess hard grease on the dowel holder shall be removed.

5.4.4 Construction Joints

A butt construction joint shall be made perpendicular to the centerline of the pavement at the close of each day's work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete will have taken its initial set. This joint shall be formed by using a clean plank header having a nominal thickness of fifty (50) mm, a width of not less than the thickness of the pavement and a length of not less than the width of the pavement. The header shall be cut true to the cross-section of the finished pavement and shall be accurately set and held in place in a plane at right angles to centerline and perpendicular to the surface of the pavement.

The top surface of the header shall be protected with steel as approved by the Engineer. On the face along the center of the header there shall be fastened a trapezoidal piece of metal or wood the full length of the header. Seventy millimeters wide and at least forty millimeters in depth as per drawing to form a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars hereinafter specified. Upon resumption of work any surplus concrete remaining upon the base course shall be removed. The header shall then be carefully removed and fresh concrete deposited against the old in such a manner as to avoid injury to the edge of the old concrete. The fresh concrete shall be vibrated into the groove in a manner to ensure an interlocking joint.

Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the plans. The edges of the joint shall be grooved, edged, and sealed with the material used for sealing expansion and contraction joints.

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No construction joint shall be placed within 3 m of an expansion, contraction, or other construction joint.

5.5 Consolidating and Finishing for Concrete Pavement

5.5.1 Sequence

The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish either using paving medium for in-form placing of concrete or using slip form construction. The addition of superficial water to the surface of the concrete to assist in finishing operations generally will not be permitted. If the application of water to the surface is permitted by the Engineer, it shall be applied as a fog spray by means of approved spray equipment.

5.5.2 Finishing at Joints

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in sub-section 4.5.3. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to over and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 200 mm from the joint. Segregated concrete shall be removed from the front of and off the joint; the screed shall be lifted and set directly on top of the joint, and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

5.5.3 Machine Finishing

The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by an approved finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give the proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

5.5.4 Hand Finishing

Hand finishing methods will not be permitted, except under the following conditions. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade; in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used.

The screed for the surface shall be at least 600 mm longer than the maximum width of the pavement to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of a suitable vibrator.

5.5.5 Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a longitudinal float, using one of the following methods:

Hand Method: The hand-operated longitudinal float shall not be less than 3.6 m in length and 150 mm in width, properly stiffened to prevent flexibility and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete shall be worked with a sawing motion, while held in a floating position parallel to the pavement centerline and passing gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or soupy material shall be wasted over the pavement edge on each pass.

Mechanical Method: The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from an isolated beam and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with, the side forms or pavement subgrade. If necessary, long-handled floats having blades not less than 1500 mm in length and 150 mm in width may be used to smooth and fill in open textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of mechanical methods. When strike-off and consolidation are done by hand and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of a long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating any excess water and laitance shall be removed from the surface of the pavement by a straightedge 3 m or more in length. Success drags shall be lapped one-half the length of the blade.

5.5.6 Panel Size and Numbering

Every panel of pavement quality concrete shall be numbered for their identification and to distinguish them from each other. Size of the outer line of the number shall be 200×300 mm and each panel shall have a specific four (04) digit number having a suitable size as approved by the Engineer.

5.5.7 Straight-Edge Testing and Surface Correction

After the pavement has been struck off and consolidated and while the concrete is still plastic, it shall be tested for trueness with a 5 m straightedge. For this purpose, the Contractor shall furnish and use an accurate 5 m straightedge swung from handles 900 mm longer than one-half the width of the pavement. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline of the pavement and the whole area, gone over from one side of the pavement to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance shall be removed from the surface of the pavement. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

5.6 Surface Texture

The surface of the pavement shall be finished with a broom, saw cut groove, plastic groove, or wire combing or burlap drag finish for all newly constructed concrete pavements.

5.6.1 Brush or Broom Finish

If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 2mm in depth. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

5.7 Skid Resistant Surfaces

In addition to either a broom, brush or burlap finish in the plastic concrete pavement (as per subsection 4.5.6), skid resistant surfaces comprising either saw-cut grooves, plastic grooves or wire combing shall be provided as specified below and as directed by the Engineer.

5.7.1 Saw-Cut Grooves

i. For new concrete pavements that have hardened, transverse grooves shall be saw-cut in the pavement forming a 6×6×31 mm configuration. The grooves shall be continuous for the entire runway length. They shall be saw-cut transversely in the runway pavement to within 3 m of the runway pavement edge to allow adequate space for equipment operation. The maximum transverse saw-cut grooves shall not exceed 40 m. The tolerances for the saw-cut grooves shall meet the following:

- i. Alignment tolerance: ±38 mm in alignment for 23 m.
- ii. Groove tolerance: Minimum depth 5 mm. Maximum depth 8 mm. Minimum width 5 mm. Maximum width 8 mm.
- iii. Center-to-center spacing: Minimum spacing 31 mm. Maximum spacing 50 mm.

Saw-cut grooves shall not be closer than 76 mm to transverse paving joints. Grooves may be continued through longitudinal construction joints. Cleanup of waste material shall be continuous during the grooving operation. Waste material may be disposed of by either flushing with water, sweeping, or vacuuming. Waste material must not be allowed to enter the airport storm or sanitary sewer system.

5.7.2 Plastic Grooves

The grooves formed in the plastic concrete shall be 6×6×31 mm. The grooves shall be continuous for the entire runway length and width. The tolerances for the grooves formed in plastic concrete shall meet the following:

- i. Alignment tolerance: ±76 mm in alignment for 23 m.
- ii. Groove tolerance: Minimum depth 3 mm. Maximum depth 10 mm. Minimum width 3 mm. Maximum width 10 mm.
- iii. Center-to-center spacing: Minimum spacing 31 mm. Maximum spacing 50 mm.

5.7.3 Wire Combing

The wire combing technique shall use steel combs or tines of various dimensions to form groove-like texture in the plastic concrete pavement and shall provide grooves that are approximately 3×3 mm spaced 13 mm center-to-center.

5.8 Surface Test

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 5 m straightedge or other specified device. Areas in a slab showing high spots of more than 6 mm but not exceeding 13 mm in 5 m shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 6 mm or less. Where the departure from correct cross section exceeds 13 mm, the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

Any area or section so removed shall not be less than 3 m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joint that is less than 3 m in length shall also be removed and replaced.

5.9 Removing Forms

Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as specified for the surface. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the Contractor's expense, as directed by the Engineer. Any area or section so removed shall neither be less than 3m3m in length nor less than the full width of the paving lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3m3m in length, shall also be removed and replaced.

5.10 Protecting and Curing of Concrete Pavement

5.10.1 Initial Curing

As the surface of the freshly laid pavement is progressively finished, the initial curing and protection operations shall commence.

Upon completion of the finishing operation and while the surface of concrete is still moist, but no free water remains, a liquid curing membrane, as specified in ASTM C309 (Type 2) shall be applied to the exposed surfaces of the pavement at the rate of not less than one (1) liter per three and two-thirds (3-2/3) Sq.m of surface area when mechanical pressure distributors are used. The curing membrane, except on irregular areas, shall be applied by means of approved self-propelled mechanical pressure distributors or approved hand sprays. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during its use.

The mechanical spraying equipment shall include a full width spray bar equipped with multiple nozzles or a traversing spray which travels from one edge of the pavement to the other. In either case the path of adjacent nozzles or passes of the traversing spray shall overlap minimum of one-half (1/2) the width of the spray pattern so that all portions of the surface shall receive double applications from adjacent nozzles or passes. The pumping, pressure, and distribution arrangement shall be correlated with the forward speed to provide adequate and uniform coverage of the pavement at not less than the minimum rate required. Irregular areas to which the mechanical distributor cannot be adapted may be covered with hand sprays.

When hand sprays are used, the curing membrane shall be applied in two (2) applications, each at a rate of not less than one (1) liter per five (5) Sq.m of surface area so as to provide a total rate of application of one (1) liter per two and one-half (2/3) Sq.m of surface area. The path of the spray on the second application shall be at right angles to the path of the spray on the first application. When hand operated sprays are permitted, the equipment supplying the pressure to the spray nozzle shall be capable of supplying constant and uniform pressure to provide uniform and adequate distribution of the curing membrane compound at the rates required. If from any cause, such as rainfall soon after its application, the curing membrane is damaged, the Contractor shall immediately apply another application of curing membrane to the surface of the pavement. The rate of application for the replacement membrane shall be the same as for the original membrane.

Unless otherwise directed by the Engineer, immediately following the application of the curing membrane, an approved shade structure with canvas shall be placed approximately 300mm above the pavement surface. The shade structure with canvas shall be constructed of materials and in a manner approved by the Engineer. In no case shall any portion of the shade canvas come in contact with the pavement. The concrete pavement shall not be exposed to the direct rays of the sun for more than one (1) hour, within the first twenty-four (24) hours. The initial curing shall be continued for a period of twenty-four (24) hours from the time the curing membrane is applied.

When forms are removed, the edges of the pavement shall receive curing membrane at the rate of coverage specified for the pavement surface.

The curing membrane may be applied to the vertical edges of the pavement by means of hand sprays or by nozzles attached to the mechanical distributor, but the edges of the pavement shall be covered with curing membrane at the rate specified within thirty (30) minutes after removal of the forms.

When hot-poured joint compound is used, all joints shall be sawed during the initial curing period. The shade-canvas may be moved at joint locations for short periods of time to permit the sawing. Before being sealed, the joints shall be thoroughly cleaned of all loose saw dust, laitance, dirt, other foreign matter, and free of water. As the method of final curing is different from that of the initial curing, the cleaning, and sealing of joints shall be performed immediately following the removal of the shade-canvas at the end of the initial curing period and prior to the application of the polyethylene sheeting.

In no case shall any portion of the concrete pavement be exposed to the direct rays of the sun for more than one (1) hour.

5.10.2 Final Curing

Following jointing operations, curing membrane shall be applied to the joint area at the rate specified for the pavement surface.

Upon completion of the initial curing period and after the shade canvas has been removed and jointing operation has been completed including application of curing membrane, the pavement shall be completely covered with white opaque polyethylene film as specified in AASHTO M 171. Adjoining sheets shall be lapped a minimum of four hundred and fifty (450) mm. The sheeting shall be held in place in a manner approved by the Engineer.

Final curing shall be continued until the concrete reaches an age of fourteen (14) days. During this period, the curing membrane and polyethylene film shall be protected from damage from any cause. Any damage from any cause shall be immediately repaired by the Contractor at his expense. No traffic, including workmen shall be allowed on the surface of the pavement until the expiration of the fourteen (14) day curing period, or as directed by the Engineer.

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5.11 Sealing Joints

5.11.1 Materials

Joint sealant shall be hot-poured elastic type compound, fuel-resistant complying with ASTM D7116 for PQC airfield pavements and ASTM D6690 for other pavements.

5.11.2 Execution

After the fourteen (14) day curing period for the pavement has elapsed, the jute or other protective covering shall be removed from the joint and the joint thoroughly cleaned of all loose scale, saw dust, dirt, laitance or other matter.

Cleaning may be accomplished with a compressed air jet, air and water under pressure, wire brushes or in extreme cases the joint shall, when directed by the Engineer, be re-sawed to ensure a completely clean joint. The joint surfaces and adjacent areas of the slab shall be thoroughly cleaned and debonding tape placed at the bottom of the joint completely isolating sealant with the substrate.

The hot-poured joint material shall be heated in an approved twin walled heating unit filled with oil as per manufacturer recommendation to the temperature within the range required as shown by tests. The joint shall be filled from the bottom of the saw cut to the surface of the pavement. Any joint with a depth greater than 25 mm shall be filled with a minimum of two (2) layers, each layer being approximately equal in depth. The material shall be poured within the required temperature in the workman like manner neatly so that it should not spread on the sides of the joint and is evenly placed.

5.12 Protection of Pavement

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, or crossovers, etc. The Contractor's plans or special provisions will indicate the location and type of device or facility required to protect the work and provide adequately for traffic. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. In order that the concrete be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor will be required to have available at all time materials for the protection of the edges and surfaces of the unhardened concrete. Such protective materials shall consist of rolled polyethylene sheeting at least 0.1 mm thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin cover the surface of the unhardened concrete with the protective covering.

5.13 Opening to Traffic

The Engineer shall decide when the pavement shall be opened to traffic. The pavement will not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 550lb / Sq.in 550lb / Sq.in (3.792 MPa) when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening to traffic, the pavement shall be cleaned.

5.14 Surface Tolerances

Extreme care must be exercised in all phases of the operation to assure the pavement will pass the specified tolerances. The following tolerances are applicable:

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- i. Lateral deviation from established alignment of the pavement edge shall not exceed plus or minus 30mm in any lane.
- ii. Vertical deviation from established grade shall not exceed $\pm 6\text{mm}$ at any point.
- iii. Surface smoothness deviations shall not exceed 6mm from a 5m straightedge placed in any direction, including placement along and spanning any pavement joint or edge.

5.15 Tolerance in Pavement Thickness

Areas found deficient in thickness by more than 6mm shall be evaluated by the Engineer and, if the deficient areas warrant removal or grinding, they shall be ground or removed and replaced with concrete of the thickness shown on the plans. Ground surface shall be made rough with the beveled approved by the Engineer.

5.16 Embedded Items In Pavements

i. Suitable templates or instructions or both shall be provided for setting out items not placed in the forms. Embedded items and other materials for electrical, mechanical or other operations shall have been completed, inspected tested and approved before concrete is placed.

Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water-tightness fully equal to that of the continuous water-stop material, shall permanently develop mechanical strength not less than that of the parent section, and shall permanently retain their flexibility.

ii. Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than the limits specified as per ICAO requirements.

iii. All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.

All Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

iv. Expansion joint material and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with approved readily removable material to prevent the entry of concrete into the voids.

v. Non-Shrink Grout

Grout of placement under base and bearing plates of steel, machinery and equipment, for grouting anchor bars and dowels and for similar uses shall be as specified. The grout shall be used in accordance with the following and as per manufacturer's recommendations, and as directed by the Engineer.

Concrete surfaces to receive non-shrink grout shall be roughened, cleaned and dampened. Form shall be provided to retain the grout until sufficiently hard to support itself. Grout shall be poured in place and thoroughly rodded or strapped to prevent air entrapment and formation of voids. After non-shrink grout has received its initial set, it shall be kept damp for at least 24 hours.

PART 6-CONCRETE FOR STRUCTURES

Removal of existing damaged pavement, casting of PQC and repair of cracks in existing PQC panels.

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Works under this section of specifications shall be executed as per relevant subsections of these specifications and as per FAA Advisory Circular no. 150/5380-6C. In case of any conflict among the specifications and above-mentioned advisory circular the more stringent one shall be applicable as decided by the Engineer.

The repair works are comprises of partial or complete damaged PQC panels along with the joints including dowels, any underneath pavement structure, if required, backfilling, laying and compaction of pavement layers, provision of vapor barrier with the material and work methodology as specified and/or directed by the Engineer, introduction of required joints with complete details. Repair works also include formation of groove right over the crack, its routing, provision of debonding tape, paneling of joint edges etc.

PART 7-CONCRETE FOR STRUCTURES

7.1 Placing

Before placing of concrete, formwork shall have been completed; water shall have been removed; reinforcement shall have been secured in place; expansion joint material, anchors and other embedded items shall have been kept in position; and the entire preparation shall have been approved.

No concrete shall be placed into the foundation pits and trenches until the ground to receive the same has been examined and approved by the Engineer for this purpose.

Concrete shall be deposited continuously, or in layer of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams, planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located as shown in the Contract Documents or as approved by the Engineer. Placing shall be carried out at such a rate that the concrete, which is being integrated with fresh concrete, is still plastic. Concrete, which has partially hardened, shall not be deposited. Temporary spreaders in forms shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. They may remain embedded in the concrete only if made of metal or concrete and if prior approval has been obtained.

iii. The actual sequence of construction proposed by the Contractor shall be subject to the Engineer's approval before construction starts on any part of the structure, and this sequence shall not be varied without the Engineer's approval.

iv. The concrete shall be placed as soon after it has been mixed as is practicable. Once the concrete has left the mixer, no more water shall be added, although the concrete may be mixed or agitated to help maintain workability. The concrete shall not be used if, through any cause, the workability of the mix at the time of placing is too low for it to be compacted fully and to an acceptable finish by whatever means available.

The time between mixing and placing should be reduced if the mix is richer or the initial workability of the mix is lower than normal, if a rapid hardening cement or an accelerator is used, or if the work is carried out at a high temperature or exposed to a drying atmosphere.

The Contractor shall ensure that the delay between mixing and placing does not exceed 45 minutes under any circumstances. Any concrete, which does not satisfy this requirement, shall be discarded.

v. Concrete shall be deposited as nearly as possible in its final position to avoid re-handling. In no circumstances may concrete be railed or made to flow along the forms by the use of vibrators.

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Concreting shall be carried on as a continuous operation using methods, which shall prevent segregation or loss of ingredients.

vi. The free fall of concrete shall not be allowed to exceed two meter and where it is necessary for the concrete to be placed more than this depth; it shall not be dropped into its final position, but shall be placed through pipes fed by a hopper. When a pipe is used for placing concrete the lower end shall be kept inside, or close to the freshly deposited concrete. The diameter of the pipe shall be not less than 225mm225mm.

vii. Workmen carrying concrete to the site, and all other workmen, shall move only along runways or planks placed for the purpose and no person shall be allowed to walk on the reinforcement.

7.2 Consolidation

i. All concrete shall be consolidated by vibration, spading, rodding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Only competent workmen shall operate vibrators. Use of vibrators to transport within forms shall not be allowed.

Vibrators shall be inserted and withdrawn at points approximately 450mm450mm apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not excessive so as to cause segregation, generally from 5 to 15 sec. A spare Vibrator shall be kept on the job site during all concrete placing operations. Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process, supplemented, if necessary, by spading to work the coarse aggregate back from the formed surface.

ii. If there is any tendency for the mix to segregate during consolidation, particularly if this produces excessive laitance, the mix proportions shall be modified to effect an improvement in the quality of the concrete to the satisfaction of the Engineer and in conformity with the provisions of Clause 5.

iii. Mechanical vibrators shall be of a type approved by the Engineer to suit particular conditions.

iv. Over-vibration or vibration of very wet mixes shall be avoided.

7.3 Curing and Protection

i. Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures and mechanical injury, and shall be maintained with minimum moisture loss at a relative constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval of the Engineer.

ii. For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing, as approved by the Engineer.

a) Ponding or continuous sprinkling.

b) Application of absorptive mats or fabric kept continuously wet.

c) Application of waterproof sheet materials approved by the Engineer.

d) Application of other moisture-retaining covering as approved.

e) Application of a curing compound conforming to ASTM C309.

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The compound shall be applied in accordance with the recommendations of the manufacturer immediately after any water sheet, which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from areas to receive bonded applications.

iii. Moisture loss from surface placed against wooden forms or metal forms, and exposed to heating by the sun, shall be minimized by keeping the forms wet until they can be safely removed. After form removal, the concrete shall be cured until the end of the time prescribed as follows by one of the methods specified above.

iv. Curing in accordance with sub-clauses above shall be continued for at least 10 days in the case of all concrete except concrete with rapid-hardening Portland Cement, for which the period shall be at least 3 days. Alternatively, if tests are made of cubes kept adjacent to the structure and cured by the same methods and to the same intensity, moisture retention measures may be terminated when the average compressive strength has reached 70 percent of the minimum specified works cube strength. If one of the first four curing procedures specified above is used initially, it may be replaced by one of the other specified procedures any time after the concrete is one-day old provided the concrete is not permitted to become surface dry during the transition.

v. When the mean daily outdoor temperature is less than 5°C (41°F), temperature of the concrete shall be maintained between 10 and 20°C (50°F–68°F) for the required curing period specified above.

When necessary, arrangements for heating, covering insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature with measures to avoid concentration of heat. Combustion heaters shall not be used during the first 24 hours, unless precautions are taken to prevent exposure of the concrete to exhaust gasses, which contain carbon dioxide.

When necessary, provision for wind-breaks, shading, spraying, sprinkling, ponding or wet covering with a light colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as concrete hardening and finishing operation will allow.

vi. Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 3°C 5.4°F in any one hour or 10°C 18°F in any 24-hour period.

vii. Concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibrations, during the curing period. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods by application of curing procedures, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to overstress the concrete.

7.4 Works in Extreme Weather

i. Unless adequate protection is provided, and approval is obtained, concrete shall not be placed during rain. Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.

ii. When the temperature of the surrounding air is expected to be below 5°C during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 13°C for sections less than 300mm in any dimensions nor 10°C for any other sections.

iii. When necessary, concrete material should be heated before mixing and carefully protected after placing. In general, heating of mixing water alone to about 60°C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals. No frozen material or concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 25 liters per bag of cement.

If water or aggregate is heated above 38°C, the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 38°C.

iv. During hot weather, the temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or cold joints and should not exceed 32°C. For mass concreting, this temperature should not exceed 21°C. When the temperature of the concrete exceeds 32°C, precautionary measures approved by the Engineer shall be put into effect. When the temperature of the steel is greater than 50°C, steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or ice flakes, or well crushed ice may be substituted for all part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.

Other precautions recommended by ACI Standard 305 shall also be adopted.

7.5 Construction Joints

i. Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be approved by the Engineer.

ii. Joints not shown on the drawings shall be so made and located as to least impair the strength of the structures and shall need prior approval of the Engineer. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset a distance equal to twice the width of the secondary beam. Joints in walls and columns shall be at the underside of floor slabs or beams, and at the top of footings or floor slabs. Beams, brackets, column, capitals, haunches and drop panels shall be placed at the same time as slabs. Joints shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

iii. Reinforcing steel shall continue across the joints. Key and inclined dowels shall be provided as and where directed by Engineer. Longitudinal keys at least 40mm deep shall be provided in all joints in walls and between walls and slabs or footings.

iv. When the work has to be resumed on a surface which has hardened, such surface shall be roughened in an approved manner which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.

v. The hardened concrete of construction joints and of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in unexposed walls and all others not mentioned herein shall be dampened (but not saturated) immediately prior to placing of fresh concrete.

vi. The hardened concrete of joints in exposed work, joints in the middle of beams, and slabs; and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout similar in proportions to the mortar in the concrete. The grout shall

be as thick as possible on vertical surfaces and at least 12mm thick on horizontal surfaces. The fresh concrete shall be placed before the grout has attained initial set.

vii. When the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle, and brushed, care being taken to avoid dislodgement of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 150mm in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.

viii. Stop ends for movement joints or construction joints shall be made by splitting them along the lines of reinforcement passing through them, so that each portion can be positioned and removed separately without disturbance or shock to the reinforcement or the concrete. Stop ends made of expanded metal or similar material may only be left permanently in the concrete with prior written approval of the Engineer. Where such stop ends are used, no metal may be left permanently in the concrete closer to the surface of the concrete than the specified cover to the reinforcement. Wood strips inserted for architectural treatment shall be inserted to permit swelling without pressure on the concrete.

7.6 Expansion Joints

Expansion joints shall be provided wherever indicated on the Drawings or as directed by the Engineer. In no case shall the reinforcement, or other embedded items be run continuous or through an expansion joint. All expansion joints shall be carefully placed so as not to be displaced during concreting. The method of placing the expansion joints shall be strictly in accordance with the Drawings and/or as directed by the Engineer. All materials for use in the expansion joints shall have prior approval of the Engineer before placing order for supply.

7.7 Embedded Items

Sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.

Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.

All embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with approved readily removable material to prevent the entry of concrete into the voids.

PART 8-FINISHING OF FORMED SURFACES

8.1 General

i. After removal of forms, the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Contract Documents.

ii. When finishing is required to match a small sample furnished to the Contractor, the sample finish shall be reproduced on an area at least 10 Sq.m in an inconspicuous location Designated by the Engineer before proceeding with the finish in the specified location.

iii. Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 6. Tolerances for concrete construction defined as 'tolerances', are to be distinguished from irregularities in finish as described herein. The finish requirements for concrete surfaces shall be as generally specified in this clause and as indicated on the Drawings. Finishing of

concrete surfaces shall be performed only by workmen who are skilled in concrete finishes. The Contractor shall keep the Engineer informed as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer. Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the limits herein after specified.

Surface irregularities are classified as abrupt or gradual. Offsets caused by displaced or misplaced form sheathing or lining or sections, or otherwise defective form lumber will be considered as abrupt irregularities and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 2 m for testing of formed surfaces and 3 m for testing of unformed surfaces.

8.2 As-cast Finishes

Unless otherwise specified or indicated on the Drawings the classes of finish shall apply as follows:

8.2.1 Rough Form Finish

No selected form facing materials shall be specified for rough form finish surfaces. The holes and defects shall be patched. Fins exceeding 5 mm in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

8.2.2 Fair Face Finish

Fair face finish applies to concrete formed surfaces, the appearance of which is considered by the Engineer to be of special importance, such as surfaces of structures prominently exposed to public view. Location of surfaces of concrete structures requiring fair face finish are shown in the Drawings. Surface irregularities, measured as described in subsection 4.8.2.1, 'Rough form finish', shall not exceed 5 mm for gradual irregularities and 2.5 mm for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints. Abrupt irregularities at construction joints and elsewhere in excess of 2.5 mm and gradual irregularities in excess of 5 mm shall be reduced by grinding so as to conform to the specified limits. Abrupt irregularities at construction joints shall be ground on 1 to 20 ratio of height to length.

Unless otherwise approved, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. The form facing material shall produce a smooth, hard, uniform texture on the concrete. It may be plywood, hardboard, metal, plastic paper, or other approved material capable of producing the desired fair face finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or similar defects shall not be used.

PART 9-REPAIR OF DEFECTS

9.1 General

i. Any concrete failing to meet the specified strength or not formed as shown on drawings, concrete out of alignment, concrete with surfaces beyond required tolerances or with defective surfaces which cannot be properly repaired or patched in the opinion of the Engineer shall be removed at Contractor's cost.

The Engineer may reject any defective concrete and order it to be cut out in part or in whole and replace at the Contractor's expense.

ii. All ties, bolt holes, and all repairable defective areas shall be patched immediately after form removal.

9.2 Repair of Defective Areas

i. Defective and honeycombed concrete shall be removed down to sound concrete. The area to be patched and an area at least 150mm150mm wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately 1-part cement to 1-part fine sand passing No.25 BS Sieve and shall then be well brushed into the surface.

ii. The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not less than 1-part cement to 2-1/22-1/2 parts sand by weight. White Portland cement shall be substituted for a part of the gray Portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch.

iii. The quantity of mixing water shall be no more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

iv. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface to permit initial shrinkage; it shall be left undisturbed for at least 1 hour before being finally finished. The patched area shall be kept damp for at least 7 days. Metal tools shall not be used in finishing a patch in a formed wall, which will be exposed.

v. Where as-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast surfaces shall not exceed 0.2 Sq.m in each 100 Sq.m of as-cast surface. This is in addition to form tie patches, if the project design permits ties to fall within as-cast areas.

vi. Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good color match with the concrete when both patch and concrete are cured and dry. After initial set, surfaces of patches shall be dressed manually to obtain the same texture as surrounding surfaces.

vii. Patches in architectural concrete surfaces shall be cured for at least 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

9.3 Tie and Bolt Holes

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar. If architectural appearance requires, these holes may be filled partially creating the desired round clear holes' pattern on surfaces exposed to view.

9.4 Proprietary Materials

If permitted or required by the Engineer, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations with prior approval of the Engineer.

PART 10-CONCRETE CONSTRUCTION TOLERANCES

All tolerances shall be as per ACI 117.

Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, maximum permissible deviations from established lines, grades, and dimensions shall conform to the following. The Contractor is expected to set and maintain concrete forms so as to ensure complete work within tolerance limits. These allowable tolerances shall not relieve the Contractor of his responsibility for correct fitting of indicated materials and components. These tolerances are not cumulative.

10.1 Allowable Variation from the Plumb (or the specified batter for inclined walls)

- i. In the lines and surfaces of columns and walls, and in rises in any 3 m of length or height: 6 mm Maximum for the entire length or height: 25 mm
- ii. For exposed corner columns, control joint grooves and other conspicuous lines in any bay or 6 m maximum: 6 mm Maximum for the entire length or height: 13 mm

10.2 Variation from the level or from the Grades indicated on the drawings.

In beam soffits, and in rises measured before removal of supporting shores. In any 3 m of length: 6 mm in any bay or in any 6 m maximum: 10 mm Maximum for the entire length: 19 mm

10.3 Variation of the linear structure lines from established position in plan and related position of columns & walls.

In any bay or 6 meters: ± 13 mm Maximum for the entire length: ± 25 mm

10.4 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs & walls.

Up to 300mm: -6 mm +10 mm More than 300mm: -10 mm +13 mm

10.5 Footings

10.5.1 Variation in Dimensions in Plan

Minus (minus variation applied to concrete only, not to the reinforcing bars or dowels) (formed)

10.5.2 Misplacement or Eccentricity

2 percent of the footing width in the direction of misplacement but not more than (applies to concrete only, not to reinforcing bars or dowels). +50mm

10.5.3 Reduction in Thickness

Minus 5 percent of specified thickness.

PART 11-ACCEPTANCE OF STRUCTURE

11.1 General

- i. Completed concrete work, which meets all applicable requirements will be accepted subject to the other terms of the Contract Documents.

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ii. Completed concrete work, which fails to meet one or more of the requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the Contract Documents.

iii. Completed concrete work, which fails to meet one or more of the requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the Contract Documents. In this event, modifications may be required to assure that remaining work complies with the requirements.

11.2-Dimensional Tolerances

i. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of sub section 4.10 shall be considered potentially deficient in strength and subject to the provisions of sub section 4.11.4.

ii. Formed surfaces resulting in concrete outlines larger than permitted by the tolerances of sub section 4.10 may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to be removed in accordance with this clause.

iii. Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected as decided by the Engineer or if misplaced items interfere with other construction.

iv. Inaccurately formed concrete surfaces exceeding the limits of sub section 4.10 or as mentioned in the relevant Section of 'Formwork' shall be removed and replaced, and those that are exposed to view, may be rejected, or shall be repaired, or removed and replaced, as directed by the Engineer.

11.3 Appearance

Architectural concrete with surface defects exceeding the limitations described in relevant Clauses of this section shall be removed and replaced. Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods. Concrete not exposed to view is not subject to rejection for reason of defective appearance.

11.4 Strength of Structure

i. Strength of the structure in place will be considered potentially deficient if it fails to comply with any requirement which is relevant to the strength of the structure, including but not necessarily limited to the following conditions:

a) Concrete strength requirements not considered to be satisfied in accordance.

b) Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements as specified under section 'Reinforcement' or in the Contract Documents.

c) Concrete, which differs from the required dimensions or location in such a manner as to reduce the strength.

d) Curing less than that specified.

e) Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.

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- f) Mechanical injury, construction fires, premature removal of formwork, likely to result in deficient strength.
- g) Poor workmanship likely to result in deficient strength.
- ii. Structural computations and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- iii. Core tests may be required when the strength of the concrete in place is considered deficient.
- iv. If core tests are inconclusive or impractical to obtain or if structural computations do not confirm the safety of the structure, load tests may be required and their results evaluated, in accordance with ACI Standard 318.
- v. Concrete work judged inadequate by structural computations or by results of a load test shall be reinforced with additional construction, if so directed by the Engineer or shall be replaced, at the Contractor's expense.
- vi. The Contractor shall bear all costs incurred in providing the additional testing and/or computations required by this section.

12. MEASUREMENT AND PAYMENT

12.1 General

Except otherwise specified herein or elsewhere in the Contract Documents, no measurement and payment will be made for the under mentioned specified works related to the relevant items of the Bill of Quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

- i. All types of formwork.
- ii. All types of expansion, construction and contraction joints in pavement quality concrete (PQC) works including joint fillers, sealant, caps, grease, reinforcement in odd shaped panels, dowel bars and its fixing with epoxy grouts, tie bars etc.
- iii. All types of expansion, construction, contraction joints in building works including joint assemblies, joint fillers, joint sealants.
- iv. All sampling, mixing and testing as specified.
- v. Concrete mix design.
- vi. Vapour barrier (geotextile fabric) and debonding tape or mechanical insertions.
- vii. Impervious sheeting, burlap covering, liquid membranes compound, additives, non-shrink grout, epoxy resins and water stops.
- viii. Anchor bolts for temporary structures and other embedded parts.
- ix. All submittals including shop drawings, co-ordination drawings etc.
- x. Repair and replacement of defective work.
- xi. Surface texture, skid resistant surfaces & surface test.
- xii. Curing
- xiii. Installation/fixing in position of all precast / prefabricated concrete elements, as shown on drawings.
- xiv. Panel Numbering of each panel of pavement quality concrete.
- xv. Thickness covers in PQC if required to ascertain deficiencies in elevation and PQC.
- xvi. Wastage of materials.
- xvii. Beveling of edges formed after saw cutting.

12.2 Plain and Reinforced Concrete

12.2.1 Measurement

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Measurement of acceptably completed works of plain, reinforced concrete and PQC will be made on the basis of number of Cu.m of concrete actually provided, placed, consolidated, finished, cured in position, complete as shown on drawings or as specified/directed.

12.2.2 Payment

Payment will be made for the acceptable measured quantity of plain, reinforced concrete and PQC on the basis of unit rate per Cu.m quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.3 Prefabricated Concrete Spiral Stair

12.3.1 Measurement

Measurement of acceptably Completed Work of Prefabricated Concrete spiral stair will be made on the basis of actual number of prefabricated concrete spiral stair provided installed & fixed in position as complete unit as shown on drawings or as directed by the Engineer.

12.3.2 Payment

Payment will be made for the acceptable measured quantity of prefabricated concrete spiral stair on the basis of unit rate per number quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.4 Gate Valve Chamber, Air Release Valve Chamber & Washout Valve Chamber

12.4.1 Measurement

Measurement of acceptably Completed Work of Gate Valve Chamber, Air Release Valve Chamber & Washout Valve Chamber of specified size including earthwork, stone soling, PCC/ RCC, steel reinforcement bars, ladder rugs, bitumen coating, CI cover with frame etc will be made on the basis of actual number of Gate Valve Chamber, Air Release Valve Chamber & Washout Valve Chamber provided installed & fixed in position as complete unit as shown on drawings or as directed by the Engineer.

12.4.2 Payment

Payment will be made for the acceptable measured quantity of Gate Valve Chamber, Air Release Valve Chamber & Washout Valve Chamber on the basis of unit rate per number quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.5 Fire Hydrant Chamber

12.5.1 Measurement

Measurement of acceptably Completed Work of Fire hydrant chamber above ground "Air side apron area" of specified size including earthwork, stone soling, PCC/ RCC, steel reinforcement bars, ladder rugs, bitumen coating, DI/CI cover with frame etc provided installed & fixed in position as complete unit as shown on drawings or as directed by the Engineer.

12.5.2 Payment

Payment will be made for the acceptable measured quantity of G Fire hydrant chamber on the basis of unit rate per number quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.6 Cement Concrete Manhole

12.6.1 Measurement

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Measurement of acceptably Completed Work of cement concrete manhole including earthwork, stone soling, PCC/ RCC, steel reinforcement bars, ladder rugs, bitumen coating, D400 CI/DI manhole cover with frame etc complete unit as shown on drawings or as directed by the Engineer.

12.6.2 Payment

Payment will be made for the acceptable measured quantity of G Fire hydrant chamber on the basis of unit rate per number quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.7 Precast Fair Faced Concrete / Finishing Elements

12.7.1 Measurement

Measurement of acceptably completed works of Precast fair faced Concrete will be made on the basis of number of Cu.m of concrete actually provided, placed, consolidated, finished, cured in position, complete as shown on drawings or as directed.

12.7.2 Payment

Payment will be made for the acceptable measured quantity of Precast fair faced Concrete on the basis of unit rate per Cu.m quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.8 Cement Concrete (Plinth Protection)

12.8.1 Measurement

Measurement of acceptably completed works of cement concrete in (Plinth Protection) including bitumen seal with rubberized material will be made on the basis of actual volume in cubic meter of concrete actually provided and placed in position as shown on drawings or as directed by the Engineer.

12.8.2 Payment

Payment will be made for the acceptable measured quantity of specified cement concrete on the basis of unit rate per cubic meter quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

12.9 Pavement Quality Concrete (PQC)

12.9.1 Measurement

Measurement of acceptably completed works of PQC laid after dismantling of existing PQC Panels will be made on the basis of number of Cu.m of concrete actually provided, placed, consolidated, finished, cured in position, complete as shown on drawings or as specified / directed.

12.9.2 Payment

Payment will be made for the acceptable completed works of PQC panels on the basis of unit rate per Cu.m quoted in the BoQ and shall constitute full compensation for all the works related to the item.

12.10 Repair of Cracks in PQC Panels

12.10.1 Measurement

Measurement of acceptably completed works of repair of cracks in PQC panels will be made on the basis of length of cracks in meter, complete as shown on drawings or as specified / directed.

12.10.2 Payment

Payment will be made for the acceptable completed works of repair of cracks in PQC panels on the basis of length of cracks in meter quoted in the BoQ and shall constitute full compensation for all the works related to the item.

SECTION 0160 – STRUCTURAL STEEL WORK

1 SCOPE

The work under this section of the Specifications consists of furnishing all material, labour, plant, equipment and appliances, fabricating, erecting, installing, testing, painting and all other items incidental to Structural steel work for a complete job as shown on the drawings, specified herein and/or as directed by the Engineer.

2.0 APPLICABLE CODES AND STANDARDS

Latest edition of the following codes and standards are applicable to the work of this section:

- AISC, 1969 Specifications for the design, fabrication and erection of structural steel for buildings.
- ANSI / AISC 360 Specification for Structural Steel Buildings.
- AISC 303 Code of Standard Practice, for Steel Buildings and Bridges.
- AISC Specifications for structural joints using ASTM A325 or A490 bolts.
- AISC & SSPC Guide to shop painting of Structural Steel.
- ASTM A6 Standard specifications for general requirements for rolled structural steel bars, plates, shapes and sheet piling.
- ASTM A36 Standard Specification for Carbon Structural Steel.
- ASTM A53 Standard Specification for Pipe, Steel, Black & Hot Dipped, Zinc Coated, Welded and Seamless Steel Pipes.
- ASTM A307 Standard Specification for Carbon steel bolts and studs and threaded bolts 60000 PSI tensile strength.
- ASTM A325 Standard Specification for Structural bolts, Steel, Heat treated withdrawn and replace by ASTM F3125. 120/105 ksi minimum tensile strength.
- ASTM A653 Specifications for steel sheet zinc coated (galvanized) or zinc iron alloy coated galvanized by the hot dipped process, alloyed coating.
- ASTM A490 Standard Specification for Structural Heavy Hex bolts, alloy steel, heat treated, 150 ksi minimum tensile strength with Type 1 and Type 3 weathering steel bolting class.
- ASTM A354 Standard Specification for quenched and tempered alloy steel bolts, studs and other externally threaded fasteners.
- ASTM A501 / ASME SA501 Standard Specification for Hot formed welded and seamless carbon steel structural tubing.
- ANSI / NAAMM Metal Bar Grating MBG 531
- ASTM A563-07 Standard Specification for Carbon and alloy steel nuts.

3.0 MATERIALS

3.1 Washers

Washers shall conform to the requirements of ANSI B18.22.1 and shall be of structural grade steel appropriate for the type of bolts for which they are used. For oversized holes, the washers shall be large enough to cover the entire hole by at least 6mm or as directed by the Engineer.

3.2 Studs

Steel Studs / Shear Connectors shall conform to the requirements of Structural Welding Code – Steel, AWS D1.1.

3.6 Paints

3.6.1 All material shall be acceptable, proven first grade products and shall meet or exceed the minimum standards of specified manufacturers like Jotun, SIPCO, PATSA and ICI paints. During painting works an approved Quality Control inspector or a technical representative shall be provided by the manufacturer to oversee the painting and coating application. The Quality Control Inspector shall be liable to confirm in writing to the Engineer of the correct use of their product and the DFT by approved Thickness Gauge Meter, on job site as per Specification.

3.6.2 Anti-corrosive Surface tolerant epoxy primer by JOTUN or approved equivalent.

3.7 Copper Slag Abrasive

Copper Slag abrasive or grit or approved equivalent.

4.0 CONNECTIONS

All connections shall be designed and detailed for 75% of the effective capacity of the member. A minimum of two bolts or equivalent welding shall be used per connection. Shop connection may be welded or bolted. Field connections shall be bolted unless noted otherwise on design drawings or approved by the Engineer.

5.0 ALLOWABLE STRESSES

Allowable design stresses for structural steel members and their connections, including temporary bracings and shoring shall be in accordance with AISC Specifications.

6.0 SHOP DRAWINGS

6.1 Shop drawings shall be submitted by the Contractor, for structural steel works, for acceptance in accordance with the requirements or the Contract Documents.

6.2 Shop drawings furnished for this section shall conform to the best standards of the construction industry. Shop drawings shall be prepared by and under the supervision of competent engineering personnel. Prior to submittal, the Contractor shall check each shop drawing for compliance with the requirements of the Contract Documents.

6.3 Shop drawings shall include plans, elevations, sections and complete details to describe clearly, at an ample scale, all work to be provided. Drawings shall be accurately dimensioned and shall be noted clearly.

6.4 All connections shall be designed and detailed, per sub-section 4 above, by the Contractor on the shop drawings. Design calculations for connections shall be made as per AISC specifications and shall be submitted along with the shop drawings after checking and signing by the Contractor for approval.

6.5 The shop drawings shall include:

(i) **An erection scheme**, in suitable size, having the following information:

- Location of erection elements in respect of axis and Marks as well as picking points of these elements with respect to each other or with the existing steel or reinforced concrete structures.
- Joints showing erection welding sizes and lengths, bolts diameter and numbers.

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- Chart showing list of assembling marks having columns such as Mark, Description, Quantity, Weight of each Mark, total weight and Remarks with grand total in the end.
- Chart showing List of Erection Bolts, Nuts and Washers in tabulated form, detailing information such as size, quantity, weight and their grand totals.
- Quality of materials.
- Quality and type of welding electrodes.
- Measures to be adopted against unscrewing of bolts.
- Painting instructions.
- Erection sequence.
- References to relevant drawings.
- Except in special cases all scheme drawings shall be made in single fairly thick lines.
- The recommended scale of erection scheme is 1:50, 1:100, 1:200, for joints 1:5, 1:10 or 1:20.

(ii) **Fabrication drawings** in suitable size shall contain the following information:

- Each Shop Assembly (Mark) shall be drawn separately showing necessary lines, elevations, sections with reference to axis, center lines, location of holes, cleats, plates, lugs etc. fully dimensioned with part numbers.
- Bolts and holes sizes.
- Welding symbols and welded joints requirements, in accordance with AISC manual of steel construction and AWS specifications.
- Geometrical Setting out dimensions necessary for the assembly of an element. Location and details of joints as calculated by the Contractor.
- Instruction for welding, dimensions of weld, edge preparations methods of welding, and methods for control of distortions.
- List of symbols for bolts and holes used.
- List of symbols for welds used.
- Edge distance (general).
- Welding sizes and lengths (general).
- Standards and quality of materials.
- Type and quality of welding electrodes.
- Tests for welding.
- Reference to related erection scheme drawings.
- Reference to design and working drawings.
- Parts list.
- Instructions for surface preparation, painting, primer and finish coats.

- Recommended scales for fabrication drawings are preferably 1:10 or 1:20, and for joints and details 1:1, 1:2, or 1:5.

7.0 FABRICATION

The Contractor shall notify the Engineer about any problems or doubts/errors, if any, in the drawings for clarifications/rectification well in time to prevent any fabrication errors. Fabrication shall not be commenced until approval has been obtained from the Engineer.

7.1 Straightening of Material

Rolled material, before being worked upon shall be straightened within tolerances as per ASTM specifications A6. Straightening necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 1200°F (650°C).

7.2 Cutting

As far as practicable cutting shall be done by shearing. Oxygen cutting shall be done where shear cutting is not practicable and shall preferably be done by Machine. All edges shall be free from notches or burs. If necessary, the same shall be removed by grinding.

7.3 Holes Punching/Drilling

Holes shall be punched where thickness of the material is not greater than the diameter of bolt + 3mm. Where thickness of the material is greater, the holes shall either be drilled or sub-punched and reamed to size. Die for all sub-punched holes and drill for all sub-drilled holes shall be at least 2mm smaller than the nominal diameter of the rivet or bolt.

7.4 Welding

7.4.1 All execution and inspection of welding shall be done in accordance with the provisions of the American Welding Society Specifications. No welding for piping/electrical supports shall be made transversely to any tension flanges or beams or columns.

7.4.2 Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications, or as mentioned on drawing.

7.4.3 Surface to be welded shall be free from loose scale, slag, rust, grease, paint or any other foreign matter.

7.4.4 Butt welds shall be full penetration welds, unless otherwise specified and permitted.

7.4.5 Avoid the use of temporary welded attachments during fabrication as much as possible. After fabrication is completed, remove the weld with the base material without encroaching on the minimum required base material thickness. After the surface has been restored.

7.4.6 Do not begin structural welding until joint elements are tacked in intimate contact and adjusted to dimensions shown with allowance for any weld shrinkage that is expected. Weld heavy sections and those having a high degree of restraint with low hydrogen type electrodes. No member shall be spliced without approval.

7.4.7 For notch-toughness specified material, all weld metal, processes and preheat requirements shall be compatible to assure notch-tough composite weld metal.

7.4.8 Shop splices of webs and flanges in built-up girder shall be made before the webs and flanges are joined to each other.

7.5 Tolerances

Tolerances for Structural Steel shall be as per AISC Specifications unless noted otherwise.

8.0 WELDER QUALIFICATIONS

8.1 All welders contracted to perform work shall be required to show written evidence that they have been properly tested in compliance with the approved welding procedures.

8.2 Welders shall have been qualified in the proposed procedure by an established laboratory acceptable to the Engineer within the preceding 90 days.

8.3 All welders shall be qualified for the type of weldment, grade of steel, thickness of steel, welding process and welding position that they are employed to weld. Welders and welding operators that have not been performance qualified, for all material and thickness ranges used on the job, shall be restricted to welding only that portion of the work for which they are qualified.

8.4 Engineer reserves the right to have welders or welding operators prequalified or removed from the job as he deems necessary during the progress of work. Engineer's decision regarding the qualifications of any welder shall be final.

9.0 WELDERS IDENTIFICATION

9.1 Each welder shall be assigned a unique identifying number or symbol that he shall use to identify all welding resulting from his skills.

9.2 Stenciled markings shall be applied within 40mm of the weld using low stress concentration dies. Written symbols are also acceptable.

9.3 A record shall be kept of these symbols by the Contractor. The records shall show welder's name, symbol assigned, procedures to which qualified, employment and test dates. This record shall always be available to the Engineer's Representative.

10.0 TEST ASSEMBLY

10.1 Fabricated components such as Beams, Girders, Bracing, as and where required by planning, shall be test assembled in the shop prior to transportation to site. Test assembly work and procedure should be planned during fabrication process. Each test assembly shall be got inspected from the Engineer's Representative and shall be dismantled only after his approval in writing.

11.0 SURFACE PREPARATION / PAINTING

11.1 Surface Preparation

These Specifications shall govern the procedures and materials required for surface preparation and coating of the specified structures. All fabrication and assembly of a particular section shall be completed before surface preparation begins. All blast cleaning on metal surface should be carried out by Copper Slag abrasive and grit should not be recycled to avoid contamination of surface in accordance with the SSPC specification required for that particular area. Blasting anchor profiles shall be consistent with manufacturer's recommendations. All blasting should be scheduled in a manner which enables paint to be applied in accordance with the manufacturer's recommendations and on the same day as blasting occurs. All welded area and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatters, slivers, laminations and under laying mill scale exposed during blasting shall be removed or repaired. Bolt holes shall be drilled and de-burred prior to blasting. Sharp edges shall be ground or filed to provide a visible radius. The abrasives used for blasting will be sized to give the specified anchor profile as determined by this specification. A mesh size will be used as prescribed for thickness of paint to be applied. The maximum particle size shall be no larger than that passing a 16 mesh screen. No acid washes or other cleaning solutions or solvents may be used on metal surfaces after being blasted. This includes any inhibitive washes intended to prevent rusting. All oil and/or grease contamination shall be removed by water based degreaser before starting to blast like glo-flo heavy duty degreaser or

equivalent. No intermediate or finish coating shall be applied prior to fabrication without prior approval from Engineer. Blasting shall be done in an area removed from painting operations and freshly coated surfaces to prevent contamination. Contaminated coatings shall be re-blasted by Contractor to bare metal and reapplied. After blasting Contractor shall thoroughly clean all blast grit and dust from both internal and external surfaces, including removal from crevices, recesses etc.

11.2 Coating Application

Coating application will be done according to paint manufacturer's recommendations included with the materials and will be subject to inspection by Engineer. The blast-cleaned surfaces shall be coated with primer during the same day as blasted and at least one hour prior to sundown of the day, and also before any rusting occurs. A minimum of 150mm (6 inches) around edges of sand blasted area will be left un-primed unless adjoining a coated surface. Any steel/metal that is not primed and is wet by rain or moisture shall be re-blasted prior to application of primer. All coating shall be allowed to dry thoroughly, but not less than the manufacturer's specified time, prior to application of a succeeding coat. The surface shall be clean. All coating materials furnished by Contractor shall be furnished in unopened, clearly identifiable containers. Mixing of different coatings shall not be permitted. Containers shall remain closed until required for use. No paint shall be used that has expired its shelf life. All coating film thickness shall be as specified and shall be checked by the Engineer or his Representative. Damage to intermediate coats, prior to application of the next coat, shall be repaired by Contractor to provide the coating sequence and film thickness as specified. After the prime coat has been applied, all hard-to-spray areas such as corners, edges and welds, may be brush painted with the same paint and film thickness. The finished job shall not contain sags, runs, wrinkles, spots, blister or other application flaws. Holidays in the final coat at edges, corners, welds and inaccessible areas may be protected by spraying or hand brushing an additional layer of topcoat provided excessive build up does not occur. All components shall be thoroughly stirred before, during and after mixing. The mixed coatings shall be continuously stirred by mechanical spray pot agitators or other approved means. The volume to be mixed shall be accurately measured. All mixing shall be done in clean containers, free from traces of grease, other type paints, or other contaminants. All containers shall be kept covered to prevent contamination by dust, dirt or rain.

11.3 Repair of Damaged Area (Touch-Up)

All external surfaces where coating is damaged during fabrication, transportation and erection shall be repaired as follows: Top coat damaged, but base coat undamaged, will be repaired by removing damaged coating with sand paper or other means acceptable to the Engineer (wire brushing will not be acceptable) and applying top coat as specified. Coating damaged to base metal where blasting is not approved shall be mechanically cleaned as specified in other Section and applying a three coats system as specified in relevant sections. Care will be taken to avoid damaging the coatings surrounding repaired areas and to assure complete tie-in of the coating with surrounding areas. Remove damaged areas by spot blast and feather into surrounding coating with sandpaper. Clean all loose materials from surface. Contractor shall repair the coating on all damaged areas prior to final acceptance of the Engineer.

11.4 Galvanizing (Zinc Coating)

Galvanizing, wherever specified, shall be applied in a manner and of a thickness and quality conforming to the requirements of ASTM A123 standard specifications for zinc (Hot dipped galvanized) coating on products fabricated from rolled, pressed and forged steel shapes, plates, parts and strips. Components shall be galvanized i.e. zinc coated after complete fabrication i.e. welding, drilling etc. the process shall consist of removal of rust and mill scale by pickling in hydrochloric acid or sulphuric acid followed by water wash and prefluxing in tanks containing zinc

ammonium chloride and then fluxing with ammonium chloride. The fluxed components shall then be passed through a drying oven prior to immersion in a bath of virtually pure molten zinc.

12.0 PAINT AND COATING SYSTEMS FOR STEEL GATE AND STEEL METAL WORKS

The paints and coating systems have been specified hereunder for steel/metal works like pipe support, angle iron support in trenches, manufactured by Jotun paint or approved equivalent as approved by the Engineer and all such surfaces as shown on the Drawings and/or as directed by the Engineer. All paint applications to be carried out by airless spray.

12.1 Exterior Paint System for Steel Structures

12.1.1 Surface Preparation

Abrasive blasting to Near White with copper slag in accordance with SSPC-SP10 and SSPC-AB1 to provide 40 to 60 microns anchor profile.

12.1.2 Paint System

- **Primer:** Surface tolerant epoxy mastic to be applied at 70 microns DFT.
- **Intermediate Coats:** Surface tolerant epoxy mastic paint to be applied in two layers, each layer of thickness 100 microns DFT of approved color. (JOTAMASTIC 87 or approved equivalent).
- **Final Coat (Topcoat):** Two components polyurethane enamel of 60 microns DFT of approved color (HARDTOP XP AS or approved equivalent) to applied as topcoat.

13.0 INSPECTION AND TESTS

13.1 Manufacturer's Test Certificate for all material used shall be furnished by the Contractor for Engineer's scrutiny and approval.

13.2 Rolling tolerance of all shapes and profile according to AISC shall be in accordance with the provisions of ASTM A6 specifications. These shall be checked by the Contractor before commencing work and shall be rejected if found not within limits.

13.3 Materials shall be tested for conformance with the specified standards at an approved testing laboratory as and when directed by the Engineer.

13.4 Contact surfaces of connections using high strength bolts in friction type connections shall be got inspected and approved from the Engineer before bolting.

13.5 All bolted connections shall be got inspected and approved from the Engineer for types, size, number of bolts and installation including tightening.

13.6 Inspection and Testing - Welding

13.6.1 General

Welding shall be inspected and tested by an approved testing laboratory during fabrication and erection of structural steel as follows: The testing laboratory shall be responsible for conducting and interpreting the tests. It shall state in each report whether or not the test specimens conform to all requirements of the Contract Document and shall specifically note any deviations therefrom. Certify all welders and make 100 percent visual inspections and tests as follows: Record types and defects found in the welding work. The measures required and performed to correct such defects. In addition to the requirements of AWS D 1.1, paragraph 8.15, each weld shall be visually free of slag, inclusions and porosity. In addition to visual inspection of all welds, magnetic particle, ultrasonic and radiographic inspection shall be made of all welds as specified below. Magnetic particle tests shall be made on the root pass and finished weld. The method of magnetic particle

test shall be in accordance with ASTM E109. Any type of crack or zone of incomplete fusion or penetration shall not be acceptable. Radiographic testing technique and standards of acceptance shall be in accordance with AWS D 1.1. Ultrasonic testing shall be performed in accordance with AWS D 1.1. Welding inspection and test report showing evidence of the quality of welding shall be submitted by the Contractor. For each section of weld inspected and tested, furnish a report which clearly identifies the work, the welder's identification, the areas of inspections and test, the acceptability of the welds, and signature of the inspector or laboratory incharge. Each report shall be completed at the time of inspection or test. For radiographic examination, furnish a complete set of radiographs in addition to the reports. All inspection and testing shall be carried out in presence of the Engineer or his representative.

13.6.2 Test Methods

Use the following test methods as specified and as per instructions of the Engineer. The following list is in descending order. When a particular test method is specified for a joint and the method is impractical to use, use the next highest method practicable as per instructions of the Engineer. The alternative method will be subject to approval, NDT procedures and techniques shall be in accordance with AWS D 1.1, section 6.7.

- a) Radiographic Method: In addition to the requirements of AWS D 1.1, comply with ASTM E94.
- b) Ultrasonic method.
- c) Magnetic particle method.
- d) Liquid Penetration Method: Visible-dye, solvent removable method only.

13.6.3 Members Designated for Tests

a) **Built-up Members:** Examine 100 percent of flange-to-flange and web-to-web welding by the radiographic method. For all web-to-flange and pipe column seam welding, examine ten percent of each welder's work as follows: Full penetration groove welds by the ultrasonic. Fillet welds and partial penetration groove welds by the magnetic particle method.

b) **Moment Connection Joints:** Examine 100 percent of all flange-to-flange and web-to-web welding as follows: Full penetration groove welds by the ultrasonic method or other method as designated by the Engineer. Fillet welds and partial penetration groove welds by the magnetic particle method. For all web-to-flange welding, examine ten percent of each welder's work as follows: Full penetration groove welds by the ultrasonic method or radiographic method as approved by the Engineer. Fillet welds and partial penetration groove welds by the magnetic particle method.

c) **Column Base Plates:** Examine 100% of all welding for connection of base plate to column.

d) **Bracing Connections:** Examine 100 percent of all welding for connection of diagonal bracing as follows: Groove welds by the ultrasonic method. Fillet welds by the magnetic particle method.

13.6.4 Requirement for ten percent Examination

a) Examine a 300mm section of weld in each 3m increment of each welder's work as directed by the Engineer. If the examination meets the acceptance standards of AWS D 1.1, the 3m of weld represented will be accepted.

b) If the examination fails to meet the acceptance standards, examine two additional 300mm sections in the 3m increment as directed by the Engineer. If both of these examinations meet the acceptance standard, the 3m of weld represented will be accepted. Repair the defects detected in the first examination and re-examine.

c) If one or both of the examinations fails to meet the acceptance standards, examine the remaining weld of the 3m increment. Repair the areas that do not meet the acceptance standards and re-examine.

13.6.5 Repair and Re-Testing of Welds

Repair defective welds in accordance with AWS D 1.1, or replace the weld, and re-test repaired and replaced welds by the same method and acceptance standard used to examine the original weld. In addition, when defective welds are found, the testing laboratory shall determine the cause of the defective welding and institute immediate corrective action. All defective welding shall be repaired or replaced at the Contractor's expense.

13.7 Rejection

Neither the fact that the materials have been tested nor that the manufacturers test certificates have been furnished shall affect the liberty of the Engineer to reject material found not according to these specifications. Materials or workmanship not in conformance with the provisions of these specifications shall be rejected at any time, after delivery or during the progress of the work or the completion and erection at site.

14.0 ERECTION

14.1 Bracing

All steel structures shall be carried up true and plumb within the limits defined in the AISC code of standard practice and temporary bracing shall be introduced wherever necessary to take care of all construction loads to which the structure may be subjected including the equipment and the operation of the same. Such bracing shall be left in place as long as required for safety. Wherever piles of materials, erection equipment and other loads are carried during erection, proper provision shall be made by the Contractor to take care of the stresses resulting from such loads.

14.2 Alignment

No permanent bolting or welding shall be done at site during erection until as much of the structure as will be stiffened thereby has been properly aligned and approved by the Engineer.

14.3 Joints Using High Strength Bolts

All structural joints using high strength bolts shall be executed and inspected in accordance with "AISC Specification for structural joints using ASTM A325 or A490 bolts". High strength bolts and nuts, loosened after tightening, shall be discarded and replaced with unused bolts and nuts.

PART 15 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0170 - STAINLESS STEEL WORK

1. SCOPE

The requirement of this section is to apply to all stainless-steel work which forms a part of the basic design and finish of the project. Certain major items are specified under other sections of these Specifications, in which case applicable portions of this section are included by reference.

Applicable portions of other sections of these Specifications are hereby included by reference to establish minimum quality standards and shall become a part of this section as if written out in full herein.

The work covered by this section of Specifications consists of supply of all material, labour, plant, equipment and appliances including cladding, welding, bolts, nuts, washers, anchor bolts, embedded parts etc, fabrication and erection in accordance with the specifications and as per drawings and as directed by the Engineer.

2. TECHNICAL REQUIREMENTS

A. General

- a) Provide units composed of brake formed shapes with visible portions of profile matching detail indicated on the drawings, and free from additional slots, grooves, fins or other.
- b) Fabricate and assemble all work in the shop wherever possible and otherwise pre-fit as required to reduce field fabrication to a minimum.

B. Design

Design anchors to allow for horizontal and vertical expansion. Screws, nuts, washers, bolts and reinforcement shall be aluminum, and of adequate strength for the proposed use.

C. Appearance

- a) Fit member neatly and to hairline accuracy with profile extending into joints without additional trim. Match flush joints to form perfectly smooth plane; match offset joints to hairline butt fit to flat surface beyond point of tangency of corner radius. Units using extra trim to conceal misalignment will not be acceptable.
- b) Make all connections by means of concealed fasteners; exposed fasteners will be permitted where essential. Use countersunk flat head machine screws for exposed fasteners as approved by the Engineer.
- c) Where additional strength of section is required to meet structural requirements, provide additional wall thickness or stiffeners inside the extrusion. Width of face (sight line) dimensions indicated on the drawings is maximum permissible exposed surfaces.
- d) Manufacturer's standard sections will be acceptable only when such extrusions are substantially in accordance with the profiles indicated on the drawings as accepted by the Supervising Engineer.

3. SUBMITTALS

A. Samples

Submit the following samples of materials and assemblies specified herein:

- a) Preliminary Approval Samples: All finishes.
- b) Product Samples: Hardware.
- c) Range Samples: All finishes.

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d) Test Samples: Upon request.

B. Shop Drawings

a) Project Shop Drawings: All fabricated materials.

4. SAMPLES

A. Samples

Before any work is performed, the following samples shall be submitted:

a) Representative samples of appropriate size of all stainless steel included in this work, to show final finished appearance.

b) Representative samples of welded connections, mired joint, and butt weld and typical brake form and bend for bar sheet stock to show final finished appearance.

c) Representative samples of proposed mechanically fastened connections to show final assembled appearance.

B. All samples shall be labeled to show material finish, thickness and specific use and location on work.

C. For project reference, one set of record samples will be retained by the Supervising Engineer, and kept available at the job site and one returned to the Contractor.

5. SHOP DRAWINGS

Submit shop drawings in accordance with Conditions of Contract. Coordinate shop drawings with material description to show location and extent of various finishes.

6. MAINTENANCE INSTRUCTIONS

Prepare and deliver to the Supervising Engineer a complete maintenance manual.

Such documents are an integral part of the requirements of these Specifications and require close cooperation between the basic metal manufacturer, the fabricator and the finisher.

Maintenance information shall include specific instructions for:

Routine cleaning instructions with recommendations for materials and schedule applicable to locality and exposure.

Recommendations for major cleaning as required to maintain appearance.

7. MATERIALS

A. Stainless Steel

a) Materials not otherwise specified, in accordance with requirements of "Structural Steel Work".

b) All Bar Stock including Shapes: Cold drawn AISI Type 1018 steel.

c) Stainless Steel: ASTM A167 Type 302. Other 300 series stainless steels will be acceptable where required to suit specified fabrication requirements.

d) Stainless steel plates (18/8) conforming to ASTM A167, ASTM A240, ASTM A554 (type 304,309S, 316,307 304L) shall be provided at locations as shown on drawings. The plates shall be provided with suitable anchors where required for embedding in concrete pavement.

B. Support Devices

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- a) Reinforcement: Meet requirements of "Reinforcement" section.
- b) Fasteners used in assembling sections: Exactly matching adjacent surfaces where exposed or AISI 300 series stainless steel.
- c) Steel Anchors: Hot dip galvanized, or AISI 300 series.
- d) Inserts: For required anchorage into concrete or masonry work, furnish inserts of cast iron, malleable iron or 2.8 mm steel hot-dip galvanized after fabrication.
- e) Expansion Anchor Devices: Fed. Spec. FF-S-325 Group III, Type 4, Class 1, Int. Amendment 3: Molly "Parabolt" or equal.

C. Paint for Ferrous Metal

Primer as follows: equivalent product manufactured by one of the approved manufacturers listed under "Painting and Finishing"; Fed. Spec. TT-P-86e, Type II, or "Tnemec" cement-in-oil type.

D. Setting Grout

Rapid setting grout warranted by manufacturer to be compatible with aluminum; UPCI "Bostick 275"; similar by Steelcote. Grace or Acme Highway Products using less than full unit of powder so that mixture is pourable; or use L & M Crystex Grout. Metallic grout is not acceptable.

E. Accessory Materials

- a) Joint Filler: Expanded cellular neoprene, closed cell, tape, coated with nonstaining adhesive one surface; ASTM D 1056 "Testing Sponge and Expanded Cellular Rubber Products". Type SC-41: shape as required.
- b) Protective Coverings: After finishing procedures have been completed, apply protective wrappings of paper or plastic film. Keep material dry until wrappings are removed. Coatings, if used, must be completely removed.

8. STAINLESS STEEL FINISHES

Finish designations are indicated herein in accordance with the standards of the American Iron and Steel Institute.

9. FABRICATION

A. General

Comply with requirements of "Structural Steel Work", Section 0160.

B. Welding and Grinding Stainless Steel

- a) All welding shall be in accordance with appropriate recommendations of the American Welding Society and shall be done with electrodes and by methods recommended by the manufacturer of the alloys being welded. Type, size, and spacing of welds shall be as shown on approved shop drawings. All welds behind finished surfaces shall be so done as to minimize distortion or discoloration on the finished side. All weld spatter and welding oxides on finished surfaces shall be removed by descaling or grinding.
- b) Unless otherwise shown or specified, all weld beads on exposed polished surfaces shall be ground and polished to match and blend with finish on adjacent parent metal. Grinding and polishing shall be done only with clean wheels and other abrasives free from iron compounds.
- c) Thoroughly clean material after grinding or polishing to remove all contaminants which might affect appearance.

10. PROTECTION AND CLEANING STAINLESS STEEL

All work shall be protected from damage of any kind during handling, transportation and at the project site. All material shall be stored under waterproof cover on wood blocking or on suitable floors.

Finished surfaces shall be covered with protective paper, tape, or other approved strippable coating prior to shipment from the fabricator. Should construction schedules delay removal of protective strippable coating, periodic inspection at increasingly frequent intervals shall be made to be certain coating may be easily removed.

Upon completion, all exposed surfaces shall be thoroughly cleaned in accordance with the recommendations of the stainless-steel producer.

11. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0180 - MISCELLANEOUS STEEL WORK

1.0 SCOPE

The work under this section of Specifications consists of supply of all material, labour, plant, equipment and appliances required for Miscellaneous Steel works such as embedded items, steel pipe railing and any other work shown in the drawings and as directed by the Engineer.

2.0 APPLICABLE STANDARDS

Latest edition of the following standards are relevant to these Specifications, wherever applicable:

AISC Code of Standard practice. ASTM A-36 for structural steel. ASTM A-53 steel pipe for railing. AISC/SSPC Guide to Shop painting for structural steel. AWS D1.1 Structural Welding Code - Steel Specifications for welding of steel structures.

3.0 DRAWINGS.

3.1 DESIGN DRAWINGS

Design working drawings shall be supplied to the Contractor. These shall contain main dimensions, sizes of members, typical details, etc.

3.2 SHOP DRAWINGS

Shop drawings shall be prepared by the Contractor from the construction drawing, taking into consideration the instructions given by the Engineer and submitted to the Engineer for his approval. No work shall commence until shop drawing is approved by the Engineer.

4.0 MATERIAL

Except otherwise stated in the drawings, the material specifications shall conform to the following standards. Wherever necessary the Contractor may use equivalent alternative material subject to approval of the Engineer.

4.1 STRUCTURAL STEEL

Structural Steel shall conform to the requirements of ASTM A-36 or equivalent.

Pipe for handrail shall conform to the requirements of ASTM A-53.

4.2 WELDING

Welding Electrodes shall conform to the specifications for mild steel covered Arc-welding Electrodes, AWS A5.1 latest edition. Equivalent locally manufactured electrodes may be used subject to the approval of the Engineer.

5.0 FABRICATION

The Contractor shall notify the Engineer about any problem or doubts/errors discovered in the drawings supplied by the Engineer for clarification/rectification well in time to prevent any fabrication errors. Fabrication shall not be commenced until approval has been obtained from the Engineer.

5.1 STRAIGHTENING OF MATERIAL

Rolled material, before being worked upon must be straightened. Straightening necessarily shall be done by mechanical means or by the application of a limited amount of localized heat.

5.2 CUTTING

As far as possible cutting must be done by shearing. Oxygen cutting shall be done where shear cutting is not possible and shall preferably be done by Machine. All edges shall be free from gauges, notches or burs. If necessary, the same shall be removed by grinding.

5.3 HOLES PUNCHING/DRILLING

Holes shall be punched where thickness of the material is not greater than the diameter of bolt by (+1/8) inch. Where the thickness of the material is greater, the holes shall either be drilled or sub-punched and reamed to size. The dia for all sub-punched holes and the dia. of all drilled holes shall be at least 1/12 inch smaller than the nominal diameter of the rivet or bolt.

5.4 WELDING

5.4.1 General: The execution and inspection of welding will be done in accordance with the provisions of the American Welding Society Code for Welding in Building construction, D1.1.

5.4.2 Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications.

Surface to be welded shall be free from loose scale, slag, rust, grease, paint or any other foreign matter except mill scale which withstands vigorous wire brushing.

5.5 Tolerances

The maximum variation in the distance from centre to centre of holes for rivets or bolts shall not be greater than 1mm.

5.6 Methodology

Fabrication shall be carried out using all the necessary tools, plant and equipment in accordance with methodology for fabrication approved by the Engineer.

6.0 INSPECTION AND TESTS

The inspection of welding shall be performed in accordance with the American Welding Society specifications and as directed by the Engineer.

Materials and workmanship not in reasonable conformance with the provisions of these specifications shall be rejected at any time during the progress of the work or the completion and erection at site.

7.0 ERECTION/INSTALLATION

Erection/Installation work shall be carried out by using required tools, plant and equipment in accordance with methodology for erection approved by the Engineer.

8.0 SURFACE PREPARATION/PAINTING

8.1 SURFACE PREPARATION

8.1.1 All steel shall be cleaned free from loose scale, rust, burs, slag, etc. by means of sand / grit blasting and/or other approved means as recommended by the manufacturer of paint.

8.1.2 The sand / grit used for this purpose shall conform to the type as specified in SSPC-SP 6. It should be free from earth, dust, clay and moisture. For this, the Contractor shall submit the gradation (no less than that passing through a 16 mesh screen U.S. sieve series) and source of sand along with the sample for approval of the Engineer prior to commencing the sand blasting operation.

8.1.3 The size of sand particles and air pressure size of the hose nozzle shall be correlated to give proper and acceptable surface.

8.2 PAINTING

8.2.1 Immediately after surface preparation all material shall be applied with two coats of red lead oxide primer and two coats of synthetic enamel.

8.2.2 One final coat of paint shall be applied after erection of all components is complete.

8.2.3 The type of primer and paints to be applied shall be as specified in section 8.3. The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.

8.2.4 All painting shall be in accordance with the paint manufacturer's specification/recommendations.

8.2.5 The above is applicable to all steel work covered under this section of specification.

8.2.6 Steel work/Surfaces not to be painted

i) Steel work to be encased/embedded in concrete or surface in contact with concrete shall not be painted, but shall be given a cement wash after surface preparation.

ii) Bolt and nuts threads shall be protected by greasing till they are tightened and painted.

8.3 PRIMER AND PAINT

All structural steel components, unless specified otherwise, shall be applied with

i. Primer: Surface Tolerant Epoxy of 70 Micron DFT

ii. Intermediate Coats: Surface Tolerant Epoxy mastic paint to be applied in two layers, each layer of thickness 100 micron DFT of approved color. (Jotamastic 87 or approved equivalent)

iii. Final Coat: (Top Coat)

Two component polyurethane enamel of 60 micron DFT of color applied after erection. (Hardtop XP AS approved equivalent)

9.0 GALVANIZING

Steel platform, pipe works supports, ladder, etc. specified as well as screws and nuts associated shall be hot-dip galvanized, electrolytically galvanized or sheradized, as appropriate to the particular element.

Galvanizing shall be performed in accordance with VDE Standard 0210.

Material: For galvanizing, only original blast-furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

for screws, washers, nuts and similar hardware a minimum of 60 micron.

for all other parts, except for parts intermittently or permanently submerged in water, a minimum of 70 micron

for parts intermittently or permanently submerged in water, a minimum of 140 micron, in accordance with "VDEw, Druckrohrleitungen - Association of German Electricity Utility Companies, Steel Penstocks".

Cleaning: All material to be galvanized shall be cleaned carefully of rust, loose scale, dirt, oil, grease, and other foreign substances. Particular care shall be taken to clean slag from welded areas.

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Galvanizing of plates and shapes: Where pieces are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping.

Material on which galvanizing has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanizing repair compound; in this case, the compound shall be applied in accordance with the manufacturers' instructions.

Soldering shall be done with a soldering iron using 50/50 solder (tin and lead). Surplus flux or acid shall be washed off promptly and the work shall be performed so as not to damage the adjacent coating or the metal itself. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

10.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0190 – PILING WORKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, appliances and materials and performing all operations in connection with the execution and testing of bored reinforced concrete cast-in-place piles complete and in strict accordance with this section of the Specifications and the applicable drawings and subject to the terms and conditions of the contract.

B. Related Sections:

1. Section 0150 - Concrete Works

2. Section 0100 - Earthwork

1.2 APPLICABLE STANDARDS

A. British Standards:

B.S.8004 Foundations

B. ASTM Standards:

D 1143 Standard Test Methods for Deep Foundations under Static Axial Compressive Load

D 3689 Standard Test Methods for Deep Foundations under Static Axial Tensile Load

D 3966 Standard Test Methods for Deep Foundations under Lateral Load

D 4945 Standard Test Method for High-Strain Dynamic Testing of Piles

D 5882 Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations

D 6760 Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross hole Testing

C. ACI Standards:

ACI 318 Building Code Requirements for Reinforced Concrete

D. In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials.

1.3 SUBMITTALS

The CONTRACTOR shall prepare the following, but not limited to, documents for submission to the ENGINEER for approval prior to any execution of the works.

A. Concrete mix design for all grade of concrete to be used as specified in the Contract Drawings.

B. Manufacturer's certificate and test reports for all products to be used.

C. Method statements for bore piling and concrete casting procedure.

D. Method Statement for Static Load Pile Testing.

E. Method Statement for Non-Destructive Integrity Pile Testing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. For detail specification of cement, aggregates and concrete refer to Section 0150 - Concrete Works

B. For detail specifications of reinforcement refer to relevant section.

2.2 DESCRIPTION OF PILES

The piles shall be bored cast-in-place, reinforced concrete piles. The pile diameter, working depth, design axial and horizontal loads, group configuration, number of working piles, and the test programme shall be as shown on the Structural Drawings and as summarised in the Pile Schedule that the Contractor shall extract from the Structural Drawings and submit with his Method Statement for the Engineer's approval before any piling work commences. The nominal diameter of piles is defined as the outside diameter of the temporary driving casing which is used to carry out the boring to the elevation required and which is later withdrawn, all as described hereinafter. The pile concrete shall be the grade specified in the Concrete Grade Table consolidated under Section 0150 and shall in no case be lower than 3,000 psi cylinder strength.

The casing shall penetrate to the bottom of the bore hole and not be withdrawn except as stipulated hereinafter. However, depending upon the final and general site conditions the ENGINEER may, at his sole discretion, allow omission of the last portion of the pile near its tip.

Parameter	Specification
Pile Type	Bored Cast-in-Situ Reinforced Concrete Piles
Pile Diameter — All Caps F1, F2, F3, F4	1,000 mm (1.0 m)
Concrete Strength	$f'_c = 4,500$ psi minimum (self-compacting concrete for in-situ placement)
Main Reinforcement	ASTM A615 Grade 60; $f_y = 60,000$ psi
Lateral Ties / Spirals	ASTM A615 Grade 40; $f_y = 40,000$ psi
Minimum Cover to Pile Face	75 mm (3 inches)
Concrete Placement Method	Tremie pipe from bottom of bore upwards (no vibration)

Foundation Ref.	Structure / Cap Size	Nos. of Caps	Piles per Cap	Total Piles	Pile Dia. (mm)	Pile Length (m)	Working Load per Pile (Tons)
ATCT-F1	ATCT — tower core raft, 70'-7" × 37'-6", cap thickness 33"	1	18 (6 × 3)	18	1,000	20	126
ATCT-F2	ATCT — 18' × 18', cap thickness 27"	16	4	64	1,000	15	76
ATCT-F3	ATCT — 18' × 31', cap thickness 27"	4	6 (2 × 3)	24	1,000	15	76
ATCT-F4	ATCT — 6'-6" × 21', cap thickness 21"	4	2	8	1,000	15	76
FS-F1	Fire Station — two-pile cap	6	2	12	1,000	15	76
FS-F2	Fire Station — two-pile cap	8	2	16	1,000	15	76
TOTAL WORKING PILES	—	39	—	142	—	—	—

Foundation Ref.	Structure / Cap Size	Nos. of Caps	Piles per Cap	Total Piles	Pile Dia. (mm)	Pile Length (m)	Working Load per Pile (Tons)
Test piles	Sacrificial initial test piles (Clause 3.12B A)	—	—	2	1,000	As working piles	—
TOTAL PILES	—	—	—	144	—	—	—

Notes to the Pile Schedule:

1. All piles are bored cast-in-situ reinforced concrete, nominal diameter 1,000 mm (3'-3"), reinforced with 20 nos. #6 vertical bars with #3 spiral ties throughout the full pile length, in accordance with Sections A-A and B-B of the Structural Drawings.
2. Pile lengths shown are estimated. Final penetration shall be determined in accordance with Clause 2.3 following the results of the initial load tests specified in Clause 3.12A.
3. Foundation references are prefixed ATCT- and FS- to distinguish the two structures, both of which employ foundation marks F1 and F2 on their respective drawing sets (Drawings S-01 to S-14 for the ATCT and S-01U to S-07U for the Fire Station).
4. Working loads for the Fire Station pile types FS-F1 and FS-F2 are not stated on the Structural Drawings and have been taken as 76 tons. [ASSUMPTION – VERIFY with the Structural Consultant prior to issue.]

2.3 PENETRATION OF PILES

The estimated minimum length of piles below the prepared ground level is specified in the Drawings. Depending on the results of pile-loading test described later under this section and depending also on supplementary soil information obtained in the course of execution of the actual pile work, the ENGINEER may at his own discretion order the CONTRACTOR to vary the penetration of some or all of the piles as the case may be.

PART 3 - EXECUTION

3.1 EXECUTION OF BORE HOLE

The CONTRACTOR may use any percussion rotary or vibration method, or any combination thereof for executing the bore hole to the elevation required but the use of water jets or of any other method or methods for the execution of the bore hole which tend to disintegrate or to appreciably loosen the soil strata surrounding the bore hole is expressly prohibited.

3.2 LIMITATION OF BORING SEQUENCE

No boring operations shall take place nearer than 10 ft (3 meters) from any pile for which concreting operations are in progress or from any newly completed pile until at least forty-eight (48) hours have elapsed from the last concreting operation on that pile.

3.3 REMOVAL OF SOIL

The soil inside the bore hole shall be removed by auguring or some similar method. It is expressly prohibited to pump out or to attempt to pump out the water in the bore hole or to use pumping or water-jetting to assist with the removal of soil or any other materials from the casing.

3.4 SAMPLES AND BORE HOLE LOGS

Two soil samples shall be taken from the bottom 12 inches (300 mm) in each bore hole and shall be preserved in sealed and adequately labeled glass containers until personally inspected by the ENGINEER who shall then issue instructions regarding the further disposal of these samples.

In addition to these two bottom samples which shall be taken from each bore hole, the CONTRACTOR shall also keep a complete bore log with a visual classification supported by an adequate number of samples provided in sealed and adequately labeled glass jars, for not less than two pile bore holes for examination. These bore holes shall be selected at the extreme ends of each pile group, should they show significantly different results. The ENGINEER's Representative may order additional bore hole logs to be kept for intermediate pile bore holes. Adequate number of samples shall mean not less than one sample for every 5 ft (1500 mm) of bore hole and, in addition, not less than two samples at every significant change in the soil strata.

3.5 TOLERANCES

The out-of-position tolerance shall not exceed 2 inches (50 mm) in any direction. The out-of-plumb tolerance shall not exceed 1% (one percent) in any direction.

The bow shall not exceed 2 inches (50 mm) in any direction. In order to control the amount of bow in the piles, exact records shall be kept of the amount of out-of-plumb of each bore hole and the withdrawal of the casing or guide pipe shall be in strict alignment therewith.

3.6 TOP OF THE CASING

In the last stages of the concreting operations described hereinafter, the top of the casing shall be at an elevation of not less than 3 ft (900 mm) above that of the soffit of the pile cap as marked on the drawings for the purpose of making it possible to continue concreting up to that elevation; all as stipulated hereinafter.

3.7 INSPECTION

After the boring has reached its final penetration as stipulated or as may be additionally ordered by the ENGINEER on the basis of the test load results and other data obtained in the field, and after it has been completely cleaned of all earth and otherwise made ready to receive the reinforcement and thereafter the concrete, the CONTRACTOR shall so inform the ENGINEER. The ENGINEER or his deputy shall check the actual penetration achieved, the cleanness of the bore hole and the amount and direction, if any, by which the bore-hole is out of position and/or out of plumb; and having satisfied himself on these and on any other points which he may consider relevant, shall personally sign an acceptance voucher for the bore hole authorizing the CONTRACTOR to proceed with placing the reinforcement. The CONTRACTOR shall under no circumstances proceed with placing the reinforcement in the bore hole, or with the subsequent concreting, without having first obtained this written authority separately for each and every bore hole signed by the ENGINEER.

3.8 PILE REINFORCEMENT

The reinforcement for piles shall be as specified in Drawings. The piles shall be reinforced for the full length of the pile.

The reinforcement for each pile shall be assembled on the ground by means of binding wire in such a manner as to form a rigid cage. Concrete spacer blocks specially precast for this purpose shall be securely attached to the reinforcement at suitable spacing in such a manner as to ensure that the concrete cover is maintained throughout and the reinforcement cage is not displaced in the casing in the course of subsequent concreting operations. Most particular care shall be taken to ensure that none of these spacer blocks can swivel around to the inside of reinforcement cage and that, in general, there are no obstructions of any kind inside the reinforcement cage due to spacer blocks or lapped reinforcement or for any other reason which might interfere with the

smooth travel of the concreting skip if the underwater method of concreting described hereinafter is to be used. The entire reinforcement cage assembly shall then be carefully lifted and carefully lowered into the bore hole previously made ready to receive it as described in previous sections.

Should the CONTRACTOR prefer to lower the reinforcement cage assembly into the bore hole in two or three sections, he may do so provided he observes the same lapping requirements as for assembly on the ground, namely that the main longitudinal reinforcement shall be lapped for not less than 40 bar diameters. In addition, concrete spacer blocks must be located immediately above the laps at three points spaced around the cage so as to ensure the correct positioning of the reinforcement cage in the bore hole.

Upon completion of this operation, the CONTRACTOR shall notify the ENGINEER or his deputy who shall satisfy himself of the adequacy of this work and shall then issue to the CONTRACTOR, separately for each and every pile, a written authorization to proceed with concreting.

3.9 CONCRETING

Concreting shall be subject to the following specifications in addition to those mentioned for the "Materials" section.

a) Concrete piles may be attacked by ground water containing destructive acids, alkalis or chemical salts but the cause of the most severe damage is usually the rusting of the reinforcement and spalling of the concrete. To minimize these effects, the concrete shall be dense and of high quality, obtained by proper selection of the aggregate and mix design, strict supervision over workmanship in mixing and placing concrete, adequate cover to reinforcement and careful handling of the piles to minimize stresses and formation of cracks during placing.

b) The bottom of the casing should be kept far enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The joints of the casing should be made as tight as possible to minimize inflow of water or leakage of air, where compressed air is employed to facilitate concreting.

c) Where the concrete is cast-in-place in a tube or casing, its consistency should be suitable to the method of compacting employed in the formation of the piles. Where a casing is withdrawn from cohesive soils for the formation of a cast-in-place pile, the concrete should be used as dry as practicable to minimize the softening of the soil by excess water. Care shall be taken to prevent, as far as possible, the separation of the ingredients in passing the reinforcement.

d) After installation to final depth and immediately before placing the concrete, the inside of the casing or bore shall be free from any foreign matter.

e) Concrete shall be so placed as to fill the entire volume of the casing or bore without the formation of voids caused by faulty consolidation or entrapped air. The column of concrete placed shall be observed in the case of a few piles initially cast and the average figure obtained shall be used to check whether there is undue deviation in the column of the concrete placed for the subsequent piles.

f) When concrete has to be placed through water, it shall be done with necessary precautions with specific approval of the ENGINEER. The most reliable results in concreting underwater in a confined space, followed by early withdrawal of the protective casing, are obtained when the slump of the concrete being deposited is controlled within the limits of between 3 to 4 inches (75 & 100 mm) for a standard slump cone. The mix proportions shall specially have to be designed by the CONTRACTOR for this slump.

g) The concrete shall be placed by means of a skip lowered and raised inside the reinforcement cage by means of a crane, or other appropriate mechanical means. The outer dimensions of the skip shall be such that it can be freely lowered and raised inside the reinforcement cage and the

manner of lowering and raising it shall be so controlled that the reinforcement cage is not distorted or displaced in the course of concreting.

The bottom of the skip shall be of a conical or appropriate pyramidal shape to enable it to easily penetrate into the previously deposited concrete by a distance of not less than 12 inches (300 mm) and it shall be fitted with an automatic or manually operated device for opening the discharge trap when the skip has achieved that penetration. To ensure the satisfactory placing of concrete in this manner, the skip should be allowed to accelerate or even to drop freely near the bottom of its course whereas the withdrawal of the skip should be gradual in order to ensure that all the concrete in the skip is in fact deposited well below the level of the fresh concrete in the casing.

The success of this method of concreting requires an experienced and conscientious skip operator as well as competent Engineering supervision and the ENGINEER shall satisfy himself on these points before allowing the CONTRACTOR to proceed with this work.

h) Concrete shall be placed in sufficient quantity to ensure that during withdrawal of the casing a sufficient head of concrete is maintained to prevent the inflow of soil and water.

i) The rate of placing concrete shall be such that the casing is filled with concrete at a rate of not less than 30 ft (9 meters) per hour and not more than 50 ft (15 meters) per hour.

j) With the method of placing described above and especially using a concrete with a slump of 3 to 4 inches (75 to 100 mm), no compaction other than the impact of the skip is necessary and none shall be allowed because of the danger of mixing.

k) Concreting shall continue until the concrete has reached an elevation 3 ft (900 mm) higher than the soffit of the pile cap as marked on the drawings.

3.10 WITHDRAWAL OF TEMPORARY CASING

The withdrawal of the temporary casing is a critical operation affecting the soundness of bored cast-in-place reinforced concrete piles. Two conditions are essential for the success of this operation:

Firstly, the direction of withdrawal must be in the strictest alignment with the actual direction of the casing in the ground.

Secondly, the timing of the withdrawal and the method used for the withdrawal of the casing must be such as not to disturb the freshly cast concrete in the piles.

Irrespective of the method used, the technically satisfactory withdrawal of the casing requires adequate equipment, an experienced and conscientious operator and competent Engineering supervision, and the CONTRACTOR shall not be allowed to proceed with this work until the ENGINEER is satisfied with the adequacy of the CONTRACTOR's equipment and with the proficiency of his personnel. The most usual cause of unsatisfactory performance is that the CONTRACTOR's equipment might prove to be insufficiently powerful to achieve withdrawal of the casing by steady pull so that the CONTRACTOR is faced with the choice of either abandoning the casing in the bore hole or attempting to withdraw it by jerking. Jerky withdrawal of the casing, particularly if delayed by breakdowns or mishaps, disturbs the freshly deposited concrete and may grossly impair the strength of the pile. It is consequently expressly stipulated that the CONTRACTOR shall not be allowed to proceed with this work until the ENGINEER is satisfied that all his equipment, including all component parts thereof such as tripods, pulleys, blocks, ropes, hooks, winches and all other sundries, are sufficiently powerful and sturdy to ensure the satisfactory progress of this work without mishaps and difficulties.

3.11 PILE TOPS

It has been stipulated that the level of the concrete in the piles at the end of the concreting operations must be not less than 3 ft (900 mm) higher than the soffit elevation of the pile cap as marked on the drawings. The concrete in the topmost portion of bored or drilled cast-in-place reinforced concrete piles is never fully satisfactory. The top portions of the piles shall be inspected by the ENGINEER and the CONTRACTOR shall then break back the concrete in the top portion of the piles to final elevation of the top of the piles which is 6 inches (150 mm) above the soffit of the future pile cap, while also exposing the length of pile reinforcement required for lapping and bond within the pile cap. The CONTRACTOR shall check and record the actual findings of the broken-off tops of piles against previously established benchmarks. The tolerance for this final elevation shall be as shown on the drawings.

The CONTRACTOR shall also establish and record the actual coordinates of the centers of the broken-off pile tops with respect to the theoretical center lines of each pile cap as shown on the drawings, and the tolerance in this respect shall not exceed two inches (50 mm) in any direction as stipulated herein before.

The unsatisfactory concrete in the top portions of some or all piles may extend further down than the final elevation of the tops of the piles. In that event the CONTRACTOR shall break back such greater lengths of such piles as may be ordered by the ENGINEER and shall build up such piles to the final elevations required by means of reinforced concrete pedestals with dimensions as required. Should defective concrete or other defects extend to a depth endangering the load bearing capacity of the pile, the ENGINEER may order such further remedial measures as he may see fit, including the provision of additional piles, which may also require extension of the pile caps, all of which shall be at the CONTRACTOR's expense.

It is brought to the notice of the CONTRACTOR that payment for all piling work shall be only as stipulated in the Schedule of Quantities, that is to say, the CONTRACTOR shall be paid only for the actual length of piles in place measured from the soffit of the pile caps and that no payment shall be made either for the demolished upper portions of piles as described above or for any reconstruction, substitution, extension or other extras, wastages or spillage which the CONTRACTOR may incur in executing the work to the complete satisfaction of the ENGINEER.

3.12 LOAD TEST

In general, the load test shall be carried out in accordance with ASTM D 1143 - Standard Test Methods for Deep Foundations under Static Axial Compressive Load.

The load test stipulated herein is intended for the purpose of proving in the field that the penetration of piles is adequate to obtain an ultimate load bearing capacity of the piles of not less than twice the design value. A secondary objective of this pile loading test is to establish whether any significant pile settlements are likely to occur up to the design load values. Load tests may be carried out on index piles and/or on working piles for proof testing.

It is the Contractor's responsibility to employ and compensate a specialized testing firm.

Prior to the acceptance of final pile design and installation of any working piles, the CONTRACTOR shall be required to install index piles and carry out ultimate load tests to obtain the necessary information to confirm the design. All index test piles shall be instrumented. An instrumentation programme to measure the transfer of load from the pile shaft and pile top to the soil is to be proposed by the CONTRACTOR for the approval of the ENGINEER. The test load of an ultimate load test for bored cast-in-place piles shall be three times the designed working load of the pile. It shall be carried out in at least two cycles, the first cycle being to two times the designed working load.

The ultimate compressive or tensile load test pile, to be installed separately from the working piles and in a position selected by the ENGINEER, shall be of the same material and dimensions as the working piles.

Test Type	Standard
Sonic Integrity Test (SIT)	ASTM D5882
High-Strain Dynamic Test (PDA)	ASTM D4945
Static Compression Load Test	ASTM D1143
Pile Position Survey	Engineering survey

3.12A SCHEDULE OF LOAD TESTS

The CONTRACTOR shall carry out the following minimum programme of pile testing. The quantities stated are minima and shall be read together with the Schedule of Quantities. The ENGINEER may order additional tests where results are inconclusive or where boring records indicate variable strata, and such additional tests shall be valued at the rates tendered for the corresponding test type.

Ref.	Test	Standard	Pile Group	Test Load	Nos.
T1	Initial (ultimate) vertical compression load test on sacrificial pile	ASTM D1143	ATCT-F1	378 tons (3.0 × working load)	1
T2	Initial (ultimate) vertical compression load test on sacrificial pile	ASTM D1143	ATCT-F2, ATCT-F3, ATCT-F4, FS-F1, FS-F2	228 tons (3.0 × working load)	1
T3	Routine (proof) vertical compression load test on working pile	ASTM D1143	ATCT-F1	189 tons (1.5 × working load)	1
T4	Routine (proof) vertical compression load test on working pile	ASTM D1143	ATCT-F2, ATCT-F3, ATCT-F4, FS-F1, FS-F2 — one test per type	114 tons (1.5 × working load)	5
T5	Lateral load test on working pile, applied cyclically	ASTM D3966	ATCT	10% of working load	1
T6	Tension (uplift) load test on working pile	ASTM D3689	ATCT	1.5 × design uplift load	1
T7	Low-strain pile integrity test (PIT)	ASTM D5882	All working piles (100%)	—	142
T8	Crosshole sonic logging (CSL)	ASTM D6760	10% of working piles plus both initial test piles	—	17
T9	High-strain dynamic pile test (PDA) with CAPWAP analysis	ASTM D4945	Distributed across pile types as directed by the Engineer	—	4

3.12B SEQUENCE AND CONDITIONS OF TESTING

A. Initial test piles (T1 and T2) shall be sacrificial piles installed separately from the working piles at positions selected by the ENGINEER, of the same material, diameter, reinforcement and installation method as the working piles. They shall form no part of the permanent works and shall be measured separately in the Schedule of Quantities.

B. Both initial load tests shall be completed and the test reports approved in writing by the ENGINEER before the CONTRACTOR commences installation of any working pile. No claim for delay arising from this requirement shall be entertained.

C. The reaction system for the initial tests shall be an anchor-pile reaction frame. Kentledge shall not be used for test loads exceeding 200 tons. The CONTRACTOR shall submit full details of the proposed reaction system, including anchor pile design and frame calculations certified by a Professional Engineer, for the ENGINEER's approval prior to testing.

D. Reaction piles for the routine, lateral and tension tests (T3 to T6) shall be working piles. Reaction members shall be located at a clear distance of not less than three times the pile diameter, and in no case less than 3.0 m, from the test pile.

E. Not less than twenty-one (21) days shall elapse between completion of all concreting operations on any test pile and the application of test load, in accordance with Clause 3.14.

F. Load testing shall not be carried out when the ambient air temperature is below -5°C , nor during periods of snowfall or when snow or ice is present at the test station. Where testing extends into the winter period, the CONTRACTOR shall provide enclosure and heating to maintain instrumentation within its calibrated operating range, and shall protect reference beams and datum benchmarks against frost heave. All costs of such provision shall be deemed included in the rates.

G. Access tubes for crosshole sonic logging (T8) shall be four nos. steel tubes of 50 mm internal diameter per pile, installed to the full pile length, secured to the inner face of the reinforcement cage at equal spacing, capped and filled with clean water. Tubes shall be installed in all piles nominated for CSL and in both initial test piles, and the CONTRACTOR shall nominate the piles for the ENGINEER's approval before cage assembly.

H. The tension test (T6) shall be carried out only where net uplift is indicated at the tower core under the governing load combination. The ENGINEER shall confirm the design uplift value in writing before the test is programmed.

I. Where any test result fails to satisfy the acceptance criteria of Clause 3.18, the CONTRACTOR shall carry out such additional testing, remedial work or provision of additional piles as the ENGINEER may direct, entirely at the CONTRACTOR's expense.

3.13 LOCATION OF TEST PILE

The location of the test pile shall be provided by the Engineer.

3.14 TIME OF TESTING

Not less than 21 (twenty-one) days shall elapse between the end of all concreting operations on the test pile and the application of any test loads.

3.15 METHODS OF LOADING

The purpose of the load test is not only to determine the ultimate load bearing capacity of the pile but also to obtain information on settlement and other aspects of the behavior of the pile which may lead to an adjustment of the penetration specified for the permanent piles in the foundations.

The apparatus and methods for the application of test load must be capable of applying known vertical loads to the top of the test pile without inducing any horizontal thrust, twist or movement in the pile. Full details of the proposed apparatus and methods shall be submitted by the CONTRACTOR to the ENGINEER for his prior approval.

The suggested method of applying loads for axial compression load tests is by jacking against a box or platform resting on cribbing constructed over the top of the pile and loaded with suitable kentledge with a total weight of not less than twice the design value.

The suggested methods of applying loads for axial tension load tests are cantilever pulling method or fulcrum pulling method using calibrated jacks or crane and pressure dial or platform load.

The hydraulic jack should be able to maintain each increment of desired load constant under increasing settlement (for axial tension load tests, settlement means uplift of pile). The jack and the gauge for the jack should be calibrated as a unit not more than two weeks prior to the test and should represent actual loads with an accuracy of ± 2 percent. Loading apparatus and methods requiring anchored reaction members shall be located at a sufficient distance from the test pile so as not to affect the results of the tests nor to interfere with any of the permanent works.

The load should be applied to the pile in cumulative, equal increments of 50, 75, 100, 125, 150, 175 & 200 percent of the proposed working load. If the CONTRACTOR possesses equipment or kentledge required for higher loads and the ENGINEER instructs so, further loading increments should be added until failure (as measured by a rapid progressive increase in settlement) occurs.

After completion of the loading cycle the load should be removed and the rebound recorded until there is no further measurable settlement. Measurable settlement shall mean a settlement of 0.001 ft (0.3 mm).

Increments of load less than the proposed working load should remain in place for a period of not less than 1 hour. The proposed working load, and each increment thereafter, should remain in place until there is no measurable settlement in a 2-hour period. The total test load shall remain in place until no measurable settlement occurs in a 2-hour period, but in any case not less than 48 hours.

3.16 OBSERVATION OF SETTLEMENT

The method and apparatus used for the observation and measurement of settlements shall be proposed and supplied by the CONTRACTOR and shall be subject to the ENGINEER's approval. Settlement shall be measured with reference to a steel bolt set in the top of the pile for this purpose. Readings to 0.001 ft (0.3 mm) accuracy should be obtained. During daylight hours three readings shall be taken for each observation. During night hours adequate artificial lighting shall be provided and six readings shall be taken. The settlement values used in plotting the curves specified below shall be the mean value of the readings taken for each observation.

Under each load increment, settlement observations should be made and recorded at 1/2, 1, 2 & 4 minutes and at each 4 minutes thereafter after application of load increment, except in the instance of the total load when after the 4-minute reading, the time interval should be successively doubled until the final settlement limitation is reached and the load is removed. The rebound shall be recorded after each decrement is removed, and the final rebound shall be recorded 24 hours after the entire test load has been removed.

3.17 LOAD TEST REPORT

A load test report shall be submitted by the CONTRACTOR in triplicate and shall contain the following information:

- A. The location of the test pile with reference to previously established monuments or other permanent features, drawn in plan to a suitable scale.
- B. A bore hole log showing reduced levels of the existing ground levels of the top of the pile, and of the ground water table, and showing also the thickness and reduced levels of various soil strata encountered during boring as well as their visual classification.
- C. A detailed test report for the instrumented index piles load test shall be submitted. The test report shall reflect, but not be limited to, the stress/strain relationship of the piles with the surrounding soil, the pile unit skin friction at ultimate load as well as the unit end bearing at ultimate load.

D. A time-load-settlement graph plotting the time in hours on the horizontal axis, the loads in tons and the recorded settlements in 0.001 ft (0.3 mm) being plotted to a suitable scale on the vertical axis respectively above and below the common time axis.

E. A load-settlement graph with the load in tons plotted on the horizontal axis; and the corresponding settlement in 0.001 ft (0.3 mm) plotted downwards on the vertical axis; all to a suitable scale and annotated with time-critical or otherwise important load values.

F. A report giving a general description of the pile and the load, and copies of the load test log in tabular form with annotations of loads and settlements and time and remarks concerning any unusual or noteworthy occurrence during the testing operation.

3.18 DETERMINATION OF PILE WORKING LOAD FROM TEST RESULTS

The maximum allowable working pile load determined from these load tests shall be taken as the least of the following four values:

- i. One half of the load that causes a gross settlement of 3% of pile diameter provided that the load-settlement curve shows no sign of failure within this range.
- ii. One half of the load causing a net settlement of 1-1/2% of pile diameter.
- iii. One half of the load at the intersection of the tangent lines to the general slopes of the upper and lower portion of the load settlement curve.
- iv. Observe the point at which the gross settlement begins to exceed 0.05 in. (1.25 mm) per ton of additional load or at which the net settlement begins to exceed 0.03 in. (0.75 mm) per ton of additional load, and divide by 2. This net settlement is defined as the total settlement under load minus recovery or rebound of the pile after the load is removed.

3.19 NON-DESTRUCTIVE TEST USING LOW STRAIN PILE INTEGRITY TESTING (PIT)

A. General Remarks: Pile Integrity Testing (PIT) is a Non-Destructive integrity test method for foundation piles. It is a "Low Strain" Method (since it requires the impact of only a small hand-held hammer). The evaluation of PIT records is conducted either according to the Pulse-Echo (or Sonic Echo - a time domain analysis) or the Transient Response (frequency domain analysis) Procedure.

B. Description of Method: Low Strain integrity testing may be applied to any concreted pile (e.g., concrete piles, drilled shafts, auger cast piles, concrete filled pipe piles). The test requires the impact of a small hand-held hammer on the shaft top and the measurement of the shaft top motion (acceleration or velocity). The input compression wave from the hammer is reflected from pile toe (or a defect) and returns to the pile top at a time related to the speed of travel of the wave in the pile material.

The pile top velocity is displayed as a function of time with an exponential increasing magnitude where high soil friction forces are present, such that the pile toe reflection is enhanced. Several records with consistent signals are averaged. The averaged, amplified velocity is the standard result of the Pulse-Echo Method. The force as a function of time may also be depicted. The Transient Response Method results in the ratio of transforms for all relevant frequencies. Testing procedures shall conform to ASTM D5882.

C. Test Equipment: The test should be performed using digital data acquisition equipment. The signal conditioning and power supply must have very high signal-to-noise ratios. The analog to digital resolution shall be at least 16 bits, and the sampling frequency at least 40,000 Hz. Data should be stored such that additional processing or further wave analysis is possible.

D. Test Personnel: The field testing shall be performed by an experienced technician with at least one year's experience in integrity testing and shall be submitted to the approval of the ENGINEER.

The interpretation of the records requires extensive experience by a graduated engineer with at least three years experience in integrity testing.

E. Test Preparation: For cast-in-place piles, integrity testing shall not be performed until the concrete has cured for a minimum of seven (7) days unless otherwise approved by the Engineer. The pile head shall be free from water, dirt or other debris. The concrete at the pile top surface must be relatively smooth with sufficient space for both attachment of the motion-sensing device and hammer impact area. 100% of all piles shall be integrity tested. The location of piles designated for integrity testing shall be specified by the Engineer after pile installation.

F. Result Presentation: The testing engineer shall present a report within 10 working days after performing the field test to provide the initial results and identification/evaluation. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions.

G. Acceptance and Rejection: Shafts with no significant reflections from locations above the pile toe and with a clear pile toe reflection may be accepted. Where no clear toe reflection is apparent, the experienced test engineer shall state to which shaft depth the test appears to be conclusive. Where reflections from locations with significant reductions above the pile toe are observed, the pile has a serious defect. If the record is complex, the results may be deemed inconclusive. The decision to reject and replace, or repair, any defective shaft is at the sole responsibility of the Engineer-of-Record for the foundation.

H. Remedial Action: Rejected or questionable piles may be replaced. Questionable piles may also be subjected to further testing, e.g., static load testing, dynamic load testing, core drilling, ultrasonic logging, etc. Remedial action may include pressure grouting through core holes. If the pile top appears questionable, further pile top cut-off and retesting may be advisable. Any cost incurred for remedial action resulting from CONTRACTOR's error in surveying, improper installation, or inadequacy of load testing shall be borne by the CONTRACTOR.

3.20 NON-DESTRUCTIVE TEST USING HIGH-STRAIN DYNAMIC PILE TESTING (PDA)

A. Description: High-strain dynamic testing is performed by obtaining and analyzing records of shaft force and velocity under drop weight impacts for evaluations of shaft load carrying capacity, structural integrity, and load-movement and shaft-soil load transfer relationships. Testing procedures shall conform to ASTM D4945 unless otherwise noted.

B. Equipment: The Contractor shall supply all materials and equipment required to prepare the test shaft, dynamically load the shaft, and return the shaft to a condition suitable for use in the finished structure. Equipment includes: shaft top extension (if permanent casing not used), means to ensure flat and level shaft top, drop weight (1-2% of anticipated pile capacity), guide for variable drop heights (3-7 ft), shaft top cushion of plywood (2-6 inches thick), steel striker plate (minimum 2 inches thick), power supply, surveyor's transit, etc.

C. Dynamic Testing Firm: It is the Contractor's responsibility to employ and compensate a specialized testing firm. Testing is to be performed by an independent testing specialist from a firm with a minimum of five (5) years experience in dynamic shaft load testing. The actual test shall be conducted and/or supervised by a Licensed Professional Engineer with at least two (2) years of dynamic testing or who has achieved Basic Level or better on the Foundation QA Examination for Providers of PDA Testing Services. Selection of the firm must be acceptable to the Engineer.

The independent dynamic testing firm must supply: Pile Driving Analyzer (PDA), four calibrated strain transducers, four calibrated accelerometers. Prior to testing, the Professional Engineer must perform wave equation analyses (using GRLWEAP or equivalent) to determine the suitability of the proposed dynamic loading equipment and acceptable range of ram drop heights.

D. Procedure: (Summary) Construct test shaft using approved techniques. Provide test area (two shaft diameters length) cased if necessary. Make shaft test area accessible. Cut windows for gage attachment if casing present. Attach gages. Apply plywood cushion and striker plate. Apply at least two hammer impacts, starting with minimal drop height. Upon completion, return pile to acceptable production condition.

E. Reporting of Results: The Professional Engineer shall submit a timely report including field results and at least one CAPWAP analysis. CAPWAP analyses shall be performed by an engineer that has achieved Advanced Level or better on the Foundation QA Examination for Providers of PDA Testing Services. The report must include Wave Equation analysis results, CAPWAP analysis results, measured force, transferred energy, stress, Case Method bearing capacity, and assessment of pile capacity and integrity.

3.21 POWER OF THE ENGINEER

Should the ENGINEER have any reason to doubt the rigorous accuracy and complete reliability of the pile loading test, he may, at his sole discretion and without recourse, reject all the results obtained on the test pile and order the CONTRACTOR to carry out new tests on a new test pile, and the CONTRACTOR shall do so at his own expense without claiming any additional remuneration.

3.22 METHODS OF MEASUREMENTS OF PILING WORKS:

a) General Measurement Rules

Works shall be measured net the fixed in position as per Drawings and instruction of the ENGINEER. Each measurement shall be taken to the nearest 1/2" (12 mm). This rule shall not apply to any dimensions stated in descriptions.

b) Piling Equipment

Unless otherwise specifically stated in the bill of quantities, or herein, the item of allowing for all piling equipment shall be deemed to be inclusive of, but not limited to the following:

Bringing to SITE frames, rigs and all associated equipment for piling. Erecting and setting up frames, rigs and associated equipment for piling and moving to first pile position. Removing from last pile position, dismantling and removing from SITE all piling frames, rigs and associated equipment. Bringing all necessary pile testing equipment to SITE for carrying out the test specified, erecting and assembling as required, and subsequent dismantling and removal from SITE. Temporary ramps, accesses and hard standings, staging, SITE leveling or preparation and all clearance away after completion of piling and testing. All standing time between pile load tests.

c) Bore Hole Measurement

Executing the bore holes for piles shall be measured in linear feet (meter) for the actual length of bore holes measured from the commencing ground surface.

The item shall include, but not to limited to, the following:

Formation of complete bore hole for pile, the provision of all materials for casings, linings and all labor to achieve the complete bore hole.

Overcoming any obstructions (including old foundations) encountered.

Keeping bore holes free from water. Any measures necessary for the satisfactory placing and compaction of concrete below water table. Temporary back-filling of empty bore if so required, and later removal of back-filling. All costs incurred in moving plant from pile position to pile position and

for its installation to commence work. All costs incurred in traveling time from pile group to pile group etc. No extras will be considered if the setting out of the works is such as to prevent uniform working on pile groups or clusters or if it necessitates moving on and returning later to complete the work. All standing time. Disposal of all surplus material arising to areas of fill or to CONTRACTOR's tip off SITE. Provision where applicable for the inspection of the bore hole or casing including all safety measures and apparatus. Provision of boring records as required.

d) Concrete Measurement

i) Concrete for the piles shall be measured in cubic feet for the specified nominal diameter of piles and the actual length of piles in place measured from the soffit of the pile caps. No payment shall be made either for the demolished upper portions of piles, as described in these Specifications, or for any reconstruction, substitution, extension or other extras, wastages or spillage's which the CONTRACTOR may incur in executing the work to the complete satisfaction of the ENGINEER.

ii) Unless otherwise specifically stated in the bill of quantities, or herein, all items for concrete for piles shall be deemed to be inclusive of, but not limited to the items detailed in specifications Section 0150 - Concrete Works.

e) Reinforcement Measurement

i) Unless otherwise specifically stated in the bill of quantities or herein, all items of reinforcement shall be deemed to be inclusive of, but not limited to, the items detailed in specifications Section 0150 - Concrete Works.

ii) Reinforcement shall be classified and measured as detailed in specifications Section 0150 - Concrete Works.

f) Pile Completion

The item of completing the piles shall be lump sum for each pile. The item shall include, but not be limited to, the following:

Cutting pile tops to expose sound concrete and cleaning away debris, bending reinforcement to position for casting into pile-cap, base or slab.

Any reconstruction, substitution, extension or other extras, wastages, or spillage not covered under these specifications.

g) Load Test Measurement

Load tests shall be measured by enumeration, separately for each test type and test load stated in the Schedule of Quantities, and shall be deemed to include: provision of the test pile where sacrificial; provision of reaction piles, anchors, frames, beams, kentledge and all temporary works; supply, installation, calibration and removal of all jacks, gauges, transducers, dial gauges, reference beams and datum benchmarks; installation of instrumentation for strain and load transfer measurement on initial test piles; supply and installation of crosshole sonic logging access tubes; all loading, unloading, holding and observation periods including standing time; enclosure, heating and weather protection; interpretation; and submission of test reports in triplicate in accordance with Clause 3.17.

No separate payment shall be made for tests repeated as a consequence of unsatisfactory results, defective piles, or rejection of results by the ENGINEER under Clause 3.21.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

SECTION 0200 - BRICK MASONRY

1.0. SCOPE

The work under this section consists of furnishing all plant, labour, equipment, appliances, materials and in performing all operations in connection with supplying and constructing brick masonry, complete in strict accordance with this section of the specifications and applicable drawings and subject to the terms and conditions of the Contract. The scope of this section of specification is covered with detailed specification as laid down herein.

2.0 APPLICABLE CODES AND STANDARDS

Latest editions of the following ACI codes and ASTM Standards referred to herein, are applicable to these Specifications.

ACI Codes

ACI 530 Building Code Requirements for Masonry Structures

ACI 530.1 Specifications for Masonry Structures

ASTM Standards

ASTM C 62 Building Bricks (Solid Masonry units made from clay or shale)

ASTM C 207 Specification for Hydrated Lime for Masonry purpose

ASTM C 216 Facing Bricks (Solid Masonry units made from clay or shale)

ASTM C 67 Sampling and Testing Bricks

ASTM C 270 Mortar for Unit Masonry

ASTM A 615 Deformed and plain billet bars for concrete reinforcement

3.0 SUBMITTALS

3.1 Manufacturer's Data

Submit two copies of the manufacturer's specifications and other data for each type of brick and accessory required. Instructions shall be included for handling, storage, installation, and protection of units and accessories.

3.2 Samples

Submit three samples of each type of brick and accuracy required, also samples of the full range of exposed texture to be used in the completed work.

3.3 Test Reports

Reports on compressive strengths of brick and mortar; and tensile tests of reinforcing steel.

3.4 Certificate of Compliance

For Cement. Reinforcing Steel.

4.0 MATERIALS

4.1 Cement & Aggregates

Portland cement shall conform to the requirements of ASTM C 150 Type-1 or BS-12 (low alkali) also refer Section 0150.

White cement shall conform to BS-12 for pigmented mortar.

All aggregates for mortars shall conform to the requirements of ASTM C 144.

All water used in the manufacture of bricks and in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, alkali, salts and other impurities. The water shall be tested in accordance with ASTM D 596, where directed by the Engineer.

4.2 Plain & Coloured Mortars

Mortar shall meet the requirements of ASTM C 270. Mortar shall be type S having a minimum compressive strength of 12.4 MPa.

Proportioning of mortar shall be in accordance with the requirements of ASTM C-270. For all types of brick work the proportion of mortar shall not be less than 1 part of type-1 cement, 1/2 part of hydrated lime, to 3 parts of sand or as approved by the Engineer.

For Facing brick use coloured mortar as shown on the drawings. The colour of mortar shall match with the colour of bricks as close as possible and as approved by the Engineer. The proportion of mortar shall not be less than 1 part of white cement, 1/2 part of hydrated lime, to 3 parts of sand or as approved by the Engineer. The colour pigments manufactured by Bayerrox or approved equivalent shall be used.

Methods and equipment used for mixing mortars will be such which will accurately determine and control the amount of each separate ingredient entering into the mortar. Mortar shall be mixed only in sufficient quantities for immediate use and shall be used within 30 minutes after mixing. Stiffened mortars shall be re-tempered by adding water to restore the required consistency. Mortars not used within 2-1/2 hours after initial mixing shall be discarded. The mixers shall be thoroughly cleaned and washed at the end of each day's work.

4.3 Bricks

All bricks shall be first class type and of best quality, conforming to the requirements of ASTM C 62. Size of bricks should be 228 x 144 x 75mm (9 x 4.5 x 3 inches). Contractor shall submit samples of facing and building bricks for approval prior to commencement of work. Defective bricks shall not be used. For Facing bricks, the variation in colour shall be as little as possible and as per approval of Engineer. Bricks shall be selected from the best Bhattas (Kilns) situated in the vicinity of Skardu.

Building bricks shall conform to ASTM C 62, grade MW. Minimum compressive strength of average of 5 bricks is 2500 psi and not less than 2200 psi of individual brick. Maximum water absorption by immersing an oven dry sample in cold water for two hour shall not absorb more than 1/5th of the weight of brick.

Facing bricks shall conform to ASTM C 216, grade MW. Minimum compressive strength of average of 5 bricks is 2500 psi and not less than 2200 psi of individual brick. Maximum water absorption by immersing an oven dry sample in cold water for two hour shall not absorb more than 1/6th of the weight of brick.

4.4 Other Materials

All materials specified hereunder shall be manufactured by either Schomburg, Ressichem, BASF or Patsa.

4.4.1 Salt Neutralizing Solution

Hexafluorosilicate a salt neutralizing solution, to wash brick walls prior to application of cement plaster, waterproof coating, or a water repellent coating.

4.4.2 Non-Staining Water Repellent Coating

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Deep penetrating polysiloxanes base water repellent coating for application on the Facing brick masonry walls.

4.4.3 Water Proofing within the Cavity Walls

Polymer modified cement-based waterproof slurry to form an impervious rigid coating Aquafin-1K of Schomburg or equivalent as specified, applied as first coat.

Polymer modified cement based waterproof slurry to form an impervious flexible coating Aquafin-2C of Schomburg or equivalent as specified, applied as second coat

4.4.4 Joint Sealant

Single component polyurethane joint sealant at flexible joints of the masonry walls as shown in drawings.

4.4.5 Fireproof Coating

Spray Applied Fire Resistive Material (SFRM) ISOLATEK Type 400 or equivalent for application on sealants to protect it from fire.

4.4.6 Stainless Steel Grade 304, Z - Type and Finish Tail Anchors

Anchors shall be fixed within the cavity walls as shown in drawings.

4.4.7 Reinforcement

Reinforcement bars shall be embedded at joints and corners as shown on drawings and material shall follow the relevant section of these specifications.

5.0 PLACING

The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the brick nor delay the use of mixed mortar. Bricks shall not be placed during heavy rains to washing away the mortar from the brick. Mortar already spread which becomes diluted by rain shall be discarded and replaced before continuing with work. All bricks to be used in brick masonry shall be soaked in water for three to four hours before they are used to ensure that each brick is thoroughly and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brick masonry.

Bricks shall be laid "frog" upward (except for lining in drain) with mortar joints and in stretcher bond or as approved by the Engineer. Both bed and vertical joints shall be 8 to 10mm thick in building bricks and 6 to 8mm in facing bricks as shown in the drawings and completely filled with mortar as specified herein. Each brick shall be bedded by firmly tapping with the handle of trowel. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. Excess mortar at the outer edges shall be removed and joints drawn straight and flash raked. Weep holes in the cavity walls shall be made as per drawings. Construction debris within the cavity walls shall be removed to keep the cavity thoroughly clean after masonry work has been completed.

Work required to be embedded in the brick masonry should be installed as the work progresses. At the completion of the work, holes or defective mortar joints shall be cut out and re-pointed.

5.1 Pointing for Building Bricks

Bricks shall be laid true to line, level and plump. All joints shall be perfectly straight, parallel and sharp. Brick of irregular shape, size, damaged and defective edges and faces shall be rejected outright. Works done with defective edges and faces shall be rejected and the Contractor shall replace, without additional cost, all defective and unacceptable works.

Exterior faces of the walls shall be finished by striking the joints as the work proceeds. Tooling shall be done when the mortar is partially set but still sufficiently plastic. The joints shall be struck by raking the green mortar after the brick work has been laid. Finish the joints with a pointing tool. Care shall be taken that the striking tools do not develop a cutting edge as the object of striking the joint is to compress the mortar into the joints. No pointing is required for the building bricks.

5.2 Pointing for Facing Bricks

To form horizontal and vertical joints in the facing bricks, remove carefully the already cement mortar while it is still green, to a depth of nearly one inch from the face of the brick. Clean the space thoroughly. After the curing period has elapsed, fill the space with colour mortar by compressing and packing into the joint space, and strike with a specially developed tool to form the keyed joints, concave rounded as shown in the drawings and as approved by the Engineer. Contractor shall ensure that the finished concave pointing is in perfect shape, is free of cracks and blemishes. Curing of the freshly laid coloured mortar shall proceed as specified.

6.0 WATERPROOF COATINGS & JOINT SEALANT

6.1 Neutralizing Solution

All brick walls shall be washed with hexafluorosilicate salt neutralizing solution prior to application of cement plaster or a waterproof or water repellent coatings.

6.2 Waterproof Coating within Cavity Walls

Waterproof Coatings shall be applied on internal one side of the cavity wall as shown. Apply first coat with a polymer modified cement based waterproof slurry to form an impervious rigid layer applied @ 1.5 kg per square meter (Aquafin-1K of Schomburg or equivalent as specified) and the second coat with a flexible polymer modified cement based waterproof coating @ 1.5 kg per square meter (Aquafin-2C of Schomburg or equivalent as specified). Both the coats shall be applied in accordance with manufacturer's recommendations.

6.3 Non-Staining Water Repellent Coating on Facing Walls

Deep penetrating polysiloxanes base water repellent coating shall be applied on the facing brick masonry walls. Prior to the application of the coating Contractor shall ensure that the efflorescence on the bricks has been cleaned thoroughly. Contractor shall allow ample time to dry off the internal moisture of bricks. At least 15 days' time in summer and 30 days in winter shall be given for this purpose after completion of the brick masonry work or as approved by the Engineer.

6.4 Joint Sealant

The top of masonry wall at soffit of the beams or slabs, shall be filled with polyurethane joint sealant as per drawings and manufactured recommendations. Fireproofing coating shall be applied on Polyurethane sealants in fire zone areas.

7.0 CURING AND REPAIR

All brick masonry shall be water cured and shall be kept wet for at least seven days by an approved method which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements of the specifications for water used in the manufacture of bricks.

If, after the completion of any brick masonry work, the brick is not in alignment or level or does not conform to the lines and levels shown on the drawings, or shows a defective surface, it shall be removed and replaced by the Contractor, without additional cost to Engineer. Repairing or patching of the defective area will not be acceptable unless allowed, in writing, by the Engineer.

8.0 SCAFFOLDING

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

The Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding which is unsafe in the opinion of the Engineer shall not be used until it has been strengthened and made safe for use of workmen. Cost of scaffolding etc., shall be included by the Contractor without additional cost to the Engineer.

Damage to masonry from scaffolding or from any other cause shall be repaired by the Contractor at his own cost.

9.0 TOLERANCES

All tolerances shall be as per requirements of ACI-530.1

10.0 DAMP PROOF COURSES

All damp-proof courses unless otherwise specified shall be 2 inch thick, consisting of cement concrete having a 28-day minimum cube strength of 21 N/mm², mixed with approved quality water proofing compound as per manufacturer's specifications and shall be laid at required levels as per drawings and instructions of the Engineer. The damp proof course shall be tamped, consolidated, leveled and edges and corners made to the requirements of the relevant drawings including finishing and curing complete.

11.0 CLEANING AND PROTECTION

At the completion of the work, all holes, and defective mortar joints shall be cut and repointed. Exposed masonry shall be protected against staining or other damage, and excess mortar shall be cleared off the surfaces as the work progresses. All exposed masonry shall be clean, smooth, fine and shall be of acceptable finish approved by the Engineer.

12.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0210 - FURNITURE, PLANTERS, TELEPHONE HOODS, DISPOSAL UNITS, ASHTRAYS, BUMPER RAIL, AND COUNTERS

1. SCOPE

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with supply and installation of furniture, planner, telephone hoods, disposal units, ashtrays, bumper-rail and counters in accordance with this section of specifications, the applicable drawings and subject to terms and conditions of the Contract.

2. APPLICABLE CODE & STANDARDS

The Code & standards applicable to the works specified in this section are using the code NFPA 101, NFPA 260, NFPA 261, ASTM E1537 and PBS-P100 (Facilities Standards for the Public Buildings Service).

3. SUBMITTALS

The following submittals are required:

A. Manufacturer's catalog or manual

B. Product Data: Manufacturer's data sheets for each product to be used, including:

1. Preparation instructions and recommendations.
2. Storage and handling requirements and recommendations.

3. Installation methods.

C. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections and relationship with adjacent construction.

D. Verification Samples: For each finish product specified, two samples, representing actual product and finish.

E. Mock-up: Submit a mock-up for evaluation of finish quality check.

4. QUALITY ASSURANCE

A. Manufacturer Qualifications: Minimum 5 years experience manufacturing similar products.

B. Installer Qualifications: Minimum 2 years experience installing similar products.

5. FIRE HAZARD CLASSIFICATION

Provide material which will meet the requirement of fire resistance and comply with applicable codes and standards.

6. FURNITURE AND EQUIPMENT

This section covers the supply, delivery, assembly and installation of all furniture and ancillary equipment for the New Air Traffic Control Tower (ATCT) and ARFF Station at Skardu International Airport, as itemised in the Bill of Quantities and described in the sub-clauses below. All items shall be of Master brand (or approved equivalent), supplied complete with all fittings, fixtures and accessories, and shall carry a minimum one (1) year manufacturer's warranty with lifetime after-sales service.

6.1 EXECUTIVE DESKS AND SIDE RACKS

Supply and installation of executive-grade office desks and side racks, complete in all respects. All units shall be of knock-down (KD) construction with imported hardware, nail-less structure, veneer or laminate finish pressed on MDF with PVC edge-banding, and powder-coated MS substructure where applicable. Colours shall be as approved by the Engineer.

6.1.1 Master Executive Side Rack – Model No. MO-ED-ES-19 (ARFF Office – Mezzanine Floor)

- Table Size: L 4' × D 2' × H 30"; polish finish veneer pressed on substrate.
- Wooden edges, inlay and CNC machining; Handles and Knobs in Antique Brass finish.
- Leatherette padding on top surface; drawer unit with three drawers having noiseless sliding channels and soft-close mechanism.
- Imported KD fittings; colours customisable in available shades.



6.1.2 Master Study Desk – Model No. MO-MD-BS-08 (Male Dormitory – Mezzanine Floor)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Table Size: L 4' × D 2'; laminate finish pressed on MDF; PVC edge banding.
- Nail-less, easy-to-dismantle, MS powder-coated structure; sheet thickness 1 inch; imported KD fittings.



6.1.3 Master Manager Desk – Model No. MO-MD-BS-12 KENDAL (PAA Offices – First Floor)

- Table Size: L 5' × D 2.5'; laminate finish on MDF; PVC edge banding.
- Nail-less, MS powder-coated structure; sheet thickness 1 inch; imported KD fittings.



6.1.4 Master Office Desk – Model No. MO-MD-BS-08 (Training/Break-Out – First Floor)

- Table Size: L 4' × D 2'; all features as clause 6.1.2 above.



6.1.5 Master Office Desk – Model No. MO-MD-BS-06 (Training/Break-Out – Second Floor)

- Table Size: L 4.5' × D 2'; nail-less laminated structure; sheet thickness 1 inch.



6.2 CONFERENCE TABLES

Supply and installation of executive conference tables with polish-finish veneer on MDF/wood substrate, leatherette top padding, imported KD fittings and wooden structure, in the Conference and OCC Hall (First Floor).

6.2.1 Master Conference Table – Model No. MO-MT-MS-06, Size L 22' × D 5' × H 30"

- Polish finish veneer pressed on MDF; wooden structure; leatherette padding on top.
- Imported KD fittings; colours customisable in available shades.



6.2.2 Master Conference Table – Model No. MO-MT-MS-06, Size L 25' × D 5' × H 30"

- All features as clause 6.2.1 above.



6.3 CLUSTER WORKSTATIONS

Supply and installation of aluminium-profile cluster workstations in the Comops Room (First Floor). Each workstation shall include tackable front and side screen panels.

6.3.1 Master Aluminium Cluster Workstation (Comops Room – First Floor)

- Laminate finish as per approved theme; 2 mm PVC lipping on all edges.
- Easy to dismantle; nail-less construction; sheet thickness 1 inch.
- Front aluminium profile and MS powder-coated legs; tackable front and side screens.
- One year warranty and lifetime after-sales services.



6.4 CAFETERIA AND CAFE FURNITURE

6.4.1 Master Café Table – Model No. MO-MULLER-MT-01 (Training/Break-Out – First Floor)

- Table size: 36" Dia × H 30"; laminate finish; PVC edge banding; nail-less structure.
- Imported KD fittings with noiseless hinges; sheet thickness standard.



6.4.2 Master Cafeteria Chair (Training/Break-Out – First Floor)

- Polypropylene shell with foam seat padding; chrome structure; multi-colour options.
- Floor-protective glides; imported chair; one year warranty and after-sales services.



6.5 EXECUTIVE AND HIGH-BACK CHAIRS (HBC)

Supply and installation of executive high-back revolving chairs featuring lockable revolving and tilting mechanism, gas-lift seat-height adjustment, and castors meeting BIFMA and DIN standards.

6.5.1 Master Executive HBC – Model No. A2916 (ARFF Office – Mezzanine Floor)

- Complete stainless steel structure; imported leatherette seat and back.
- Lockable revolving/tilting mechanism pivoted at front; extra torsion adjustment; fixed-position angle control.
- Gas-lift seat height; swivel; imported twin castor wheels meeting BIFMA and DIN standards.
- Unique curved lumbar-support shells; adjustable PU arm rests.
- Guaranteed imported foam on seat and back; Knee-Tilt Mechanism with lockable positions.



6.5.2 Master Genesis ORTHO HBC (PAA Offices – First Floor)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Sleek integral skin with wooden arms; ortho back-seat sheet for posture support; PP wooden armrests.
- Twin-wheel castors (BIFMA/DIN); high-frequency veneer shell compression for posture care.
- Guaranteed PU Master Molty Excel Foam of highest density; Knee-Tilt Mechanism with lockable positions.
- Colour customisable in Master fabric without extra cost.



6.6 VISITOR, RECEPTION AND TRAINING CHAIRS

6.6.1 Master Visitor Chair-01 (ARFF Office – Mezzanine Floor and PAA Offices – First Floor)

- Rosewood, Mahogany or Hard Solid Wood structure; ergonomic and aesthetic design.
- High-frequency compression on multi-layered veneer shell; faux leatherette upholstery on seat and back.
- High-density quick-recovery foam; unique curved shells for lumbar support.
- Premium MoltyFoam seat; flexibility in Master fabric or leatherette upholstery.
- One year warranty and lifetime after-sales services.



6.6.2 Master Anatom Reception Chair (Male Dormitory Study Area, Training/Break-Out Rooms)

- Lockable revolving/tilting mechanism; sleek integral skin with PP arms; gas-lift seat height.
- Extra torsion adjustment; fixed-position angle control; twin-wheel castors with nylon base (BIFMA/DIN).
- High-frequency veneer shell compression for posture care; unique curved lumbar-support shells; PP armrests.
- Guaranteed PU Master Molty Excel Foam of highest density; Permanent Contact Mechanism with 3 lockable positions.
- Colour customisable in leatherette or Master fabric.



6.6.3 Master Mesh Mid-Back Chair – Model No. B-3018 (Conference and OCC Hall – First Floor)

- Lockable revolving/tilting mechanism; sleek integral skin with PU arms; gas-lift seat height.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Twin-wheel castors with nylon base (BIFMA/DIN); breathable fabricated mesh back.
- Unique curved shape with lumbar support; 4-D Polyurethane armrests; imported foam on seat.
- KT Mechanism with desired lockable positions.



6.6.4 Master Genesis Eco Low-Back Chair (Comops Room – First Floor)

- Lockable revolving/tilting mechanism; sleek integral skin with PP arms; gas-lift seat height.
- Twin-wheel castors with nylon base (BIFMA/DIN); high-frequency veneer shell compression for posture care.
- Guaranteed PU Master Molty Excel Foam; Permanent Contact Mechanism with 3 lockable positions.
- Colour customisable in leatherette or Master fabric.

6.6.5 Master Training Chair – Model No. MO-JUDY (Training/Break-Out Rooms – First and Second Floors)

- Ergonomic and aesthetic; fabricated mesh back; fabricated seat with high-density quick-recovery foam.
- MS powder-coated structure; Premium MoltyFoam seat; flexibility in Master fabric or leatherette.



6.7 SOFA SETS

Supply and installation of sofa sets at locations shown in the BOQ and drawings. All sofas shall incorporate PU Master Moly Excel Foam of highest density (Core Density 34 Kg/m³; ball rebound resilience 32%; Tensile Strength 14.5%; Elongation 125%; Compression 3.4%). Structures shall be of spruce wood with wooden legs unless otherwise stated. Upholstery fabric or leatherette as approved by the Engineer.

6.7.1 Master Two-Seater Sofa Aspen (ARFF Office – Mezzanine Floor)

- Spruce wood structure; wooden legs; sofa cushions included; flexibility in upholstery fabric.



6.7.2 Master Single-Seater Sofa Aspen (ARFF Office – Mezzanine Floor)

- Same construction and specification as clause 6.7.1 above.



6.7.3 Master Two-Seater Chesterfield Sofa (Lounge – Mezzanine Floor)

- Natural finish and upholstery; base in solid rosewood with natural finish.
- Clean Atlas sofa-set lines; flexibility in upholstery fabric and leatherette.



6.7.4 Master Two-Seater Sofa Augusta (PAA Offices – First Floor)

- Spruce wood structure; wooden legs; sofa cushions; flexibility in upholstery fabric.



6.7.5 Master Single-Seater Sofa Augusta (PAA Offices – First Floor)

- Same construction and specification as clause 6.7.4 above.



6.7.6 Master Three-Seater Sofa – Sof-22 (Male and Female Lounge, ATCT Floor)

- Spruce wood structure; exported quality velvet upholstery; gold accent legs.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Hand-upholstered in leatherette with slim, distinct and edgy profile.



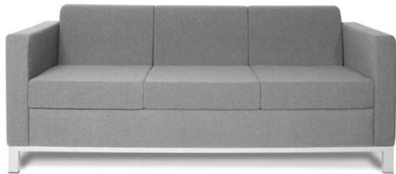
6.7.7 Master Single-Seater Sofa – Sof-22 (Male and Female Lounge, ATCT Floor)

- Same construction and specification as clause 6.7.6 above.



6.7.8 Master Three-Seater Sofa – Sof-01 (OCC Waiting and Retrieving Room – First Floor)

- Spruce wood structure; exported quality velvet upholstery; gold accent legs.
- Hand-upholstered in leatherette with slim, distinct and edgy profile; flexibility in upholstery fabric.



6.7.9 Master Single-Seater Sofa – Sof-01 (OCC Waiting and Retrieving Room – First Floor)

- Same construction and specification as clause 6.7.8 above.



6.8 SIDE TABLES AND CENTRE TABLES

Supply and installation of side tables and centre tables with Al-Noor MDF laminated tops, nail-less structure, 2 mm PVC lipping on all edges and standard sheet thickness.

6.8.1 Master Linea Side Table – L:559 mm × W:356 mm × H:610 mm (ARFF Office and PAA Offices)

- Déco finish on MDF; MS base with matching powder-coated finish; standard sheet thickness.

6.8.2 Master Centre Side Table – L 40" × W 40" × H 18" (Lounge – Mezzanine Floor, ATCT Floor)

- Al-Noor MDF laminated top; nail-less structure; 2 mm PVC lipping on all edges.



6.8.3 Master Sofa Side Table – L 20" × W 20" × H 18" (Lounge, Male/Female Lounge, ATCT Floor)

- Al-Noor MDF laminated top; nail-less structure; 2 mm PVC lipping on all edges.



6.8.4 Master Sofa Centre Table – L 48" × W 20" × H 18" (OCC Waiting and Retrieving Room)

- Al-Noor MDF laminated top; nail-less structure; 2 mm PVC lipping on all edges.



6.8.5 Master Sofa Side Table – L 18" × W 18" × H 18" (OCC Waiting and Retrieving Room)

- Al-Noor MDF laminated top; nail-less structure; 2 mm PVC lipping on all edges.

6.9 LOW-HEIGHT STORAGE UNITS

6.9.1 Master Low Height Storage – Model No. MO-SLH-04 (PAA Offices – First Floor)

- Size: 72" × 15" × H 34"; laminate finish; PVC edge banding; nail-less structure.
- Imported KD fittings with noiseless hinges; standard sheet thickness.
- Colours customisable in available laminates; one year warranty and lifetime after-sales services.



6.10 DORMITORY FURNITURE

Supply and installation of dormitory furniture for Male and Female Dormitories. Quantities for First Floor dormitory furniture shall be confirmed following review of drawings by the Engineer.

6.10.1 Master Single Bed with 6" Mattress and Single Side Tables (Male Dormitory – Mezzanine Floor)

- Bed Size: L 78" × D 42"; laminate finish with velvet upholstery; easy to dismantle; imported KD fittings.
- Mattress: 78" × 42" × 6" with Molty Gold pillow; complete as per design.
- One year warranty and lifetime after-sales services.



6.10.2 First Floor Male and Female Dormitory Beds and Furniture

Quantities and specifications to be confirmed by the Engineer and updated in the BOQ prior to procurement.

6.11 PRAYER AREA MATS

Supply and installation of prayer area mats at designated prayer rooms within the ATCT facility. Quality, size, pattern and quantities shall be as confirmed by the Engineer. All mats shall be of heavy-duty, durable, cleanable and fire-resistant material suitable for the intended use.

6.12 RECORD ROOM RACKS AND ALMIRAH

Supply and installation of heavy-duty steel or laminate-finish record room racks and almirahs for storage and filing of official documents. Types, sizes and quantities shall be confirmed by the Engineer and updated in the BOQ prior to procurement.

6.13 ATCT CABIN CHAIRS AND ARFF CABIN CHAIRS AND SOFAS

Supply and installation of ergonomic cabin chairs for the ATCT Operations Floor and ARFF cabin areas, including sofa seating for ARFF crew rest areas as shown on drawings. Chair types shall meet the operational ergonomic requirements of the respective areas. Specifications, quantities and approved makes shall be confirmed by the Engineer prior to procurement.

7. EXECUTION

7.1 General Inspection

Examine the areas and conditions under which the furnishings are to be installed. Do not proceed until unsatisfactory conditions have been corrected.

8. INSTALLATION

8.1 Delivery

Deliver furniture and equipment to the locations indicated and place as directed by the Engineer.

8.2 Unpacking

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Unpack and uncreate furniture & equipment and assemble & service as required for use. Vacuum or wipe clean as required. Prepare surface as recommended by the manufacturer.

All packing materials shall be carefully removed and disposed of at designated places without damage to the existing facilities.

8.3 Damage

8.3.1 Furniture: Damaged Furniture shall be repaired only when after repair furniture shall be in perfect useable condition and as approved by the Engineer. Remove damaged furniture, without any additional cost, which cannot be repaired and shall be replaced with new furniture.

8.3.2 Equipment: Replace all damaged and rejected equipment.

8.3.3 Building: Special care shall be taken to avoid damage to the walls, doors, flooring or finishes during delivery and installation of furnishings. Damaged areas shall require to be repaired, without any additional cost, to match with adjacent / surrounding materials.

8.4 Procedure

8.4.1 General: All furniture and equipment shall be fully assembled, adjusted and installed in each room as shown in drawings or as directed by the Engineer. Particular care shall be taken to align and maintain proper spacing between furniture and equipment considering operational and functionality requirement of the particular area.

8.4.2 Leveling: Floor standing units shall be leveled using built-in levelers, properly aligned to allow even installation. Suspended furniture shall be securely attached and set plumb, level and true to line.

8.4.3 Gang Bolting: Wherever two or more units or other like items are located side by side, these items shall be gang bolted together after leveling. Where specified, tops shall be secured to supports, ends and sides shall be flush.

8.4.4 Stability: Seating and other similar items shall be assembled and installed with necessary hardware to ensure stability.

8.4.5 Trim: Miscellaneous trim pieces, filler pieces, special bases, and like items shall be furnished and installed as indicated or required.

8.4.6 Adjustment: Perform necessary adjustments for proper operation.

8.5 Coordination of Telephone and Electrical Equipment

The Contractor shall coordinate with the Engineer for installation of telephone and electrical equipment at each workstation and shall provide a mounting board for telephone equipment as required.

Contractor shall run telephone cable and electrical wires through the raceways.

8.6 Accessories

a) Clearly label each carton or package with the following:

8.6.1 Project name

8.6.2 Item code number

8.6.3 Contractor

8.6.4 Manufacturer

8.6.5 Manufacturer's product designation (name, model or number)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

8.6.6 Destination (facility building)

b) Accessory packages shall be packed in one carton and delivered to location in one cartooned unit. Placed in the designated area immediately prior to acceptance of the area.

9. PROTECTION AND CLEAN-UP

9.1 Protection

All furniture and equipment items shall be protected during transportation with clear polyethylene covers not less than 0.15mm thick, which shall not be removed until completion of installation at final destination and its acceptance by the Engineer.

9.2 Clean-up

No accumulation of packaging or carting materials will be permitted. Remove debris daily. Leave areas clean and ready for use. Remove temporary protection prior to acceptance.

10. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0220 CARPENTRY, JOINERY & MILL WORK

1. SCOPE

The work covered under this section of Specifications consists of providing all material, labour, plant, equipment, appliances and performing all operations in any floor and at any height connected with the fabrication and erection of all woodwork, building carpentry, joinery & mill work, CDF partition, construction assembly, surface finish treatment and building decorative wooden feature and all cabinet type items, construction assembly, surface finish treatment and building in of all cabinet type items, supports etc. of wood or metal and incidentals, associated woodwork appurtenances, procuring and applying preservatives, installation of "Finish Hard Ware" in connection with finish woodwork as per details shown on the Drawings or as directed by the Engineer.

2. APPLICABLE STANDARDS

Latest editions of following British and ISO Standards are relevant to these specifications wherever applicable.

2.1 ISO (International Organization for Standardization)

1891 Bolts, screens, nuts and accessories- Terminology and nomenclature.

1097 Plywood - Measurement of dimensions of panels.

1098 Veneer plywood for general use- General requirements.

2427 Veneer plywood with rotary cut veneer for general use- Classification by appearance of panels with outer veneer of beech.

2429 Plywood - Veneer plywood with rotary cut veneer for general use- Classification by appearance of panels with outer veneers of brand-leaved species of tropical Africa.

3804 Plywood- Determination of dimension of test pieces.

3805 Plywood- Determination of density.

3806 Plywood- Determination of moisture content.

6442 Door leaves- Measurement of defects of general flatness.

6443 Door leaves- Measurement of dimensions and of defects of squareness.

6444 Door leaves- Test of behavior under humidity variations.

2.2 BSI (British Standards Institution)

459 Wooden doors.

1186 Quality of timber and workmanship in joinery.

1127 Hinges

1331 Builder's hardware for housing.

1567 Wood door frames and linings nails.

1202 Nails

1203 Specifications for synthetic resin adhesive for ply wood.

1204 Synthetic resin adhesives for wood.

1282 Guide to choice, use and application of wood preservatives.

1494 Fixing accessories for building purposes.

1579 Connectors for timber.

3842 Treatment of ply wood with preservatives.

3. MATERIALS

3.1 Timber

3.1.1 Hard Wood:

Hard wood shall comprise of oak, beech, walnut mahogany, teak, iroko and sheesham.

3.1.2 Soft Wood:

All soft wood shall consist of pines, spruce, hemlock and douglas fir or cedrous deodar (referred in the document as deodar), wood locally known as 'Partial' to be used in shutter core where specified.

3.1.3 General Characteristics:

All the timber shall be in accordance with the requirements of BSI No: 1186, 'Quality of Timber and Workmanship in Joinery'.

The whole of the timber shall be from the heart of sound and fully grown tree, uniform in substance, straight in fibre, first class quality properly seasoned, free from large or loose dead- knots, open shakes and excessive sapwood. The scantlings of all timbers shall be bright, sound and square edged. The moisture content of timber shall not be more than 10 (ten) percent in case of soft wood and 7 (seven) percent in case of hard wood.

3.1.4 Preservation of Wood:

Prior to installation of all finish wood works in their respective positions, preservatives shall be applied to safeguard the wood work against fungus, termite and bores.

The preservatives shall be of the best available quality as approved by the Engineer. The method of application shall be strictly in accordance with the manufacturer's instructions. The treatment and application of all the preservatives shall comply with the requirements of BS- CP 98:1964.

3.1.5 Adhesive:

The adhesives shall conform to the requirements of BSI No. 745 "Animal Glues for Wood" manufactured by M/s Hoest or approved equivalent.

Nails and Screws:

All nails and screws shall comply with requirements of BSI NO.1202 and 1210 respectively.

3.2 Ply Wood

3.2.1. Grade and Quality

Where plywood is specified, it shall be of first quality grade manufactured from tropical hardwoods in accordance with the provisions in BS 1455 or other approved equivalent standard. It shall be made up of either rotary- cut or sliced veneers bonded together in balanced, multiply construction with an adhesive or WBP (weather and boil- proof) quality.

The veneers shall be reasonably matched for colour and shall be free from knots, worm and beetle holes, splits, dote, glue stains, tilling or inlaying of any kind or other defects. No end joints shall be permitted.

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The plywood shall be highly resistant to weather, micro- organisms, cold and boiling water, steam and dry heat. It shall be free of manufacturing defects such as defective bonding, pleats, overlaps, blisters and gaps.

The ply wood shall comply in all respects with BSI No. 1455:1963. All the ply wood shall only be obtained from manufacturers approved by the Engineer. All plywood shall be manufactured with phenol pharamalldihide or any other approved water proof adhesive but not with urea pharamalldihide.

Ply wood used for doors, and other similar works shall be to the thickness and size as shown on the Drawings or as directed by the Engineer. The grade shall be first quality and the face and back shall be free from end joints, dead knots, overlaps, patches and other similar defects. The surfaces shall be free, smooth for painting or polishing.

3.2.2. Testing Quality of Adhesion in the Plywood

In order to ascertain the bonding quality of the adhesive between successive veneers or layers in the plywood the Contractor shall submit to the Employer for approval test certificates from an approved testing laboratory certifying that the following test requirements have been met.

i) The Wet Test in Hot Water or Steam (Test method to follow Appendix 'B' of BS 1455).

Based on the knife test (Appendix C of BS 1455) no glue line shall have a bond quality less than two, and the average value for all those tested shall not be less than five.

ii) The Wet Test in Water at 15°C (Test Method to follow Appendix BZ of BS 1455).

Based on the knife test, no glue line shall have a bond quality less than two and the average value for all those tested shall not be less than five.

iii) The Mycological Test (Test Method to follow Appendix B 3 of BS 1455).

At the conclusion of the test, none of the test pieces shall show any delimitation, blistering on the surfaces or separation of the joints between veneers at the edges.

3.2.3. Moisture Content

At the time of leaving the factory, finished boards shall have a moisture content, as determined by the test method described in Appendix D of BS 1455, of 8% to 12%.

3.2.4. Finishing

Boards shall be sanded or scraped on both sides equally.

3.2.5. Delimitation

Any board showing delimitation or blistering shall be deemed not to comply with the requirements of this Specification.

3.3 Medium Density Fibre (MDF) Board

Medium-density fibreboard, laminated or acrylic as shown in the drawing, to be used on the project shall be LASANI manufactured by Al- Noor MDF Board Industries or approved equivalent of thicknesses as specified in the drawings. Board shall be manufactured with water proof resinous glues and shall be guaranteed by the manufacturer. All boards required for the exterior surfaces of cabinets shall be laminated with formica in approved colour and texture in factory as specified

3.4 Compact Density Board (CDF)

Compact high Density Fiber Board of specified thickness (density 1000kg/m³ both sides melamine laminated coating, scratch resistance, splash water resistance and flame retardancy / fire

resistance for cubicles and wash rooms & other wet areas with complete set of hardware (SS 304 grade) or as specified or as shown in drawing or as recommended by the manufacturer and approved by the Engineer.

3.5 Wood-plastic Composite (WPC) Material

3.5.1 Material

WPC material sections (solid or hollow) should compose of Wood fiber / wood flour and suitable thermoplastic such as polyethylene, polypropylene, polyvinyl chloride, polylactic acid etc. to full the requirements of functionally, environment, fire resistance etc. of the particular product in shapes, sizes, color and texture as shown in drawings, as recommended by the manufacturer and as approved by the Engineer.

WPC section should consist of minimum 55% wood, 30% PVC / PE, 15% binder and additives and in compliance to the requirements of codes / standards listed below. Products should be made up of plastic type High Density Polyethylene (HDPE) material.

a) TSE EN 479 b) TSE EN 317

3.5.2 Fixing and Installation

a) Fixing and installation details / arrangements shall be proposed as necessary to further install / fix features / element as per design as recommended by the fabricator / manufacturer and approved by the Engineer.

4. SAMPLES

All samples of the material used for the work under this Section of Specification shall be approved by the Engineer and same type of material shall be used throughout the work. If the Engineer desires to get the material tested, this will be got done by the Contractor at his own cost from a laboratory approved by the Engineer.

5. FABRICATION

wrought timber shall be used. Sawing shall be done with sufficient oversize margin to finally meet the requirements of specified sizes and dimensions of the finished work.

6. PROTECTION OF MATERIALS

All materials and assembled units shall be protected from weather and stored in such a way as to prevent decay, warping and attack by fungus and termites.

7. WOODEN DOORS

7.1 Materials

7.1.1 First class Teakwood as approved by the Engineer shall be used for door frames and door shutters except the core of shutters which shall be partial wood as specified and shown on drawings.

7.1.2 Architraves, beads, lippings shall be of Teakwood of specified sizes and fixed as per details shown on Drawings.

7.2 Ground, Blocking & Nailing Strips

Ground, blocking and nailing strips shall be provided as necessary to receive the work included herein and as required for the work of other trades.

Except as otherwise shown or specified, ground blocking and nailing strips shall be secured in place as follows:

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7.2.1 To steel- by means of 3/8" diameter bolts spaced not over 3 feet.

7.2.2 To brick wall by the use of cut nails spaced not more than 1.5 feet apart and driven directly into the block.

7.2.3 To poured concrete by means of 1/4" diameter galvanized expansion bolts spaced not more than 1.5 feet part or by any approved method.

7.3 Exterior and Interior Door Frames

All exterior and interior door frames shall be fabricated of wooden sections of first class teakwood frame as shown on drawings.

All exposed surfaces of frames and architraves/beads shall be lacquered finished of approved shade as shown on the drawing or as per the instructions of the Engineer.

The door frames shall be secured in place by means of 4 inches screws or MS holdfast 6 inches thick and matching Rawal plugs and built into the plastered masonry after the same has dried. 4 number screws in each jamb and 2 number for upto 3.5 feet width and 3 number for upto 5 feet width of doors in the head shall be used, alternatively, prefixing of door frame with shim detail of door can be used as instructed by the Engineer. The specified details are for reference only, however, contractor shall submit fixing / hardware details in shop drawings for approval of the Engineer as per hardware details shown in the drawing or as recommended by the manufacturer.

7.4 Door Shutters

The shutters will be fixed to the frames with approved quality fittings as per hardware schedule.

7.4.1 All doors, shutters shall be fabricated in a workman like manner strictly to the correct sizes and shapes as shown on the Drawings or as directed by the Engineer.

7.4.2 The door shutters shall be built in sections, properly jointed and glued together. The surfaces shall be prepared for painting or polishing.

7.4.3 All door shutters shall be paneled, fabricated from first class teakwood as shown on drawings.

7.4.4 Each door shall be constructed so as to permit the installation of hinges, knobs and locks in the position shown on the Drawings. Lock rails should also be provided with all flush doors.

7.4.5 Completed doors shall be sound, rigid and free from defects and warp. All edges shall be aligned and smooth, joints shall be close fitting, hard wood doveled or mortised framed and of strength to maintain frame and of strength to maintain the structural properties of the member connected. All adjoining faces and edges shall be flush and smooth. Edges shall be rectangular and solid.

7.4.6 All exposed surfaces of wooden frames and wooden shutters shall be painted with lacquered finished or polished finish of approved shade as per the instructions of the Engineer.

7.4.7 Chamfers shall be made as shown on the drawings or as directed by the Engineer.

7.5 Fitting, Hanging and Trimming

All the doors shall be fitted, hung and trimmed as hereinafter specified and as indicated on the Drawings.

Doors shall have a clearance of 1/8" at sides and top unless otherwise directed by the Engineer and shall have 1/2" clearance at bottom. Doors shall be hung and trimmed with hardware as specified. All the locks shall be installed at the same height and shall be located at height as directed by the Engineer. Where directed by the Engineer margin for carpet shall be incorporated in the door shutter.

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Door undercut shall be min. 1/2" and max. 3/4" or as shown on drawing and as approved by the Engineer

7.6 Hardware

Hardware in stainless steel material shall be of premium quality heavy duty and well finished material including hinges, push and pull bars, door locks, door stopper door closures etc. which shall be of make Dorma, Yale or approved equivalent as per attached hardware schedule. The Contractor shall obtain prior approval from the Engineer for quality, shape, pattern, and brand of all the hardware materials by providing samples and catalogues, etc., and shall provide and fix only the approved hardware materials.

Hardware shall be carefully and securely fitted. Upon handing over the work, hardware shall be demonstrated to operate freely. Keys shall be placed into respective locks and upon acceptance the work keys shall be tagged and delivered to the Engineer.

Contractor may provide suitable alternative hardware solution as per manufacturer recommendation for Engineer's approval.

7.7 Quality Assurance

7.7.1 Tolerances: Doors shall be fabricated to following tolerances

- Size: Plus or minus 1/16 in overall dimensions
- Maximum Warp: 1/8"
- Squareness: Maximum diagonal difference 1/8" of (between length of diagonal measured on face of door from upper right corner to lower left corner and length of diagonal measured from upper left corner to lower right corner).

7.7.2 Manufacturer's Qualifications: The manufacturer of doors herein specified shall have been in business of manufacturing doors of type specified for minimum period of five years.

7.8 Submittal

7.8.1 Provide manufacturer's literature completely describing products.

7.8.2 Provide shop drawings showing door types, details and locations, referred to the door type and hardware group shown on door and hardware schedules.

7.8.3 Provide certificates stating that doors were constructed with timber of the species specified having moisture content and meeting equilibrium and relative humidity requirements.

7.8.4 Submit samples of plywood, MDF etc. for selection of colour and grain.

7.8.5 Procurement of materials shall be made only after the shop drawings and samples have been approved by the Engineer.

7.9 Product Delivery, Storage and Handling

7.9.1 Deliver and store products in waterproof, protective containers with seals unbroken and labels intact until time to use.

7.9.2 Keep products dry, stack products off ground on level platforms, fully protected from weather, including direct sunlight.

7.9.3 Identify type, size and location of each door before delivery in order to permit installation at correct location.

7.10 Installation

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7.10.1 Install doors at correct openings and assure smooth swing and proper closer with frames.

7.10.2 Install finish hardware in accordance with manufacturer directions.

8. LATTICE SCREENS / JAFFREY

8.1 Materials

Well- shaped / cutted teakwood Jaffrey / lattice screen as per design and pattern shown in drawings and as approved by the Engineer shall be used.

8.2 Fixing and Installation

Fixing and installation details / arrangements shall be proposed as necessary to further install / fix lattice member / Jaffrey on the panel or screen as recommended by the fabricator / manufacturer and approved by the Engineer.

9. WOODEN PELMET

9.1 Materials

Well- shaped /cutted Teakwood pelmet (wall mounted) with fixing arrangement as specified and shown on drawings and as approved by the Engineer.

9.2 Fixing and Installation

Fixing and installation details / arrangements shall be proposed as necessary to further install / fix pelmet as recommended by the fabricator / manufacturer and approved by the Engineer.

10. HARD WOOD HANDRAIL & DECORATIVE MOULDING

10.1 Materials

Well- shaped /cutted Teakwood Handrail decorative moulding feature / elements in lacquered finish with complete fixing arrangements shall be provided as approved by the Engineer shall be as specified and shown on drawings:

10.1.1 Glazed panel in Aluminum Channel with rubber packing

10.1.2 Stainless Steel and Teakwood Panel with plywood backing and MS Bar Support

10.2 Fixing and Installation

Fixing and installation details / arrangements shall be proposed as necessary to further install / fix pelmet as recommended by the fabricator / manufacturer and approved by the Engineer.

11. WOODEN CABINETS

All cabinets including fittings, fixtures and hardware shall be supplied of approved manufacturer and shall be of best quality fabricated by using materials and details as shown on the drawings.

11.1 Shop Drawings

The Contractor shall submit detailed shop drawings on the basis of the manufacturer's specifications including all fittings, fixtures and hardware and the same shall be got approved from the Engineer before fabrication. Samples of materials to be used in cabinets together with specifications and literature shall be supplied to the Engineer for his approval prior to start of works. The colour shade shall be as approved.

11.2 Installation

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All cabinets shall be installed in position by the manufacturer's skilled workmen specialized in the job. Works shall be executed in accordance with approved shop drawings and the manufacturer's instructions.

The Contractor shall inspect the delivered cabinets and related parts for indication or location, size required by field measurements, finishing hardware and similar preliminary works. Verify locations for installation, required floor and wall finishes, painting and all other related work. Cabinet shall exactly flush wall surfaces. Cut and fit accurately scribe strips at wall surfaces. Secure wall cabinet to blocking. Concealed fasteners, all joints surfaces shall be smooth and even. Doors and other moving parts shall exactly fit in the frame. Refit, as necessary to ensure proper and easy operation. Refit, if necessary, all cabinet and shelves hardware, test for proper operation, remove for painting and other finishing and properly replace in position with all fittings and accessories.

All work shall be thoroughly protected from damage at all times by suitable methods approved by the Engineer. Adjacent work shall similarly be protected from damage. Any damage or disfigurement shall immediately be corrected at Contractor's expense.

11.3 The works offered under this item should allow a reasonable choice variation of design/colour, etc. to suit individual test/needs, i.e. one standard design may not apply to all buildings of one type.

11.4 Cabinet work, generally all framing will be in treated hardwood with portions etc. in best quality teakwood / deodar and commercial laminated plywood or as shown on the drawing. All exposed surfaces will be covered by approved laminates. Exposed edges, if any, will be covered by polished hardwood / teakwood / deodar wood lipping. Cabinet tops shall be with or without marbles and as per details shown in the drawing or as approved by the Engineer.

12. DEFECTIVE WORK

In the event of non- conformance to specification and drawings, the wood works shall be rejected by the Engineer and the Contractor shall remove and replace the rejected work by new work of same specifications.

13. SURFACE PREPARATION

The surfaces of all wood works shall be prepared in the manner as directed by the Engineer for polishing or painting.

14. MOCK-UP SAMPLE

After approval of shop drawings and tests etc., the contractor shall submit at his own cost one mock- up sample of each type of wood works complete with all fixing, fixtures accessories prior to the actual fabrication of the bulk.

The samples shall be returned to the Contractor for incorporation in the works after installation of at least 80% of the works.

15. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0230 - ALUMINUM DOORS, WINDOWS, VENTILATORS, GLAZED PARTITION, AND COMPOSITE ALUMINUM CLADDING.

1. SCOPE

The work under this section of specification includes furnishing all labour, equipment, appliances and materials and performing all operations in carrying out the work of aluminium doors, windows, ventilators, glazed partition and composite aluminium cladding. All related items such as sealants, rubber gasket for glazing, fly proofing, rollers, latches, fastenings, glazing, anchor bolts and all items supplied by other trades and customarily built in and/or installed in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. APPLICABLE STANDARDS

Latest editions of following ISO and British Standards are relevant to these Specifications wherever applicable.

2.1 ISO (International Organization for Standardization)

1804 - Doors - Terminology

6442 - Door Leaves - Measurement of defects of general flatness

6443 - Door Leaves - Measurement of dimensions and defects of squareness

6444 - Door Leaves - Test of behaviour under humidity variations (successive uniform climates)

6612 - Windows & Doors - wind resistance tests

6613 - Windows & Doors - Air permeability test

2.2 BSI (British Standard Institution)

1227 - Hinges

4873 - Aluminium alloy windows

3. GENERAL

3.1 Doors, windows and ventilators to be provided shall be aluminium doors, windows, partition wall frame and ventilators of profile, pattern and design shown on drawings and shop drawings as approved by the Engineer. The Contractor shall provide manufacture literature completely describing the product instructions for installation and maintenance.

3.2 All the sections used for doors, windows and ventilators shall be of best quality aluminium products such as equal and unequal angles, channels, tubes, corrugated strips, mouldings etc., in accordance with international standards conforming to ASTM B 308 & B 221.

3.3 All doors, windows and ventilators, shall be of type and size indicated on drawings and shall conform to the requirements shown and specified herein.

3.4 Contractor shall arrange tests and analysis if directed by the Engineer of scaled models of each doors, windows and ventilators type - at the maker's works or any laboratory specified by the Engineer for the material supplied by the manufacturer.

3.5 The contractor shall submit shop drawings which shall show full construction details, quantities and locations, fastenings and attachment to adjacent construction and materials. Shop drawings shall be submitted at the proper time to allow for checking, revisions, agreement and to permit manufacturer's product delivery and start of site work to suit the building programme. The

Contractor shall submit representative samples of finished doors, windows and ventilators anchoring mechanism, embedded parts, fastenings, glass panes, accessories and other materials for the Engineer's approval based on details as specified or as shown in drawings. After approval of shop drawings and tests etc., the Contractor shall submit at his own cost one mock-up sample of each type of aluminium works complete with glazing, all components assembly method and required fittings and accessories prior to the actual fabrication of the bulk. The samples shall be returned to the Contractor for incorporation in the works after installation of at least 80% of the works. Fabricate and assemble all work in the shop of the approved manufacturer to reduce field fabrication to a minimum unless otherwise directed by the Engineer.

3.6 The glass shall conform to specification laid down under chapter 'Glazing section no. 6250' and shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to size as shown on drawings, so as to fit the grooves in ventilators members. All the glass shall be best quality of approved manufacture or equivalent standard as approved by the Engineer.

3.7 The structural shape of the Aluminium members shall be of uniform quality, colour and temper, clean, round, commercially straight and free from injurious defects.

3.8 All doors, windows and ventilators shall be fabricated as a complete unit, fully airtight and watertight, including rubber gasket for glazing, rollers, latch, anodized in specified colour, inclusive of glass sheet, all as approved by the Engineer.

3.9 Contractor shall, on request, get certificate signed by the manufacturer stating that each lot has been sampled, tested and inspected and has met the requirements in accordance with these specifications, and the same shall be furnished to the Engineer.

3.10 The shop drawings shall clearly show that there shall be no penetration of rainwater from the exterior to the interior in case of severe wind and rainstorm. This has to be specially ensured in sill section.

4. MATERIAL

4.1 Frames / shutters

The frames of aluminium door, windows and ventilator shall be formed from rolled, strip or extruded aluminium. The thickness of sectional members shall be at least 2.0 mm. All outer / frame sections of openable / fixed windows. Ventilators and louvers curtain wall shall be 4" (100 mm) minimum in width. The Frames for doors and door/windows curtain wall shall be at least 4" (100 mm) in width. As shown on the drawings, aluminium frames shall be provided as per international standard approved by the engineer.

4.3 Fasteners shall be stainless steel of a type selected to prevent galvanic action with the components fastened.

4.4 Gaskets shall be vinyl glazing channel gasket to commercial standard CS-230-60.

4.5 Hardware shall be manufacturer's standard hardware. Flush to match doors, windows, ventilators and louvers finish. Floor mounted concealed type double action/swing imported door closures shall be provided to all doors. Heavy-duty in-matching finish stays shall be provided to all openable windows, ventilators and louvers. Stays shall be attached to the window frame so as could be replaced easily.

4.6 Joint sealant shall be approved elastomer.

4.7 All Aluminium sections shall be powder coated in accordance with the standards of Aluminium Association of USA. The anodisation shall be of not less than 70-90 microns. The anodic oxide surface shall be properly sealed.

4.8 For powder coated finish aluminium sections to be coated shall be mill finish. The sections shall be firstly degreased with a degreasing chemical to remove all/any stains. The sections will then be given a chromating coating and electro static powder coating in the desired colour with a powder-coating machine. After colour coating the sections will be baked at baking temperature of 220 degree Centigrade for 25 minutes PVDF (polyvinylidene fluoride) coatings should be used for protection.

4.9 All sliding/openable windows shall have sliding/openable wire/fly screen shutters in window matching finish with wire/fly screen of size so as not to permit the entry of flies and mosquitoes. The wire mesh shall be 30 SWG. 14 mesh (14 x 14 openings per square inch).

5. DESIGN REQUIREMENT

The Contractor shall design the installation to meet or excel the following requirements.

5.1 Tolerances

The Contractor shall be responsible for agreeing to all dimensions with the Engineer before proceeding with the manufacture and for making provision to allow for building tolerances required by the Engineer. Contractor shall also take site measurements of the structure completed before manufacturing.

5.2 Thermal & Seismic Movements

The window and glazing assemblies are to be constructed and installed in the openings with sufficient tolerance and, where necessary, to provide for joints incorporated in couplings, to provide for expansion and contraction as will be caused by the local seismic and climatic conditions and temperature changes, winter to summer - day to night without buckling, distortion of joints, or other harmful effects.

6. WORKMANSHIP

The Contractor shall be responsible for the protection and installation of all items furnished. All items shall be installed plumb and square and shall be solidly anchored in a good workman like manner in accordance with the manufacturer's instruction and as specified herein. The Contractor shall be responsible for the protection of installed items from damage by other trades. All items shall be left in operating, neat and clean condition, free from dirt, finger marks, etc. The Contractor shall be responsible for final cleaning before the final acceptance. The glass panes shall firmly be secured in the rebates with the rubber gasket. Ensure that the beads and grooves are clean, dry and cleaned at the time of glazing. The complete unit shall be airtight and watertight.

7. PRODUCT DELIVERY AND STORAGE

7.1 Deliver doors, windows and ventilators in a manner preventing damage to units. Store materials off the ground under cover in a manner preventing deterioration or damage.

7.2 All embedded parts and anchor bolts shall be delivered to the site carefully and keeping the fabricated shape and configuration. All these parts shall be suitably marked for identification.

8. ERECTION

Rawplugs and anchoring bolts shall be embedded into the concrete or brick masonry for holding the doors, windows and ventilators in their correct positions. Care shall be taken to install the doors, windows and ventilator in line and plumb & solidly anchored in a good workman like manner in accordance with the drawings. Should any scale or scratch appears on the surface of doors, windows and ventilators, the contractor shall at his own expense and at the Engineer's direction have all exposed surfaces cleaned to bare bright specified colour. All works shall be installed strictly in accordance with the manufacturer's printed instructions.

9. PROTECTION AND CLEANING

9.1 Temporary protection shall be achieved by applying water soluble protective coating capable of withstanding the action of lime mortar.

9.2 Apply coating in the manufacturer's plant to the exposed surfaces of all components.

9.3 Before application of coating, remove all fabrication compounds, moisture and dirt accumulations.

10. DEFECTIVE WORK

In the event of non-conformance to specifications and drawings the aluminium work shall be rejected by the Engineer and the Contractor shall remove and replace the rejected works by new work of same specifications.

11. GUARANTEE

11.1 The manufacturer shall furnish his standard written guarantee against leakage of rain, excessive infiltration of dust and air and all defects in materials and workmanship covering all work under this section.

11.2 Such guarantee shall be in addition to and not in lieu of all other liabilities which manufacturers and the Contractor may have by law or by other provisions of the Contract Documents.

12. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0235 – ARFF GARRAGE DOOR

1. GENERAL

1.1 Scope

This Section specifies the design, manufacture, supply, installation, testing, and commissioning of insulated, power-operated vehicle bay (apparatus/garage) doors for the ARFF (Aircraft Rescue and Fire Fighting) vehicle room of the Fire Station at Skardu International Airport, including all associated hardware, controls, safety devices, and thermal-sealing systems necessary to achieve the operational and environmental performance required herein.

1.2 Reference Standards

The Contractor shall comply with the latest editions of the following, and any conflict shall be resolved in favor of the more stringent requirement, subject to the Engineer's determination:

- FAA Advisory Circular AC 150/5210-15A, Aircraft Rescue and Firefighting Station Building Design (vehicle bay door criteria).
- ICAO Doc 9137, Airport Services Manual, Part 1 — Rescue and Fire Fighting (vehicle readiness and station environmental control provisions).
- ICAO Annex 14, Volume I — Aerodrome Design and Operations.
- ANSI/DASMA 102 and UL 325 (or equivalent recognized standard) for power-operated door safety.
- Building Code of Pakistan, seismic and wind load provisions).

1.3 Site and Environmental Design Conditions

Skardu International Airport is located at approximately 2,228 m (7,310 ft) AMSL in a high-altitude, cold semi-arid mountain climate with a wide diurnal and seasonal temperature range, low ambient humidity, intense solar radiation, and seasonal snowfall. The airfield is a joint civil/military facility. Vehicle bay doors and associated envelope components shall be designed for the following indicative site conditions, to be confirmed by the Contractor against the site-specific meteorological data appended to the bidding documents:

Parameter	Design Value (indicative)
Winter design (outdoor) temperature	-25°C (extreme minima lower)
Summer design (outdoor) temperature	40°C
Required maintained vehicle room (garage) temperature	13°C ± 2°C (per ICAO Doc 9137)
Elevation	≈ 2,230 m AMSL
Snow / frost exposure	Significant seasonal snowfall and freeze-thaw cycling
Wind loading	Per site-specific wind study / Building Code of Pakistan

Note: ICAO Doc 9137, Part 1, recommends that vehicle bay ambient temperature be maintained at approximately 13°C so that ARFF vehicle engines, hydraulic and pneumatic systems, foam concentrate, and batteries remain within their operating range and are capable of achieving the required response readiness at all times, including sub-zero exterior conditions.

1.4 Submittals

- Manufacturer's technical data sheets, U-value/thermal performance certificates, and structural (wind load) calculations.
- Shop drawings showing door assembly, jamb/head/sill details, thermal break, and interface with wall insulation and vapor barrier.
- Control system schematics including safety edge, photo-electric reversing sensors, and interface with the station fire alarm/dispatch system.
- Operation and maintenance (O&M) manuals, spare parts list, and warranty certificates.

2. DESIGN REQUIREMENTS

2.1 Door Type and Configuration

Provide factory-insulated, sectional (or vertical-lift) power-operated overhead doors purpose-selected for cold-climate ARFF service. Drive-through (bi-directional) bay configuration shall be provided where indicated on the drawings to reduce vehicle turnaround time and minimize door-open duration and associated heat loss.

2.2 Door Sizing

- Minimum clear opening: 16 ft (4.87 m) width × 16 ft (4.87 m) height; standard opening: 18 ft (5.48 m) width × 18 ft (5.48 m) height, sized to suit the largest ARFF vehicle in the current and planned fleet, whichever governs.
- Minimum clearances: 1.8 m between vehicle and walls/storage; 2.4 m between vehicles parked side by side; 1.5 m between vehicles parked end to end; 1.5 m between vehicle and bay doors; adequate overhead clearance above vehicle roof height to clear door tracks/mechanisms and any roof-mounted equipment.

2.3 Operating Speed

- Maximum full-open time: 16 seconds (approximately 0.3 m/second), operable by remote control from the watch/alarm room, by a control station at each door, or automatically via the station alarm system.
- Adjustable auto-close timers shall be provided to minimize heat loss when the bay is unattended, without compromising unobstructed emergency egress.

2.4 Thermal Performance

Given the requirement to maintain the vehicle room at 13°C under Skardu's winter design conditions, the door assembly (not the HVAC system alone) shall contribute materially to the building thermal envelope performance as follows:

- Insulated steel or aluminum sectional panels with rigid polyurethane (CFC-free) core, nominal thickness 40–45 mm.
- Panel thermal transmittance: U-value not exceeding 0.5 W/m²K (or R-value not less than R-16, US units), verified by an independent test certificate.
- Full-perimeter weather seals (head, jamb, astragal/meeting rail, and bottom seal) rated for sub-zero flexibility without hardening or cracking.
- Thermal break at all metal-to-metal contact points in tracks and hardware to minimize condensation and cold bridging.
- Maximum allowable air infiltration rate at the specified design wind pressure, tested per ASTM E283 or equivalent, to be stated by the manufacturer and reviewed by the Engineer.

3. MATERIALS AND CONSTRUCTION

3.1 Panels

- Galvanized/pre-painted steel or marine-grade aluminum skins, minimum 24-gauge (or approved equal), factory finished in a color to match the station facade, resistant to UV degradation from high-altitude solar exposure.
- Vision panels, where required, shall be double-glazed tempered safety glass, insulated, and positioned to allow the driver and station personnel to view the apron from both the vehicle seat and the vehicle room floor.

3.2 Tracks, Springs, and Hardware

- Heavy-duty galvanized steel tracks and torsion springs rated for the specified cycle life (minimum 20,000 cycles) and for continued operation in sub-zero ambient temperatures without lubricant thickening or seizure; cold-weather rated lubricants shall be used.
- All fasteners and hardware shall be corrosion-resistant (stainless steel or hot-dip galvanized) suited to freeze-thaw and de-icing chemical exposure.

3.3 Operators and Controls

- Heavy-duty electric operator sized for the specified door weight and cycle rate, rated for continuous duty ARFF service, with cold-weather rated motor and gear-drive components.

- Each door shall have an individually operable manual chain/crank override, capable of one-person full-height operation within the 16-second standard, located on the driver's side.
- A separate master override control, capable of opening all bay doors, shall be provided in the apparatus bay and/or the watch/alarm/dispatch room.
- Photo-electric (electric-eye) reversing sensors shall be provided at a height that both protects personnel and reliably detects the forward-most projection of the ARFF vehicle (e.g., bumper or bumper turret).
- A mechanical/electrical safety edge or equivalent contact-sensing auto-reversing device shall be installed on the door bottom bar; pneumatic-only sensing devices are not acceptable given sustained sub-zero conditions.
- A red warning light, clearly visible to ARFF personnel, shall automatically illuminate whenever any bay door is in motion.

4. STRUCTURAL AND SAFETY REQUIREMENTS

- Doors and supporting structure shall be designed for the site-specific wind and seismic loads applicable to Skardu (Gilgit-Baltistan seismic zone) and shall withstand snow/ice accumulation loading on tracks and header assemblies without impairing operation.
- Door assemblies and controls shall comply with a recognized power-operated door safety standard (e.g., UL 325 / ANSI/DASMA 102 or equivalent) for entrapment protection.
- Emergency manual release shall not require special tools and shall be operable from inside the vehicle room at all times, including during a power outage.

5. ENVIRONMENTAL / HVAC COORDINATION

The Contractor shall coordinate the door thermal performance data with the mechanical (HVAC) design of the vehicle room so that the combined envelope and heating system maintain the interior at $13^{\circ}\text{C} \pm 2^{\circ}\text{C}$ under the winter design condition specified in Clause 1.3, in accordance with ICAO Doc 9137. Where the door open-time analysis (based on the 16-second operating standard and expected alarm response frequency) indicates that infiltration heat loss during door cycling would prevent the HVAC system from maintaining 13°C , the Contractor shall propose supplementary measures for the Engineer's review, such as:

- An air curtain (heated, cold-climate rated) mounted at the interior head of each bay door; or
- A vestibule/entry lobby arrangement; or
- Increased in-floor or unit heater capacity local to each bay, coordinated with the HVAC specification.

Any such supplementary measure and its associated BOQ item(s) shall be read together with the HVAC Technical Specification and BOQ for this project, and shall not be considered part of the door supply cost unless separately itemized.

6. INSTALLATION, TESTING AND COMMISSIONING

- Install strictly per the manufacturer's instructions and approved shop drawings, with head, jamb, and sill flashing and air/vapor sealing integrated with the building envelope to avoid thermal bridging or air leakage paths.
- Functionally test each door for full open/close cycle time (≤ 16 seconds), manual override operation, master override operation, photo-electric and safety-edge reversal, auto-close timer function, and warning light operation.
- Conduct a thermographic (infrared) survey of each installed door and its perimeter seal after installation to confirm the absence of significant thermal bridging, prior to issuance of the taking-over certificate.
- Demonstrate, jointly with the HVAC Contractor, maintenance of the specified 13°C garage set-point over a minimum 48-hour monitoring period spanning at least one door-cycling test regime representative of expected alarm response frequency.

7. WARRANTY, SPARES, AND MAINTENANCE

- Minimum manufacturer's warranty: 2 years on door panels, hardware, and operator; minimum 5 years on the insulated panel core against delamination.
- Provide a minimum of one complete set of critical spare parts per door (springs, cables, photo-eye pair, seals) and a recommended spares list for a 5-year operating period.
- Provide O&M manuals and on-site training to station maintenance personnel prior to hand-over.

8. MEASUREMENT AND PAYMENT

Payment shall be made on a per square feet basis under the relevant BOQ item(s), and shall be deemed to include supply, delivery, installation, all hardware, controls, safety devices, testing, commissioning, thermographic survey, O&M documentation, training, and warranty as specified herein, unless a separate BOQ item is provided for supplementary heating/air-curtain measures under Clause 5.

SECTION 0240 - ALUMINUM COMPOSITE PANEL CLADDING SYSTEM

1. SCOPE

Furnish all labour, material, equipment, tools, formwork and services required to complete the works covered in these specifications in accordance with the drawings and as approved by the Engineer.

Aluminum Composite Panel system includes but not limited to the following components:

- a. Aluminum composite panel façade with mounting system. Metal stud framing system including anchorages, shims, fuming, fasteners, gaskets and sealants, related flashing adapters, and masking (as required) for a complete watertight installation.
- b. Parapet coming, exterior column covers, soffits, sills, border, and filler items indicated as integral components of the panel system.
- c. Coordination of the works with other trades/contractors.

2. APPLICABLE STANDARDS

1. Aluminum Association

- i. AA-C22-A41: Anodized - Clear Coatings.
- ii. AA-C22-A42: Anodized - Integral Color Coatings.

2. American Architectural Manufacturers Association

- i. AAMA 508-05; Voluntary Test Method and Specification for Pressure Equalized Rain Screen Wall Cladding Systems

3. American Society For Testing And Materials

- i. E 330 Structural Performance of Exterior Windows, Curtain Walls, and Doors under the influence of wind loads.
- ii. E 283 Rate of Leakage through Exterior Windows, Curtain walls, and Doors.
- iii. D 1781 Climbing Drum Peel Test for Adhesives
- iv. E 84 Surface Burning Characteristics of Building Materials
- v. D 3363 Method for Film Hardness by Pencil Test
- vi. D 2794 Resistance of Organic Coatings to the Effects of Rapid Deformation (impact).
- vii. D 3359 Methods for Measuring Adhesion by Tape Test
- viii. D 2247 Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
- ix. B 117 Method of Salt Spray (Fog) Testing
- x. D 822 Practice for Operating Light and Water Exposure apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products.

3. SUBMITTALS

1. Submittals shall be in conformance with relevant Sections of these specifications.
2. Samples: Panel system assembly: Two samples of each type of assembly; 304mm (12") x 304 mm (12") minimum. Submit samples of typical aluminum composite panel of specified type,

thickness and color (or finish selected), 100mm (4") x 100 mm (4") minimum, along with framing system.

Shop Drawings: Submit complete shop drawings showing all design calculations, project layout and elevations, detailed scaled drawings, installation, fastening and anchoring methods, detail and location of joints, sealants, and gaskets, including joints necessary to accommodate thermal movement, trim, flashing; and accessories.

3. Affidavit certifying sufficiency and stability of aluminum composite panel system and assuring that system meets project requirements.

4. Manufacturer's Certificate regarding origin and country of manufacturer.

5. Manufacturer's literature for panel material. Panel manufacturer's product data, consisting of complete product description and specification.

6. Submit panel system fabricator's installation manual, indicating the procedures to be followed by the contractor in forming, sealing and installing the attachment system.

7. Method for maintaining installed products and precautions against cleaning materials and methods detrimental to finishes and performance.

8. Code Compliance: Documents showing product compliance with the national and local building code shall be submitted by the Contractor. These documents shall include, but not be limited to, appropriate Evaluation Reports and/or test reports supporting the use of the product.

4. QUALITY ASSURANCE

Composite Panel Manufacturer shall have a minimum of 5 years experience in the manufacturing of this product.

Composite Panel Manufacturer shall be solely responsible for panel manufacture and application of the finish.

Fabricator/installer shall be acceptable to the composite panel manufacturer and subjected to the approval of the Engineer.

Fabricator/Installer shall have a minimum 5 years experience of metal panel work similar, in scope and size to this project.

6. Aluminum Composite Panel shall be the product of approved manufacturer only.

7. The panel system shall have been pre-tested by an independent testing laboratory to provide specified resistance to air and water infiltration and structural deflection, when installed.

8. Field measurements should be taken prior to the completion of shop fabrication. Field fabrication may be allowed to ensure proper fit. However, field fabrication shall be kept to an absolute minimum with the majority of the fabrication being done under controlled shop conditions.

9. Shop drawings shall show the preferred joint details providing a watertight and structurally sound wall panel system that allows no uncontrolled water penetration on the inside face of the panel system as determined by ASTM E 331. Systems not utilizing a construction sealant at the panel joints (i.e. Rout and Return Dry and Rear Ventilated System) shall provide a means of concealed drainage with baffles and weeps for water which may accumulate in members of the system.

10. Maximum deviation from vertical and horizontal alignment of erected panels; 6mm (1/4") in 6m (20') non-accumulative.

11. Panel fabricator/installer shall assume undivided responsibility for all components of the exterior panel system including, but not limited to attachment to sub-construction, panel to panel joinery, panel to dissimilar material joinery, and joint seal associated with the panel system.

5. PANELS

1. Aluminum Composite Panels / Jaffery

Aluminum composite panel / Jaffery shall be 4 mm thick in approved colour / texture / finish, comprising 3mm noncombustible mineral-filled core sandwich between two skins of 0.5mm thick Aluminum alloy fire rated / resistant.

The surface shall be finished with a high-performance lumifion based fluorocarbon coating / PVDF coating on the topside and service coating on the reverse side.

Composite Aluminum Jaffrey laser cut as cladding / covering material shall be used from approved manufacturer.

2. Product Performance

i) Bond Integrity

When tested for bond integrity, in accordance with ASTM D1781 (simulating resistance to panel delamination), there shall be no adhesive failure of the bond between the core and the skin nor cohesive failure of the core itself below the following values;

Peel Strength: 115 N mm/mm (22.5 in lb/in) as manufactured; 115 N mm/mm (22.5 in lb/in) after 21 days soaking in water at 70°F

ii) Fire Performance

ASTM E 84 Flame Spread index, Smoke Developed index.

ASTM D 1929 A self-ignition temperature of 650°F or greater.

ASTM D-635 Requires a CC1 classification.

3. Finishes

Lumifon based metallic color dry film thickness shall be minimum 35μ and consist of conversion coat an inhibitive primer, metallic and clear lumifon based fluorocarbon coat / PVDF color 1.0 mil thickness. The reverse side of the cladding panel surface facing the wall shall have a polyester-based wash coating to protect against corrosion.

a. Hardness: ASTM D-3363; HB minimum using Eagle Turquoise Pencil.

b. Impact:

1) Test method: ASTM D-2794; Gardner Variable impact Tester with 5/8" mandrel.

2) Coating shall withstand reverse impact of 1.5% pounds per mil substrate thickness.

3) Coating shall adhere tightly to metal when subjected to #500 Scotch Tape pick-off test. Slight minute cracking permissible. No removal of film to substrate.

c. Adhesion:

1) Test Method: ASTM D-3359.

2) Coating shall not pick off when subjected to an 11" x 11" x 1/16" grid and taped with #600 Scotch Tape.

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d. Humidity Resistance:

1) Test Method: ASTM D-2247.

2) No formation of blisters when subject to condensing water fog at 100% relative humidity and 100°F for 4000 hours.

e. Salt Spray Resistance:

1) Test Method: ASTM B-117; Expose coating system to 4000 hours, using 5% NaCl solution.

3) Corrosion creepage from scribe line: 1/16" max.

4) Minimum blister rating of 8 within the test specimen field.

i. Weather Exposure:

1) Outdoor:

a. Maximum color change of 5 Delta E units as calculated in accordance with ASTM D-2244.

b. Maximum chalk rating of 8 in accordance with ASTM D-4214.

c. No checking, crazing, adhesion loss.

ii. Chemical Resistance:

1) ASTM D-1308 utilizing 10% Muriatic Acid for an exposure time of 15 minutes. No loss of film adhesion or visual change when viewed by the unaided eye.

2) ASTM D-1308 utilizing 20% sulfuric Acid for an exposure time of 18 hours. No loss of film adhesion or visual change when viewed by the unaided eye.

3) AAMA 2605 utilizing 70% reagent grade Nitric Acid vapor for an exposure time of 30 minutes. Maximum color change of 5 Delta E units as calculated in accordance with ASTM D-2244.

6. PANEL FABRICATION

1. Composition

Two sheets of aluminum sandwiching a 3mm noncombustible mineral filled solid core formed in a continuous process with no glues or adhesives between dissimilar materials. The core material shall be free of voids and/or air spaces and not contain foamed insulation material. Products laminated sheet by sheet in a batch process using glues or adhesives between materials shall not be acceptable.

2. Aluminum Face Sheets: Thickness: 0.5mm (nominal)

3. Panel Weight: 4mm: 1.12 lbs./ft²

4. Tolerances

i. Panel Bow: Maximum 0.8% of any 1828mm (72") panel dimension.

ii. Panel Dimensions: Field fabrication shall be allowed where necessary but shall be kept to an absolute minimum. All fabrication shall be done under controlled shop conditions when possible.

iii. Panel lines, breaks, and angles shall be sharp, true, and surfaces free from warp and buckle.

iv. Maximum deviation from panel flatness shall be 1/8" in 5'-0" on panel in any direction for assembled units. (Non-accumulative - No Oil Canning).

5. System Characteristics

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- i. Plans, elevations, details, characteristics, and other requirements indicated are based upon standards by one manufacturer. It is intended that other manufacturers, receiving prior approval, may be acceptable, provided their details and characteristics comply with size and profile requirements, and material/performance standards.
- ii. System must not generally have any visible fasteners, telegraphing or fastening on the panel faces or any other compromise of a neat and flat appearance.
- iii. System shall comply with the applicable provisions of the "Metal Curtain Wall, Window, Storefront, and Entrance Guide Specifications Manual" by AAMA and ANSI/AAMA 302.9 requirements for aluminum windows.
- iv. Fabricate panel system to dimension, size, and profile indicated on the drawings based on a design temperature of 70°F.
- v. Fabricate panel system so that no restraints can be placed on the panel, which might result in compressive skin stresses. The installation detailing shall be such that the panels remain flat regardless of temperature change and at all times remain air and water tight.
- vi. The finish side of the panel shall have a removable plastic film applied prior to fabrication, which shall remain on the panel during fabrication, shipping, and erection to protect the surface from damage.

7. SYSTEM PERFORMANCE

1. Composite panels shall be capable of withstanding building movements and weather exposures based on the following test standards required by the Architect and/or the local building code.

a. Wind Load

If system tests are not available, mock-ups shall be constructed and tests performed under the direction of an independent laboratory, which show compliance to the following minimum standards;

Panels shall be designed to withstand the Design Wind Load based upon the local building code, but in no case less than 50 pounds per square foot (psf). Wind load testing shall be conducted in accordance with ASTM E330 to obtain the following results.

Normal to the plane of the wall between supports, deflection of the secured perimeter-framing members shall not exceed $L/175$ or $3/4$, whichever is less.

Normal to the plane of the wall, the maximum panel deflection shall not exceed $L/60$ of the full span.

Maximum anchor deflection shall not exceed $1/16"$.

At $1\frac{1}{2}$ times design pressure, permanent deflections of framing members shall not exceed $L/100$ of span length and components shall not experience failure or gross permanent distortion. At connection points of framing members to anchors, permanent set shall not exceed $1/16"$.

b. Air/Water System Test

If system tests are not available, mock-ups shall be constructed and tests performed under the direction of an independent laboratory, which show compliance to the following minimum standards.

Air Infiltration - When tested in accordance with ASTM E283-84, air infiltration at 10.0 psf must not exceed 0.06 cfm/ft² of wall area.

Water Infiltration - (ASTM 383) Water infiltration is defined as uncontrolled water leakage through the exterior face of the assembly. Systems not using a construction sealant at the panel joints (i.e. Rout and Return Dry and Rear Ventilated Systems) shall be designed to drain any water leakage occurring at the joints. No water infiltration shall occur in any system under a differential static pressure of 15 psf with a water spray rate of 5 gallons per hour per sq.ft. minimum for 15 minutes.

c. Fire Performance Characteristics: Test in accordance with ASTM E84, E108 (modified) & E162.

d. Pressure Equalized Rain Screen Systems shall comply with AAMA 508-05 Voluntary Test Method and Specification for Pressure Equalized Rain Screen Wall Cladding Systems.

8. MATERIALS (SYSTEM COMPONENTS)

1. Extrusions, formed members, sheet, and plate shall conform with ASTM B209 and the recommendations of the manufacturer.

2. Panel stiffeners, if required, shall be structurally fastened or restrained at the ends and shall be secured to the rear face of the composite panel with silicone of sufficient size and strength to maintain panel flatness. Stiffener material and/or finish shall be compatible with the silicone.

3. Sealants and gaskets within the panel system shall be as per manufacturer's standards to meet performance requirements.

4. Fabricate flashing materials from 0.030" minimum thickness aluminum sheet painted to match the adjacent curtain wall / panel system where exposed. Provide a lap strap under the flashing at abutted conditions and seal lapped surfaces with a full bed of non-hardening sealant.

5. Fasteners (concealed/exposed/non-corrosive): Fasteners as recommended by panel manufacturer. Do not expose fasteners except where unavoidable and then match finish of adjoining metal.

9. INSPECTION

1. Surfaces to receive panels shall be even, smooth, sound, clean, dry and free from defects detrimental to work. Notify contractor in writing of conditions detrimental to proper and timely completion of the work. Do not proceed with erection until unsatisfactory conditions have been corrected.

2. Surfaces to receive panels shall be structurally sound as determined by a registered Architect / Engineer.

10. DELIVERY, STORAGE AND HANDLING

1. Protect finish and edges in accordance with panel manufacturer's recommendations.

2. Store material in accordance with panel manufacturer's recommendations.

11. INSTALLATION

1. Erect panels plumb, level, and true.

2. Attachment system shall allow for the free and noiseless vertical and horizontal thermal movement due to expansion and contraction for a material temperature range of -20°F to +180°F. Buckling of panels, opening of joints, undue stress on fasteners, failure of sealants or any other detrimental effects due to thermal movement will not be permitted.

Fabrication, assembly, and erection procedure shall account for the ambient temperature at the time of the respective operation.

3. Panels shall be erected in accordance with an approved set of shop drawings.

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4. Anchor panels securely per engineering recommendations and in accordance with approved shop drawings to allow for necessary thermal movement and structural support.
5. Conform to panel fabricator's instructions for installation of concealed fasteners. Do not install component parts that are observed to be defective and warped, bowed, dented, abraded, and broken members.
6. Do not cut, trim weld or blaze component parts during erection in a manner which would damage the finish, decrease strength, or result in visual imperfection or a failure in performance. Return component parts which require alteration to shop for re-fabrication, if possible, or for replacement with new parts.
7. Separate dissimilar metals and use gasketed fasteners where needed to eliminate the possibility of corrosive or electrolytic action between metals.
8. Sub-framing for panels will be in standard Aluminum section designed / recommended by manufacturer. Non-standard Aluminum channel will not be acceptable.

12. WARRANTY

The Contractor shall warrant that the system supplied and installed will be free from defects in materials and workmanship for a period of ten (10) years from the date of substantial completion certificate.

13. ADJUSTING AND CLEANING

1. Remove and replace panels damaged beyond repair as a direct result of the panel installation. After installation, panel repair and replacement shall become the responsibility of the General Contractor.
2. Remove masking (if used) as soon as possible after installation. Masking intentionally left in place after panel installation on an elevation, shall become the responsibility of the General Contractor.
3. Any additional protection, after installation, shall be the responsibility of the Contractor.
4. Make sure weep holes and drainage channels are unobstructed and free of dirt and sealants.

14. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0250 - GLAZING

1. SCOPE

The work under this section of the Specifications consists of furnishing all labour, equipment, tools, appliances, scaffolding and providing glass gaskets, sealants, compound and other materials required for performing all operations in connection with the installation and setting of all types of glass, glazing and glass blocks complete in every respect in accordance with the Drawings or as directed by the Engineer. The scope of this section of Specifications is covered with detailed Specifications as laid down herein.

2. APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these Specifications wherever applicable.

2.1 BSI (British Standards Institution)

952 - Glass for glazing

5051 - Security glazing part I & II

CP.152 - Glazing

3. GENERAL

3.1 Each type of glass shall have the manufacturer's label on each pane, and the labels shall remain on the glass until final cleaning.

3.2 Glazing sealant shall be as recommended by the manufacturer for the particular application.

3.3 Spacer shims (distance pieces) shall be plasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on drawings between glass and rebates, bead or cleat. Depth shall give not less than 6 mm cover of glazing sealant.

3.4 Contractor shall submit samples for each type of glass, minimum 1200mm x 1200mm in size with protective edges. Samples of glazing sealant minimum 0.1 liter of specified types shall be submitted. Samples of minimum of three glass blocks shall also be submitted.

3.5 Contractor shall submit 300mm long sample of each type of glazing gasket.

3.6 Contractor shall also submit printed materials manufacturer's installation instructions for specified glazing gaskets, compounds sealant and accessories including description of required equipment and procedures and precautions to be observed.

4. DELIVERY STORAGE AND HANDLING

4.1 Contractor shall deliver materials in manufacturer's original, unopened containers clearly labeled with manufacturer's name and address, material, brand, type, class and rating as applicable.

4.2 Contractor shall store the materials in original unopened containers with labels intact/protected from ground contact and from elements, which may damage glass.

4.3 Contractor shall handle the materials in a manner to prevent breakage of glass and damage to surfaces.

5. MATERIALS

5.1 General

Glass shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to fit the rebates so as to have a uniform clearance of 1.6mm round the panes between the edges of glass and the rebates.

5.2 Sheet glass

It shall be first quality clear glass conforming to the applicable requirements of B.S 952 "Glass for Glazing". Unless otherwise indicated glass shall be 5mm thick glass for exterior window except where obscure glass is specified. Glass shall be free from specks, bubbles, deterioration and flows of every kind.

5.3 Frosted Glass

Frosted Glass shall be 6mm thick except as otherwise indicated. Glass shall be of approved pattern.

5.4 Glazing Sealants and Compounds

Contractor shall provide material colored to match frame in which glass is installed. Provide only compounds known to be fully compatible with surfaces which they will contact as follows.

5.5 Laminated Glass

Glass details shall be as follows:

5.5.1 Glass for internal windows, ventilator & door shall be 12mm thick (6 + 6) laminated glass (clear) and of imported origin.

5.5.2 Glass for internal windows, ventilator & door shall be 12mm thick (6 + 6) laminated glass (tinted) and of imported origin.

5.5.3 Glass for external curtain wall facade (general building areas) shall be 32mm thick double glazed Insulating Glass Unit (IGU) of imported origin (Guardian / Saint-Gobain / AGC or approved equal), comprising: Outer pane: 10mm heat-strengthened tempered glass with SN-40 solar-control coating; Air gap: 12mm argon-gas-filled cavity with warm-edge spacer; Inner pane: 8mm laminated safety glass (4mm + 0.76mm PVB interlayer + 4mm), both lites clear float with chemical interlayer insertion. Glass shall be free from distortion, seeds and blemishes. U-value (centre of glass): not exceeding 1.5 W/m²K. SHGC: 0.25–0.40. VLT: minimum 40%.

5.5.4 Glass for the ATC Tower curtain wall facade shall be 46mm thick triple glazed Insulating Glass Unit (IGU) of imported origin (Guardian / Saint-Gobain / AGC or approved equal), comprising: Outer pane: 10mm heat-strengthened tempered glass with SN-40 solar-control coating; First air gap: 10mm argon-gas-filled cavity with warm-edge spacer; Middle pane: 8mm clear tempered glass; Second air gap: 10mm argon-gas-filled cavity with warm-edge spacer; Inner pane: 8mm laminated safety glass (4mm + 0.76mm PVB interlayer + 4mm), both lites clear float with chemical interlayer insertion. U-value (centre of glass): not exceeding 1.1 W/m²K. SHGC: 0.20–0.35. VLT: minimum 45%. Glass of imported origin.

5.6 Tempered Glass Swing Doors

Tempered glass swing doors shall be 12mm thick fully toughened (tempered) safety glass to BS EN 12150 or ASTM C1048, fabricated by approved manufacturers and installed through their approved fabricators. Each door shall be complete with D-Lock, silicon patch moving machines, floor springs, top pivots, pull handles and all necessary accessories. Cutting of holes, making good of damages and all associated works are included. Glass shall be free of visible defects and edge damage. Each pane shall bear the manufacturer's permanent ceramic-fired mark confirming toughened status and standard of manufacture.

5.7 Tempered Glass Partitions with Safety Film

Internal glass partitions shall be 12mm thick fully toughened (tempered) safety glass, with 3mm anti-shatter safety film (175 micron polyester, optically clear) applied to the protected face. Framing system shall comprise: aluminium section D-48 (100mm × 38mm, 2mm wall thickness), anodized to approved colour; and stainless steel top rail pipe 1.5" × 3" (18 gauge), fixed to structural soffit. All aluminium fittings, fixings and accessories are included. Glass cutting and making good of damages to walls are included.

5.8 Double Glazed Aluminium Sliding Windows

Double glazed aluminium sliding windows shall comply with British Standards and shall be of the Executive model section, fabricated from anodized aluminium extrusion 101mm × 37mm, minimum 2mm wall thickness, to approved colour. Each unit shall include aluminium insect mesh (fly) screen, all hardware fittings, weather-stripping, and all accessories. Glazing: 6mm thick tinted float glass panes (double glazed configuration); glass to conform to Clause 5.2 and 5.4 of this Section. Fixing to M.S. box pipe or aluminium surround, including cutting holes and making good damages to walls, complete.

5.9 Aluminium Curtain Wall Framing System

The aluminium curtain wall framing system for facade glazing (Items 15 and 16 of the BOQ) shall be an Aluminium Thermal Break Stick System with mullion and transom members, anodized coating to approved colour, designed for a minimum wind load of 140 km/h. System components shall include: Structural support: M.S. bracket, hot-dip galvanized, with anchor bolt assembly (Indux or approved equal); stainless steel centre bolting; Seals and jointing: EPDM gaskets; weather sealant (Dolphins / Sika or approved equal); Flashings/trimmings: 1.5mm galvanized sheet steel with 1mm thick waterproofing membrane, including all necessary hardware; Fire barriers at each floor slab edge: 2mm galvanized sheet steel with 32 kg/m³ density mineral-wool insulation, including all necessary hardware. All ironmongery and hardware required for a complete, weather-tight and structurally adequate installation shall be included.

6. INSTALLATION OF GLAZING

6.1 Glazing shall comply with the recommendations contained in the "MANUAL of GLAZING" of the Glass Marketing Association or as specifically recommended otherwise by the glass and glazing materials manufacturers.

6.2 Examine each piece of glass and discard and replace glass with edge damage or face imperfection. All glazing shall be wind tight and fully water tight on completion.

6.3 Clean glazing channels and other framing members indicated to receive glass. Remove coatings which are not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever electrometric sealants are to be used. Apply primer and sealer to joint surfaces wherever recommended by the sealant manufacturer and as shown on the drawings.

6.4 Clean excess glazing materials from surrounding surfaces immediately after installation and eliminate stains and discolorations.

6.5 Cure glazing, sealants and compounds in compliance with manufacturer's instructions to obtain high early bond strength, internal cohesive strength and surface durability.

6.6 While glazing operation is in progress great care shall be taken to avoid breakage or damage to the glass and adjoining glazing. The Contractor shall make good at his own cost, all glass broken by his workmen while cleaning or carrying out other operations. On the completion of the glazing work, all glass that has been set by the Contractor shall, if it becomes loose, within the maintenance period, be refixed at Contractor's expense.

6.7 No glazing shall be considered complete until and unless paint and other stains have been removed from the surface of the glass and checked by the Engineer for water tightness.

7. PROTECTION AND CLEANING OF GLAZING

7.1 Remove all smears, labels and excess glazing sealant. Leave clean inside and outside free from scratches. The Contractor shall be responsible for the protection of installed glass. Before final acceptance, damaged or broken glass shall be removed and replaced with new glass at no additional expense to the Employer.

7.2 All glass surfaces shall be washed clean both inside and outside within two weeks prior to final acceptance by the Employer.

8. ATC CONTROL CABIN GLAZING (SPECIAL REQUIREMENTS)

The glazing of the Air Traffic Control cabin shall, in addition to all general requirements of this Section, comply with the following performance criteria, having regard to the operational role of the cabin, the high-altitude location and the wide temperature range of the site:

- (a) Insulating glass unit (IGU): triple glazed, 46mm thick overall, comprising: Outer pane — 10mm heat-strengthened tempered glass with SN-40 solar-control low-emissivity coating (Guardian / Saint-Gobain / AGC or approved equal); First cavity — 10mm argon-gas-filled with warm-edge spacer; Middle pane — 8mm clear heat-strengthened tempered float glass; Second cavity — 10mm argon-gas-filled with warm-edge spacer; Inner pane — 8mm laminated safety glass (4mm + 0.76mm PVB interlayer + 4mm), both lites clear float with chemical interlayer insertion (2 plies). Factory pressure-equalised for installation altitude 2,230 m AMSL. Glass of imported origin (Guardian / Saint-Gobain / AGC or approved equal).
- (b) Thermal U-value of the IGU: not exceeding 1.1 W/m²K at the centre of glass (triple glazed unit). The overall window system U-value including frame shall not exceed 1.3 W/m²K.
- (c) Solar Heat Gain Coefficient (SHGC): 0.30 to 0.40, tuned to the orientation of each façade so as not to cause local over-heating of consoles.
- (d) Visible Light Transmission (VLT): not less than 0.50 (50 %) to preserve external scene visibility under all conditions.
- (e) Low-emissivity (low-e) coating on surface 2 (cavity side of outer pane). Anti-reflective coating on surface 4 (cabin side of inner pane) to suppress reflection of internal consoles into the controllers' sight-line, in accordance with ICAO Doc 9157 Part 4.
- (f) Forward tilt of the cabin glazing as shown on the architectural drawings (typically 15° outward from the vertical) to minimise reflection of cabin interior light onto the line of sight at night.
- (g) Factory pressure-equalisation of the IGU certified for an installation altitude of 2,230 m AMSL; capillary tubes (sealed at site after installation) or factory inert-gas equalisation acceptable.
- (h) Envelope air-tightness of the cabin assembly: $\leq 1.5 \text{ m}^3/(\text{h}\cdot\text{m}^2)$ at 50 Pa measured per ASTM E779 or EN ISO 9972.

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- (i) A Building Maintenance Unit or davit-and-cradle arrangement shall be provided to permit safe external cleaning of the cabin glazing. The system shall comply with BS EN 1808 and shall be designed for the project snow load on the support beams.
- (j) Each IGU shall be marked at the spacer with the manufacturer's identification, the date of manufacture and the project reference. A mock-up assembly of one full cabin panel shall be approved by the Engineer before bulk fabrication.

9. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0260 - CEMENT PLASTER AND EXTERNAL RENDERING

1. SCOPE

The work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances, and materials and in performing all operations in any floor and at any height connection with providing and installation of cement plaster, and specified external rendering complete in strict accordance with this section of the Specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. APPLICABLE STANDARDS

Latest editions of following American Society of Testing and Materials, American National Standard Institute and Metal Lathing/Steel Framing Association are relevant to these Specifications wherever applicable.

2.1 ASTM - American Society for Testing and Materials

ASTM A 109 - Specification for Steel, Carbon, Cold-Rolled Strip

ASTM A 570 - Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality

ASTM C 28 - Specification for Gypsum Plasters

ASTM C 29 - Test Method for Unit Weight and Molds in Aggregate

ASTM C 35 - Specification for Inorganic Aggregates for Use in Gypsum Plaster

ASTM C 61 - Specification for Gypsum Keene's Cement

ASTM C 150 - Specification for Portland Cement

ASTM C 206 - Specification for Finishing Hydrated Lime

ASTM C 472 - Test Method for Physical testing of Gypsum Plasters and Gypsum concrete

ASTM C 841 - Specification for Installation of Interior Lathing and Furring

ASTM C 842 - Specification for Application of Interior Gypsum Plaster

ASTM C 847 - Specification for Metal Lath

ASTM C 926 - Specification for Application of Portland Cement-Based Plaster

2.2 ANSI - American National Standards Institute Inc.

ANSI A42.1 - Gypsum Plastering

ANSI A42.3 - Lathing and Furring for Portland Cement and Portland Cement-lime, Exterior (Stucco) and Interior

ANSI A42.4 - Specification for Interior Lathing and Furring

2.3 ML/SFA - Metal Lathing/Steel Framing Association

ML/SFA - Specification for metal lathing and furring

3. TRANSPORTATION, HANDLING AND STORAGE

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

3.1 Except for sand and water, deliver materials to the site in sealed containers or bags fully identified with manufacturer's name, brand, type and grade. Store materials in a dry, well-ventilated space, under cover, off the ground, and away from surface subject to dampness or condensation.

3.2 Deliver accessories in their original containers bearing the name of the manufacturer and item identification.

4. QUALITY ASSURANCE

4.1 Allowable Tolerance for Finished Work: For flat surfaces, do not exceed 3mm in 3 meters for bow or warp of surface and for plumbness or level.

4.2 Mock-up Installation: Prior to installation of plaster work, provide sample mock-up panels using materials specified for final work. Build sample panels at site, of full thickness and approximately 1.2 x 1.2m. Demonstrate the proposed range of color, texture and workmanship to be expected in the completed work, and submit to Engineer for review. Retain sample panels construction as a standard for judging completed plaster work. Do not alter, move or destroy sample panel until plastering work is completed. Provide a sample panel for interior and exterior Portland cement plaster and plaster on metal lath.

5. JOB CONDITIONS

5.1 Protection: Protect contiguous work from moisture deterioration and soiling, which may result from plastering operations. Provide temporary covering and whatever other provisions may be necessary to minimize harmful spattering of plaster on other work.

Finished door and window frames and other surfaces which do not receive a plaster finish shall be well protected during plaster application.

5.2 Environmental Conditions:

General: Protect plaster against uneven and excessive evaporation and from strong flows of dry air, both natural and artificial. Apply and cure plaster as required by climatic conditions to prevent rapid dry-out. Provide suitable coverings, moist curing, barriers to deflect sunlight and wind, or combination of these as required.

Ventilation: Provide adequate ventilation to properly dry interior plaster during and subsequent to its application.

6. GENERAL

6.1 Except as may be otherwise shown on surfaces specified, all plaster work, both internal and external shall be ordinary Portland Cement plaster of the required thickness as shown on the drawings.

6.2 Plastering shall not commence until all electric conduits, drainage and sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are fixed in position. It shall be the responsibility of the Contractor to make sure that all such work is carried out by other contractors before starting of plaster work. Chiseling and repairing of cement plaster shall not be permitted without the approval of the Engineer.

7. MATERIALS

7.1 PLASTER ACCESSORIES

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

7.1.1 Galvanized steel furring, lathing and other plaster accessories shall conform to the material provisions of ASTM C 841 and ANSI A42.3. Plaster accessories shall include but not limited to the following:

- a. Metal Corner Beads: Fabricated from galvanized sheet, 5 mm radius bead with 38 mm wide expanded type flanges.
- b. Strip Reinforcement: Smooth edge strips of expanded metal lath fabricated from galvanized steel sheet, with uncoated steel painted after fabrication.
- c. Casing Beads: Square-edged style, with short or expanded flanges to suit kinds of plaster bases galvanized steel.
- d. Curved Casing Beads: Square-edged style, fabricated from aluminum coated with clear plastic, preformed into curve of radius indicated on the Drawings.
- e. Control Joints: Prefabricated, galvanized steel one-or two-piece type as required. Provide removable protective tape on plaster face of control joints.
- f. Metal Corner Reinforcement: Expanded large mesh diamond lath fabricated from welded wire mesh from 1.2 mm diameter galvanized wire, specially formed to reinforce corners of Portland cement plaster where exposed while allowing full plaster encasement.
- g. Expanded Metal Lath: Galvanized steel diamond mesh complying with ASTM C 847 and shall have a minimum weight of 1.85 kg/m².

7.1.2 Coordinate the depth of accessories with the thickness and number of plaster coats required in accordance with the manufacturer's recommendations and as directed by Engineer.

7.2 PORTLAND CEMENT PLASTER

7.2.1 Portland cement plaster shall have a minimum thickness of 20mm in a double coat provided using but not limited to the following materials:

- a. Base Coat Cement: Portland cement, conforming to ASTM C 150, Type I.
- b. Finish Coat Cement: Portland cement, conforming to ASTM C 150, Type I.
- c. Factory-Prepared Finish Coat: Manufacturer's standard product requiring only the addition of water; white in color unless otherwise indicated.
- d. Lime: Special hydrated lime for finishing purposes, conforming to ASTM C 206, Type S.
- e. Sand Aggregate for Base Coat: Conform to the requirements of ASTM C 897.
- f. Aggregate for Finish coat: Conform to ASTM C 897, manufactured or natural sand to match approved sample.
- g. Water for Mixing and Finishing Plaster: Potable, free of substances, capable of affecting plaster set or of damaging plaster, lath or accessories.
- h. Bonding Agents: Conform to ASTM C 932.

7.2.2 Portland cement plaster mixes and compositions:

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a. General: Comply with ASTM C 926 for Portland cement plaster base and finish coat mixes as applicable to plaster bases, materials and other requirements indicated. Submit samples of materials used for the approval of Engineer as well as mix design.

b. Base Coat: Proportion materials for respective base coats in parts by volume for cementitious materials and in parts by volume for sum of cementitious materials for aggregates to comply with following requirements for each method of application and plaster base as required. Adjust mix proportions indicated herein within the limits specified to attain workability as follows:

c. Two-coat Work over Concrete or Unit Masonry: Base coats shall be one part Portland cement, 3/4 to 1-1/2 parts lime, 3 to 4 parts sand.

d. Finish Coat: Proportion materials for finish coats in parts by volume for cementitious materials for aggregates with one part Portland cement, 3/4 to 1-1/2 parts lime and 3 parts sand.

7.3 GYPSUM PLASTER (FOR INTERNAL PLASTERING)

7.3.1 Gypsum Plaster Materials:

a. Base Coat Plaster: Conform to ASTM C 28, ready-mixed gypsum, high strength gypsum neat plaster with minimum average dry compressive strength of 19.3 MPa according to ASTM C 472 for a mix of 45 kg plaster and 0.19 m³ of sand.

b. Finish Coat Plaster: Ready-mixed gypsum finished plaster, manufacturer's standard mill-mixed gauged interior finish or high-strength gypsum gauging plaster, conforming to ASTM C 28, with a minimum average dry compressive strength of 34.5 MPa according to ASTM C 472 for neat mix.

c. Lime: Conform to ASTM C 206, hydrated lime, Type S, for finishing purposes, unless otherwise indicated.

d. Aggregates for Base Coat: Conform to ASTM C 35, sand aggregate, unless otherwise indicated.

e. Bonding Agent: Conform to ASTM C 631.

7.3.2 Gypsum plaster mixes and compositions:

a. Plaster Base Coat Compositions: Comply with ASTM C 842 and manufacturer's directions for gypsum plaster base coat proportions which corresponds to application and plaster bases as indicated below:

1. Three-coat Work over Metal Lath: Scratch and brown coats of high strength gypsum gauging plaster with job-mixed sand.

2. Two-Coat Work Over Unit Masonry and Concrete: Base coats of gypsum neat plaster with job-mix sand.

b. Finish Coat: Proportion materials for finish coat to comply with ASTM C 842 for type of finish coat and texture required.

7.4 CEMENT SAND SCREED

7.4.1 Cement Sand screed be composed of a mixture of Portland Cement type I, natural sand, crushed stone or a combination of them, as well as water and other additives as indicated on Drawings and as required by the Engineer.

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7.4.2 Submit the design mix for Engineer's approval. Cement Sand screed shall have minimum thickness of 75mm unless otherwise indicated on Drawings. Provide wire fabric reinforcement, hardener, protection layer, insulation and membrane waterproofing as required.

7.4.3 Test screed for a minimum compressive strength of 22MPa after 28 days.

8. EXECUTION

8.1 INSTALLATION OF LATHING AND FURRING - GENERAL

8.1.1 Install interior lathing and furring materials indicated for plaster to comply with ASTM C 841.

8.1.2 Install lathing and furring materials indicated for Portland cement plaster to comply with ANSI A42.3.

8.1.3 Install supplementary framing, blocking, and bracing at terminations of work for support of fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, and similar work in accordance with details indicated on Drawings or approved shop drawings.

8.1.4 Isolation: Where lathing and metal support system abuts building structure horizontally, and where partition/wall work abuts overhead structure, isolate the work from structural movement sufficiently to prevent transfer of loading into the work from the building structure. Install slip or cushion type joints to absorb deflections but maintain lateral support.

8.1.5 Frame both sides of control and expansion joints independently, and do not bridge joints with furring and lathing or accessories.

8.2 INSTALLATION OF CEILING SUSPENSION SYSTEMS

8.2.1 Coordinate installation of ceiling suspension system with installation of overhead structural systems, ducting and catwalks to ensure that inserts and other structural anchorage provisions have been installed to receive ceiling hangers in a manner that will develop their full strength and at spacing required to support ceiling.

8.2.2 Furnish concrete inserts, and other devices indicated, to other trades for installations well in advance of time needed for coordination with other work.

8.2.3 Attach hangers to structure above ceiling to comply with ML/SFA - Specifications for Metal Lathing and Furring as well as with referenced standards.

8.2.4 Install ceiling suspension system components of sizes and spacing indicated but not in smaller sizes or greater spacing than that required by the referenced lathing and furring installation standards.

8.3 METAL LATHING

Install expanded metal lath for the applications where plaster base coats are required. Provide appropriate type, configuration and weight of metal lath selected from materials required which comply with referenced lathing installation standards.

8.4 INSTALLATION OF PLASTERING ACCESSORIES

8.4.1 General: Comply with referenced lathing and furring installation standards for provision and location of plaster accessories of type indicated. Miter or cope accessories at corners; install with tight joints and in alignment. Attach accessories securely to plaster base.

8.4.2 Accessories:

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- a. Corner Beads: Install at external corners.
- b. Casing Beads: Install at terminations of plaster work, except where plaster passes behind and is concealed by other work and where metal screed, bases or metal frames act as casing beads.
- c. Control Joints: Install at locations indicated, or if not indicated, at spacings and locations required by referenced standard and recommended by plaster manufacturer and approved by the Engineer.
- d. Corner Reinforcement: Install at external corners.

8.5 PLASTER APPLICATION

8.5.1 Prepare monolithic surfaces for bonded base coats and use bonding compound or agent to comply with requirements of referenced plaster application standards for conditioning of monolithic surfaces.

8.5.2 Tolerances: Do not deviate more than 3mm in 3000mm from a true plane in finished plaster surfaces, as measured by a 3000mm straightedge placed at any location on surface.

8.5.3 Grout hollow metal frames, bases and similar work occurring in plastered areas, with base coat plaster material, and prior to lathing where necessary. Except where full grouting is indicated or required for fire-resistance rating, grout 150mm lengths at each anchorage.

8.5.4 Sequence plaster application with the installation and protection of other work, so that neither will be damaged by the installation of the other.

8.5.5 Plaster finish with metal frames and other built-in metal items or accessories which act as a plaster ground, unless otherwise indicated. Where plaster is not terminated at metal by casing beads, cut base coat free from metal before plaster sets and groove finish coat the juncture with metal.

8.5.6 Apply thickness and number of coats of plaster as indicated or as required by referenced standards, and as per manufacturer's recommendations.

a. Cement Plaster: Base coat shall be 20mm thick for concrete and CMU. Finish coat shall be 3mm.

b. Gypsum Plaster (for internal use): Base coat shall be 12mm thick. Finish coat shall be 3mm.

8.5.7 Concealed Plaster: Where plaster application will be concealed by wood paneling, above suspended ceilings and similar locations, finish-coat maybe omitted. Where plaster application will be concealed behind cabinets and similar furnishings and equipment apply finish-coat. Where plaster application will be used as a base for adhesive application of tile and similar finishes, omit finish-coat and coordinate thickness with overall dimension as shown and comply with tolerances specified.

8.6 CEMENT SAND SCREED

8.6.1 Roughened the concrete slabs to receive screeding before hardening. Clean and wet the hardened base surfaces, preferably overnight prior to laying of screeds.

8.6.2 Batch accurately aggregates and cement by weight at a ratio of cement-aggregate ranging from 1:3 to 1:4.5. Mix screeding material mechanically.

8.6.3 Lay and finish the screed mix carefully to true levels and correct heights for the required thickness. Tolerance in level over a 2 m length shall not exceed plus or minus 3 mm.

8.6.4 Provide adequate means of curing to prevent rapid drying of screed as directed by the Engineer.

8.7 CUTTING AND PATCHING

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8.7.1 Cut, patch, point-up and repair plaster as necessary to accommodate other work and to restore cracks, dents and imperfections. Repair or replace work to eliminate blisters, buckles, excessive crazing and check cracking, dry-outs, efflorescence, sweat-outs and similar defects and where bond to the substrate has failed.

8.7.2 Sand smooth-trowelled finishes lightly to remove trowel marks and arises.

8.8 CLEANING AND PROTECTION

8.8.1 Remove temporary protection and enclosure of other work. Promptly remove plaster from door frames, windows, and other surfaces which are not to be plastered. Repair floors, walls and other surfaces which have been stained, marred or otherwise damaged during the plastering work. When plastering work is completed, remove unused materials, containers and equipment and clean floors of plaster debris.

8.8.2 Provide final protection and maintain conditions which ensure plaster work being without damage or deterioration at the time of substantial completion.

9.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

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SECTION 0270 - MARBLE NATURAL STONE SLAB (TOILET COUNTERS, WALL CLADDING, FLOORING, ETC).

1. SCOPE

The work under this section of specifications, consists of providing all material, labour, plant, equipment, appliances in any floor and at any height and performing all operations required for providing and installing marble natural stone slab for toilet counters, where shown on the drawings, complete in strict accordance with this section of the specification and the applicable Drawings.

2. SUBMITTALS

The Contractor shall submit manufacturer's specifications and other product data for each type of marble stone and fixtures required, including instructions for handling, storage, installation and protection.

Shop Drawings shall be submitted showing sizes, dimensions, sections and profiles, arrangement and provisions for jointing, anchoring, fastening and supports and other necessary fixing details. Indicate locations, layouts and pattern arrangements for each stone type and colour.

Submit three ranges samples 300mm x 300mm in size of each type of stone showing colour, grade, finishing and texture for approval of the Engineer.

3. DELIVERY, STORAGE AND HANDLING

Materials shall be protected from damage during loading, shipment, delivery and storage. Non-staining materials for blocking and packing shall be used. Stack marble at site in accordance with manufacturer's recommendations and as required to prevent staining, scratching, etching or breakage.

4. MATERIALS

4.1 GENERAL

Marble shall be compact, dense, metamorphic rock of lime stone origin obtained from quarries within Pakistan. It shall have a specific gravity of 2.7 and hardness number on Moh's scale shall range from 3 to 4.

Obtain each marble stone type from a single quarry and ensure consistent colour range and texture throughout the work. All pieces shall be of uniform thickness and truly square in shape.

Provide marble slabs/sills and tiles of specified sizes in floors, stair tread & risers and counter tops as shown on drawings.

Provide marble slabs/sills and tiles of type, colour and finish for each area as directed by the Engineer.

Provide stone of specified thickness. Saw cut the back surfaces that are meant to be concealed in finished work.

Provide irregular shaped units, staircase units and skirting base units to the profiles of required shapes & sizes and polished exposed surfaces wherever specified.

4.2 MARBLE STONE TYPE

All marble stone types are to be selected as shown in drawings and approved by the Engineer for quality, colour and texture.

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Marble: Marble of approved type and colour of local origin, first class quality and high class finish acceptable to the Engineer.

4.3 BEDS AND BACKINGS

Where applicable, standard cementitious screed and mortar beds and backings, mixed and proportioned by volume shall be as follows:

Grey / White ordinary Portland Cement : 1 part

Sand : 2 parts

Water : Clean, fresh and free from deleterious substances

4.4 ADHESIVES, GROUTS AND SEALANTS

Proprietary adhesives, joint grouts and sealants of approved type as required and recommended by the manufacturer for specific application shall be used. The colour of the joint grout and the sealants shall match with the colour of stone.

5. EXECUTION

5.1 WALL CLADDING

Set in specified cement sand plaster and metallic clamp fixing arrangements as shown in drawings or as approved by the Engineer.

Point joints as soon as possible after initial set. Force grout into joints, strike flush and tool slightly concave.

Remove mortar and grout from surfaces while still moist and as the work progresses.

5.2 FLOORING, MOULDING, THRESHOLD, TRIM, SKIRTING / DADO AND STAIR STEPS

Apply cement slurry coat over surfaces of concrete substrate immediately prior to placing setting bed. Limit area of application to avoid premature drying out. Install setting bed of required thickness and set stone units before initial set occurs. Apply a thin layer of cement paste to bottom of each unit. Set stamps and level units immediately. Set units in required pattern with uniform joint widths.

Point joints as soon as possible after initial set. Force grout into joints, strike flush and tool slightly concave.

Remove mortar and grout from surfaces while still moist and as the work progresses.

Do not permit traffic on finished surface during setting and for a minimum of 24 hours after final pointing of joints.

5.3 TOILET & KITCHEN COUNTERS TOPS

Toilet & Kitchen counter tops of the specified size shall be installed in areas shown on Drawings with M.S. angle framing and fixing accessories in accordance with approved shop drawing. Joints shall be cement grouted with matching colour or with matching colour sealant.

5.4 REPAIR AND CLEANING

Remove and replace stone units which are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units which do not match adjoining stonework or are not in line and level

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as shown on Drawings. Provide new matching units, install and point joints to eliminate evidence of replacement. Repoint defective and unsatisfactory joints to provide neat, uniform appearance.

Clean stonework not less than 6 days after completion of work, using clean water and bristle brushes. Do not use wire brushes, acid or caustic type cleaning agents or other cleaning compounds which may be detrimental to the stone finish or joint grout.

5.5 PROTECTION

Provide covers, boards, supports and all other necessary materials to protect finished work from collapse, deterioration, discolouration or damage during installation and until contract completion.

5.6 POLISHING

The finished surface shall be chemically polished, acceptable to the Engineer.

6.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0280 - GRANITE NATURAL STONE SLAB AND TILE FINISHING

1. SCOPE

The work under this section of specifications, consists of providing all material, labour, plant, equipment, appliances and performing all operations required for providing and installation of granite natural stone slab and tile finishing as shown on Drawings including interior and exterior floors and wall finishing, counter tops, division panels and the like, complete in strict accordance with this section of the specification and the applicable Drawings.

2. SUBMITTALS

The Contractor shall submit manufacturer's specifications and other product data for each type of granite stone required, including instructions for handling, storage, installation and protection.

Shop Drawings shall be submitted showing sizes, dimensions, sections and profiles of slab and tile units, arrangement and provisions for joining, anchoring, fastening and supports and other necessary fixing details. Indicate locations, layouts and pattern arrangements for each stone type and colour.

Submit three range samples 300mm x 300mm (1ft x 1ft) in size of each type of stone showing colour, grade, finishing and texture for approval of the Engineer.

3. DELIVERY, STORAGE AND HANDLING

Materials shall be protected from damage during loading, shipment delivery and storage. Non-staining materials for blocking and packing shall be used. Stack granite units at site in accordance with manufacturer's recommendations and as required to prevent staining, scratching, etching or breakage.

Units of cladding granite shall be clearly marked to identify the final position in the structure as indicated in the shop drawings.

4. MATERIALS

4.1 GENERAL

Obtain each stone type from a single quarry and ensure consistent colour range and texture throughout the work.

Provide continuous slabs or tiles for continuous wall areas, intersecting planes, and countertops to provide continuous matching units.

Provide stone of type, colour and finish for each area of use as approved by the Engineer.

Provide stone of thickness as shown in the drawings or as specified. Saw-cut back surfaces which will be concealed in finished work.

4.2 TYPES

All granite stone types as shown in drawings or as specified are to be selected and submitted for quality, colour and texture approval by the Engineer.

4.3 BEDS AND BACKINGS

Where applicable, standard cementitious mortar beds and backings, mixed and proportioned by volume shall be as follows:

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Grey / White ordinary Portland Cement : 1 part

Sand : 2 parts

Water : Clean, fresh and free from deleterious substances

4.4 ADHESIVES, GROUTS AND SEALANTS

Where specified on the drawing or as directed by the Engineer, proprietary adhesives, joint grouts and sealants; suitable types as required and recommended for specific application; colour match joint grout and sealants to colour of stone shall be used.

4.5 DOWELS & ANCHORS

Contractor shall provide necessary loose steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers and other steel/brass shapes for securing granite units to other supporting and adjacent members. Provide at least two anchors for each piece.

4.6 SETTING SHIMS OR BUTTONS

Lead buttons of the thickness required for the joint size shown or specified and of the size required to maintain uniform joint width.

5. EXECUTION

5.1 PAVING, FLOORING, SKIRTING, COPING AND STAIR STEPS

Apply cement slurry coat over surfaces of concrete substrate immediately prior to placing setting bed. Limit area of application to avoid premature drying out. Install setting bed to thickness required and set stone units before initial set occurs. Set in cement sand mortar including Class C concrete screed of specified thickness, 200 x 200 wire mesh, cement mortar with approved adhesive, 20mm thick 1:3 dry cement mortar binding course and dry cement spread to bottom of each unit. Set, tamp and level units immediately. Set units in pattern required, with uniform joint widths.

Point joints as soon as possible after initial set. Force grout into joints, strike flush and tool slightly concave.

Remove mortar and grout from surfaces while still moist and as the work progresses.

Do not permit traffic on finished surface during setting and for a minimum of 24 hours after final pointing of joints.

5.2 GRANITE WALL CLADDING

Internal & External wall cladding shall be executed in accordance with CP.298, approved Shop Drawings and as per direction of the Engineer.

The granite stone of the specified size shall be set in mortar, fixed using brass dowels, brackets, metallic anchors and plugs and as per details / arrangement and in sizes shown in the drawings. The dowels, anchors or tie must not be subjected to any loading until complete hardness has taken place. Holes and mortises shall be carefully drilled or cut to avoid fracture of the tile. Patching will not be permitted and any damaged tiles shall be removed and replaced at the cost of the Contractor.

5.3 COUNTER AND VANITY TOP ALONGWITH APRON

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Counter and Vanity tops along with Apron of the specified size shall be installed in areas shown on Drawings with M.S. angle framing and fixing accessories in accordance with approved shop drawing. Joints shall be cement grouted with matching colour or with matching colour sealant.

5.4 REPAIR AND CLEANING

Remove and replace stone units which are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units which do not match adjoining stonework or is not in line and levels as shown on Drawings. Provide new matching units, install and point joints to eliminate evidence of replacement. Repoint defective and unsatisfactory joints to provide neat, uniform appearance.

Clean stonework not less than 6 days after completion of work, using clean water and bristle brushes. Do not use wire brushes, acid or caustic type cleaning agents or other cleaning compounds which may be detrimental to the stone finish or joint grout.

5.5 PROTECTION

Provide covers, boards, supports and all other necessary materials to protect finished work from collapse, deterioration, discoloration or damage during installation and until contract completion.

6.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0290 - FALSE CEILING

1. SCOPE

The work under this section of the specifications, consists of furnishing all plant, labour, equipment, appliances and materials in any floor and at any height and in performing all operations in connection with providing and installing different types of false ceiling including suspension system complete, in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. GENERAL

False ceiling shall be installed wherever indicated on the drawings by skilled technicians experienced in this type of work. Installation shall not commence in any room or space before completion of plasterwork on structural roofing/internal walling/external surfaces.

3. MATERIALS

3.1 ALUMINUM TILES

Tiles shall be of approved size, shape, texture, perforations, fire rating and colour with grooved joints and wool sound insulation including architectural features, as specified or as shown in the drawings, as shown on drawing or as approved by the Engineer shall be used.

All four edges shall be revealed to be installed by an approved recessed suspension system, strictly in accordance with the approved shop drawings, manufacturer's recommendations or instructions of the Engineer.

3.2 ALUMINUM PANELS/STRIPS

Aluminum panel / strips shall be linear or flat, perforated or un-perforated with butt joints and wool sound insulation including decorative baffle and other architectural features, in approved size, shape, texture, fire rating and colour as specified or as shown in the drawings, or as approved by the Engineer shall be used.

3.3 POLISHED HARDWOOD AND GYPSUM BOARD

Tiles / Strips shall be installed in the grid system after completion of installation of the suspension of Electrical and HVAC fixtures.

Forming ceiling panels shall be laid out in pattern including border of uniform width around all sides of each ceiling area. The pattern shall be as per shop drawings approved by the Engineer.

All panels shall be furnished and installed in an approved manner and as per approved types, sizes and surface design.

3.4 BOARD BAND/BORDER/BULKHEADS

Board band / Border / Bulk Heads shall be of any of the following type in sizes, shapes and arrangements as shown in drawings

3.4.1 Plastic emulsion painted cement board ceiling, band / border bulkhead with polished wooden / metal edge trim with compatible suspension system and provision for fixing of light and other fixtures etc.

3.4.2 Combination type including Painted-Cement Board Band / Border with polished wooden edge trim.

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3.4.3 Gypsum board ceiling with hardwood polished decorative geometric pattern and textured paint finish with details as shown in drawings.

3.4.4 Aluminum composite panel FR Ceiling // Bulkhead with compatible suspension system.

Laid out in pattern as shown in drawing or as per shop drawings approved by the Engineer.

All Board band / Border / Bulkheads shall be furnished and installed in an approved manner and as per approved types, sizes and surface design.

3.5 SUSPENSION SYSTEM

The suspension system for all types of false ceiling shall be in accordance with the recommendations of the approved false ceiling manufacturer and approved shop drawings, consisting of powder coated or galvanized or painted (as applicable or as shown in drawing) steel suspension system including universal U-channels/ main T/Cross-T Bars, wall mouldings/ edge trims, hold down/adjustment clips, galvanized hanger strips, carriers with adjustment mechanism, etc. as shown in drawing, as recommended by the manufacturer and as approved by the Engineer.

4. SUBMITTALS

4.1 Shop drawings shall be submitted showing reflected ceiling plan, locations of built in products and access facilities, dimensions, layout arrangements, hanger locations, structural connection, details of level changes, direction of pattern and panel joint details along with installation details, location and provision of light fixtures, specialized airport system / telecommunication fixtures, HVAC equipment etc. The shop drawings shall require to be approved by the Engineer in advance of undertaking this item of works.

4.2 No materials shall be procured prior to approval of shop drawings and details.

4.3 The Contractor shall incorporate the required access panels of false ceiling as per approved shop drawings.

5. PRODUCT DELIVERY, STORAGE AND HANDLING

5.1 Material shall be delivered in original, unopened, protective packaging, with manufacturer's labels indicating brand name, pattern, size, thickness and fire rating.

5.2 Material shall be stored in original protective packaging to prevent soiling, physical damage or wetting.

5.3 Cartons shall be stored in the installation area, opened at each end to stabilize moisture content and temperature, for 48 hours prior to installation.

6. JOB SITE CONDITIONS

6.1 Work which will be concealed by false ceilings shall be completed, tested, inspected and accepted before ceiling work is started.

6.2 False ceiling installation shall not begin until the area has been closed in, and temperature and humidity approximate occupancy conditions. Wet work shall be cured and dry before ceiling work is started.

6.3 Surfaces which will support the ceilings, and those to which the ceiling abut, shall be inspected and accepted for completeness and adequacy to receive the ceilings before the work begins.

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7. INSTALLATION AND WORKMANSHIP

False ceiling suspension system and panels shall be installed in accordance with the requirements of BSI-CP.290 and with the manufacturer's recommendations as approved by the Engineer.

7.1 Suspension System

The hangers as specified shall be evenly disposed as per drawings, details and place and position as shown in drawing or as recommended by the manufacturer and approved by the Engineer. The suspension system should be installed by making holes directly in the roof and shall be made good as directed by the Engineer. Their lengths clear of roofing slab shall be as per shop drawing details.

The framing of the specified section and run at spacing as per shop drawings. The jointing of runners to hangers shall be as per approved shop drawing details. The extra framing if required shall be provided for light receptacles as per approved shop drawing details.

Wall hangers shall be positively and rigidly connected to the structure and to cross runners.

7.2 False Ceiling tiles / strips

Tiles shall be installed in the grid system after completion of installation of the suspension of lighting and air conditioning fixtures.

Forming ceiling panels shall be laid out in pattern including border of uniform width around all sides of each ceiling area. The pattern shall be as per shop drawings approved by the Engineer.

All panels shall be furnished and installed in an approved manner and as per approved types, sizes and surface design.

8. FIXTURES

Light & Specialized Airport / Telecommunication System fixtures shall be installed as per approved pattern and supported in accordance with manufacturer's recommendations.

9. FINISHING

After installation, dirty, soiled or discoloured surfaces shall be cleaned and left free from defects and ready to receive any painted finish if required.

The panels which are damaged or improperly installed shall be removed and replaced by the Contractor at his cost.

10. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0300 - CEMENT CONCRETE FLOORS AND FLOOR FINISHES

1. SCOPE

The work under this section of the Specification consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in any floor and at any height in connection with the installation of cement concrete floors and floor finishes including bases, skirting and external surface treatments, complete in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. MATERIALS

2.1 CEMENT

Cement shall be ordinary Portland cement conforming to B.S. 12 or PS 232.

2.2 SAND

All fine sand shall be obtained from sources approved by the Engineer. The grading shall conform to B.S 882 Grading Zone 1 and 2 of which the gradation limits are as follows:

2.3 COARSE AGGREGATE

Coarse aggregate shall be crushed or uncrushed gravel or crushed stone, angular or rounded in shape and shall have granular, crystalline or smooth surface free from friable, flaky and laminated pieces, mica and shale. It shall not contain matters injurious to concrete. All coarse aggregate shall conform to BSS NO.882 and shall be graded as follows:

B.S. Sieve	% passing by weight
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1" (25.40 mm)	100
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3/4" (19.05 mm)	90-100
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3/8" (9.53 mm)	20-55
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3/16" (4.765 mm)	0-10
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The aggregate shall be stored on properly constructed paving or as directed by the Engineer. There shall be a physical partition between the stockpiles of coarse and fine aggregate. If required, aggregates shall be washed and screened to the satisfaction of the Engineer. Sieve analysis of all the aggregates to be used in the works shall be carried out as and when required by the Engineer. All aggregate shall be subject to the approval of the Engineer. Any aggregates not found to be of the specified/approved standard shall be rejected by the Engineer and all such rejected material shall be removed from site without delay. Floors, sub-base or base constructed with rejected aggregates shall be dismantled and rebuilt at the expense of the Contractor.

2.4 WATER

Water used for mixing concrete, curing or any other operation of the works specified herein shall be fresh, clean and free from organic or inorganic matters in solutions or in suspension. Only water of the approved quality shall be used for all constructional purposes.

2.5 PORCELAIN TILES, SKIRTING, DADO, STAIR STEPS

Porcelain tiles, skirting, dado, stair steps etc. shall be Shabbir tiles and Master or approved equivalent. The tiles shall be of type, sizes, shade and texture as specified on the drawings and shall conform to

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ISO Standard, ISO 13006 for Bla requirements & BS EN 14411:2012 as specified hereunder. Tiles shall be laid in arrangement as shown in the drawing and as per details and fixing arrangements, including provision of thermal expansion, as shown in the drawing or as recommended by the manufacturer approved by the Engineer.

2.6 CERAMIC TILE

Ceramic tiles shall be of type, sizes, shade and texture as specified on the drawings and shall conform to ISO Standard, ISO 13006 for Bla requirements & BS EN 14411:2012. Tiles shall be laid in arrangement as shown in the drawing and as per details and fixing arrangements, filled with acid resistant or any suitable grout and including provision of thermal expansion, as shown in the drawing or as recommended by the manufacturer approved by the Engineer.

2.7 CLEANING COMPOUND

The compound used for all cleaning of terrazzo shall be an approved neutral chemical cleaner free from acid and alkali or any other material that will affect the colour or otherwise damage the terrazzo and shall not affect the conductivity of terrazzo floors.

2.8 TERRAZZO TILE FLOORING / WALL PANELS

Terrazzo tiles / wall panels, pre-polished or polished after installation at place, shall be of type, sizes, shade and texture as specified on the drawings or as approved by the Engineer. Terrazzo tiles shall be first grade mechanically compressed type conforming to PS-531. Tiles shall be laid in arrangement as shown in the drawing and as per details and fixing arrangements, including provision of PVC or Stainless Steel divider strip, as shown in the drawing or as recommended by the manufacturer approved by the Engineer.

2.9 CARPET FLOORING

Carpet flooring of following types shall be provided, laid and set as per details as specified in drawings and as per manufacturer recommendations and shall be in sizes, shade, design and texture approved by the Engineer.

2.9.1 Wall to wall broadloom carpet laid on finished floor of either porcelain tiles or any other type of floor with rubberized underlay forming rows for prayers or for any other purposes as specified or approved by the Engineer.

2.9.2 Heavy duty carpet tiles in shape, sizes, texture, design and fixing / setting arrangements with rubberized underlay over cemented floor as shown in the drawing and as per details and fixing arrangements recommended by the manufacturer and approved by the Engineer.

2.10 WOODEN FLOOR TILES / WALL CLADDING

Laminated parquet wood floor tiles / wall cladding, MDF board plastic laminated sheet of specified thickness machine pressed with teak wood veneer / lipping all around etc. shall be of type, sizes, shade and texture with interlocking laminated wooden strips pasted over foam pads of specified thickness with plastic barrier or water barrier course of approved thickness on cement screed as specified on the drawings or as recommended by the manufacturer and as approved by the Engineer.

2.11 CEMENT SCREED FLOOR

Concrete / cement screed flooring of following types shall be provided as per details as specified in drawings or as per manufacturer recommendations and approved by the Engineer.

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2.11.1 Heavy Duty Cement Screed Floor of specified finish, thickness & panel size with 2mm thick Epoxy Coating.

2.11.2 Cement Concrete Screed (full body) of specified finish, thickness & panel size with hardener.

2.11.3 Cement Concrete Screed (full body) of specified finish, thickness & panel size.

2.12 PVC FLOORING

PVC tiles over abrasive rubber coarse with PVC lining of following types shall be provided and set as per details as specified in drawings and as per manufacturer recommendations shall be in sizes, shade and texture approved by the Engineer.

2.12.1 Wall to wall PVC tiles flooring of specified thickness with rubberized underlayment over screed as shown in the drawing and as per details and fixing arrangements recommended by the manufacturer and approved by the Engineer.

2.12.2 Antistatic Heavy duty PVC tiles flooring of specified thickness with rubberized underlayment over screed as shown in the drawing and as per details and fixing arrangements recommended by the manufacturer and approved by the Engineer.

3. CEMENT CONCRETE FLOORING

The materials for C.C flooring shall be the same as already specified under clause 2, "Materials".

3.1 COMPOSITION OF CONCRETE

Concrete shall be composed of Portland Cement, sand, coarse aggregate and water, all well mixed and brought to the proper consistency. The Contractor shall mix the ingredients as indicated on the Drawings. The proportions of the various ingredients shall be determined from time to time during the progress of the work and tests shall be made of samples of the aggregates and the resulting concrete. The mix proportions and appropriate water-cement ratio will be determined on the basis of the production of concrete having required workability, density, impermeability, durability and required strength.

3.2 MIXING CONCRETE

The concrete ingredients shall be mixed in a batch mixer for not less than 1-1/2 minutes after all ingredients, except the full amount of water, are in the mixer. The Engineer reserves the right to increase the mixing time when the charging and mixing operations fail to produce a concrete batch in which the ingredients are uniformly distributed and the consistency is not uniform. The concrete shall be uniform in composition and consistency from batch to batch except when changes in composition or consistency are required. Water shall be added prior to, during and following the mixer charge. Excessive over-mixing requiring addition of water to preserve the required concrete consistency will not be permitted. The concrete ingredients shall be mixed by volumetric measurement in purpose-made boxes approved by the Engineer.

3.3 CONSTRUCTION

The base course of the floor shall comprise stone ballast of 2 inches (approx. 50mm) mesh size. The base course shall be thoroughly compacted by suitable power rammers to the total consolidated thickness as shown on the Drawings and as approved by the Engineer. The interstices shall be filled with smaller size stones. The base course shall be blinded with sand and the whole surface watered. Over the well compacted base course, a layer of concrete of the required grade and thickness shall be laid, in panels of the sizes as indicated on the Drawing and as approved by the Engineer.

After the C.C bed has been cured, as directed by the Engineer, it shall be roughened and well watered before floor finishing is laid. The floor finish shall comprise cement concrete of required grade and shall be laid in panels to the required thickness as shown on the Drawings or as directed by the Engineer. The concrete after laying will be thoroughly rammed and mortar worked up to the top and smoothed with a steel trowel. The edge of each section into which the floor is divided should be defined by wooden screeds of the approved width and of a depth equal to the depth of the floor concrete.

Freshly placed concrete floor and completed floor portions as finished shall be protected to prevent loss of water by covering with damp hessian, waterproof paper, damp sand or other approved material, and shall be kept constantly damp for a period of four days or longer after concreting as directed by the Engineer. The concrete shall be allowed to dry out slowly over a period of three days after wet curing is completed.

The expansion joints shall be filled with hot bitumen of the approved grade, as directed by the Engineer.

4. INSTALLATION OF TILE FLOORING

When setting out the tiles, care shall be taken to establish the correct elevation for the floor. A gauge rod shall be used, indicating the overall measurement of a given number of tiles with specified joint width to reduce cutting.

After the floor has been machine finished, it should be covered with white, non-staining sand or rags to protect it while other work is being done. After removal, the floor shall be thoroughly scrubbed.

4.1 GENERAL

The base shall be prepared by laying cement concrete of specified grade and of thickness as shown on the drawings, or specified in the Bill of Quantities.

The curing period of the setting bed shall be as directed by the Engineer. As large an area of setting bed shall be spread at one time as can be covered with tiles before the mortar has set. Surplus mortar shall be removed. The thickness of setting bed in any space shall not be less than 20mm.

Floor and wall surfaces to receive the tiles shall be thoroughly cleaned of all dirt, dust, oil and other objectionable matters. Tiles shall be laid out from the centre line of each space in an outward direction and the pattern should be made symmetrical with a minimum number of cut tiles as directed by the Engineer.

Joints between the tiles shall be of uniform width. Tiles shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Tiles shall be laid to the straight edges.

4.2 CERAMIC / PORCELAIN TILES

The ceramic / porcelain tiles shall be laid to the required lines, levels and grades over a setting bed of cement sand mortar comprising one part of cement and 3 parts of sand by volume and the joints filled with neat white or grey cement including vertical and horizontal covers. The tile floor shall be kept wet for at least 72 hours and no traffic should be allowed on the tiles during curing period.

4.3 TERRAZZO TILES FLOORING

The tiles shall be well soaked in water and kept in a vertical position to drain out all surplus water. The bed over which the tiles would be laid shall be 20mm thick cement sand mortar as specified by the Engineer. The cement sand mortar shall be prepared and mixed with clean granular sand in the proportion of 1:3 and spread uniformly on the thoroughly wetted and moist surface. The tiles shall be

laid so that cement mortar slurry rises up in the joint. The tiles shall be laid in the pattern as specified by the Engineer. The levels and lines shall be checked with very fine white and the defects removed then and there. After 3 or 4 days the slurry from the joints shall be raked out and colored cement of required shade shall be spread in the form of slurry to fill all joints. It shall be neatly wiped off the surface when still wet. After about 10 days the area shall be rubbed and ground with Carborundum stone and the whole surface rendered smooth and washed with plenty of water. After allowing to dry the surface shall be wax polished. The finished surface shall not show any depressions in individual tiles or undulations in the floor.

4.4 Epoxy Resin Flooring

Work under this section shall comprise supply, installation, and finishing of Epoxy Resin Flooring system over prepared concrete substrates, complete in all respects and in strict accordance with the manufacturer's specifications and directions of the Engineer. The scope shall include thorough cleaning and preparation of the substrate surface to remove all dust, laitance, grease, and loose particles, followed by repair of all visible cracks, voids, and surface irregularities using epoxy mortar or an approved compatible filler to achieve a sound, level base. Upon acceptance of the prepared surface, a flooring primer coat shall be applied to enhance bond strength and adhesion between the substrate and the subsequent coating layers. Thereafter, a two-component protective epoxy coating system shall be applied in the specified number of coats to deliver a smooth, seamless, and durable monolithic finish. The completed floor system shall exhibit high resistance to abrasion, chemical attack, staining, and moisture ingress, suitable for the intended service environment. All materials shall be sourced from an approved manufacturer and applied by trained and experienced applicators using appropriate equipment in accordance with the product technical data sheets.

5.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0310 - GYPSUM BOARD DRYWALL SYSTEMS

1. SCOPE

The work under this section of the Specifications consists of furnishing all plant, labour, equipment, appliances, and materials and in performing all operations in any floor and at any height providing and installation of Gypsum Board for (i) Ceiling suspension system, wall framing and furring systems for dry walls (ii) walls and ceilings (iii) metal deck platform ceiling and ceiling suspension system complete in strict accordance with this section of the Specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. APPLICABLE STANDARDS

2.1 ANSI - American National Standards Institute, Inc.

A97.1 - Standard Specifications for the Application of Finishing of Wallboard

2.2 ASTM - American Society of Testing and Materials

ASTM A 525 - Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

ASTM A 641 - Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM A 653 - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot-dip Process

ASTM C 36 - Specification for Gypsum Wallboard

ASTM C 442 - Specification for Gypsum Backing Board and Core Board

ASTM C 475 - Specification for Joint Compound and Joint Tape for Finishing Gypsum Wallboard Construction

ASTM C 630 - Specification for Water-Resistant Gypsum Backing Board

ASTM C 645 - Specification for Non-Load Bearing (Axial) Bearing Steel Studs, Runners (Track) and Rigid Furring Channels for Screw Application of Gypsum Board

ASTM C 754 - Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum

ASTM C 840 - Specification for Application and Finishing of Gypsum Board

2.3 GA - Gypsum Association

GA 201 - Using Gypsum Board for Walls and Ceilings

GA 216 - Recommended Specifications for the Application and Finishing of Gypsum Board

GA 220 - (Reference)

2.4 BS - British Standards Institute

BS 476 - Fire Tests on Building Materials and Structures

3. SUBMITTALS

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

3.1 Product Data: Submit manufacturer's product specification and installation instructions for each gypsum drywall component, including other data as may be required to show compliance with these Specifications.

3.2 Samples: Submit manufacturer's samples for the Engineer's approval.

3.3 Shop Drawings: Submit complete shop drawing of layout and details of ceiling and/or partitions for the Engineer's approval.

3.4 Mock-Up: Install a full-size mock-up showing different elements completed for drywall partitions and ceilings.

4. TRANSPORTATION, HANDLING AND STORAGE

Comply with the requirements of transportation, handling and storage specified in ASTM C 840.

5. MATERIALS

5.1 METAL SUPPORT SYSTEM

5.1.1 Ceiling Support System as detailed below or as shown in drawings or as recommended by the manufacturer and approved by the Engineer:

a. Main Runners: Steel channels with rust inhibitive coating (Galvanized), hot or cold-rolled, minimum nominal thickness 0.6mm with 40mm flanges and channel web of suitable size.

b. Hanger Wire: Conform to ASTM A 641, soft, Class 1, galvanized.

c. Hanger Rods and Flats: Mild steel with zinc or equally rust inhibitive coating for rods and zinc or rust-inhibitive paint finish for flats.

d. Furring Members: Conform to ASTM C 645, not less than 0.6mm thick, hat-shaped with 19mm flanges.

e. Furring Anchorage: Conform to ASTM C 754, 1.6mm diameter galvanized wire ties, manufacturer's standard wire-type clips, bolts, nails or screws.

f. Direct Suspension System: Manufacturer's standard zinc-coated or painted steel system of furring runners, tees, and accessories designed for concealed support of gypsum drywall ceilings.

5.1.2 Wall / Partition Support Materials:

Runners, Studs and Furring: Formed from steel sheets conforming to ASTM C 645 with manufacturer's standard hot-dipped galvanized coating to ASTM A653, G60, and minimum 0.7 mm thick with web dimension compatible with thickness of wall as shown on Drawings. Provide holes and knockouts for utilities. Furring members shall be hat-shaped type.

5.2 GYPSUM BOARD

5.2.1 Regular Gypsum Board for General Use: Conform to the requirements of ASTM C 36, Grade R or DIN 18-180, regular, 15 mm thick for ceilings / tile ceilings, board band / borders / bulkhead, walls with tapered or beveled edges (DFB manufacturer or equivalent) as per shapes, dimension, texture and arrangements, fixing details as shown in drawings or as per manufacturer's recommendation and approved by the Engineer in paint or textured finish on to rigid metal concealed suspension system including access panel, trims, edge trims, shadow trims, expansion joints complete in all respect.

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5.2.2 Metal Deck Platform Ceiling: Shall consist of double layer, regular gypsum boards ceiling, 15 mm thick each layer and internal metal decking for use in ceiling of operation theaters and other similar function rooms, as shown on drawings. Construct ceiling system as per approved shop drawings. Gypsum board ceiling shall be fastened to structural steel bulb tees and joists spaced at regular intervals and attached to ceiling suspension system through metal decking on which cast-in-place lightweight concrete slab is poured. Sizes of hanger rods, steel joists, metal decking and bulb tees shall be as recommended by manufacturer and approved by the Engineer. Structural steel members shall conform to ASTM A 36.

5.2.3 Moisture-Resistant Gypsum Board for Toilets, Washroom, Showers, Kitchens, Cafeteria, Ablution Areas and Similar Wet Areas: Conform to ASTM C 630 or DIN 18-180, Type X, 12 mm thick for ceilings and 15 mm thick for walls with tapered or beveled edges.

5.2.4 Fire retardant wallboard: Where indicated on Drawings, use Type X, same requirements as mentioned above.

5.3 MISCELLANEOUS MATERIALS

5.3.1 Fasteners:

5.3.1.1 Screws: Self-drilling, self-tapping bulge head for use with powder-driven tool and of the type recommended by board manufacturer for the intended application.

5.3.1.2 Fasteners for furring members: Type and size shall be as recommended by furring manufacturer for the substrate and intended application.

5.3.2 Joint Treatment Materials:

5.3.2.1 Joint reinforcing tape: Perforated type, width range between 45 mm and 60 mm, and 0.3 mm thick.

5.3.2.2 Joint compound: As recommended by the board manufacturer for the intended application and in accordance with ASTM C 475.

5.3.2.3 Concealed Sealants: Mastic type, non-shrink, non-drying, non-migrating, and non-staining sealant.

5.3.2.4 Exposed Sealant: Acrylic-latex type, permanently elastic and paintable.

5.3.3 Trim Accessories:

5.3.3.1 General: Provide manufacturer's standard trim accessories of types indicated for drywall work, formed of galvanized steel unless otherwise indicated, with either knurled and perforated or expanded flanges for nailing or stapling, and beaded for concealment of flanges in joint compound.

6. EXECUTION

6.1 PREPARATION OF FRAMING SYSTEMS

Ceiling Anchorage: Coordinate work with the structural ceiling work to ensure that the inserts as well as the other structural anchorage provisions have been installed to receive ceiling hangers.

6.2 INSTALLATION OF FRAMING SYSTEMS

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

6.2.1 Ceiling Support System: Installation shall conform to ASTM C 754. Secure hangers to structural support by connecting directly to structure where possible, otherwise connect to inserts, clips or other anchorage devices and fasteners as indicated.

6.2.2 Wall Support System: Installation shall conform to ASTM C 754. Align top and bottom tracks to assure plumb wall. Secure track with suitable fasteners at a maximum of 600 mm on center. Position studs in track at 600 mm on center spacing.

6.2.3 Installation of framing system shall comply with requirements of ASTM C840 or GA 216.

6.3 BOARD INSTALLATION

6.3.1 Locate exposed end-butt joints as far from center of walls and ceilings, and stagger not less than 300 mm in alternate courses of board.

6.3.2 Install ceiling boards in the direction and manner which will minimize the number of end-butt joints, and which will avoid end joints in the central area of each ceiling.

6.3.3 Install wallboard vertically to avoid end-butt joints wherever possible.

6.3.4 Install boards with face side out. Do not install imperfect, damaged or damp boards. Butt boards together for a light contact at edges and ends with not more than 1.5 mm open space between boards. Do not force in place.

6.3.5 Installation of ceiling boards shall comply with requirements of ASTM C840 or GA 216.

7. ADJUSTMENT AND CLEANING

7.1 When face of paper for gypsum board is punctured, a new screw shall be driven approximately 30 mm from puncture and fill damaged surface with compound.

7.2 Fill cracks with compound and finish smooth and flush.

8. PROTECTION OF WORK

The required procedures for protecting drywall work from damage and deterioration during remainder of construction period shall be as recommended by board manufacturer or drywall installer and approved by the Engineer.

9. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0320 - DEMOUNTABLE PARTITIONS

1. SCOPE

The work under this section of the Specification consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in any floor and at any height in connection with the fabricating, furnishing and installing of demountable partitions, complete in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the Contract.

2. APPLICABLE CODE & STANDARDS

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The codes and standards applicable to only a portion of the work specified in this section are referenced in the relevant paragraphs.

3. SUBMITTALS

The following submittals are required:

3.1 Detail drawings and/or shop drawings.

3.2 Assembly, Erection and Installation Drawings and Manuals.

3.3 Manufacturer's data.

3.4 Certificate of Compliance.

4. MATERIALS & FABRICATION

4.1 MATERIALS:

1. Cement Board Fiber Reinforced partition and door for barricading.

2. Wooden demountable partition and door for offices comprised of wooden framing, cladding with 12mm thick high density fiber board, both sides plastic laminated with machine press and teak wood lipping all around with complete set of hardware.

3. Compact high Density Fiber Board Wall and Door of specified thickness (density 1000 kg/m³) both sides melamine laminated coating, scratch resistance, splash water resistance and flame retardancy / fire resistance for cubicles and wash rooms & other wet areas with complete set of hardware (SS 304 grade) or as specified or as shown in drawing or as recommended by the manufacturer and approved by the Engineer.

4.2 FABRICATION

4.2.1 Substructure

Base, top and wall connecting channels made of roll-formed galvanized steel 1.5mm thick, surface stove enameled dark brown (KAL 8014), recessed 19mm from the surface of the partition.

Studs made of galvanized steel set up at intervals of module size 1,200mm or 1,500mm as shown on drawings.

4.2.2 Cladding

High density laminated chipboard E1 manufactured to DIN standards; holding edges have an easy to maintain laminate (HPL) finish. For special areas cladding with real wood veneer must be possible.

4.3 GLAZING

Where required glazing should be provided. Frame made of aluminium anodized flush with the partition surface.

4.4 DOORS

Door frame made of anodized aluminium, flush with the partition.

Door leaf as 40mm sandwich element coated on both sides to match the partition surface.

- Total thickness partition: 108 mm

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- Skirting height minimal: 80 mm
- Element joints: 6 mm
- Element height: clear room height
- Module: 1,500mm
- Sound insulation value for full wall element (according to DIN 52210): 45 dB
- Fire rating (according to DIN 4102): F 30

5. EXECUTION

5.1 CONDITION OF SURFACES

Examine the substructure, adjoining construction and the conditions under which the work is to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected.

5.2 INSTALLATION

5.2.1 General

a) Install demountable partitions and accessories in accordance with the manufacturer's printed instruction, unless otherwise shown or specified.

b) Space metal studs at centers as recommended by the manufacturer. Align tracks accordingly to the partition layout at both floor and ceiling. Secure floor and ceiling channels as recommended by the manufacturer.

Support end joints on framing members.

Do not align end joints with edges of openings.

Install control joints as shown.

5.2.2 Demountable Partition

a) Floor and Ceiling Attachments: Align and secure runners accurately at the floor and ceiling in accordance with the partition layout as shown.

b) Wall Attachments: Align and secure side angle runners to intersecting walls or columns of other materials.

c) Core Boards: Cut and fit sheets between floor and ceiling runners. Cut necessary openings in core boards to accept electrical services before installation. Install core board sheets vertically.

Place cut to size section of core board over metal door frame header. After core board is installed, spot grout door frame at each anchor clip, using joint compound.

Nail core board panels together at corners and intersection of partitions using 10d minimum common nails spaced 600mm (24 inch) centers.

d) Face Layer: Provide 13mm (1/2 inch) thick face layer sheets on both faces, unless otherwise shown. Cut panels to fit completely inside floor and ceiling runners. Apply joint compound or adhesive to core board or to back of face layer sheet. Apply face layer sheet vertically to core board with vertical joints offset from core board joints. Press face layer firmly against core board to ensure an adequate bond. Secure with drywall screws as recommended by the wall board manufacturer.

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5.3 PROTECTION

Protect the demountable partitions during the construction period so that it will be acceptable without any indication of use or damage at the time of acceptance.

6.0 MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0330 - PAINTING AND COATING

1. SCOPE

The work under this section of the Specifications consists of furnishing all materials, plant, labour, equipment, appliances and performing all operations in any floor and at any height in connection with surface preparation, mixing, painting concrete works, gates, frames, walls, ceilings and all such surfaces as shown on the Drawings and/or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

2. APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications wherever applicable.

2.1 BSI (British Standards Institution)

245 - Specification for mineral solvents (white spirits and related hydrocarbon solvents) for paints and other purposes.

2521 - Lead-based priming paint for wood work.

2523 - Lead based priming paint for iron and steel.

2569 - Sprayed metal coatings.

4800 - Paint colours for building purposes.

CP.231 - Painting of building.

CP.3012 - Cleaning and preparation of metal surfaces.

2.2 FS - Federal Specifications

P-W-158E - Wax, General Purpose, Solvent Type

TT-E-489G - Enamel, Alkyd, Gloss (for Exterior and Interior Surfaces)

TT-E-506K - Enamel, Alkyd, Gloss, Tints and White (for Interior Use)

TT-E-509B(2) - Enamel, Odorless, Alkyd, Interior, Semi-gloss, White and Tints

TT-E-527C - Enamel, Alkyd, Lusterless

TT-E-543A(1) - Enamel, Interior, Undercoat, White and Tints

TT-F-336E - Filler, Wood, Paste

TT-P-19C(2) - Paint, Acrylic Emulsion; Exterior

TT-P-25E(2) - Primer Coating Exterior (undercoat for Wood, Ready-Mixed, White and Tints)

TT-P-29J(1) - Paint, Latex Base, Interior, Flat, White and Tints

TT-P-30E - Paint, Alkyd, Odorless, Interior, Flat, White and Tints

TT-P-37D - Paint, Alkyd Resin; Exterior Trim, Deep Colors

TT-P-52D(2) - Paint, Oil, (Alkyd-Oil) Wood Shakes and Rough Siding

TT-P-55B(2) - Paint, Polyvinyl Emulsion, Exterior

TT-P-81E - Paint, Oil, Alkyd, Ready Mixed, Medium Shades

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TT-P-641G(1) - Primer Coating; Zinc Dust-Zinc Oxide (for Galvanized Surfaces)

TT-P-645A - Primer Paint, Zinc Chromate, Alkyd Type

TT-P-650C(1) - Primer Coating; Zinc Dust-Zinc Oxide (for Galvanized Surfaces)

TT-P-664C(2) - Primer Coating, Synthetic, Rust-Inhibiting, Lacquer Resisting

TT-S-176E(1) - Sealer, Surface, Varnish Type, Floor, Wood and Cork

TT-S-300A - Shellac, Cut

TT-S-708A(2) - Stain, Oil, Semi-Transparent, Wood, Exterior

TT-S-711C - Stain, Oil-Type, Wood, Interior

TT-V-86C(1) - Varnish, Oil, Rubbing (for Metal and Wood Furniture)

2.3 SSPC - Steel Structures Painting Council

SP-6-63 - Commercial Blast Cleaning

SP-10-63T - Near-White Blast Cleaning

2.4 ASTM - American Society for Testing and Materials

ASTM D 16 - Standard Definitions of Terms Relating to Paint, Varnish, Lacquer, and Related Products

ASTM D 562 - Consistency of Paints Using the Strometer Viscometer

ASTM D 2833 - Standard Index of Methods for Testing Architectural Paints and Coatings

ASTM D 3276 - Standard Guide for Painting Inspectors (Metal Substrates)

ASTM D 3927 - Standard Guide for State and Institutional Purchasing of Plant

ASTM E 84 - Surface Burning Characteristics of Building Material

3. SUBMITTALS

3.1 Product Data: Submit manufacturers technical information including instructions for thinning, mixing, curing and touch-up.

3.2 Manufacturer's standard color charts.

3.3 Test Reports and certificates of compliance.

3.4 Samples: Prior to beginning work, furnish color chips for surfaces to be painted. Submit samples for the Engineer review of color and texture only. Provide a listing of material and application for each coat of each finish sample.

3.4.1 On 300mm x 300mm hardboard, provide 2 samples of each color and material, with texture to simulate actual conditions. Re-submit samples as requested by Engineer until acceptable sheen, color and texture is achieved.

3.4.2 On wood surfaces, provide 2 samples 100 x 200mm of natural and stained wood finish on actual wood types. Label and identify each as to location and application.

3.4.3 On concrete masonry, provide two 100 mm square samples of masonry for each type of finish and color, defining filler, prime and finish coat.

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3.4.4 On actual wall surfaces and other exterior and interior building components, duplicate painted finishes of prepared samples. Provide full-coat finish samples on at least 9m² of surface, as directed, until required sheen, color and texture is obtained; simulate finished lighting conditions for review of in-place work.

3.4.5 Final acceptance of colors will be from samples applied on the job.

4. TRANSPORTATION, HANDLING AND STORAGE

4.1 Deliver materials to job site in manufacturer's original new and unopened packages and containers bearing manufacturer's name and label, and following information:

Name or title of material. Manufacturer's stock number and date of manufacture. Manufacturer's name. Contents by volume, for major pigment and vehicle constituents. Thinning instructions. Application instructions. Color name and number.

4.2 Store materials not in actual use in tightly covered containers in a well-ventilated area and protect from moisture, direct sunlight and temperatures below 10°C and above limits recommended by the manufacturer. Maintain containers used in storage of paint in clean conditions, free of foreign materials and residue.

4.3 Keep storage area neat and orderly. Remove oily rags and waste daily. Take all precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of paints.

5. QUALITY ASSURANCE

5.1 Single Source Responsibility: Provide primers and other undercoat paint produced by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits.

5.2 Coordination of Work: Review other Sections of these Specifications in which prime paints are to be provided to ensure compatibility of total coatings system for various substrates. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.

5.3 Material Quality: Provide manufacturer's best quality trade sale paint material of various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.

6. JOB CONDITIONS

6.1 Do not paint when air is dust-laden or when weather and temperature conditions are unsuitable. Do not paint exterior surfaces in damp or rainy weather. Comply with manufacturer's recommendations with respect to application and drying period temperatures.

6.2 Apply water-based paints only when temperature of surfaces to be painted and surrounding air temperatures are between 10°C and 32°C unless otherwise permitted by paint manufacturer's printed instructions.

6.3 Apply solvent-thinned paints only when temperature of surfaces to be painted and surrounding air temperatures are between 70°C and 65°C unless otherwise permitted by paint manufacturer's printed instructions. (Note: likely a range error, but kept as original)

6.4 Do not apply paint when relative humidity exceeds 85% or to damp or wet surfaces; unless otherwise permitted by paint manufacturer's printed instructions.

6.5 The Contractor shall repair at his own expense all damaged or defective areas of shop-painted metal work and structural steel work. Metal surfaces against which concrete is to be placed will be furnished shop-painted and shall be cleaned prior to being embedded in concrete.

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7. MATERIALS

7.1 Material Quality: Paints (listed below), coatings, and primers shall be ready-mixed at the manufacturer's plant and shall be delivered in sealed containers, labeled and identified. Provide best quality grade of various types of coatings as regularly manufactured by acceptable paint materials manufacturers. Paints and finishes shall have Class A rating in accordance with ASTM E 84. Materials without manufacturer's identification as a standard, best-grade product will not be acceptable. Use products of same manufacturer for succeeding coats.

7.1.1 Weather resistant paint over CC Plaster, soft, exposed surfaces.

7.1.2 Epoxy Paint over MS Framing Structures.

7.1.3 Water repellent coatings.

7.1.4 Textured paint over Fair face Precast Elements.

7.1.5 Plastic emulsion paint over CC plaster, fairfaced concrete, exposed surfaces, soft.

7.2 Color Pigments: Pure, non-fading, applicable types to suit substrates and service indicated.

7.3 Color and Texture:

7.3.1 Exterior Painting: Color, and texture of the exterior paint shall be as indicated on Drawings.

7.3.2 Interior Painting: Colors, textures, and degree of luster will be as indicated on the Drawings and as per Specifications. Color selection will include safety colors for hazards in accordance with ANSI Z53.1 Safety Color Code for Marking Physical Hazards. Tint prime and undercoats approximately to the shade of the final coat but with sufficient variation to distinguish them from the preceding coat.

7.4 Mildewcide: Paints shall contain a mildewcide as recommended by the manufacturer.

7.5 Solvents and Thinners: As recommended by the paint manufacturer.

8. PAINTING SCHEDULE

8.1 Exterior Paint Schedule

8.1.1 Concrete, Plaster and Masonry - Smooth:

- a. Prime Coat: Acrylic Primer Sealer based on Copolymer Resins.
- b. Second Coat: Acrylic Copolymer Exterior Emulsion / Weather Resistant Total Dry Film Thickness (DFT) 30 micron.
- c. Finish Coat: Same as for Second Coat.

8.1.2 Concrete, Plaster, and Masonry - Textured:

- a. Prime Coat: Acrylic Primer Sealer based on Copolymer Resins.
- b. Second Coat: Acrylic Copolymer Exterior Emulsion (Sprayed Applied), Dry Film Thickness (DFT) 50 micron.
- c. Finish Coat: Same as for Second Coat.

8.1.3 Waterproof Painting System:

- a. Proprietary coating system consisting of synthetic rubber copolymer and suitable for external exposed application.

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b. Prime coats and finish coat shall be applied as per the manufacturer's written recommendations for the intended application.

8.1.4 Ferrous Metals:

a. Prime Coat: Polyamide Cured Epoxy Primer, 50 micron (DFT).

b. Second Coat: High Build Epoxy, 125 micron thick (DFT).

c. Finish Coat: Two-Component Polyurethane, semi-gloss, 50 micron (DFT).

8.1.5 Zinc-Coated Metals:

a. Prime Coat: Acrylic Water Based Primer for GI.

b. Second Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).

c. Finish Coat: Same as for second coat.

8.1.6 Painted Wood:

a. Prime Coat: Wood Primer based on Alkyd Resins.

b. Second Coat: Wood Filler based on Alkyd Resins.

c. Third Coat: Under coat based on Alkyd Resins.

d. Fourth Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).

e. Finish Coat: Same as for fourth coat.

8.1.7 Natural Finish Wood:

a. Prime Coat: Wood Stain based on Alkyd Resins.

b. Second Primer: Wood Stain based on Alkyd Resins.

c. Third Coat: Lacquer, semi-gloss, 25 micron (DFT) based on Urethane Alkyd Resins.

d. Finish Coat: Same as for third coat.

8.2 Interior Paint Schedule:

8.2.1 Concrete, Plaster, Gypsum Board, Reinforced Decorative Gypsum and Masonry:

a. Prime Coat: Acrylic Primer Sealer based on Copolymer Resins.

b. Second Coat: Acrylic Copolymer Interior / Plastic Emulsion, eggshell, Dry Film Thickness 25 micron (DFT).

c. Finish Coat: Same as for second coat.

8.2.2 Anti-Bacterial Paint Suitable for Hospital Applications on Concrete, Plaster, Gypsum Board, Reinforced Decorative Gypsum and Masonry:

a. Prime Coat: Anti-Bacterial Acrylic Primer Sealer based on Copolymer Resins, flat.

b. Second Coat: Anti-Bacterial Acrylic Copolymer Interior Emulsion, eggshell, undiluted coats at minimum 50 micron Dry Film Thickness (DFT).

c. Finish Coat: Same as for second coat.

8.2.3 Ferrous Metals: (As specified in Exterior Paint Schedule for ferrous metals)

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8.2.4 Zinc-Coated Metals: Same as specified for Exterior Paint Schedule.

8.2.5 Painted and Natural Finish Wood: Same as specified in Exterior Paint Schedule.

8.2.6 Exposed Metal Pipes, Ducts, and other Metal work: Same as specified in Exterior Paint Schedule for each type of metal.

9. EXECUTION

9.1 INSPECTION

9.1.1 Examine substrate and conditions under which painting will be performed. Proceed with the work only when conditions are satisfactory.

9.1.2 Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to formation of a durable paint film.

9.2 SURFACE PREPARATION

9.2.1 General:

a. Remove hardware and accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish-painted, or provide surface-applied protection prior to surface preparation and painting operations. Remove, if necessary, for complete painting of items and adjacent surfaces. Following completion of painting of each space or area, reinstall removed items.

b. Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.

c. Perform preparation and cleaning procedures in accordance with paint manufacturer's instructions and as herein specified, for each particular substrate condition.

d. Fill dents, cracks, hollow places, open joints, and other irregularities with a filler suitable for the purpose and, after setting sand to a smooth finish.

e. Prime surfaces not more than 8 hours after cleaning. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify the Engineer in writing of any anticipated problems in using the specified coating systems with substrates primed by others.

9.2.2 Concrete, Masonry and Plaster Works: Prepare surfaces of concrete, concrete masonry cement plaster and gypsum plaster to be painted by removing efflorescence, chalk, dust, dirt, grease, oils, and by roughening as required to remove glaze. Use abrasive blast-cleaning methods if recommended by paint manufacturer and approved by Engineer.

a. Determine alkalinity and moisture content of surfaces to be painted by performing appropriate tests. If surfaces are found to be sufficiently alkaline to cause blistering and burning of finish paint, correct this condition before application of paint. Do not paint over surfaces where moisture content exceeds that permitted in manufacturer's printed directions.

b. Clean concrete floor surfaces scheduled to be painted with a commercial solution of (text incomplete in original, but preserved as is).

9.2.3 Gypsum Board: Repair minor cracks and holes with finishing compound, and sand smooth after drying.

9.2.4 Wood: Clean wood surfaces to be painted of dirt, oil, or other foreign substances with scrapers, mineral spirits and sandpaper, as required. Sandpaper smooth those finished surfaces exposed to view, and dust off. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended

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knot sealer, before application of priming coat. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood-filler. Sandpaper smooth when dried.

9.2.5 Ferrous Metals: Clean non-galvanized ferrous-metal surfaces that have not been shop coated; remove mortar, plaster, grease, dirt, rust, loose mill scale and other foreign substances by solvent or mechanical cleaning methods that comply with the recommendations of the Steel Structures Painting Council, before priming coat is applied.

9.2.6 Shop-Primed Ferrous Surfaces: Remove grease, oil and other foreign substances with approved type of cleaner manufactured for the purpose. Exercise care to prevent damage to shop coat. Touch-up abraded or marred shop coats with paint used for priming.

9.2.7 Zinc-Coated (Galvanized) Surfaces: Remove grease and oil with a cleaner manufactured for the purpose. Treat surfaces with a chemical compound such as a phosphoric acid wash. Remove the chemical compound completely with clean, fresh water.

9.3 MATERIALS PREPARATION

9.3.1 Mix and prepare painting materials in accordance with manufacturer's directions.

9.3.2 Maintain containers used in mixing and application of paint in clean condition, free of foreign materials and residue.

9.3.3 Stir materials before application to produce mixture of uniform density, stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

9.4 APPLICATION

9.4.1 Apply paint in accordance with the manufacturer's directions. Use applicators and techniques best suited for the type of material being applied. Do not exceed manufacturers recommended coverage per gallon. Apply materials with care to a uniform and proper film thickness, showing no runs, holidays, sags, crawls, or other defects. Apply with a minimum of brush marks. Finish surfaces shall be uniform in sheen, color and texture and match approved samples.

9.4.2 Allow coats to dry thoroughly before succeeding coats are applied; allow a minimum of 24 hours between applications on any one surface unless otherwise specified by the paint materials manufacturer.

9.4.3 Sandpaper undercoats on interior metal thoroughly and uniformly to provide a smooth, even surface for finish coats.

9.4.4 Apply paint by brush, roller, spray, or other acceptable practice in accordance with the manufacturer's directions. Use brushes best suited for the type of material being applied. Use rollers of carpet, velvet back, and high-sheen wool as recommended by the paint manufacturer for material.

9.4.5 Brush-out and work all brush coats into the surfaces in an even film. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, or other surface imperfections will not be acceptable. Neatly draw all primer or first coats, unless otherwise permitted to use mechanical applicators.

9.4.6 Except as otherwise specified, apply a prime coat to material that is required to be painted or finished.

9.4.7 Apply the first-coat material to surfaces that have been cleaned, pre-treated or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

9.4.8 Number of coats and paint film thickness required is the same regardless of the application method. Sand between each enamel and varnish coat application with fine sandpaper or rub surfaces with pumice stone where required to produce an even, smooth surface in accordance with the paint manufacturer's directions.

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9.4.9 Allow sufficient time between successive coatings to permit thorough drying. Do not re-coat until paint does not deform or feel sticky under moderate thumb pressure and the application of loss of adhesion of the undercoat.

9.4.10 Paint type, color, surface treatment shall be as scheduled. Provide finish coats that are compatible with prime paints used.

9.4.11 When undercoats, stains, or other conditions show through the final coat of paint, apply additional coats until the paint film is of uniform finish, color and appearance. Ensure that all surfaces including edges, corners, crevices, welds, and exposed fasteners receive a film thickness equivalent to that of flat surfaces.

9.4.12 Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Paint surfaces behind permanently fixed equipment or furniture with prime coat only. Exposed surfaces are defined as those areas visible when permanent or built-in fixtures, convactor covers, covers for fanned tube radiation, grilles and similar items are in place in areas scheduled to be painted.

9.4.13 Where visible through registers or grilles, paint interior surfaces of ducts and void spaces with a flat, non-specular black paint.

9.4.14 Paint the back sides of access panels and removable or hinged covers to match the exposed surfaces.

9.4.15 Finish exterior doors on tops, bottoms and side edges the same as the exterior faces, unless otherwise indicated.

9.4.16 Omit primer on metal surfaces that have been shop-primed and touch-up painted.

9.4.17 Dry Film Thickness: Provide dry film thickness for each finish type, including prime and finish coats, not less than total dry film thickness as specified in painting schedule.

9.4.18 Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling such as laps, irregularity in texture, skid marks, or other surface imperfections.

9.4.19 Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, or other surface imperfections will not be acceptable.

9.4.20 Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film.

9.4.21 Completed Work: Match approved samples for color, texture and coverage. Remove, refinish or re-paint work not in compliance with specified requirements.

9.5 CLEAN-UP AND PROTECTION

9.5.1 Clean-Up:

a. During progress of work, remove from site discarded paint materials, rubbish, cans and rags at end of each work day.

b. Upon completion of painting work, clean window glass and other paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces.

9.5.2 Protection:

a. Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing or replacing, and repainting, as acceptable by the Engineer.

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- b. Provide Wet Paint signs as required to protect newly-painted finishes. Remove temporary protective wrappings provided by others for protection of their work, after completion of painting operations.
- c. At completion of work of other trades, touch-up and restore damaged and/or defaced surfaces.

10. MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0335 - PIR INSULATED SANDWICH PANELS

1. Scope

The work under this item shall consist of supplying, transporting, handling, storing, installing, fixing, sealing, finishing and protecting PIR insulated sandwich panels for walls/roof or other locations as shown on the drawings, design details and approved shop drawings.

The work shall include all panels, fixing accessories, trims, flashings, sealants, fasteners, supports, cutting, jointing, alignment, sealing, finishing and all incidental works required for a complete, weather-tight, insulated and finished installation, as directed by the Architect and Engineer-in-Charge.

2. Material Requirements

PIR insulated sandwich panels shall be factory-manufactured, rigid, pre-finished insulated panels of approved make and source. Panels shall generally comply with the following minimum requirements unless otherwise shown on drawings:

Panel type: PIR insulated sandwich panel.

Core material: CFC-free Polyisocyanurate/PIR insulation.

Panel thickness: 100 mm, or as shown on drawings/design.

Core density: 38–40 kg/m³ minimum.

External face sheet: 0.5 mm thick pre-painted galvanized iron sheet, low-rib profile, colour as approved by the Architect/Engineer.

Internal face sheet: 0.5 mm thick pre-painted galvanized iron sheet, low-rib profile, colour as approved by the Architect/Engineer.

Panel width: approximately 1000 mm, or as per manufacturer's standard and approved shop drawings.

Manufacturing: Ozone-friendly cyclopentane-based technology or approved equivalent.

Surface finish: factory pre-painted, uniform colour, free from dents, scratches, stains, rust, delamination and other visible defects.

All materials shall be new, unused, first quality and suitable for the climatic conditions of Skardu, including low temperature, wind exposure, snow load, UV exposure and thermal movement.

3. Accessories

The Contractor shall provide all necessary accessories required for complete installation, including but not limited to:

Panel fixing screws/fasteners with washers;

Jointing accessories;

Trims;

Corner flashings;

End closures;

Ridge/eaves/edge flashings where applicable;

Approved silicone/sealant;

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Foam fillers where required;

Cover strips;

Base channels/support interfaces where shown;

Touch-up paint for minor approved repairs.

All accessories shall be compatible with the panel system and shall be approved by the Engineer before installation.

4. Shop Drawings and Submittals

Before procurement and installation, the Contractor shall submit the following for approval:

Manufacturer's technical data sheet;

Panel samples and colour sample;

Shop drawings showing layout, panel direction, fixing details, joints, trims, flashings, openings and interface with structure;

Method statement for installation;

Material test certificates;

Fire performance certificate/test report;

Thermal insulation data;

Warranty certificate;

Manufacturer's installation manual.

No material shall be ordered or installed without approval of the Engineer.

5. Installation

Panels shall be installed strictly in accordance with the approved shop drawings, manufacturer's recommendations and directions of the Architect/Engineer.

Installation shall include:

Checking of supporting structure before fixing;

Proper alignment, line, level and plumb;

Accurate cutting around openings and edges;

Proper lapping and jointing;

Fixing with approved fasteners at recommended spacing;

Sealing of all joints, corners, flashings and penetrations;

Protection of finished surfaces during and after installation;

Removal of protective film where applicable;

Final cleaning and making good.

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Panels damaged during transport, handling, cutting or installation shall be replaced at the Contractor's cost if rejected by the Engineer.

6. Quality Control

The Engineer may inspect panels at factory or site before installation. Materials shall be rejected if found defective, damaged, deformed, delaminated, rusted, poorly painted or inconsistent with the approved sample.

The completed installation shall be checked for:

Alignment and level;

Firm fixing;

Proper sealing;

Joint finish;

Colour uniformity;

Weather tightness;

Surface cleanliness;

Absence of gaps, leakage paths and visible defects.

7. Warranty

The Contractor shall provide manufacturer's warranty for PIR insulation and panel system. The minimum warranty shall cover manufacturing defects, delamination, insulation failure and installation defects for the period approved under the Contract. Paint/steel sheet warranty shall be as per manufacturer's standard warranty and approved by the Engineer.

8. Measurement and Payment

Measurement shall be made in square feet (Sft) of actual approved installed panel area, measured on the finished surface as shown on drawings and accepted by the Engineer.

The BOQ quantity is 26,841.94 Sft.

The quoted rate shall include supply, transportation, loading, unloading, storage, handling, installation, fixing accessories, trims, flashings, sealants, cutting, wastage, tools, tackles, scaffolding/access arrangement, protection, cleaning, testing, warranty and all incidental works required for complete installation.

No separate payment shall be made for accessories, fasteners, sealants, flashings, trims, cutting, wastage, protection or minor adjustments unless specifically stated in the BOQ.

SECTION 0340 - ROAD WORKS

PART 01 — GENERAL REQUIREMENTS

1.1 Project Description

This specification covers all road works associated with the construction of the Air Traffic Control Tower (ATCT), Fire Station, and allied facilities at Skardu International Airport, Gilgit-Baltistan, Pakistan. Works include access roads, service roads, and internal circulation roads within the airport boundary as shown on Drawings.

1.2 Scope of Roads

Drawing Ref.	Road Alignment	Length (m)	Road Width (m)	Remarks
R-04 / R-08 / R-09	ATC Tower to Apron	521.97	14.50	Primary access
R-04 / R-09 / R-10	ATC Tower to Old Runway PAA	1,050.60	14.50	Main perimeter road
R-04 / R-09 / R-10	ATC Tower to Old Runway PAA (cont.)	1,050.60	14.50	See profile sheets
R-04 / R-10	PAA Runway to PAF Runway	223.10	14.50	Connector road
R-04	ATC Tower to PAA Runway (N-S link)	~500	14.50	Internal service road

NOTE: All dimensions are in METERS unless indicated otherwise. Coordinate System: WGS84.
Pavement Height: 0.95 m above finished grade.

1.3 Road Cross-Section Summary

All roads are dual carriageway, symmetrical about centerline. Total formation width: 14.50 m as shown on Drawings R-06 and R-07.

Element	Width (m)	Cross-fall	Notes
Drain/Curb (each side)	2.00	—	Steel grating drain with Precast PCC kerb (3000 PSI)
Shoulder (shy distance, each side)	1.50	2%	Compacted granular, matches carriageway crossfall
Carriageway (each side of CL)	3.75	2%	Asphalt pavement; 2% fall away from centerline

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

TOTAL ROAD WIDTH	14.50	—	Symmetrical — fill section, cut section, cut & fill
Side Slopes (fill)	1V:1.5H	—	Embankment slopes per Drg. R-06
Side Slopes (cut)	1V:1H	—	Cut slopes per Drg. R-07

1.4 Applicable Standards & References

- Overseas Road Note 31 (TRL, UK) — Primary design standard
- NHA General Specifications (Pakistan, latest edition) — Works execution standard
- AASHTO LRFD Bridge/Highway Design Specifications
- ASTM International — Material testing standards
- Pakistan Standards & Quality Control Authority (PSQCA)
- PAA / ICAO airport pavement design requirements

SUBMITTAL PROCEDURES

1.1 Pre-Construction Submittals

Mobilization Plan, Organizational Chart, Programme of Works (Primavera / MS-Project)

HSE Plan, QA/QC Plan, Traffic Management Plan

Performance Bond and Insurance documents

Plant calibration certificates: Asphalt Batch Mix Plant (third-party, Engineer-approved)

Survey team credentials: Licensed Land Surveyor + 2 assistants; Total Station calibration certificate (≤ 6 months old)

BM register and daily survey log

Job Mix Formula (JMF) + Trial Section report (50 m full width)

1.2 Material Source Approvals (Before Delivery)

Aggregates: LAA, soundness, flakiness, gradation test reports

Bitumen: penetration, softening point, ductility, flash point test reports

Water quality certificate

NOTE: *No material shall be incorporated without Engineer's written approval.*

1.3 During Construction

Daily field test results: FDT, MDD/OMC, layer gradation

AWC plant samples: extraction, gradation, Marshall

Pavement cores: 1 per 500 m² for thickness and density

Weekly QC Report to Engineer

Survey check report on every layer (subgrade, GSB, ABC, AWC)

1.4 At Completion

Full as-built drawings (plan, profile, cross-sections)

All test certificates and QC records

Photographic record

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QUALITY REQUIREMENTS

1.1 Testing Frequencies

Layer / Material	Test Type	Frequency	Standard
Subgrade	FDT (Sand-Cone / Nuclear)	Every 500 m ² per layer	Modified AASHTO MDD
Granular Subbase (GSB)	FDT, Gradation, Atterberg	Every 500 m ² per layer	AASHTO T180
Aggregate Base Course (ABC)	FDT, Gradation, LAA, PI	Every 500 m ² per layer	AASHTO T180
Prime Coat	Application rate check	Each section	MC-30 / MC-70
AWC (plant)	Extraction, gradation, Marshall	Per shift / per 100 tonnes	AASHTO T166, T245
AWC (pavement core)	Thickness, density	1 per 500 m ²	AASHTO T230
AWC (survey)	Line, level, crossfall	Every layer, full length	NHA Tolerances

PART 02 EARTHWORK

SITE CLEARING

1.1 Description

Clear, grub, and strip the full formation width including side slopes and drainage channel areas.

2.1 Products — Topsoil

Topsoil stripping minimum 150 mm depth. Stockpile separately for landscaping reuse at an Engineer-approved location with proper drainage and protection.

3.1 Execution

Clear all vegetation, roots, and organic material within the road formation.

Dispose of unsuitable material at Engineer-approved spoil area only.

Do not mix stripped topsoil with sub-soil excavation.

Maintain dust suppression by water bowsing twice daily.

Cover stockpiles in windy conditions.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

EARTHWORK & GRADING

1.1 Summary

Earthwork comprises cut and fill operations to achieve formation levels as shown on the Road Profile and Cross-Section drawings (R-06, R-07, R-08 through R-37).

1.2 Road Profile Data

Longitudinal profiles for each alignment extracted from drawings are summarized below:

Alignment	Start Station	End Station	Start Elev. (m)	End Elev. (m)	Grade (%)
ATC Tower to Apron	0+000	0+521.97	2228.52	~2229.6	+0.27% (approx.)
ATC Tower to Old Runway PAA (Segment 1)	0+000	0+540	2228.52	2230.00	0.00% / flat
ATC Tower to Old Runway PAA (Segment 2)	0+540	1+050.60	2230.00	2218.68	-4.63%
ATC Tower to Old Runway PAA (Segment 3)	1+010	1+050.60	~2219	2218.68	-0.45%
PAA Runway to PAF Runway	0+000	0+223.10	~2219	~2219	Level / minor

NOTE: Vertical Curve data: PVI STA 0+050, PVI Elev. 2230.00, K=185.98, LVC=50 m (start of alignment); PVI STA 0+760, PVI Elev. 2230.00, K=16.20, LVC=75 m (mid-section); Low Point STA 10+024.70, Low PT Elev. 2218.79, PVI STA 0+995.70, PVI Elev. 2216.90, K=11.06, LVC=50 m (end). Refer to profile drawings for all PVI data.

1.3 Embankment (Fill) Sections

Side slopes: 1 Vertical: 1.50 Horizontal (1V:1.5H) for fill areas

Embankment layers: maximum 200 mm loose thickness per compacted layer

Compaction: 95% Modified AASHTO MDD

Proof-roll embankment after every two layers using loaded tipper truck (≥ 10 t axle load)

Do not place embankment on frozen, wet, or soft ground

1.4 Cut Sections

Side slopes: 1 Vertical: 1.00 Horizontal (1V:1H) for cut areas

Side slopes: 1V:1.5H for cut-and-fill transition zones (as shown on Drawing R-07)

Dispose of surplus cut material at Engineer-approved spoil area

Bench cut slopes in hard material where instability risk exists

2.1 Subgrade Requirements

Parameter	Requirement	Test Method	Reference
CBR (minimum)	5%	AASHTO T193	Drg. R-02, General Note 1c
Compaction depth	Top 300 mm (1.0 ft)	—	Drg. R-02, General Note 3
Compaction standard	95% Modified AASHTO MDD	AASHTO T180	Drg. R-02, General Note 3
FDT frequency	1 per 500 m ² per layer	Sand-Cone / Nuclear	Drg. R-03, Section C3
Proof-roll	Required before GSB placement	Loaded truck	Drg. R-03, Section C3

3.1 Execution — Earthwork

Set out centerline, edges, ROW, and toe lines at 20 m intervals and at every PI/PC/PT.

Install reference pegs and offset pillars. Maintain BM register and daily survey log.

Execute cut/fill to formation levels per Plan & Profile drawings.

Correct any soft or pumping spots in subgrade before proceeding.

Verify all BMs and control points jointly with the Engineer (ref. Drawing 0-01).

PART 03 EXTERIOR IMPROVEMENTS

AGGREGATE BASE COURSES

1.1 Summary

This section specifies Granular Subbase Course (GSB) and Aggregate Base Course (ABC) for all road alignments at Skardu Airport.

1.2 Pavement Layer Schedule

Layer	Thickness (mm)	CBR Req.	Zone	Drawing Ref.
Asphaltic Wearing Course (AWC)	50	—	Carriageway (full width)	R-06, R-07
Aggregate Base Course (ABC)	80	≥ 80%	Carriageway (full width)	R-06, R-07
Granular Base	300	—	Carriageway (CL zone)	R-06, R-07

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Granular Base (shoulder zone)	380	—	Outer zones	R-06, R-07
Granular Subbase Course (GSB)	150	≥ 30%	Full width	R-06, R-07
Compacted Subgrade	300 min.	≥ 5%	Full width	R-06, R-07
TOTAL PAVEMENT STRUCTURE	880 (CL) / 960 (shoulder)	—	—	—

2.1 Products — Granular Subbase Course (GSB)

Property	Requirement	Test Standard
CBR	≥ 30% (minimum)	AASHTO T193
Gradation & PI	Per NHA Schedule	AASHTO T27 / T89
Max. layer thickness (loose)	≤ 200 mm	—
Compaction	100% Modified AASHTO MDD	AASHTO T180
Surface tolerance	± 15 mm	3 m straightedge

2.2 Products — Aggregate Base Course (ABC)

Property	Requirement	Test Standard
CBR	≥ 80% (minimum)	AASHTO T193
Material	Crushed, hard, durable	Visual + AASHTO T96
Los Angeles Abrasion (LAA)	≤ 30%	AASHTO T96
Soundness	≤ 12%	AASHTO T104
Flakiness Index	≤ 25%	BS 812
Plasticity Index (PI)	≤ 6	AASHTO T90
Max. layer thickness (loose)	≤ 150 mm	—

Compaction	100% Modified AASHTO MDD	AASHTO T180
Surface tolerance	± 10 mm	3 m straightedge

3.1 Execution — Base Courses

Verify and certify subgrade completion before placing GSB.

Place GSB in maximum 200 mm loose layers; compact to 100% Modified AASHTO MDD.

Place ABC in maximum 150 mm loose layers; compact to 100% Modified AASHTO MDD.

Apply prime coat on finished ABC surface before AWC placement.

Maintain crossfall at -2% (away from centerline) throughout construction.

Check surface tolerance against 3 m straightedge after each layer.

PART 04 ASPHALT PAVING

1.1 Summary

Asphaltic wearing course (AWC) for all road surfaces. Design based on Overseas Road Note 31 and NHA specifications. AWC thickness: 50 mm.

2.1 Materials — Prime Coat

Property	Requirement	Notes
Bitumen Grade	Cutback MC-30 or MC-70	NHA Schedule item
Application Rate	0.8–1.2 L/m ²	Over dry, broomed ABC
Application Temperature	50–70 °C	Cutback bitumen
Curing Time	24–48 hours minimum	Protect from traffic until absorbed

2.2 Materials — Tack Coat

Property	Requirement	Notes
Bitumen Grade	RC-70 or Emulsion SS-1h	NHA approved
Application Rate	0.25–0.40 L/m ²	Between bituminous layers
Surfaces	Between all bituminous layers; vertical faces of joints, kerbs, structures	—

2.3 Materials — Asphaltic Wearing Course (AWC)

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Property	Requirement	Reference
Bitumen Pen. Grade	60/70 pen (ARL / NRL approved)	NHA Schedule
Bitumen Content	4.0–5.5% by weight of mix	Job Mix Formula (JMF)
Aggregate	Per NHA Schedule	Source-approved before use
Design Method	Marshall	AASHTO T245
Marshall Stability	$\geq 1,000$ kg	AASHTO T245
Marshall Flow	2–4 mm	AASHTO T245
Air Voids (Va)	3–5%	AASHTO T269
VMA	Per NHA Specifications	—
VFA	Per NHA Specifications	—
Compaction (field)	$\geq 96\%$ of JMF density	AASHTO T166 / T230
Thickness	50 mm	Drawings R-06, R-07

2.4 Temperature Limits (NHA — Strictly Enforced)

Process	Temperature Limit	Action if Violated
Bitumen storage in tank	Max 165 °C (never exceed 175 °C)	Stop heating, investigate
Aggregate heating in dryer	150–170 °C	Adjust burner
Mixing at plant	150–165 °C	Adjust and re-check
Discharge at paver	≥ 140 °C (reject if < 135 °C)	Reject load, return to plant
Initial / breakdown rolling	≥ 130 °C	Start rolling immediately after paving
Intermediate rolling	100–130 °C	Pneumatic-tyre roller phase
Final rolling	≥ 80 °C	Steel tandem finish pass

Ambient air temperature	$\geq 10^{\circ}\text{C}$ and rising	No paving in rain, snow, or on damp / frozen surface
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3.1 Execution — Asphalt Paving

Submit and obtain approval for JMF and Trial Section (50 m full width) before regular paving.

Apply prime coat to ABC surface. Allow 24–48 hr curing before placing AWC.

Apply tack coat between all bituminous layers and at vertical faces.

Pave with self-propelled crawler-track paver; minimum working width 2.5 m; electronic grade and slope sensors with averaging ski/beam ≥ 9 m for main road.

Use Material Transfer Vehicle (MTV) to avoid segregation and temperature drop.

Rolling sequence: Breakdown rolling (Steel Tandem 8–10 t) immediately behind paver. Intermediate rolling (Pneumatic-tyre 15–25 t @ 0.55–0.85 MPa tyre pressure). Finish rolling (Steel Tandem 8–10 t).

Longitudinal joints: offset between successive layers ≥ 150 mm. Joints to be hot, vertical, painted with tack coat.

No paving in rain, snow, or when ambient temperature $< 10^{\circ}\text{C}$.

PART 05 — CURBS, KERBS & GUTTERS

1.1 Summary

Precast PCC kerb stones and steel grating drainage channels as shown on Drawing R-06 (Typical X-Section of Fill).

2.1 Products — Kerb Stones

Item	Specification	Drawing Reference
Type	Precast PCC Kerb Stone	Drg. R-06 Detail
Concrete Strength	3,000 PSI (≈ 20.7 MPa)	Drg. R-06 Detail
Kerb Dimensions (standard)	150 (base) $\times$ 350 (height) mm profile	Drg. R-06 Kerb Stone Detail
Precast PCC Kerb (alternate)	150 $\times$ 150 $\times$ 100 mm section with lean concrete base PCC (1:4:8)	Drg. R-06 PCC Kerb Detail
Installation	Set on compacted earth with 1.5-inch clear cover reinforcement	Drg. R-06 Section A

2.2 Products — Drainage Channel (Steel Grating)

Item	Specification	Drawing Reference
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Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Type	Steel Grating Drain	Drg. R-06 Detail 'A'
Drain Width	2.00 m each side (within Drain/Curb zone)	Drg. R-06
Channel Box	PCC 1:2:4 reinforced with #3@9" C/C bars, 4" cover	Drg. R-06 Detail 'A'
Grating Frame	6.35 × 6.35 × 0.63 angle iron welded frame	Drg. R-06 Detail 'A'
Cramp	2.54 × 2.54 × 0.31 cramp welded to 5.08 × 5.08 × 0.63 angle iron frame	Drg. R-06 Detail 'A'

PART 06 — PAVING SPECIALTIES (TUFF PAVERS)

1.1 Summary

Tuff pavers are specified for the pedestrian plaza and entry forecourt areas as shown on the road plan drawing (R-04). Provide interlocking concrete block paving (Tuff Tiles) in designated areas.

2.1 Products

Tuff Paver (Interlocking Concrete Block): minimum compressive strength 35 MPa (5,000 PSI)

Thickness: 60 mm for pedestrian areas; 80 mm for light vehicle areas

Laying pattern: herringbone (45° to traffic direction)

Bedding sand: sharp, clean, 25–50 mm compacted depth

Edge restraint: kerb as specified in Section

3.1 Execution

Prepare base compacted to 95% MDD before laying sand bed.

Lay pavers on compacted sand bed, maintain consistent joint width 2–4 mm.

Fill joints with dry fine sand and vibrate in using plate compactor.

PART 07 — FENCING & SITE FURNISHINGS

1.1 Scope

Provide footpath, road shoulders, and ROW boundary fencing as shown on drawings. Footpaths 5'-0" (1.52 m) wide are indicated along all main road alignments on Drawing R-01.

PART 08— UNDERGROUND UTILITIES IN ROAD CROSS-SECTION

1.1 Summary

The road cross-section incorporates conduits for utilities within the drainage/curb zone on each side of the road as shown on Drawings R-06 and R-07.

2.1 Products

Item	Specification	Location
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Electrical Conduit	Ø 150 mm PVC/HDPE conduit	Drain/Curb zone, each side
Fibre Optic (FO) Conduit	Ø 100 mm PVC/HDPE conduit	Drain/Curb zone, each side
Depth of Cover	Minimum 600 mm below finished surface	Per utility routing drawings
Bedding	Sand bedding 150 mm all around	Prior to drainage concrete channel

NOTE: *Install all conduits before placing drainage channel concrete. Co-ordinate utility routing with MEP engineer. Provide draw-wire in each conduit.*

TEMPORARY FACILITIES & CONTROLS

PLANT, MACHINERY & EQUIPMENT

1.1 Minimum Equipment Requirements (NHA Standard)

Equipment	Minimum Specification	Notes
Asphalt Batch Mix Plant	Fully automatic, min 100 TPH; 4 cold-feed bins, rotary dryer, vibrating hot screen, hot bins, mineral-filler silo, bitumen tank ≥ 30 t, bag-house dust collection	Plant calibration cert (third-party) before trial mix
Plant Location	Within 40 km haul distance from laying point; EPA/NOC required	Separate stockpile bays per fraction
Asphalt Paver	Self-propelled crawler-track; hydraulic screed 2.5–6.0 m; electronic grade & slope sensors; avg. ski ≥ 9 m	MTV recommended
Breakdown Roller	Steel Tandem vibratory, ≥ 10 t	AASHTO T177
Intermediate Roller	Pneumatic-tyre 15–25 t @ 0.55–0.85 MPa	Valid calibration required
Finish Roller	Steel Tandem 8–10 t	Valid weight certificate
Earthwork Roller (GSB/ABC)	Vibratory smooth-drum ≥ 10 t	—
Motor Grader	≥ 125 HP	For shaping and grading
Water Bowser	$\geq 6,000$ L each	One per active section
Bitumen Distributor	Calibrated spray bar (prime/tack coat)	—
Tipper Trucks (HMA)	Insulated body with tarpaulin cover	For hot mix transport
Total Station	Accuracy 1", with Auto Level ≤ 0.5 mm/km	Calib. cert ≤ 6 months
On-site QC Lab	Sieve analysis, Atterberg, MDD/OMC, FDT, CBR, LAA, Marshall, extraction, bitumen pen/softening/ductility, core density	Established before works start

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

HSE REQUIREMENTS

HEALTH, SAFETY & ENVIRONMENT

1.1 General

Mandatory PPE: helmet, hi-vis vest, safety boots, gloves, ear protection (near plant).

Traffic management: TCP, signage, flagmen, and lighting during night works.

Dust suppression: water bowsing twice daily; cover stockpiles in windy conditions.

Spill kits at fuel point and bitumen tank at all times.

Mobilize within 14 days of NTP.

Submit HSE Plan, QA/QC Plan, and Traffic Management Plan before commencement.

1.2 Environmental Controls

Stockpile topsoil separately for reuse — no disposal without Engineer approval.

Dispose of unsuitable/surplus material at designated Engineer-approved spoil area.

Obtain EPA/NOC for asphalt plant location before operation.

Plant area to be away from residential zones; paved access road provided.

Separate stockpile bays per aggregate fraction with drainage and fencing.

1.3 Plant Worthiness

All machinery in sound working order with road-worthiness certificates.

All rollers with valid calibration and weight certificates.

Total Station and QC lab equipment calibrated within 6 months.

APPENDIX A — KEY DRAWING SCHEDULE

Drawing No.	Drawing Title	Content
R-01	ATC Roads Plan (Satellite View)	Overall airport road layout
R-02	General Notes	Design basis, CBR parameters, NHA notes
R-03	General Notes for Contractor	Mobilization, plant, earthworks, pavement, QC, HSE
R-04	Plan	Road alignment plan with stationing
R-05	Route Co-ordinates	WGS84 station co-ordinates for all alignments
R-06	Typical Cross Section (Fill, 14.50 m)	Pavement layers, drain, conduits, kerb details
R-07	Typical Cross Section (Cut & Cut-Fill)	Cut slopes, same pavement structure
R-08 to R-09	ATC Tower to Old Runway PAA (Plan & Profile)	Horizontal + vertical alignment, grade data
R-10	ATC Tower to Old Runway PAA (Profile cont.)	Vertical curve data, elevations
R-11 onwards	Additional road profiles and cross-sections	As listed in drawing register

APPENDIX B — COORDINATE REFERENCE DATA (WGS84)

All coordinates are in WGS84. Station increment: 20.00 m for all alignments. Sample coordinates from Drawing R-05:

Station	Northing (m)	Easting (m)	Alignment
0+000.00	3,909,931.1585	549,195.5965	ATC Tower to Apron
0+521.97	3,910,367.5192	548,909.1714	ATC Tower to Apron (End)
0+000.00	3,909,902.0723	548,200.0759	ATC Tower to Old Runway PAA

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1+050.60	3,910,478.5773	549,078.3653	ATC Tower to Old Runway PAA (End)
0+000.00	3,910,507.0050	549,121.6741	PAA Runway to PAF Runway
0+223.10	3,910,629.4275	549,308.1815	PAA Runway to PAF Runway (End)

NOTE: Full coordinate tables for all alignments are given on Drawing R-05. All levels and dimensions are in METERS unless otherwise noted.

Contractor's Geotechnical Investigation

Before commencement of earthwork, road, pavement, foundation, underground tank, retaining wall, utility trench or any substructure work, the Contractor shall carry out confirmatory geotechnical investigation at site and submit the complete subsoil investigation report to the Engineer/Employer for review and confirmation.

The investigation shall include boreholes/test pits, Standard Penetration Tests (SPT), disturbed and undisturbed sampling, groundwater observations, laboratory testing, bore logs, subsoil profiles, CBR values for pavement areas, bearing capacity, settlement assessment, soil classification, chemical analysis of soil/groundwater and recommendations for foundation, subgrade, embankment and pavement works.

Minimum investigation frequency shall be as follows, unless otherwise increased by the Engineer due to weak, variable or doubtful ground conditions:

Work Area / Structure	Minimum Boreholes / Test Pits
Road and pavement area	1 borehole/test pit per 2,500 m ² , minimum 3 locations
Road alignment	1 borehole/test pit at every 250 m interval, minimum 2 locations
ATCT / major building foundation	Minimum 4 boreholes, one near each corner/grid zone
ARFF / service buildings	Minimum 2 boreholes per building block
Underground water tanks / septic tanks / deep structures	Minimum 2 boreholes per structure
Culverts, retaining walls and major drains	Minimum 1 borehole/test pit at each structure location
High embankment or soft/loose soil area	Additional boreholes as directed by the Engineer

Borehole depth shall be adequate to establish the complete subsoil profile and shall not be less than 6 m below proposed formation/foundation level for road and pavement works, and not less than 10 m below foundation level for buildings and underground structures, unless refusal is encountered earlier in rock or otherwise approved by the Engineer.

SPT shall generally be carried out at 1.0 m depth intervals or at change of strata, in accordance with ASTM D1586/NHA practice. Laboratory testing shall be performed in an approved laboratory as per ASTM/AASHTO standards.

No related permanent work shall proceed until the geotechnical report has been submitted and reviewed by the Engineer. Review by the Engineer shall not relieve the Contractor from responsibility for correctness of investigation, interpretation and execution of works.

Unless separately provided in the BOQ, no separate payment shall be made for geotechnical investigation, testing, reporting, reinstatement and all related works; the cost shall be deemed included in the relevant BOQ rates.

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MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0350 – CONSTRUCTION OF TUBEWELL AND PERFORMANCE OF AQUIFER TEST

PART 1 – GENERAL

1.1 SCOPE

This section covers the specifications of the items/works related to construction of Tubewell and performance of Aquifer test.

1.2 PROGRAMME OF WORK

The Contractor shall submit the work programme showing his plan to complete the works within time. The timetable of the work is the essence of the contract. The contract may be terminated if the Contractor falls behind in programme and if it is in the judgment of the Engineer that the measures proposed by the Contractor are inadequate to complete the whole work within the contract period. No payment shall be made to the Contractor in respect to the loss of profits or expenses incurred if the contract is terminated due to the Contractor falling behind in the Programme.

1.2.1 Working Site

Skardu International Airport, Pakistan

1.2.2 Order of the Work

The Engineer will determine the order in which the work is to be carried out.

1.2.3 Machinery and Equipment

The Contractor shall be solely responsible for furnishing at site the drilling rig and related equipment, instruments, appliances, accessories, materials, labour, technicians etc. required to complete the works to the satisfaction of the Engineer.

1.2.4 Drillers and Supervisory Staff

The Contractor shall have at site at all times qualified, experienced and thoroughly competent persons for the execution and supervision of the drilling and related works.

1.3 MOBILIZATION AND DEMOBILIZATION

1.3.1 Mobilization

Mobilization shall include transporting the drilling rig and all related accessories, materials and staff to the site of work.

1.3.2 Material Inspection

Materials supplied by the Contractor must be inspected and approved for construction at the Site(s). The Contractor shall ensure that materials are suitable, comply with technical specifications, and cause no delays due to quality or preparation.

1.3.3 Demobilization

Demobilization shall consist of removal from the site of the drilling rig, related accessories, equipment and extra materials after completion of the work, leaving the Site clear, clean and tidy to the satisfaction of the Engineer. Transportation to Contractor's store or elsewhere is at Contractor's expense.

PART 2 – PRODUCTS

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

2.1 TUBEWELL CASING COMPONENTS

- **Slotted Tubewell Casing** – PVC Class 'D', against water-bearing formations.
- **Blank Tubewell Casing** – PVC Class 'D', against non-water-yielding formations.
- **Bail Plug** – bottom of casing, PVC Class 'D' with plug.

Casing diameter as specified in Bill of Quantities. Jointing system shall be flush (no collars or bolts protruding).

2.2 GRAVEL SHROUDING MATERIAL

- Clean, washed, water-worn, carbonate-free, hard, well-rounded, no thin/flat particles.
- Source: Skardu nearby quarry or other approved location.
- Gradation for slot sizes 1.0 to 1.5 mm:

U.S. Standard Sieve No.	Sieve Size (mm)	% Passing for slot size 1.00 – 1.5 mm
4	4.75	100
8	2.36	75-91
10	2.00	59-75
12	1.70	38-54
16	1.18	16-32
20	0.85	(as per image)

2.3 TRANSITION SEAL MATERIAL

Coarse bentonite (pellets/chips) to separate filter pack from cement-based seals. Hydration: ~1 gallon water per 2 lb bentonite, allow ~1 hour.

2.4 WELL CAP

Mild steel, 1/4" (6mm) thickness, diameter same as well opening. Prevents entry of surface water, floodwater, persons, or animals.

2.5 PIEZOMETERS (for Aquifer Test)

- Diameter: 125 mm
- Casing material: PVC Class 'B', 75 mm diameter
- Arrangement: one test well + three piezometers at distances of 3 m, 15 m, 30 m from main well.
- Clean hand pump required.

2.6 TESTING EQUIPMENT

- Water-lubricated or oil-lubricated test pump capable of $\geq 150\%$ of tubewell rated capacity.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Valve for fine discharge adjustment.
- Electric measuring device for drawdown.
- Imhoff cone (1000 mm) for sand content.
- Flow measurement devices (orifice, meter, weir box) – remain Contractor's property.

PART 3 – EXECUTION

3.1 CONSTRUCTION OF TUBEWELL – PREPARATION

- Transport all plant, labour, materials to site.
- Prepare site: pit for water storage, arrange drilling water.
- Drill borehole, collect & preserve lithological samples in polyethylene bags (every 5 ft or change of lithology).
- Electric logging (see 3.3).
- Lower blank & slotted casings.
- Place gravel shrouding.
- Verify verticality & straightness.
- Develop and test tubewell.
- Collect water samples for chemical quality testing.

3.2 DRILLING PROCEDURES

- **Method:** Reverse rotary rig.
- **Borehole diameter:** 22/18 inches as per drawing.
- **Verticality tolerance:** deviation $\leq$ half the borehole diameter over entire length. Pump assembly shall hang exactly vertical.
- **Protection:** Contractor shall prevent caving/sloughing; stabilize unstable materials as approved.
- **Abandonment:** If borehole is lost or abandoned before required depth due to Contractor's negligence, Contractor drills new hole at alternative location at own expense – no payment for abandoned work.
- **Failure to achieve full depth:** Contractor shall drill new borehole until required depth is reached, at own cost.

3.3 ELECTRIC LOGGING

3.3.1 Types of Logs (continuous record)

- Short Normal (406 mm) resistivity
- Long Normal (1626 mm) resistivity
- SP log

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Gamma log

3.3.2 Measurement Device

Capable of continuous recording to drilled depth; calibrated before work; inspected and approved by Engineer.

3.3.3 Re-measurement (at Contractor's cost)

- Ambiguous data due to poor operation.
- Non-compliance with specifications.

Four copies of final logs with interpretation submitted to Engineer within 7 days of logging.

3.4 INSTALLATION OF CASING AND GRAVEL PACK

- **Casing installation:** PVC Class 'D' blank/slotted sections as directed. Length from top to bottom depth determined by Engineer.
- **Centralizers:** Attached at ~12 m intervals to center casing in borehole.
- **Straightness/plumb:** Entire assembly shall be straight and concentric. Any tubewell not meeting requirement shall be abandoned and replaced at Contractor's expense.
- **Gravel placement:**
 - Thickness ≥ 4.75 mm annular space.
 - Use tremie pipe or similar, introduce at two points 180° apart.
 - Lower tremie to bottom, pour gravel, raise in 1.5 m intervals.
 - Temporary casing (if used) to be withdrawn in 1.5–3 m intervals with gravel filling each stage before withdrawal.
- **Transition seal:** 1.5 m of bentonite pellets/chips above filter pack. Add water for hydration. Allow ~1 hour before placing cement-based seals.
- **Well cap:** Must be installed after drilling – secure, welded as specified.

3.5 DEVELOPMENT AND TESTING

3.5.1 Initial Development

Pump at **150%** of designed capacity. Bail out any sediment. Development complete when water is clear, sand-free, and discharge constant (Engineer's satisfaction).

3.5.2 Final Development & Sand Tests (Summary table from document)

Phase	Activity	Duration
Development	Pump at 75%,100%,125%,150% of rated capacity (one hour each step)	4 hours
1st Recovery	Measure water levels	1 hour

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Phase	Activity	Duration
Sand Test 1	Pump at 150% of rated capacity, measure initial specific capacity	1 hour
Re-development	Pump at 150% of rated capacity, surge/backwash every 5-10 min	3 hours
Re-sand Test	Pump at 150% of rated capacity, measure second specific capacity	1 hour
2nd Recovery	Measure water levels	2 hours

Sand content criteria:

- After first 5 min: < 100 ppm
- After 10 min: < 30 ppm
If exceeded, Contractor resumes development at own expense until satisfied.

Specific capacity requirement:

If second sand test specific capacity is >10% greater than first sand test, development incomplete – Contractor shall resume development.

3.5.3 Step Test & Final Pumping (after 2-hour recovery)

- Four-hour step test at 75%, 100%, 125%, 150% (one hour each). Last increment at 150%.
- Then pump at 150% of design capacity for 4 hours.

3.5.4 Oil-lubricated pumps precautions

Minimize oil leakage; promptly remove any oil from water surface using detergents or emulsification; otherwise Engineer may restrict to water-lubricated pumps.

3.6 PERFORMANCE OF AQUIFER TEST

Method: Pump-out test – non-steady state formula (Theis 1935, modified by Jacob & Cooper 1946). Compute transmissivity, specific yield, cone of influence.

3.6.1 Pre-pumping Phase

Monitor water levels in test well and three piezometers every 60 minutes. Record variations due to barometric pressure, temperature, traffic, etc. Data attached to final report.

3.6.2 Pumping Phase

Pump at constant discharge **95 m³/hr** for **48 hours continuously**.

Pump capacity sufficient for >95 m³/hr; engine capable of constant speed for 48 hours.

Typical arrangement of Tubewell and piezometers – image (original document, page 9)

3.6.3 Collection and Analysis of Water Sample

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Contractor collects 2 groundwater samples from tubewell; arranges chemical, biological, and arsenic analysis from approved laboratory. Submit results to Engineer.

3.6.4 Data and Records (Contractor's responsibility)

Accurate drilling history, fluid/circulation losses, time log, lithological log with depths. Use Engineer-approved forms. All records become property of Employer. Original data handed over to Engineer.

3.7 SITE CLEANUP

After completing all works, Contractor shall remove all machinery, equipment, plants, waste materials and clear the site to the Engineer's satisfaction.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0360 – PLUMBING

PART 1 – GENERAL

1.1 SCOPE

Providing all material and equipment and performing all work for complete execution and completion, including testing and commissioning of all plumbing works as shown and/or specified. Systems include: Cold and Hot Water Supply, Sanitary Drainage, Roof Drainage.

1.2 GENERAL REQUIREMENTS

All materials and equipment as specified; submit samples, catalogues, sketches, name of manufacturer, guarantee before installation. Approval does not absolve Contractor of responsibility. Contractor responsible for work until final acceptance; replace damaged/lost/stolen items. All openings covered and protected. Open ends of pipes plugged. Misuse of fixtures prohibited. Metal trimmings covered with non-corrosive grease. Upon completion, all fixtures cleaned, polished. Pipes cleaned of oil/grease before erection. Special tools delivered at no additional cost. Pipes installed straight, right angles, parallel to walls, with correct gradients, alignment, inverts.

Minimum distance between services per applicable codes. Pipes supported on hangers and brackets. Waste-water outlet from each fixture individually trapped. Each vent terminal extends to outer air.

Cast iron soil and drainage fittings: vertical to horizontal – short sweep or long-turn for $\geq 75\text{mm}$, long sweep or extra-long-turn for $< 75\text{mm}$; horizontal to vertical – quarter bend or short turn. All fittings with hubs aligned upstream. No drainage or vent piping drilled. Exterior openings sealed with rodent-proof collars. Roof joints watertight with flashing. Each pipe, fitting, trap, fixture marked with maker's mark, weight, type, class.

Proper size increasers/reducers for dissimilar sizes. Fittings with obstruction to flow prohibited. Each fixture trap water seal 50-100mm. No double trapping. Piping on firm bed. Vertical piping securely held; horizontal supported to prevent sagging. Hangers and anchors metal, securely attached to building.

Piping in concrete/masonry in sleeves for access. Roof drain leaders in columns permanently embedded. Indirect waste from food handling with air gap at least twice effective diameter of drain.

1.2.1 General Requirements for Water Supply:

The following general notes shall apply to all water supply installations throughout the project:

- (a) All water supply pipe diameters mentioned are external diameters (OD) unless otherwise mentioned.
- (b) Provide isolation gate valve on all cold and hot water supply lines at the inlet to each toilet/fixture group. Valves at accessible locations.
- (c) All cold water supply pipes: PPR-PN 25 (Polypropylene Random Pipe, PN 25) unless otherwise stated.
- (d) All hot water supply and return pipes: PPR (PN 25) unless otherwise stated.
- (e) Provide thermal insulation on all hot water and hot water return pipes.
- (f) All pipes suspended along ceiling or concealed in walls and run at high level unless otherwise specified.
- (g) All WCs, wash basins, and sinks to be provided with T-stop cock.

- (h) All pumps to be provided with flexible connector at suction and discharge.
- (i) Fire water pipe: M.S. Schedule 40 unless otherwise stated.
- (j) Provide pressure reducing valves (PRV) on hot and cold water pipes above false ceiling in each bathroom/kitchen; inlet 120 psi, outlet up to 30 psi.
- (k) All joints shall be airtight and watertight. Pipe sleeves with caulking for all penetrations through concrete structures.
- (l) Seismic restraints per the referenced building code applicable for Skardu (Seismic Zone 4).
- (m) Freeze protection: All water, drainage and condensate pipes exposed in unheated spaces or routed through unheated voids shall be insulated (minimum 25 mm closed-cell elastomeric foam with aluminium cladding where externally exposed) and provided with self-regulating electric heat-tracing (10 W/m at 10 °C) controlled by pipe or ambient thermostat at +5 °C. The heat-tracing supply shall be from the emergency generator board. Refer also to Section 0723 — Glycol Freeze-Protection Package — for the hydronic loops.

1.2.2 General Requirements for Sewerage & Drainage:

- (a) All soil, waste, and vent pipes: uPVC Class B unless otherwise stated.
- (b) All manhole covers: heavy-duty cast iron, Class D400 (40T traffic rated).
- (c) All vertical WCs and urinals: provided with Muslim shower.
- (d) Rain water disposal pipes: uPVC Class B (vertical); uPVC Class D (horizontal on lower floors).
- (e) All sewerage piping from fixtures to manholes and gully traps: uPVC.
- (f) Minimum pipe slopes: 1:80 for 100 mm dia.; 1:100 for 150 mm dia.; 1:200 for 225 mm and larger.
- (g) Minimum slope of roof valley drainage line: 0.02% to 0.025%.
- (h) Long radius bends to be used at the foot of all vertical soil/waste stacks.
- (i) Bottle traps to be used with all wash basins.
- (j) All completed drainage and storm systems to be tested and approved in accordance with IPC requirements before concealment.

1.3 COLD & HOT WATER PIPES AND FITTINGS – PP-R

PP-R Pipes & Fittings: PP-R (PN25) Polypropylene Random-Copolymer, conforming to ISO 15874, DIN 8077, DIN 8078, DIN 16962 with heat fusion welded joints.

Installation: Runs per drawings; vertical plumb, parallel to wall; horizontal close to walls or hung from roofs. G.I. sleeves for pipes through floors/walls (inside dia $\geq$ 15mm > pipe OD). Sleeves in exterior walls and pits with anchor flanges, caulked and sealed watertight.

Pipe work Supports: Mild steel painted with two coats metallic zinc primer. Clips and brackets with 1/3mm rubber liners (shore-hardness A 40-50). Supports allow free expansion/contraction. Supports adjacent to joints, changes of direction, branches. Intervals per manufacturer's recommendation.

PART 2 – PRODUCTS

2.1 Pipe Material Schedule

Service	Material
Cold Water Supply (Internal)	PPR-PN 25
Hot Water Supply (Internal)	PPR-PN 25

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Cold Water Main (External/Buried)	Galvanised Iron (GI) / PE-100
Soil Pipes (Internal)	uPVC Class B
Waste Pipes (Internal)	uPVC Class B
Vent Pipes	uPVC Class B
Storm/Rainwater (Internal Downpipes)	uPVC Class B/D
External Sewer Lines	uPVC Class B
Fire Main Pipe (All)	M.S. Schedule 40 Seamless
Tube Well Column Pipe	GI 4" dia

2.2 Water Storage Tanks

Underground Water Storage Tank:

Parameter	Specification
Tank Dimensions	24'-0" × 24'-0" × 6'-0" deep (7,315 mm × 7,315 mm × 1,829 mm)
Capacity	30,000 Gallons (136,380 litres)
Minimum Domestic Reserve	10,000 Gallons
Construction	RCC, 1:2:4 mix; walls and floor waterproofed with crystalline waterproofing (CJ) and PVC waterstop at construction joints
Internal Finish	1:3 cement plaster, smooth finish
Access Manholes	2 No.; Size: 2'-4" × 4'-0"; heavy-duty cover with frame
Ventilation	2" vent pipe at both ends (typical)
Pump Room	15'-0" × 5' × 5' DEEP, adjacent to tank; booster pump with gate valve, check valve, pressure gauge
Booster Pump	Submersible type; flexible joint at suction and discharge; gate valve and check valve at discharge

Overhead Water Tanks:

Parameter	Specification
Tank Size	7'-6" × 19'-0" × 4'-0" Deep
Capacity	3,000 Gallons (each) / 3,500 Gallons (as noted on plan)
Construction	RCC or masonry; 1/2" thick waterproof terrazzo layer lining
Manholes	2 No. per tank; 24" × 24"; 6mm G.I. cover with frame and hinges
Inlet / Outlet	2" dia inlet; 2.5" dia outlet; 2" spare outlet sleeve; 2" washout; 2" overflow; 2" vent pipes both ends

2.3 Tube Well:

Parameter	Specification
Capacity	0.5 Cusec; Submersible Pump Type
Bore Diameter	20"

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Total Depth	Approximately 640 ft (upper 200 ft + middle 240 ft + variable lower section)
Housing Pipe (Upper ~200 ft)	12" Fiberglass, 6mm wall thickness
Blind Pipe (Middle ~240 ft)	8" blind pipe, 5mm wall thickness
Grouting	Cement-sand mortar (1:2) from surface to 50 ft depth
Column Pipe to UG Tank	4" G.I. pipe
Discharge Header	M.S. plate; 90-degree flanged bend; 4" gate valve; 4" check valve; pressure gauge; flow meter; air release valve

2.4 Septic Tank and Soakage Well

Septic Tank SP-01	
Parameter	Specification
Type	Two-chamber RCC septic tank
Plan Dimensions	12'-0" × 13'-6" overall; two chambers of 3'-8" width each, separated by 6" RCC dividing wall
Effective Depth	4'-6"
Construction	RCC walls, 6" thick; blinding concrete below; floor sloped 1:12 toward outlet
Internal Finish	1:3 cement plaster, smooth
Covers	20" dia M.S. steel cover 3mm thick for each chamber; 4" dia access holes; M.S. rungs at 12" c/c
Inlet / Outlet	8" uPVC inlet pipe from building sewer; 8" uPVC outlet to soakage well
Soakage Well	
Parameter	Specification
Type	12 ft Diameter Soakage Well
Construction	Brick masonry (1:4) — unplasticized perforated walls to allow seepage; approximately 9" wall thickness
Depth	Sunk up to 4'-0" below finished ground level; total depth per soil conditions
Infill	2" brick ballast inside well for filtration
Top Slab	RCC; #4 bars @ 10" C/C; 4" × 4" × 1/2" angle iron frame at top
Inlet	9" RCC inlet pipe from septic tank

2.5 Domestic Water Transfer Pump

Parameter	Specification
Type	Centrifugal pump
Approved Makes	KSB, Grundfos, or Engineer-approved equivalent
Capacity	85 GPM each
Total Pumping Head	110 ft
Impeller	Stainless steel

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Motor	Water-cooled, 440 V, 3-phase, 50 Hz
Configuration	2 Nos. (1 duty + 1 standby); automatic changeover panel

2.6 Drainage Sump Pump

Parameter	Specification
Type	Non-clogging centrifugal submersible drainage sump pump
Capacity	50 GPM against 25 ft total head
Motor	Water-cooled, IP Class 68, 400 V, 3-phase, 50 Hz
Configuration	2 Sets (1 duty + 1 standby); auto/manual switches; dry running protection; low/high level controls

2.7 Rainwater Harvesting System

Parameter	Specification
Harvesting Tank Dimensions	20'-0" × 15'-0" × 10'-0" deep (6,096 mm × 4,572 mm × 3,658 mm)
Capacity	20,000 Gallons (90,920 litres)
Recharge Pit	5'-0" × 15'-0" × 10'-0"; Capacity: 5,000 Gallons
Filter Media (Section A-A)	Bottom: 6" stone layer (3 ft depth); Middle: 3" stone layer (1 ft); Top: 1" crushed stone (1 ft)
Recharge Below Tank	4" × 14" perforated pipe penetrating to water table for groundwater recharge
Pumps	2 No. submersible (1 running + 1 standby); Q = 30 GPM; H = 50 ft; HP = 1.0; 2" force main
Manholes	600 × 600 mm service manholes with covers — 4 No. as shown on plan

2.8 Pipe Support Schedule (Per Drawing PH-MD-01)

Pipe Size	Rail Spacing
1/2" to 3/4"	5'-0" (1,524 mm)
1" to 1.5"	6'-0" (1,829 mm)
2" to 3"	8'-0" (2,438 mm)
4"	10'-0" (3,048 mm)
6" to 8"	10'-0" (3,048 mm)
10" to 12"	12'-0" (3,658 mm)

Synthetic or natural conforming to ASTM standards.

PART 3 – EXECUTION

3.1 INSTALLATION – COLD & HOT WATER PP-R PIPES

Run and arrangement per drawings. All vertical pipes plumb, parallel to wall. Horizontal runs close to walls or hung from roofs. G.I. sleeves for pipes through floors/walls (inside dia ≥15mm > pipe OD). Sleeves in exterior walls and pits with anchor flanges, caulked and sealed watertight. Pipe supports as described.

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3.2 INSTALLATION – G.I. PIPES (if used)

Screwed joints tight without filler except approved jointing compound or tape. Flanged joints to BS 10 Table D. Sleeves as above.

3.3 INSTALLATION – SOIL, WASTE AND VENT uPVC PIPES

Install to lines and grades. Above ground: hangers and supports approved type, not more than 1.5m centers. Steel clamps, hangers, supports: one coat red oxide primer + two coats synthetic enamel paint. Push-fit/solvent cement jointing. Sleeves for pipes through walls/floors. Vent pipes with approved cowl, rise ≥ 760 mm above roof.

3.4 PLUMBING FIXTURES – MATERIALS AND INSTALLATION

All fixtures imported, best quality, approved manufacture. Smooth impervious surfaces, free from defects. Taps and cocks chrome plated. Fixtures installed for easy cleaning. Wall hung fixtures rigidly supported. Fixtures set level, proper alignment. Supply lines prevent backflow.

Wash Basins: Vitreous China (counter top, with/without pedestal). Complete with 20mm CP brass sensor basin mixer or lever type or double knob, 20mm CP stop-cocks, CP brass bottle trap (individual) or CP brass P trap (battery), CP brass strainer, heavy cast iron brackets.

Water Closets (European): Best quality. Low level flush tank with double push button (3L/6L). Seat bakelite, open front. In-wall carrier system for wall-hung toilets.

Bidet: Wall hung vitreous China, 1 hole punched, overflow, fixation set, anti-scale coating, anti-bacterial glazing.

Water Closets (Asian): Vitreous China with cistern 12-15 litre. Foot rests, cast iron P trap.

Kitchen Sink: Stainless steel, double/single deep-bowl. Complete with 20mm CP mixer for hot/cold, CP brass strainer.

Bath Tub: Vitreous China. Complete with 20mm CP mixer or pillar cock, CP brass chain with 40mm rubber plug.

Urinal: wall hung, with CP brass P trap, 15mm CP stop-cock.

Shower Head: CP adjustable, complete with CP extension pipe, CP stop cock.

Mixer for Shower: CP concealed with hot/cold taps, diverter.

Janitor Sink: White fire clay, hardwood pad, stainless steel bucket grid, CP brass bib tap 20mm, CP brass P-trap 50/40.

3.5 MISCELLANEOUS PLUMBING ITEMS – INSTALLATION

Bronze Valves: ≤ 75 mm bronze, PN-16. Accessible with ladder. Open/shut indicators on handle.

Taps and Cocks: Brass, gun metal, chrome plated. Hydraulic test 1.96 MPa, no leak.

Floor Drains/Floor Traps: Cast iron or uPVC, 50mm min water seal, stainless steel grating, P-trap, removable bucket strainer, cleanout.

Cleanouts: Cast iron or uPVC, CP brass cover. Turned up through floors, flush with floor.

Float Valve: Piston type to BS 1212-1, polyethylene float.

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Vent Cowell: Cast iron with stainless steel clamp.

Glass Mirror: Best quality, securely fixed on hard board.

Towel Rail, Toilet Paper Holder, Soap Dispenser/Dish, Grab Bars: CP stainless steel.

Hand Drier: Best quality, infrared proximity switch.

Gully Traps: P-trap 65mm water seal, cast iron frame & cover, internally plastered with pudlo.

Grease Traps: In RCC chamber per drawings.

Fiber Glass Water Tank: Thermosetting polyester resin reinforced with glass fiber, to BS 3496 type E. Manhole opening, outlets, vent pipe with cowl, built-in feet.

Electric Water Heaters: Automatic storage type, 6 bar working, 10 bar test. Thermostatic control, T&P relief valve, high limit control. Inner tank heavy gauge anti-rust G.I., insulation glass wool, outer body 16 gauge MS.

Gas Water Heaters: Automatic storage type. Inner/outer shell thickness per table (14 SWG to 10 SWG inner, 22 SWG outer). Working pressure 5 bar, test 10 bar. Accessories: thermostatic control, safety pilot, T&P relief valve, burner, drain valve, auto-shut off.

3.6 ROOF DRAINAGE – CAST IRON RAIN WATER PIPES

Cast iron pipe to BS 416, below ground to BS 437. Joints lead caulked or elastomeric (rubber ring) to BS 2494. Centrifugally (spun) cast, grade 10 to BSS 1452. Coated pipes: tar basis or natural bitumen. Hydraulic test 0.07 MPa. Installation: clamps ≤ 1500 mm centers. Caulked joints packed with oakum/hemp, filled with molten lead ≥ 25 mm deep. Pipes passing through walls/floors with sleeves. Vent pipes with cowl, rise ≥ 750 mm above roof.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0370 – DUCTILE IRON PRESSURE PIPES AND FITTINGS

PART 1 – GENERAL

1.1 SCOPE

The work under this section includes furnishing all plant, labour, equipment, appliances, materials and performing all operations required in connection with supply, installation, testing, flushing, disinfection and commissioning of Ductile Iron Pressure Pipes and Pipe Fittings as specified herein, in the bill of quantities, as shown on the drawings and/or as directed by the Engineer.

1.2 APPLICABLE CODES AND STANDARDS

All works and materials under this section shall conform to the latest edition of the applicable codes and standards. When the requirements of these specifications or the drawings exceed the code requirements, the Contractor shall be bound by the specifications and/or drawings for those requirements.

1.3 GENERAL REQUIREMENTS

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

1.3.1 Pipes and fittings shall be new and unused and of Western European, North American or Japan make origin.

1.3.2 Pipes and fittings shall be UL listed and FM approved for the intended use in firefighting network/system. The Contractor shall provide all necessary documents to confirm the required certification before installation or laying.

1.3.3 Where manufacturers of pipes and fittings are specified, they shall be of the same manufacturers unless otherwise approved by the Engineer.

1.3.4 Where more than one similar item of pipes and fittings are specified, they shall be of the same manufacturer.

1.3.5 The Contractor shall submit to the Engineer for approval the following information:

(i) Name and address of the manufacturer

(ii) Country of origin, make and model

(iii) Dimensions and wall thicknesses of pipes and fittings

(iv) Material and thicknesses of coating and lining

(v) MTC – mill test certificate from the manufacturers

(vi) Method of jointing, testing and commissioning

(vii) Manufacturer accreditations: ISO 9001 and 14001, Third Party International Inspection Certificate before shipment from an agency approved by the Engineer, and manufacturer's QA/QC document.

1.3.6 Approval by the Engineer shall not be construed as authorizing any deviation from the specifications unless specifically brought to notice.

1.3.7 Approval by the Engineer shall not relieve the Contractor of his contractual responsibility regarding satisfactory performance and other requirements.

1.4 SPECIAL REQUIREMENTS

1.4.1 Pipes and fittings shall be suitable for the intended use.

1.4.2 Every pipe shall be tested at the manufacturer's works to specified hydraulic test pressure, maintained sufficiently long for proof and inspection.

1.4.3 Each pipe and fitting shall be permanently marked or engraved with:

- Manufacturer's name or trademark
- Manufacturing date
- Manufacturing number
- Nominal diameter in mm
- Class or pressure rating
- Manufacturer's inspection mark
- Standards according to which the pipes and fittings have been manufactured

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

- Heat number embossed on all pipes, fittings and flanges

1.4.4 Unless otherwise specified, diameters of pipes and fittings shall be nominal. Actual inside/outside diameters and tolerances shall be according to the specified standards.

1.4.5 Unless otherwise specified, service ratings of pipes and fittings shall not be less than the maximum pressure, test pressure and expected increase in pressure during testing.

1.4.6 Unless otherwise specified, wall thicknesses shall be according to class, schedule or duty. Wall thicknesses shall be measured at locations excluding jointing ends. Wall thicknesses of fittings shall not be less than those of corresponding pipes.

1.4.7 Pipes and fittings ends shall be matching and compatible with each other and with the ends of valves and appurtenances.

1.4.8 Unless otherwise approved, pipes, fittings and jointing materials (rubber rings, gaskets, nuts, bolts, etc.) shall be from the same manufacturer.

PART 2 – PRODUCTS

2.1 PIPES

Ductile Iron Pressure Pipes shall conform to ISO 2531, K-9.

2.2 FITTINGS

Ductile Iron fittings and specials shall conform to ISO 2531, K-12. They shall have the required shapes, dimensions and ends to be joined with the Ductile Iron pressure pipes.

2.3 INTERNAL LINING

Internal lining of Ductile Iron pipes, fittings and specials shall be cement mortar lined according to ISO 6600. Lining of pipes shall be done in factory using centrifugal method. Lining of fittings and specials shall be done in factory or, if permitted in writing by the Engineer, at Site by an approved method. The lining shall be smooth and must not show visible hair cracks, spitting or honeycombing. Where water contains significant sulphates or chlorides, sulphate resistant cement shall be used.

2.4 EXTERNAL COATING

Ductile Iron pipes and fittings shall be externally coal tar epoxy coated. Coating thickness shall not be less than 100 microns. Manufacturer's recommendations for repair of coatings shall be shared with the Engineer while obtaining approval of the repair method.

2.5 MATERIAL

The material shall consist substantially of ductile iron with only those additives needed to facilitate manufacture of sound, durable pipes and fittings of good surface finish, mechanical strength and corrosion resistance. Additives shall not constitute a toxic hazard or impair chemical/physical properties. The pipe and fitting material shall not have any detrimental effect on water quality.

2.6 JOINTS

Ductile Iron pressure pipes and fittings shall be spigot and socket joined with elastomeric rubber ring. Flanges required for connecting with valves shall conform to B.S. 4504 or approved equivalent. Elastomeric rubber rings shall conform to B.S. 2494 or approved equivalent.

PART 3 – EXECUTION

3.1 TRENCHING

Pipe trenches shall be excavated to required depth as indicated on the drawings. The bottom shall be carefully levelled. In-situ field density of trench bottom shall be determined and compacted if in-situ density is less than 60% of relative density as determined by ASTM D 1557 & ASTM D 1556. Testing shall generally be carried out at spacing of 250 metres. If soft clayey or loose material is encountered, 300 mm of this material shall be replaced by specified bedding material without extra cost. If excavation is carried below required depth, the excess excavated part shall be refilled with bedding material at no extra cost. No bedding material shall be placed nor any permanent work commenced until the trench has been inspected by the Engineer and permission to proceed is given.

3.2 INSTALLATION

3.2.1 Transportation, Handling and Storage

The Contractor shall be responsible for proper transportation, handling (loading/unloading) and storage of pipes and fittings per manufacturer's recommendations and direction of the Engineer. Crane, rope or nylon slings, lifting beams with flattened hooks or scissor-dogs shall be used; hooks and dogs shall be well padded and fitted with locking devices; steadying ropes are essential. Pipes and fittings damaged during transportation, handling, storage or lowering shall be rejected and replaced at Contractor's expense. Storage of Ductile Iron pipes, fittings, rubber rings and gaskets shall be under shade to prevent damage by sunlight and extreme heat.

3.2.2 Inspection

Pipes and fittings shall be visually inspected for any evidence of damage or hair cracks. The ends shall be inspected for local irregularities that could affect water tightness of joints. Damaged items shall be rejected and replaced at Contractor's expense. Upon arrival of material at site, the Contractor shall request inspection of the complete lot along with necessary documentation.

3.2.3 Laying and Jointing – Above Ground (Unburied)

Pipelines shall be laid true to location, alignment and grade as shown on the drawings and/or as directed. All vertical pipelines shall be erected plumb and parallel to walls and other pipelines. All horizontal pipelines shall be kept close to walls and parallel to floor, ceiling, roof and other pipelines. Deviations require Engineer's approval before installation.

Elastomeric joints shall be made with rubber rings: the ring shall be inserted in the groove of the socket end and the spigot end pushed into the socket end. Flanged joints shall be made watertight with gasket, nuts and bolts.

Pipelines passing through walls, floors or roofs shall be provided with black steel pipe sleeves. The annular space between pipe sleeve and outside diameter of the pipe shall not be less than 15 mm, and shall be filled with approved packing and sealant. Pipelines passing through water-retaining structures shall be provided with black steel puddle (anchor) flange. The Contractor shall submit shop drawings showing dimensions and thicknesses of sleeves and puddle flanges for approval before installation.

3.2.4 Laying and Jointing – Below Ground (Buried)

Pipelines shall be laid in accordance with British Code of Practice CP 2010 (Part 2) in trenches on a bed and surrounded on all sides with well compacted fine sand up to the height shown on drawings or as directed, true to location, alignment and grade.

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Backfilling shall be carried out in specified sequence. Recesses shall be excavated in the bottom and sides of the trench to accommodate joints, fittings and appurtenances; these recesses shall be filled with fine sand and well compacted manually. Great care shall be taken to avoid abrasion. Pipelines with grades or joints disturbed after laying shall be removed and re-laid as per specifications.

Pipes, fittings and specials shall be lowered into the trench with care using tackle, shear legs, mobile crane or approved method. When lifting gear is used, positioning of slings shall be checked for proper balance when the pipe is just clear of the ground.

All debris and foreign material shall be removed from inside the pipe before a joint is made. When laying is not in progress, the open end shall be fitted with a temporary end closure as approved.

Small changes in direction may be made by deflecting the last laid pipe after the joint has been made. If deflections exceed specified limits, standard degree bends or a number of short pipe lengths shall be used.

3.3 TESTING

The completed pipeline or each convenient section (as necessary due to elevation differences) shall be subjected to a hydrostatic pressure test not less than one and a half times the maximum pressure to which the pipeline will be subjected. The proposed fire network shall be pressurized with already installed pumps in the existing pump station for the parking lot. The Contractor shall confirm the pressure rating of these existing pumps and the shut-off head of the jockey pump to determine maximum expected pressure. All fittings, specials, valves and appurtenances shall also be subjected to hydrostatic testing while installed. Maximum test section length shall not exceed 500 metres.

Before testing, the pipeline section shall be cleaned and sufficient backfill material placed over the centre of each pipe to prevent movement under test pressure. Pipe ends shall be properly sealed and adequately secured with temporary anchors. All permanent anchors/thrust blocks shall be in position and shall have developed adequate strength before the test starts.

The section under test shall be filled with water, taking care that all air is displaced through valved vents at high points. After filling, the pipeline shall be left for wetting under a lower pressure for not less than twenty-four hours. After the wetting period, more water shall be pumped in until test pressure is reached, then the section shall be completely cut off. The test pressure shall be maintained for at least two hours or as directed. Field test pressure shall be 1.5 times the normal working pressure of 10 bar in the system. If a drop in pressure occurs, the quantity of water added to re-establish test pressure shall be carefully measured.

If pressure measurements are not made at the lowest point, allowance shall be made for static head between lowest point and measurement point to ensure test pressure is not exceeded at the lowest point.

If any abnormal movement, distortion, squirm or leakage is detected, the test pressure shall be released immediately and the cause investigated and rectified with Engineer's approval.

3.4 FLUSHING

After installation and testing, pipelines shall be flushed with water until all dust, dirt, scales and extraneous matter are removed. During flushing, all valves and appurtenances shall be closed and opened several times.

3.5 DISINFECTION

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Fire water pipelines and systems shall be disinfected with chlorine or chlorine compound solution. The solution shall be introduced into the pipelines by a suitable method and retained for at least 24 hours. The dosage shall not be less than 50 mg/litre of chlorine. At the end of the test period, the chlorine residual at pipe extremities shall not be less than 25 mg/litre. Following complete disinfection, the pipeline shall be thoroughly flushed until the chlorine residual is less than 1 mg/litre.

3.6 COMMISSIONING

After successful completion of testing, flushing and disinfection (where required), duly approved by the Engineer, the complete pipeline network shall be commissioned. All valves and appurtenances shall be set at proper openings and all parameters set at specified or manufacturers' recommended values.

3.7 PIPEWORK SUPPORTS

All pipework supports in buildings shall be of mild steel rolled sections and shall be painted with two coats of approved rich metallic zinc primer. Straps, rods and hangers shall be of galvanized mild steel.

Straps shall be provided on all pipe supports, with a pair of nuts and washers on each leg and the supporting flange clamped tight between the pair of nuts to form a rigid guide allowing the pipe to slide axially.

Horizontal pipework along walls shall be supported on channel frames securely fixed to the column. All pipes shall slide on pipe supports and straps shall form a rigid guide.

Vertical pipework shall be supported at the base or at anchor points to withstand the total weight of the riser. Brackets from risers shall not be used as a means of support for the riser.

Pipework supports shall be designed and installed to allow free movement due to expansion and contraction. Supports shall be anchored to steel or reinforced concrete columns, walls, beams or slabs. Each support shall independently carry all operational loads of pipework and water.

All pipes shall be individually supported. Pipes shall not be supported from other pipes. Points where pipes pass through walls, floors, connections to plant, equipment and heat emitters, etc., do not constitute points of support.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0380 – FIRE PROTECTION

PART 1 – GENERAL

1.1 SCOPE OF WORK

Furnishing all plant, labour, equipment, appliances and materials for supply and installation of black steel pipes and fittings for fire fighting system, portable fire extinguishers, fire hose cabinets as shown, in compliance with NFPA requirements.

1.1.1 System Description

The fire protection system for the ATCT, ARFF building, and allied facilities at Skardu International Airport consists of a multi-system approach, but is not limited to this:

- (a) Wet pipe automatic sprinkler system (NFPA 13) — Fire Station ground floor, mezzanine, first floor, and rooftop occupied areas.
- (b) FM-200 (HFC-227ea) gaseous suppression system — ARFF rotating cab and ATCT cab (special hazard areas per Drawings FF-06 and FF-07).
- (c) Internal fire hose cabinet system with landing valves, hose reels, dry powder, and CO₂ extinguishers on all floors.
- (d) External pillar-type fire hydrant network.
- (e) Two-way breeching inlet (fire department pump connection) at ground floor.
- (f) Underground water storage tank (dedicated firefighting reserve) with firefighting pump sets.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

Item	Requirement
Fire pipe material	M.S. Schedule 40 seamless pipe; painted red throughout
Maximum line pressure	All fire water lines exceeding 12 bars to have PRVs; no fire water line to have line pressure exceeding 12 bars
Pipe penetrations	Pipe sleeves with approved caulking compound at all floor, roof, and wall penetrations
Expansion joints	Pipe expansion fittings provided at all building expansion joints
Portable extinguishers	Located and sized as indicated on drawings per NFPA 10
Flow and tamper switches	Connected to BMS and Fire Alarm Panel (per NFPA)
Isolation valves	All isolation valves in fire system to comply with NFPA requirements

2.2 UNDERGROUND FIRE FIGHTING WATER TANK

Parameter	Specification
Tank Size	40 ft × 30 ft × 9 ft deep (per Drawings S-30, S-31)
Capacity	Approximately 59,900 Imperial Gallons
Construction	Underground RCC; CJ waterproofing with PVC waterstop at all construction joints
Sump Pump in Tank	Size: 2.5 ft × 2.5 ft × 3 ft deep

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Pump Room	30 ft × 12 ft × 11 ft, adjacent to tank
Access	Service manhole 2'-6" × 2'-6" with cast iron cover; 3/2" vent pipe (typical)
Pipe Connections	4" M.S. overflow/washout; 4" M.S. inlet; 4" M.S. fire fighting outlet; 4" M.S. spare; 4" fire test/return
RCC Slab Reinforcement (Base, per S-31)	#4 @ 8" C/C Top and Bottom in both directions; Slab thickness: 12"
RCC Slab Reinforcement (Top, per S-31)	#4 @ 6" C/C longitudinal; #4 @ 9" C/C transverse; Top and Bottom; Slab thickness: 12"
Concrete Grade	f _c = 4,000 psi minimum; ASTM A615 Grade 60 rebar

2.3 FIRE FIGHTING PUMP SET (NFPA 20 Compliant)

Component	Specification
Electric Duty Pump	Horizontal centrifugal; 50 Hz × 380 V, 3-phase; Capacity: 500 GPM @ 9 bar; Capable of operating remotest 2-1/2" hydrant at 250 GPM @ minimum 4.5 bar
Diesel Standby Pump	Horizontal centrifugal, engine-driven; Capacity: 500 GPM @ 9 bar; Automatic control panel, pressure switch, pressure gauge, diesel tank
Jockey Pump	Electric motor-driven; 50 Hz × 400 V, 3-phase; Capacity: 25 GPM @ 9.5 bar; Automatic control panel
Compliance	NFPA 20 — Standard for the Installation of Stationary Pumps for Fire Protection
Pump Room Fittings	Gate valves, NRV, expansion joints, air release valve, headers, pressure relief valve, pressure gauges, supports

2.4 AUTOMATIC SPRINKLER SYSTEM (NFPA 13)

Fully automatic wet-pipe sprinkler system to NFPA 13 (latest edition) for all occupied areas. Dry-pipe or pre-action system in unheated ARFF vehicle bays where ambient temperature may fall below +4°C.

Occupancy	Hazard Classification
Offices, dormitories, ATC areas	Light Hazard per NFPA 13
ARFF Vehicle Bays	Extra Hazard Group 2 (flammable liquids) per NFPA 13
Fuel storage areas	Extra Hazard Group 2 per NFPA 13
Plant rooms, electrical rooms	Ordinary Hazard Group 2 per NFPA 13

Sprinkler heads: concealed or semi-recessed pendant type (K-5.6) in finished areas; upright in ARFF bays. Alarm check valve with pressure gauges, water motor alarm bell, flow switch, and inspector's test connection for each zone. Hydraulic calculations to be submitted for Engineer approval before installation.

2.5 Portable Fire Extinguishers (NFPA 10)

Type	Specification
Dry Chemical Powder (Portable)	Stored pressure; Class A, B, C & E; 6 kg capacity; Fire rating: 34A 183B; Working pressure: 14 bar; Test pressure: 30 bar

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CO ₂ (Portable)	5 kg; Operating temperature: -20 to +60°C; Max allowable pressure: 174 bar; Test pressure: 250 bar
Ceiling-Mounted Automatic	6 kg ABC Powder; Operating temperature: -30°C to +60°C; Operating pressure: 15 bar; Sprinkler head activation trigger

2.6 Pillar Type Fire Hydrant (External)

Parameter	Specification
Type	Pillar type fire hydrant (wet-type, above ground)
Inlet	4-inch flanged connection (150 mm, Class 150)
Outlets	Double deliveries, 2-1/2" female instantaneous coupling with blank cap and chain
Body	Mild Steel main body; Butterfly valve: 100mm Ductile Iron; Outlets: Brass
Finish	Red electrostatic powder coating; Nut and bolts: galvanized
Spacing	Maximum 60 m spacing around perimeter of ATCT/ARFF building

PART 3 – EXECUTION

3.1 INSTALLATION OF FIRE HOSE CABINET

Flushed with outside finishes or on wall as approved. Fire hose connected to fire water system through hydrant 65mm x 40mm valve.

3.2 INSTALLATION OF PORTABLE FIRE EXTINGUISHERS

Installed at 1 meter height above finished floor. Fixed to wall/column with painted steel clamps or stored in steel/concrete cabinets. Cabinets with glazed steel door, two coats anti-corrosive signal red enamel over red oxide primer. Lock arrangement: door opened from inside by breaking glass and from outside with key. Validity at least one year after defect liability period.

3.3 MARKINGS ON EXTINGUISHERS

Colour code per NFPA. Information on body: instructions, agent name, weight/volume, gross weight, filling pressure, classes of fires, manufacturer's name, year of manufacture.

3.4 TESTING AND COMMISSIONING

As per NFPA-10.

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PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0390 – TESTING AND COMMISSIONING

PART 1 – GENERAL

1.1 SCOPE OF WORK

Furnishing all plant, labour, equipment, appliances and materials for testing and commissioning of all water line, drainage system and fixture in parts and as a whole as specified.

1.2 GENERAL

Testing includes complete visual inspection of whole plumbing and fire fighting system and verification of performance. All supply documents, operating instructions, acceptance documentation and maintenance regulations checked.

1.3 FIXTURES AND FITTINGS – TEST PROGRAMME

Check type and catalogue number. Check all equipment for service ability, correct operation, freedom from damage. Flow and water capacity checked on full connection of lavatories, showers, water closets; draining capacity measured.

1.4 POTABLE WATER SUPPLY SYSTEMS (HOT & COLD) – TEST PROGRAMME

Check method of laying and sealing water connections. Visual inspection of entire network for laying, fixing, suspension. Check function of valves, air relief valves, check valves, pressure reducers, thermostats, pumps. Check pipe insulation, equipment labeling, pipes and flanged connections for strain.

Hydraulic Pressure Test: Before insulation. Pump system to required pressure, close valves, disconnect pump. Test pressure as detailed for two hours. No drop in pressure, no leaks = satisfactory. Faults repaired and retested.

Test Pressure and Procedure: Fill pipes slowly with potable water to exclude air. Apply test pressure 5.5 bar (1.5 x max working pressure). No measurable loss of pressure for at least 30 minutes.

1.5 DRAINAGE SYSTEMS – TEST METHODS

Water Testing: Close all openings with testing plugs. Develop min static head 0.5 bar. Fill water, check level for no drop for at least 15-30 minutes. Higher stacks tested in sections from top.

1.6 FIRE FIGHTING SYSTEMS – STAND PIPE SYSTEM

Same hydraulic pressure test as potable water supply.

1.7 COMMISSIONING

After successful testing, contractor shall clean all lines at no extra cost with method approved by site Engineer prior to handing over.

PART 2 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0400 – POLYETHYLENE (PE) PIPES AND FITTINGS

PART 1 – GENERAL

1.1 SCOPE

Furnishing all plant, labor, equipment, appliances, materials for providing and laying of Polyethylene Pipes and Pipe fittings.

1.2 GENERAL REQUIREMENTS

Pipes and fittings new and unused. All HDPE pipe and fittings from single manufacturer with experience. Submittal to Engineer: manufacturer's name, country of origin, pressure rating, SDR ratio, wall thicknesses, MTC, method of jointing, testing, commissioning, manufacturer's accreditations (ISO 9001, 14001, QA/QC). Approval does not relieve Contractor of responsibility.

1.3 SPECIAL REQUIREMENTS

Pipes suitable for intended use. Every pipe tested at manufacturer's works to specified hydraulic test pressure. Each pipe and fitting permanently marked: Manufacturer's name/trademark, manufacturing date, number, nominal diameter, class/pressure rating, inspection mark, standard, heat number embossed. Service ratings $\geq 1.5 \times$ max working pressure. Wall thicknesses per class. Ends matching and compatible. All jointing materials same manufacturer.

PART 2 – PRODUCTS

2.1 MATERIALS

Manufacturing: Polyethylene with additives to facilitate manufacture. No toxic hazards, no impairment of welding properties or chemical/physical properties.

Pipe: Conform to ISO 4427-2019 or DIN 8074, appropriate class PN-8 to PN-32, test pressure $1.5 \times$ working pressure.

Quality: No detrimental effect on water composition. Toxic substances not exceed ISO 4427 values.

Fittings: Compatible, conform to ISO 4427-3:2019, 3458, 3459, 3501, 3503 or BS 5114.

PART 3 – EXECUTION

3.1 HANDLING AND STORAGE

Proper handling per manufacturer's recommendations. Stack at approved places. Transportation secure, minimal movement. Use cranes for off-loading; rope or nylon slings, lifting beams with flattened hooks or scissor-dog, well padded. Storage under shade, not exposed to sunlight/extreme heat. Damaged pipes rejected and replaced.

3.2 JOINTING

Butt Fusion Joint: For pipes $\leq 75\text{mm}$ – compression fittings; $> 75\text{mm}$ – butt fusion. Comply with ISO 4427 and Generic Butt Fusion Joining Procedure. Factory qualified or trained technician. Same class and type of raw material.

Mechanical Joint: Polyethylene flange adapters backed by stainless steel flanges to ANSI B16.5. Corrosion resisting bolts/nuts Type 316 Stainless Steel. Tighten to manufacturer's specified torques; apply bituminous coating after installation. Full-face neoprene gasket.

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3.3 INSTALLATION

Install per manufacturer's instructions, drawings, specification. Factory qualified technician for heat fusion joints. Do not drop pipe or force through directional bore. Use ropes, fabric or rubber protected slings. Store on level ground, free of sharp objects. Lay to lines and grade with bedding and backfill. Open ends closed when not laying. Defective pipe removed and replaced.

Open Trench Installation: Centerline deviation $\leq 1/16"$ per foot. Good alignment. Assembly mark aligned. Prevent flotation. Trench boxes not allowed below top of pipe.

Cleaning/Flushing/Disinfection: Clean all new pipe lines by forcing cleaning swab. Flushing velocity ≥ 2.5 ft/s. Disinfection of potable water lines by chlorination (≥ 50 mg/l chlorine, retain ≥ 24 hours, residual ≥ 25 mg/l). Flush until chlorine residual < 1 mg/l.

Hydrostatic Pressure Test: Test pressure $\geq 1.5 \times$ max working pressure. Fill, leave under low pressure for 2 days. Maintain test pressure ≥ 2 hours. No abnormal movement, distortion, squirm, or leakage. Submit test plan to Engineer ≥ 10 days before test.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0410 – STEEL PIPES & FITTINGS

PART 1 – GENERAL

1.1 SCOPE

Furnishing all plant, labor, equipment, appliances, materials for supply, installation, testing, disinfection (potable water only), flushing and commissioning of black steel pipes and pipe fittings, U-turn vent pipes and overflow funnels.

1.2 APPLICABLE CODES AND STANDARDS

ASTM A-53, A-234; ANSI B16.5; B.S.4504 (part1), B.S.534, B.S.1965, B.S.3601, B.S.3063, B.S.4147, B.S.4161, B.S.4515; ISO 898; C.P.2010.

1.3 GENERAL REQUIREMENTS

Pipes and fittings new, unused. Same manufacturers. Submittal: name/address, country of origin, dimensions/wall thicknesses, coating/lining material and thicknesses, MTC, warranty, jointing/testing/commissioning method.

1.4 SPECIAL REQUIREMENTS

Every pipe tested at manufacturer's works. Pipes and fittings permanently marked (make, nominal diameter, class/pressure rating, standard, heat number embossed). Service ratings not less than maximum pressure. Wall thicknesses per class/schedule/duty. Ends matching. All jointing materials same manufacturer.

PART 2 – PRODUCTS

2.1 PIPE

Black steel grade 'B' seamless/spirally welded schedule 40 (or wall thickness per BOQ) conforming to ASTM A53.

2.2 FITTINGS

Conform to ASTM A-234 or ANSI B16.5.

2.3 JOINTS

Welding or flange (except valves and appurtenances). Welded joint to B.S.4515. Flanges to B.S.10. Nuts/bolts hexagon to ISO 898. Gaskets flat to B.S.3063.

2.4 EXTERNAL COATING

FBE (Fusion Bonded Epoxy) minimum 200 microns.

2.5 INTERNAL COATING

Anti-corrosive epoxy coated.

PART 3 – EXECUTION

3.1 TRANSPORTATION, HANDLING AND STORAGE

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Per manufacturer's recommendations. Crane, rope/nylon slings, lifting beams with flattened hooks or scissor-dog, padded. Damaged replaced.

3.2 INSPECTION

Visual for damage or hair cracks. Damaged replaced.

3.3 LAYING AND JOINTING – ABOVE GROUND

Clean interior. Install to lines and grades. Welding by qualified/licensed welders using electric arc welding. Supports: galvanized steel clamps, brackets, hangers. Thrust anchors at changes in pipe diameters/directions, branches, dead ends. Shop drawings for supports and thrust anchors.

Pipes through floors/ceilings/roof/walls in non-water retaining structures: encased in black steel pipe sleeve (annular space ≥ 1 inch), filled with approved packing, sealed. Through water retaining structures: leak proof puddle flange (flange diameter $>$ pipe OD by ≥ 100 mm for ≤ 150 mm pipe, ≥ 150 mm for > 150 mm pipe). After installation, exposed bared or damaged surfaces epoxy coated.

3.4 BELOW GROUND

Laying per BS CP2010: Part 4. Lower into trench without abrasion. Lay on specified bedding material. Backfill per specified material and sequence, compacted to 95% of AASHTO modified density. Thickness of compacted layer ≤ 150 mm. Concrete thrust blocks at changes.

3.5 TESTING

Test pressure $\geq 1.5 \times$ max working pressure. Fill, wet for 24 hours. Maintain test pressure ≥ 2 hours. Inspect all joints.

3.6 FLUSHING AND COMMISSIONING

Flush with clean water until all dust, dirt, scales removed. Commission after successful testing.

3.7 OVERFLOW FUNNEL

Fabricated from mild steel heavy gauge, welded to M.S. pipe flange.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0420 – STEEL PIPES & PIPE FITTINGS FOR FIREFIGHTING INSIDE BUILDINGS

PART 1 – GENERAL

1.1 SCOPE

Supply, installation, testing, disinfection (potable water), flushing and commissioning of black steel pipes and pipe fittings for firefighting inside buildings.

1.2 APPLICABLE CODES AND STANDARDS

Same as Section 0410 plus NFPA requirements.

1.3 APPLICABLE SECTIONS OF TECHNICAL SPECIFICATIONS

Section 0100 Earthwork, 0140 Formwork, 0150 Concrete Works.

1.4 GENERAL REQUIREMENTS

Same as Section 0410.

1.5 SPECIAL REQUIREMENTS

Compliance with NFPA. Every pipe tested at manufacturer's works. Markings as Section 0410.

PART 2 – PRODUCTS

2.1 PIPE

Black steel to ASTM A53 schedule 40, listed per NFPA.

2.2 FITTINGS

ASTM A-234.

2.3 JOINTS

Welding (except valves). Welded joint to B.S.4515. Flanges to B.S.10. Nuts/bolts ISO 898. Gaskets B.S.3063.

PART 3 – EXECUTION

3.1 TRANSPORTATION, HANDLING AND STORAGE

Per Section 0410.

3.2 INSPECTION

Same as Section 0410.

3.3 LAYING AND JOINTING – ABOVE GROUND

Clean interior. Install to lines and grades. Welding by qualified/licensed welders. Supports: galvanized steel clamps, brackets, hangers. Thrust anchors at changes. After installation, pipes, fittings, supports, anchors painted with two coats red oxide or zinc chromate primer + two coats synthetic enamel.

3.4 BELOW GROUND

Same as Section 0410.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

3.5 TESTING AND FLUSHING

Same as Section 0410.

3.6 COMMISSIONING

Same as Section 0410.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0430 – UNPLASTICISED POLYVINYL CHLORIDE (uPVC) PIPES AND PIPE FITTINGS (SEWER/GRAVITY)

PART 1 – GENERAL

1.1 SCOPE OF WORK

Furnishing all uPVC pipes, plant, labor, equipment, appliances, materials for installing and testing of sewer pipes.

1.2 APPLICABLE CODES AND STANDARDS

B.S.3505, P.S.3051, B.S.4346.

1.3 GENERAL REQUIREMENTS

Pipes new, unused. Same manufacturers. Submittal: name/address, country of origin, dimensions/wall thicknesses, MTC, method of jointing/testing/commissioning.

1.4 SPECIAL REQUIREMENTS

Pipes suitable for intended use. Every pipe tested at manufacturer's works. Each pipe permanently marked (manufacturer's name/trademark, date, number, nominal diameter, class/pressure rating, inspection mark, standard, heat number embossed). Service ratings not less than max pressure. Wall thicknesses per class. Ends matching. Jointing materials same manufacturer.

PART 2 – PRODUCTS

2.1 PIPES

uPVC Sewerage Pipes to B.S.3505 or P.S 3051.

2.2 MATERIAL

Substantially polyvinyl chloride with additives for manufacture. No toxic hazard, no impairment of welding or chemical/physical properties. No detrimental effect on water composition. Lead, tin, other toxic substances within B.S 3505 limits.

2.3 JOINTS

Solvent cement to B.S.4346.

PART 3 – EXECUTION

3.1 FACTORY TESTS

Contractor informs Engineer of schedule. Engineer may visit factory. Contractor arranges tests: dimension measurements (wall thickness, diameter, length), visual inspection. Pipes marked with embossed number for project consignment. MTC submitted.

3.2 SITE DEMONSTRATION TEST

Contractor arranges manufacturer's representative to explain and demonstrate pipe jointing, laying, hydraulic pressure testing procedure for all pipe sizes. Separate demonstration per size. Pipes and rubber rings selected at random by Engineer. Whole stock rejected if demonstration fails.

3.3 HANDLING AND STORAGE

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Proper handling per manufacturer's recommendations. Stack at approved places. Transportation secure. Off-loading with cranes, rope/nylon slings, lifting beams with flattened hooks or scissor-dog, padded. Storage under shade, not exposed to sunlight/extreme heat. Damaged rejected and replaced.

3.4 LAYING AND INSTALLATION

Trenching: Excavate to required depth. Bottom leveled. If soft clay or loose material encountered, replace 300mm with specified bedding material.

Bedding Material: Sand, well graded, passing #200 $\leq 10\%$, free from boulders, clay, cinder, ashes, rubbish.

Laying: Start at lowest point. Socket upstream. Each length straight, true alignment, position, gradient, invert per drawings. Openings tightly closed when not in progress. Prevent floating. Lower into trench with derricks, ropes, belt slings (no dropping). Full length resting on prepared bed.

Jointing: Solvent cement type. Jointing surfaces dry, clean, free from oil, grease, tar, mud, sand.

3.5 TESTING

Infiltration (crown of pipe below water table): Empty pipe, close ends, measure depth after 1 hour. Infiltration not exceed allowable limits.

Ex-filtration (water table below crown): Isolate section between manholes. Internal pressure test 1.20m head above crown at high end (max 6.0m at low end). Measure water quantity after 1 hour.

Allowable Limits: ≤ 6 litres per mm diameter per km of sewer per 24 hours.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0440 – VALVES & APPURTENANCES

PART 1 – GENERAL

1.1 SCOPE

Supply, installation, testing and commissioning of valves and appurtenances.

1.2 GENERAL REQUIREMENTS

Renowned manufacturers. New, unused. Valves for firefighting: UL listed and FM approved. Material suitable for pipeline, similar to pipeline. Service ratings not less than 10 bars. Valve ends appropriate class/material/type. Install per drawings. Clean interior before installation. Test pressure not less than 1-1/2 x working pressure; no leakage. Adequately supported and labeled. Manufacturer's literature and operation manual provided.

PART 2 – PRODUCTS

2.1 CAST IRON GATE VALVES

Flanged ends, wheel handle, to B.S.5150. Flanges to B.S.4504 Part 1 or EN1092-1. Working pressure 10-25 bars. Close clockwise. Valve body cast iron, flanges cast iron, shaft stainless steel, disc stainless steel with bronze trim, seat cast iron with bronze trim. Inside surfaces enameled, outside epoxy coated.

2.2 CAST IRON CHECK VALVES

Non-slam, swing type, flanged ends, to B.S.5153. Flanges to B.S.4504 Part 1 or EN1092-1. Working pressure 10-25 bars. Direction of flow permanently marked. Body cast iron, flanges cast iron, shaft/spring stainless steel, disc/seat stainless steel with bronze trim, disc/shaft seal rubber (O-ring). Inside enameled, outside epoxy coated.

2.3 DUCTILE IRON GATE VALVES

Flanged ends, wheel handle, to B.S.5150 or EN1171. Flanges to B.S.4504 Part 1 or EN1092-1. Working pressure 10-25 bars. Body, bonnet, wedge of ductile iron; wedge seat bronze; stem stainless steel; hand wheel ductile iron; body seat bronze. Inside enameled, outside epoxy coated.

2.4 BRONZE GATE VALVES

To B.S.5154. Working pressure 10-25 bars. Ends flanged to B.S.4504 Part 1 or EN1092-1. Hose bibs with concrete pedestal as shown.

2.5 BRONZE CHECK VALVES

To B.S.5154. Same ratings.

2.6 BUTTERFLY VALVES

To B.S.5155. Working pressure 10-25 bars. Flanges to B.S.4504 Part 1 or EN1092-1. Direction permanently marked. Body cast iron/ductile iron (per BOQ), seat ring EPDM, disc stainless steel with bronze trim, stem S.S Cr.13, lever/gear cast iron/ductile iron. Stem O-ring EPDM.

2.7 SURGE RELIEF VALVES

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Spring operated globe type to ISO or equivalent. Body cast iron with stainless steel trim. Spring stainless or high tensile steel. Flanges to B.S.4504 Part 1 or EN1092-1. Working pressure min 16 bars. Adjustable.

2.8 DUCTILE IRON DOUBLE ACTING AIR VALVE

Automatic air release with small and large orifices. EN 1074-4. Ductile iron body, cover, flange; stainless steel ball floats; epoxy powder coating min 300 micron. For pipelines 150-300mm: double air valve DN50. At all high points. Firefighting: UL listed and FM approved per BOQ.

2.9 FLOAT VALVES

Copper alloy piston type to BS 1212. Float copper to BS 1968.

2.10 PRESSURE REDUCING VALVE

Screwed, brass body/screws, spring/bonnet/regulation handle synthetic, valve insert corrosion resisting synthetic, mesh strainer with stainless steel mesh (0.16mm), strainer chamber transparent synthetic, 1/2" connection for pressure gauge both sides, two pressure gauges (0-16 bar). Double socket wrench.

2.11 ABOVE GROUND FIRE HYDRANTS

Ductile Iron body to AWWA C502-80. PN16, test 1.5 x working. Lower part ductile iron with drain opening. Upper part ductile iron with one 100mm outlet and two 65mm outlets. Connection between upper and lower as security break device. 100mm coupling to BS 750, 65mm couplings brass quick release/instantaneous. Inside coating pure enamel or epoxy resin. Outside bright red (RAL 3000) epoxy resin.

2.12 BELOWGROUND FIRE HYDRANTS

Type per drawing, vertical on ductile iron tee. EN 14339:2005 and BS 750. Ductile iron body. PN16, test 1.5 x working. Exterior surfaces two coats black bituminous enamel. Installed in watertight chamber. Letter "F" or "FIRE" inscribed on cover.

PART 3 – EXECUTION

3.1 INSTALLATION OF VALVES

Install in chambers with watertight covers or above grade per drawings. Before installation: clean interior, inspect components, test to 1-1/2 x working pressure, coat internally/externally. After installation: securely anchor, test, retouch damaged paint, label.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

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SECTION 0450 – MANHOLES AND VALVE CHAMBERS

PART 1 – GENERAL

1.1 SCOPE

Construction of manholes/valve chambers including providing and fixing C.I./D.I or RCC cover and frame, ladder rungs, etc.

1.2 APPLICABLE SECTIONS OF SPECIFICATION

Section 0100 Earth Work, 0140 Form Work, 0150 Concrete Works, 0200 Brick Masonry, 0460 Cast Iron Covers with Frames and ladder rungs.

PART 2 – PRODUCTS

2.1 CONSTRUCTION

Manholes and valve chambers of reinforced cement concrete top, walls, base slab of RCC per drawings.

PART 3 – EXECUTION

3.1 CONSTRUCTION

Excavation, backfilling, disposal of surplus/rejected earth, plain and reinforced cement concrete, formwork, reinforcement, C.I./D.I or RCC cover and suitable frame, ladder rungs, benching per specifications. C.I. frame and ladder rungs set in place at time of pouring concrete.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0460 – CAST IRON/DUCTILE IRON COVERS WITH FRAMES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Installation of Cast Iron/Ductile Iron Cover with Frame, Gratings and ladder rungs.

1.2 APPLICABLE CODES AND STANDARDS

BS EN 124 “Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas”.

PART 2 – PRODUCTS

2.1 CAST IRON/DUCTILE IRON COVERS WITH FRAME

Sizes and duty per drawings. Cover complete with frame. Top roughened, name/logo of Employer marked, locking and lifting arrangement. Class and test load:

- A15: 15 KN
- B125: 125 KN
- C250: 250 KN
- D400: 400 KN
- E600: 600 KN
- F900: 900 KN

2.2 CAST IRON/DUCTILE IRON GRATING AND FRAME

Sizes and duty per drawings. Class and test load per above table.

2.3 LADDER RUNGS

Galvanized steel ladder rungs with epoxy coating, size per drawings.

PART 3 – EXECUTION

3.1 INSTALLATION

Frame set in place at pouring of concrete. Cover tightly fit in frame.

PART 3 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0470 – PUMPING MACHINERY

PART 1 – GENERAL

1.1 SCOPE

All labor, materials, and equipment to furnish and install pumps and triturator along with motors and all other accessories.

1.2 REFERENCES

ASTM A36 (Structural Steel), A48 (Gray Iron Castings), A53 (Pipe), A108 (Steel Bars), A276 (Stainless Steel Bars), A297 (Steel Castings), A536 (Ductile Iron Castings).

1.3 SPECIAL REQUIREMENTS

Furnish with each pump/triturator properly identified characteristic curves (capacity, head, efficiency, brake horsepower). Stable throttling curves, suitable for unrestricted parallel operation. Electric driven per BOQ. Not overload or trip when operating against zero pressure. No cavitation damage. Bearings suitable for continuous/intermittent operation without external sealing/cooling. Capable of delivering specified quantity at specified pressure. Factory tested for FAT in presence of Employer/Engineer. Installed at positions shown, perfect alignment. Provide reducer/enlarger if necessary.

1.4 SUBMITTALS

Product Data (specifications, installation/start-up instructions, pump characteristic curves). Shop Drawings (dimensions, weight loadings, clearances, assembly methods). Wiring Diagrams. Certificate of Compliance. Maintenance Data (trouble-shooting guide).

1.5 TRANSPORTATION, HANDLING AND STORAGE

Deliver in manufacturer's original protective packing. Handle carefully, do not install damaged. Store in clean dry place, protect from weather, dirt, fumes, water, debris.

1.6 WARRANTY

All pumping assemblies guaranteed min 1 year after satisfactory installation, testing, commission, acceptance. Water pressure booster system as a whole also guaranteed 1 year.

1.7 QUALITY ASSURANCE

Manufacturer regularly engaged in manufacture of pumps/triturator with characteristics, sizes, capacities required, products in satisfactory use for not less than 5 years. Performance certified by pump manufacturer. Single source responsibility for all components.

PART 2 – PRODUCTS

2.1 GENERAL

Materials new and unused. Statistically and dynamically balance rotating parts. Construction permits complete servicing without breaking piping or motor connections. Pumps/triturator connections flanged. Non-overloading characteristics. Stable characteristic curve; head increases with decrease in delivery; max head at zero flow not exceed discharge pressure at rated duty by more than 25%.

2.2 HORIZONTAL CENTRIFUGAL PUMPS & MOTOR (FOR POTABLE WATER)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Horizontal centrifugal pump and motor of specified capacity/head. Totally enclosed, fan cooled, squirrel cage induction motors. Body cast iron, impeller bronze or stainless steel, pump shaft stainless steel, shaft sleeve stainless steel. Mechanical seal. Suction/discharge flanges rated $\geq 1.5 \times$ working pressure. Efficiency not less than 60%. Motor 3-phase, 415/380 volts, 50 Hz, protected against low voltage, overheating, phase failure.

2.3 POTABLE WATER BOOSTER PUMP SET

Hydro-pneumatic pressure tank of specified capacity with neoprene rubber diaphragm. Skid mounted with automatic motor control for dry run protection. Stainless steel piping. L/C flexible pipe, gate valve, non-return valve, pressure switch & gauge. Tank rated working pressure 6 kg/cm², test 9 kg/cm², comply with ASME Code for Pressure Vessel.

Pump sleeve, intermediate chamber/guide vanes, impeller, suction inter-connector, spline shaft cover plates of stainless steel. Base plate painted steel. Gate and check valve on pump discharge, gate valve and foot valve on pump suction. Minimum run timer adjustable 0-6 min. Low water level cut-off switch.

2.4 SUBMERSIBLE BOREHOLE PUMP & MOTOR (FOR TUBEWELL)

Stainless Steel 304 or above. Pump casing, impeller, shaft, wear ring, diffuser all stainless steel. Motor 3-phase, 415/380 volts, 50 Hz, protected. Work out actual flow and head based on exploratory bore. Pump size with respect to bore casing.

2.5 HORIZONTAL CENTRIFUGAL SEWAGE PUMPS & MOTOR (FOR WASTEWATER)

Horizontal non-clogging sewage pump. Body cast iron, impeller stainless steel, pump shaft stainless steel, shaft sleeve stainless steel. All wetted materials suitable for chemical attack from municipal sewage & blue wastewater (from aircraft). Mechanical seal. Efficiency $\geq 55\%$. Non-clog impeller allows sizable spherical solids to pass. Operate through level switches in wet pit.

2.6 SUBMERSIBLE PUMP & MOTOR (FOR WASTEWATER)

Integral sealed unit with strainer. Body cast iron, impeller stainless steel, shaft stainless steel, bearings pre-lubricated, motor air filled water tight. Discharge flange threaded to BS 21, working pressure 10 kg/cm². Motor built-in overload protection, low voltage, over-heating, phase failure. Automatic operation per levels in wet pit. Suction/discharge flanges steel drilled to B.S 4504 or B.S 10, working pressure 10 bars.

2.7 TRITURATOR / MACERATOR (FOR BLUE WATER DISPOSAL)

Minimum flow rate 100 m³/hr, continuous operation for 08 hrs/day. Cutterhead casing Gray Cast Iron (EN-JL 1040), connection DN150 PN16 DIN EN 1092, shear plate Molybdenum high speed steel (1.3343/AISI M2 hardened), headstock unalloyed structural steel 1.0570, cutter material hard metal AISI 1045, bearing housing Gray Cast Iron. Mechanical seal silicon carbide, FPM elastomer. All wetted parts suitable for chemical attack. Operate through level switches in wet pit or manually.

2.8 PUMP ACCESSORIES

Pressure switches, pressure transducers, level switches, reducer/enlarger.

2.9 MOTOR PROTECTION

Motors $\leq 3\text{kw}$ direct on line; larger star-delta starter. Protection against under voltage, overvoltage, overload, over-heating, phase failure. Rated for voltage fluctuation $\pm 10\%$, frequency fluctuation $\pm 2\text{Hz}$.

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2.10 CONTROL

Potable Water Supply Pumps: Manual and automatically controlled by level switches in Overhead Water Tank. **Wastewater Pumps:** Manual and controlled by level switches in wet pit. **Triturator/Macerator:** Through level switches in wet pit or manually.

2.11 PRESSURE GAUGES

Copper alloy, bourdon tube, 100mm dial face, engraved 0-16 bar or 1.5 x working pressure. Installed with isolating plug/ball valve.

2.12 WATER LEVEL INDICATOR

230V AC, 50 Hz, complete with float, float chains, counter-weights, chain clamps, mounting brackets, chain guide roller. At least 5 switch-contacts.

2.13 LEVEL SWITCHES

At least 3 switch-contacts, suitable for specific gravity of fluid.

2.14 FOOT VALVE FOR PUMPS

Brass, integral strainer, spring loaded vertical check disc.

2.15 BELL MOUTH SUCTION FITTING

Same material as suction pipe.

2.16 CHAIN AND PULLEY BLOCK ARRANGEMENT

Capable to lift specified load. I-beam standard AISI girder. Travel wheels of dia-forged steel on ball/roller bearings. Chain block capable of standard clearance/lift. Subject to no-load and full-load tests.

2.17 BAR RACK/SCREEN

Mild Steel, rectangular bars 12mm x 50mm, 50mm c/c. Bolts, anchor bolts, washers submerged: Type 316 stainless steel. All anchors stainless steel. Protective coating epoxy min 200 microns.

2.18 MAINTENANCE MANUALS AND TOOLS

Comprehensive manual for assembly, operation, lubrication, adjustment, repair, with parts list. Special tools for maintenance and repair. Manufacturer's recommended spare parts list submitted for approval.

PART 3 – EXECUTION

3.1 INSTALLATION

Examine area and conditions. Provide access around pumps per drawings (not less than manufacturer's recommendation). Install on minimum 100mm high concrete base with anchor bolts poured in place. Submersible drainage non-clogging pumps installed in sum pits per drawings.

3.2 SHOP TESTING

Pump performance tests per HI E35.01, E37.01, E39.01. Five points from shut-off head to run-out including guaranteed point. All pumps hydrostatically tested for leaks at 1.5 x design pressure. Submit manufacturer's test certificates.

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3.3 FIELD TESTING

Field performance test witnessed by Engineer.

3.4 ADJUSTING AND CLEANING

Check alignment, realign within tolerances. Lubricate before start-up. Clean factory-finished surfaces; repair marred surfaces with touch-up paint.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

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SECTION 0480 – FLUSHING, TESTING, DISINFECTION AND COMMISSIONING OF PIPELINE

PART 1 – GENERAL

1.1 SCOPE OF WORK

Flushing, testing, disinfection and commissioning of all water lines and system.

1.2 WATER FOR FLUSHING AND TESTING

Contractor arranges required quantity of water.

1.3 FLUSHING

Flush section by section (normal length 500m). Flushing velocity ≥ 2.5 ft/s. Continue until clean water flows. Dispose flushed water as directed.

1.4 PRESSURE AND LEAKAGE TEST

Follow relevant specifications for various types of pipes and fittings. Contractor locates and repairs defective joints/pipes at own expense.

1.5 DISINFECTION

Potable water lines only. Chlorination: ≥ 50 mg/l chlorine, retain ≥ 24 hours, residual ≥ 25 mg/l at pipe extremities. Flush until residual < 1 mg/l.

1.6 COMMISSIONING

Commission after successful testing. Remove all temporary arrangements.

1.7 TESTING OF FIREFIGHTING SYSTEM/NETWORK

Test per NFPA standards. Submit Testing Protocol and Procedure for approval. Testing assembly arranged by Contractor.

PART 2 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0490 – GENERAL REQUIREMENTS FOR ELECTRICAL WORKS

PART 1 – GENERAL

1.1 SCOPE OF WORK

The works related to the Electrical system included in the scope of this Contract are shown on the Drawings, stated in the Specifications and Bill of Quantities, and explained in these specifications. The works shall broadly include but not be limited to:

Item	Description
a.	Main Panel Board (LT Switchboard) — indoor, floor-mounted, factory-assembled
b.	Distribution Boards (DBs) — free-standing and wall-mounting types
c.	Internal Wiring — PVC conduit and cable installation throughout
d.	LED Light Fittings and Fixtures (all new lighting shall be LED type)
e.	Cables, Conduits and Cable Trays — PVC conduit, power cables, underground armoured cables
f.	Earthing System — earth electrodes, CPCs, earth bars, equipotential bonding
g.	Telephone System — outlets, distribution boards, junction boxes
h.	Computer / Data System — CAT-6A UTP cabling, data outlets, network switches, Wi-Fi
i.	CCTV System — IP cameras, NVR, monitors; minimum 30-day retention
j.	Fire Alarm System — addressable smoke/heat detectors, break glass, sounders, FACP
k.	Public Address System — amplifiers, speakers, wiring in PVC conduit
l.	Access Control System — RFID card/biometric readers, control panels
m.	MATV System — TV outlet points, junction boxes, splitters
n.	Lightning Protection System — air terminals, down conductors, earth electrodes
o.	UPS System — online double-conversion for all ATC critical systems; min. 30 min backup
p.	Emergency Lighting System — battery-backed LED emergency luminaires
q.	Diesel Standby Generator Sets — 300 KVA (primary) + 150 KVA (secondary/backup)

The Contractor shall also supply any other equipment not specifically mentioned but necessary for proper operation of the system as intended. The Contractor shall be solely responsible for ensuring proper functional requirements and for furnishing any additional equipment and modifications as desired and/or approved by the Engineer.

The Contractor shall timely carry out field survey to identify the route of feeders and exact location of new 11 KV VCB Panels to be connected with the existing 11KV buses through bus bar extension work. The utility company is to take up the extension work within the Grid station. However, the Contractor is fully responsible to ensure timely coordination and approval from the utility related to termination of required number of 11 KV feeders through extension on both 11 kV busses of the existing 11KV switch gears to erect an 11 KV ring circuit.

The Contractor shall have good knowledge of International Civil Aviation Organization/Federal Aviation Authority (ICAO/FAA) recommendations and shall ensure implementation along with any additional requirements as per tender documents or these authorities.

1.2 RULES AND REGULATIONS

The entire electrical installation/work shall be carried out by a licensed Contractor authorized to undertake such work under the provisions of the Electricity Act 1910 and The Electricity Rules 1937 as adopted and modified up to date by the Government of Pakistan.

All works shall be carried out in accordance with the latest edition of the Regulations of the Electrical Equipment of Buildings issued by the Institute of Electrical Engineers – London, the Tender Documents, The Electricity Rules 1937, and bye-laws in force. Any discrepancy shall be brought to the notice of the Engineer for instructions; the Engineer's decision shall be final.

The Contractor shall ensure that the connection of the 11 kV cable with the existing 11 kV switchgear at the grid station is certified by, and acceptable to, the Water and Power Department of the Government of Gilgit-Baltistan (GB Power Department), which is the electricity supply authority for Skardu.

1.3 AMBIENT CONDITIONS

All material and equipment supplied and installed shall be designed, manufactured and tested to meet the following ambient conditions unless specifically stated otherwise:

Parameter	Value
Maximum indoor ambient temperature	40°C
Minimum indoor ambient temperature	-20°C
Maximum outdoor ambient temperature	50°C
Minimum outdoor ambient temperature	-20°C
Maximum relative humidity	100%
Minimum relative humidity	20%
Maximum altitude of project	2230 meters
Design basic wind speed	70 miles/hr
Fastest mile wind velocity	As per ASCE 7-22 with altitude correction at 2,230 m AMSL; refer to Section 0010 §1.02.1
Seismic Zone	Zone 4 per Building Code of Pakistan; $Z = 0.4$; ASCE 7-22 with Risk Category IV ($I_p = 1.5$ for non-structural components)

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The atmospheric condition is highly humid. Wind loading shall also be considered as per applicable local Codes and Standards. All offered/supplied electrical equipment, devices and material shall be strictly in line with the project site conditions.

1.4 STANDARDS

The latest standards, codes and recommendations of reputable institutions (BSS, VDE, IEC, NEC, NFPA, ICAO, FAA, etc.) shall be applicable. Where the Specifications differ from standards, the equivalent or better specifications shall govern. Wherever applicable, equipment shall also conform to Pakistan Standards and Quality Control Authority (PSQCA) and Pakistan Standard Institution (PSI). The Contractor shall maintain at the site office one copy of the standards/codes/recommendations applicable to the works and will furnish the same as required by the Engineer/Employer.

1.4.1 Licensing Requirements

All electrical work shall be carried out only by a licensed contractor authorised under the Electricity Act 1910 and the Electricity Rules 1937, as adopted in Gilgit-Baltistan. The Contractor shall sign a formal contract with the electrical sub-contractor. The final electrical installation shall be inspected and passed by the Electric Inspector designated by the Government of Gilgit-Baltistan before commissioning.

1.5 SYSTEM DATA

Unless otherwise specified, all equipment and material shall be designed to operate satisfactorily with the following minimum requirements without de-rating:

- **HT Voltage:** 11kV, 3 phase $\pm 10\%$
- **LT Voltage:** 400V, 3 phase $\pm 10\%$; 230V, 1 phase $\pm 10\%$
- **Frequency:** 50 Hz ± 2 Hz

Colour coding for live parts shall be according to IEC 60445:2017 & BS7671:2008:

Network	Conductor	Coding	Colour
A.C.	Phase 1 (L1)	—	red
	Phase 2 (L2)	—	yellow
	Phase 3 (L3)	—	blue
	Neutral (N)	—	black
D.C.	Positive (L+)	—	white
	Negative (L-)	—	black
Earthing	Protective Earth (PE)	—	green/yellow
	Earth (E)	—	green/yellow

Control Cables: Shall be manufactured according to specifications for L.T. Cables, multi-core, PVC insulated, withstanding site conditions. Cross section as per system requirement. All cores shall be numbered and/or colour coded. At least 20% spare cores shall be provided in all Control Cables.

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1.5.1 Electrical Load Data:

Load Category	Connected Load / Capacity
Lights and Power (connected)	225.97 kW (demand: 123.00 kW)
Lift	30.00 kW
Public Health (plumbing pumps, etc.)	15.00 kW
HVAC System	200.00 kW
Total Diversified Demand (80% diversity)	294.40 kW
Transformer Capacity Required	630 KVA (460 KVA at 0.8 PF; 368 kW at 80% load factor)
Generator Capacity — Primary	300 KVA (with AMF panel and ATS; transfer time ≤ 10 seconds)
Generator Capacity — Secondary / Backup	150 KVA

1.5.2 ATC Cab Lighting Requirements

ATC cab lighting shall be fully dimmable (0–100%), non-reflective in glass, and energy efficient. Colour rendering index (CRI): minimum Ra 80. Illuminance at ATC control positions: 500 lux. Night vision protection mode: switchable to low-level red lighting. Dimmer controls: Polaron Controls UK, Strand Lighting, Altenburger, or Engineer-approved equivalent. All lighting in the ATC Visual Control Room shall comply with ICAO Doc 9157 requirements for control room lighting.

1.5.3 Earthing System Requirements

Comprehensive earthing system per BS 7671 / IEC 60364-5-54. Earth electrode: copper-bonded steel rods, minimum 2.4 m long. Target earth resistance: ≤ 1 Ohm for the ATC Tower (critical aviation facility). Multiple rods in parallel if required. All metalwork, conduits, cable trays, trunking, switchboard enclosures, and structural steelwork bonded to the main earthing terminal (MET). Green-yellow CPCs in all conduits (14 SWG minimum).

1.6 EQUIPMENT

1.6.1 Equipment Manufacturer

All equipment and material shall be standard products of reputable and ISO certified manufacturers with similar manufacturing experience of at least five years.

For imported equipment, only authorized local distributors/suppliers of the Original Equipment Manufacturer (OEM) shall be considered. For all OEM equipment, the Contractor shall clearly identify the brand, country of manufacture, and the local agent in Pakistan who can provide local maintenance assistance. Local agent reference shall include: company name, address in Pakistan, contact persons, phone numbers, valid email, reference in similar fields, authorized distribution certificate from OEM, and certified engineer's certificate. After-sales service, spares and support shall be available with the manufacturer/authorized distributors.

1.6.2 Country of Origin

Equipment manufactured in Israel and India is not acceptable. The Contractor shall clearly mention origin of equipment in his bid. Subassembly or part assembly from other countries must be disclosed. No relaxation will be entertained after award of Contract.

1.6.3 Quality Assurance

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All materials and equipment shall be new, unused and of best quality. Standard components of regularly engaged manufacturers shall be offered. All equipment and components shall have been thoroughly tested and proven in actual use. Equipment shall have current year of manufacturing. Manufacturers' quality control shall be in accordance with ISO 9000 series (or DIN equivalent). Manufacturers with quality control certified according to ISO 9000 series will only be acceptable; certified copy shall be attached to bid.

1.6.4 IP Degree of Protection

The equipment shall have IP degree of protection as follows unless mentioned otherwise:

- IP 42 for indoor areas
- IP 54 for indoor damp areas
- IP 65 for outdoor areas

After installation, the Contractor shall provide high performance epoxy paint on all Switchboards and related electrical equipment. If properly rated equipment is not available, the Contractor shall provide field enclosures to attain the required IP degree of protection. Cooling/exhaust fans and/or anti-condensate heaters shall also be provided if necessary. No separate payment shall be made; it is deemed included in the relevant BOQ item.

1.6.5 Protective Paint Coating for Electrical Equipment Components

Indoor sheet steel metal works (all types of Electrical Switchgears/Distribution Boards, RMU, Kiosk Type Substation, Transformers, DG Sets, Cable trays, etc.) shall be coated with a protective paint system in accordance with ISO 12944 Corrosivity Category "C2" with Medium Durability. Priming coat(s) shall be epoxy based; top coat shall be polyurethane based with colour shade RAL 7032/7035 or as approved.

Outdoor metal works (transformer, cable trays, outdoor LT Distribution Boards, lighting poles, etc.) shall be coated with protective paint system in accordance with ISO 12944 Corrosivity Category "C3" with Medium Durability. Priming coat(s) epoxy based; top coat polyurethane based with colour shade RAL 7032/7035 or as approved. Appropriate bonding/adhesion material such as Etch Primer is recommended for galvanized surfaces before application.

The Contractor shall submit to the Engineer for approval:

- Paint manufacturer's confirmation that proposed paint system is compatible with the intended surface.
- Paint manufacturer's confirmation that proposed paint products are compatible with each other.
- Paint products catalogues.
- OEM's recommended surface preparation methodology.
- Number of coats.
- DFT per coat.

1.6.6 Nameplate

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All equipment shall have stainless steel name plates mounted in a visible position. Entries shall be indelibly marked in English by engraving and include data per applicable IEC and other standards, plus any specified requirements. The Contractor shall also supply all labels, instruction and warning plates (English and where specified Urdu) necessary for identification and safe operation. All labels, nameplates, instructions and warning plates shall be securely fixed with stainless steel rivets, plated self-tapping screws or other approved means (adhesives not permitted).

1.6.7 Identification & Labeling

All devices, meters, cabling, wiring and auxiliaries shall be properly labelled for identification using flameproof material with indelible ink/markings. Labeling shall ensure uniformity and facilitate study of control diagrams during operation and maintenance. Labels shall be of suitable size to be visible from operating conditions/positions.

1.6.8 Lamp Test Facility

All equipment / Switchboards / Motor Control Centers, etc. shall be provided with common lamp test facility.

1.6.9 Climatic Design Conditions for Electrical Equipment

Parameter	Design Value
Maximum Ambient Temperature	+40 °C — refer to project-wide design temperatures in Section 0010 §1.02.1. All electrical equipment shall be qualified for continuous operation at this maximum value.
Minimum Ambient Temperature	–25 °C — equipment qualification minimum. Cold-start capability mandatory for generators, switchgear, motors and transformers. Refer to project-wide design temperatures in Section 0010 §1.02.1.
Maximum Relative Humidity	90% — tropical-grade insulation and anti-condensation heaters in all switchgear
Altitude Correction	All electrical equipment rated at 2,230 m AMSL; de-rate per IEC standards (approximately 0.79 × sea-level air density)

1.7 SHOP DRAWINGS, MATERIAL SUBMITTALS, AND TECHNICAL DATA

1.7.1 Required Submittals

The Contractor shall submit for each electrical equipment as a minimum:

- Structural drawings (foundations, RCC details, dimensional plans, elevation, sections, loading details).
- Electrical drawings: line/schematic diagrams for HT Switchboards, LT Switchboards/ATS/Synchronization Panel, LT Outdoor Distributors, LT Distribution Boards, Motor Control Centers; detailed wiring/control diagrams, elevations, internal component layout, top/bottom/side views.
- Complete shop drawings with execution/fixing/installation details (number of wires, conduit size, cable routes, cable schedules) for Lighting Layouts (including Façade Lighting), Power Layouts, Cable Tray Layouts, Grounding Layouts, Lightning Protection System Layouts, Ground Powering Unit (400Hz), Cathodic Protection System (CPS), Solar Power System

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(SPS), DC Supply System, MV and LV cabling details, Manhole/Duct works, Danger Sign Board dimensional and installation details, Combined and Coordinated Ceiling Layouts.

- Equipment installation details for Power Transformer, LV DG Set, Kiosk type substation, HT Switchboard(s), LT Switchboard(s)/ATS/Synchronization Panel, LT Outdoor Distribution Board(s), LT Distribution Board(s), Motor Control Centre(s), Ground Powering Units, Cathodic Protection System, Solar Power System, DC Supply System.
- Airfield Lighting System drawings: line diagrams of Distribution Boards, Constant Current Regulators with detailed wiring diagrams; Airfield Lighting Layouts; cabling, grounding/earthing; integration with existing ALCMS and ILCMS details; conduit & pipes layout; dismantling and reinstallation details.
- Apron Flood Lighting drawings: line diagrams of Apron Distribution Boards with wiring diagrams; Apron Lighting Layouts; lighting distribution calculation sheets with lux levels marked grid-wise; power/earthing layout; integration of control & monitoring with existing ALCMS.
- Advance Visual Docking Guidance System drawings.
- Technical literature and manufacturer's characteristic data with description of materials and weights.
- As-Built Drawings of existing conditions.
- Combined Services Layout Diagrams (coordinated with existing services).
- Foundation and Trench Arrangement Drawings.
- Technical submittals for: LV D.G. Set, Power Transformer, HT Switchboard, Ring Main Unit, KIOSK type Substation, LT Switchboards/ATS/Synchronization Panel, Motor Control Centres, LT Outdoor Distribution Boards / LT Distribution Boards, UPS System, Airfield Lighting System, Apron Flood Lighting System, A-VDGS, Solar Power System components, Cathodic Protection System components, DC Supply System components, Miscellaneous Items (Lighting Poles).
- Technical submittals with material samples for: Light Fixtures, HT/LT Cables, Wiring Accessories, Conduits/Pipes & Fittings, Earthing & Lightning Protection System, Miscellaneous Items (Cable Trays/Ladders, Under floor metal trunking, Ceiling/Bracket Fans, Switch disconnectors/LBS with weatherproof enclosure box), 400Hz GPU, CPS, SPS, DCSS.
- Testing and commissioning time table and protocols.
- Design calculations/software-based simulations: illumination calculations, voltage drop calculations, comprehensive short circuit software simulations, selective coordination analysis, thermal soil resistivity measurement, lightning protection risk assessment and rolling sphere analysis, earthing calculations based on measured thermal soil resistivity, and simulations for 400Hz GPU, CPS, SPS, DC supply system.

No separate payment shall be admissible for software-based simulations, design calculations, analysis, measurement, field testing, etc.; cost shall be deemed included in the relevant BOQ item.

1.7.2 Submission and Review Process

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At least three (3) copies of shop drawings, submittals and/or technical data shall be submitted to the Engineer for review and approval. The Engineer will review all documents and make changes as required. The Contractor shall ensure full compliance with comments.

Engineer's approval must be obtained before any equipment, device or material is purchased or fabrication commenced. Approval is general and does not relieve Contractor of responsibility.

Each drawing/document will be returned marked:

- (a) "APPROVED"
- (b) "APPROVED EXCEPT AS NOTED"
- (c) "REVISE AND RESUBMIT"
- (d) "NOT APPROVED"

"NOT APPROVED" documents are rejected; Contractor shall offer alternates and resubmit four copies. "REVISE AND RESUBMIT" documents shall be corrected and resubmitted (four copies). For "APPROVED EXCEPT AS NOTED", the Contractor may proceed but shall incorporate changes; resubmission may be required if Engineer considers necessary. Revised submittal within 7 days.

The Contractor must allow 28 working days for Engineer's review (as specified in Section 0010). The Contractor is responsible for discrepancies, errors or omissions in his drawings even if reviewed. Any delay in approval caused by incompleteness, shortcomings, non-submission of required information, etc., is attributable to the Contractor and will not be a reason for extension of time (EOT).

Symbols for electrical equipment shall conform to NFPA, NEC, IEEE, IEC, and/or DIN. Soft copies of all applicable codes/standards will be provided by the Contractor to the Engineer. All circuit diagrams shall be drawn so they can be assembled in a standard hard-core, non-detachable binder and unfolded without being detached.

1.8 MANUFACTURER'S INSTRUCTIONS

The Contractor shall supply to the Engineer six (6) properly bound copies of manufacturer's instruction manuals for installation, testing, commissioning, operation and maintenance of the specified equipment, including spare parts and tools manuals. At least two copies shall be original. Installation instructions shall be submitted 2 weeks prior to commencement of installation; operation and maintenance instructions at commissioning. Failure to provide documents shall result in withholding of certificates and deduction of suitable amount from payments.

1.9 GUARANTEE

The Contractor shall furnish written guarantee of the manufacturer or supplier with respect to satisfactory performance of each equipment. Guarantee shall cover replacement and repair of parts or whole equipment defective in material or workmanship for the Defects Liability Period as defined in the Conditions of Contract. The Contractor shall be fully responsible for timely repair or replacement.

1.10 DANGER BOARDS, SIGNS, SHOCK/FIRST AID CHARTS AND FIRE FIGHTING EQUIPMENT

Danger Boards having signs and designation of the room shall be installed on the external door of DG Set Room, HT, LT, and Power transformer rooms. Painted Danger Sign and Designations shall be provided on Kiosk Type Substation. Shock/First Aid Charts shall be installed in H.T, L.T, Low Voltage DG Set, Transformer Rooms and Kiosk Type Substation. Portable firefighting extinguishers suitable for electrical fire shall be provided in H.T, L.T, Power Transformer Rooms and Kiosk Type Substation.

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1.11 ASSOCIATED CIVIL WORKS

Except where separately stated in the Bill of Quantities, the cost of all civil works associated with any BOQ item of electrical works (excavation, backfilling, compaction, foundation pads, thrust boring, chiseling, making openings, etc.) shall be deemed included in the price quoted against respective electrical items.

All openings made in external/internal walls, slab, ceiling, etc. for electrical works shall be filled after installation with suitable heat and fire-resistant mortar, suitably rated with respect to building fire zones, to ensure no ingress of water or spread of fire. All unutilized conduit/pipe/slab openings shall be sealed with same material. Repair of any damage to civil works caused by the Contractor during installation is included. No separate payment shall be made.

PART 2 – PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

All equipment and material shall conform to the standards, ratings, and quality requirements specified in Part 1. Specific product requirements for each system (DG Sets, Transformers, Switchboards, Cables, etc.) are detailed in their respective sections of the Specifications. The Contractor shall provide only products that are new, of current manufacture, and from approved manufacturers with ISO 9000 certification.

2.2 PROTECTIVE PAINTING

As specified in clause 1.6.5, all indoor and outdoor metal works shall be coated with protective paint systems per ISO 12944 Corrosivity Category C2 (indoor) or C3 (outdoor), with epoxy primer and polyurethane top coat, colour RAL 7032/7035 or approved. Etch primer for galvanized surfaces.

2.3 NAMEPLATES AND LABELS

Stainless steel nameplates with engraved English text; labels, instruction and warning plates in English (and Urdu where specified), fixed with stainless steel rivets or plated self-tapping screws.

2.4 CONTROL CABLES

Multi-core, PVC insulated, with at least 20% spare cores, numbered and/or colour coded.

PART 3 – EXECUTION

3.1 INSTALLATION INSTRUCTIONS – GENERAL

The Contractor shall install all system components and appurtenances in accordance with manufacturer's recommendations and provide all necessary interconnections, services and adjustments for a complete functional system.

The Contractor shall provide instrumentation and communication grounding as necessary. All penetrations shall be sealed to preclude water entry using silicone material.

The Contractor shall furnish all labour, materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not furnished by him or others. The Contractor shall supply and install all erection materials (foundation bolts, washers, nuts, etc.) without additional cost.

The Contractor shall set out the works as per Specifications and Drawings and properly position equipment on specified foundation/location. Manufacturer's instructions for installation shall be

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followed. Any defect or faulty operation due to not following manufacturer's instructions shall be corrected at Contractor's own cost.

Deviation from working drawings deemed necessary due to site conditions shall be submitted for Engineer's approval before starting work.

3.2 FACTORY ACCEPTANCE TESTS (FAT)

3.2.1 Scope

Factory tests are to be carried out in the presence of both the Employer and the Engineer. All type and routine tests on DG Sets, HT Switchboards, Power Transformers / Kiosk type Substations, LT Switchboard, ATS, Synchronization Panel, LT Distribution Boards, Motor Control Centers, HT Cables, LT Cables, Control Cables, Cathodic Protection System (CPS), 400Hz Aircraft Ground Power Units System, Solar Power System (SPS), Advance Visual Docking Guidance System (AVDGS), Airfield Lighting System equipment, and all other equipment shall be performed at the manufacturer's works in the presence of the Engineer and the Employer or their representative.

Type tests may be waived if test certificates are submitted from an Engineer-approved standard laboratory of international repute, but routine tests shall still be carried out.

The Contractor shall submit the test procedure to the Engineer/Employer for approval at least 4 weeks before carrying out the tests. Factory test procedures shall be drawn in accordance with relevant code/standards, standard practices and manufacturer's recommendation.

The Contractor shall inform the Engineer/Employer about date and time of test of each equipment at least two weeks in advance. This shall be after test procedures are approved.

The Contractor shall make necessary arrangements and provide all facilities for representatives of Employer/Engineer for conducting inspection, at Contractor's cost. Travel, visa, boarding, lodging costs shall be Contractor's responsibility. The Contractor shall provide daily allowance (as specified in section 0010) for out-of-pocket expenses to each representative, in cash (US\$) before travel.

The Contractor shall submit tests procedures for approval well in advance. All relevant submittals, shop drawings and requisite technical data shall be approved prior to start of production. The Contractor shall give at least 3 weeks' notice for attending inspections/tests.

All domestic and foreign FATs shall be carried out in presence of Employer and Engineer or their representatives.

3.2.2 Transformer Tests (minimum per IEC 60076)

- Measurement of Polarity and Phase relationship
- Measurement of Load Losses & Current
- Measurement of No-load losses & Current
- Induced Over-Voltage Withstand Test
- Separate Source Voltage Withstand Test
- Measurement of Winding resistance for both MV & LV
- Measurement of Insulation resistance using megger
- Measurement of Short Circuit Impedance and Load Losses

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- Measurement of Dielectric Strength of Oil
- Functional Test of Buchholz Relay

3.2.3 Diesel DG Set – Standard Witness Test

The approved DG Set shall be subject to inductive load duration tests at manufacturer's premises per applicable codes/standards:

- Inspection of Generator Set prior to Set Test
- Load Acceptance demonstration (single step load application)
- Load Duration Test: 1 hour at 100% rated at 0.8pf (45 min at 100% + 15 min at 110%), then 1 hour at 100% rated at 1.0pf (45 min at 100% + 15 min at 110%)
- During load test, record every 15 minutes: Time, kW, Power Factor, all L-L voltages, line currents, frequency, oil pressure, engine coolant temperature, alternator temperatures.
- Demonstrate: Manual Control, Automatic Starting and Rest Attempts, Emergency Stop Control (Local & Remote), Automatic Mode, Cooling Run.

Documentation to be provided: Extended Load Run Certificate, Standard Factory Test Certificate, Certificate of Inspection, Engine Test Certificate, Alternator Test Certificate, Transient graphs, Calibration Certificates.

3.2.4 HT Switchboards, LT Switchboards, ATS, Synchronization Panel, LT Outdoor Distribution Boards / Distribution Boards, Motor Control Centres (MCC) / Apparatus Control Panel (ACP)

Contractor shall submit proforma/list for essential routine tests per IEC 62271-1 & 62271-200 for HT Switchboard, and per IEC 61439 for LT Switchboard, ATS, Synchronization Panel, to be carried out at manufacturer's/assembler's premises during FAT.

Routine tests for LT Distribution Boards, LT Outdoor Distribution Boards, MCC, ACP shall be carried out per relevant international standards.

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked. Phases shall be properly identified. Trip circuits checked. Correct size/function of fuses, disconnect switches, interlocks, indicating lights, alarms, remote control devices shall be per approved drawings. Nameplates checked. Protective relays tested and set at site prior to commissioning. Lamp test facility checked.

3.2.5 HT Cables / LT Cables

Contractor shall submit proforma/list for essential routine tests per IEC 60502-2 for 8.76/15kV grade HT Cables; per IEC 60502-1 / BS 6346 for 600/1000V grade multicore LT Cables; per BS 6004 for 450/750V grade single-core LT Cables and 300/500V grade single-core/multicore LT Cables.

3.2.6 Solar Power System

Factory Acceptance tests are to be carried out in presence of Employer and Engineer. Type and routine tests on Solar PV Panels, DCDB/SCB/SMB, String Inverters, ACSB/ACCB, low tension cables (DC and AC), etc.

3.3 SITE ACCEPTANCE TEST (SAT) / FIELD TESTING

3.3.1 Scope

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Upon completion of installation, the Contractor shall perform field tests on all equipment, cables, materials and systems in presence of Engineer or his representative. The Contractor shall submit for approval complete test details (procedure, observations, expected results). The Contractor shall furnish all tools, instruments, test equipment, materials and qualified personnel.

All tests shall be made with proper regard for protection of personnel and equipment. Cost of damages or rectification due to accidents shall be Contractor's responsibility. The Contractor shall record all test values and provide four (4) copies certified by Engineer, including test method, equipment, diagrams. Witnessing by Engineer does not relieve Contractor of guarantees or other obligations.

3.3.2 Low Voltage D.G. Set

Prior to tests, submit manufacturer's detailed test procedures for approval. Carry out full site load and no-load tests per applicable IEC, ISO, IEEE, BS standards. Tests shall include:

Basic Tests: Insulation Resistance, Earth Continuity, Earth Loop Impedance, Polarity, Phase Rotation, Voltage and Frequency, Starting System, Protection Equipment.

Battery: Nominal Voltage, Discharge Voltage, Specific Gravity of Electrolyte, Level of Electrolyte, Charging System.

Lubrication: Check as required by manufacturer.

Operational Check at Start-up: Oil Pressure, Fuel Oil Leaks, Operation of Safety Devices, Operational Speed, Automatic Control, Instrument Check, Exhaust Check, Undue Vibration.

Operational Check after one hour run: Oil Pressure, Oil Leaks, Cooling System, Oil Temperature.

Commissioning Test: 25% full load 2 hrs, 50% full load 5 hrs, 75% full load 8 hrs, 100% full load 8 hrs, 110% full load 1 hr.

All results recorded and compared with design data. If required load not available, Contractor shall provide dummy load at no extra cost. Correct functioning of control equipment shall be proved.

3.3.3 Battery Charger

Static type, trickle and boost charging, capacity to fully recharge completely discharged batteries within four hours at boost charge.

3.3.4 Control Panel

Provide all necessary control and monitoring devices for Diesel Generating Sets as specified.

3.3.5 Airfield Lighting System

Test per ICAO recommendations and FAA Specifications regarding light intensity and light emission. Perform and record in presence of Engineer:

- Visual inspection of all light fixtures and constant current regulators (CCR)
- Visual inspection of isolating transformers and arrangement in pits/housing
- Insulation resistance tests of all individual and switching circuits (phase to earth) using 5kV megger – reading not less than 1 mega Ohm
- Operation test of all lights from existing ALCMS and ILCMS

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- Switching of all brightness steps from control workstation
- Operating tests on CCR for each switching circuit
- Operating test including all controls on control workstation
- Operating tests of modular system
- Operating tests of lamp failure alarm
- Test of lamp failure alarm, total power failure, secondary circuit failure on all circuits

3.3.6 Insulation Resistance Test

Make insulation resistance test on all electrical equipment using megger:

- 500 volts for circuits up to 250V
- 1000 volts for circuits 250-500V
- Up to 5 kV for 11 kV circuits (as advised by equipment manufacturer)

Values shall be as per BSS, IEEE, NEC, ICEA and Pakistan Electricity Rules.

Before connections at cable ends or joints, test each cable section. All cables subject to high voltage test per standard. Each conductor of multi-core cable tested against others and earth. If readings below minimum, replace cable and retest. If joint provided, test sections; joint made only after tests satisfactory. Finally test completed cable including joints.

Switchgears: insulation resistance measurement after installation but before wiring. Test between open contacts of circuit breakers, switches, and between each phase and earth. If low, determine and remove cause (dry-out by heaters if moisture). Corrective measures: repeat readings twice at 12-hour intervals; maximum range not exceed 20% of average value. After tests, reconnect equipment. Polarity test on single pole switching devices.

3.3.7 Earth Resistance Test

Make earth resistance tests, separating and reconnecting each earth connection. Soil treatment or corrective measures as determined by Engineer.

Electrical resistance of ECC together with earthing leads from earth electrode to any other position shall not exceed 1 ohm. Test per Electrical Inspector's requirements. Where multiple earth electrodes, measure each electrode using resistance bridge instrument.

Lightning protection system: test for continuity and earth resistance. Combined earth resistance at any point shall not exceed 10 ohms.

3.3.8 Special System Test

Test components of DC supply, Cathodic Protection, Lightning Protection, Solar Power System, 400Hz GPU, AVDGS, etc., per respective technical specification sections. Any specific test recommended by OEM/Local Vendor/Govt. inspector shall also be carried out as approved by Engineer without additional cost.

3.3.9 Completed Tests

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After equipment is tested and accepted by Engineer, the Contractor is responsible for its proper protection so that subsequent testing does not cause damage.

3.3.10 Expenses

All expenses (travel, documentation, boarding, lodging, allowances, etc.) for carrying out tests and witnessing by Engineer and Employer shall be borne by Contractor and deemed included in BOQ rates.

3.4 SPARE PARTS

Contractor shall provide spare parts as identified in Appendix-D. Total amount carried to relevant BOQ item.

3.5 SPECIAL TOOLS

Contractor shall provide special tools as indicated in Appendix-C and as may be deemed essential for assembly, adjustment, dismantling, installation and operation & maintenance (O&M). Total amount carried to relevant BOQ item.

3.6 STATEMENT OF COMPLIANCE

Contractor shall submit an overall in-writing compliance signed and stamped with the items of these specifications in the form of Statement of Compliance (required at bidding stage). During material submittal review stage, Contractor shall submit his own proposal and OEM's para-wise compliance of relevant specification section with each material submittal. Absence of such compliance will lead to rejection.

3.7 WARRANTY OF GOODS

Contractor shall provide warranty of equipment as specified under respective sections, for the period defined. Effectiveness of warranty from OEM commences from effective date of Taking Over Certificate issued by Engineer. All warranties are to be endorsed in Employer's name, and an undertaking shall be submitted from OEM and local representatives for ensuring compliance of services during Warranty Period.

3.8 APPENDICES TO BE FILLED IN BY TENDERER

Details regarding equipment manufacturers, deviations, technical data, special tools, spare parts, etc., shall be furnished in the appendices attached with form of tenders, in accordance with the "Requirements of Electrical Works" in the instructions to Tenderer.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0500 – LOW VOLTAGE DIESEL GENERATOR SET

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of complete Diesel Generator set including Synchronizing/Load Sharing Panel, ATS/AMF Panel and other equipment.

1.2 GENERAL

Standard design of reputed manufacturer, brand new, current year. Prime duty rating per ISO 8528, indoor installation IP23. Capable for unbalance loads up to 30%, operation at -25°C and altitude 2230m. Prime rated power output with overload capability 10% above rated for 1 hour in any 12 hours per ISO 3046, BS 5514. Direct coupled engine-generator, 1500 rpm. Capable of sustaining 25% overspeed. Suitable for full load starting, max transient voltage drop 15%, restore to 97% within 1.5 sec. Capable for parallel operation.

1.3 APPLICABLE STANDARDS/CODES

BS 5514, BS 4999, BS 5000-99, IEC 60034.

1.4 WARRANTY

Min 2 years from OEM, commencing from Taking Over Certificate.

PART 2 – PRODUCTS

2.1 DIESEL ENGINE

Four stroke, compression ignition, prime duty. Electric starter, DC lead acid batteries. Alternator type automatic charging system and static battery charger in control panel. Engine rated for prime duty with overload 10% for 1 hour in 12 hours.

Air Intake: Turbo charger, dry type filter, attenuators.

Lubrication: Gear type positive pressure pump, 230V AC mains operated heater with thermostat in crankcase. Constant oil level regulator.

Cooling: Forced air draft, water-cooled radiator, 50°C ambient, engine driven centrifugal pump, thermostatically controlled, shut down timer.

Exhaust: Residential type silencer, flexible connector, thermal insulation over entire length.

Speed Governor: Electronic, maintain frequency $\pm 2\%$, stable speed within 15 sec, $\pm 5\%$ variation during load change.

Fuel Day Tank: Skid mounted, 8-hour capacity. Level switch for low fuel (annunciation, prevent start, stop). Overflow, vent, supply, discharge valves, inspection cover, drain valve, glass sight gauge.

2.2 GENERATOR

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Synchronous. 10% overload for 1 hour in 12 hours. Permanent magnet excitation, brushless rotating diodes. Two-third pitch winding, Class-F insulation, temperature rise per Class-B. Anti-condensate heaters thermostatically controlled. Thermistors for winding protection.

Voltage Regulation: $\pm 2.5\%$ no-load to full load. Transient voltage drop $< 15\%$ at full load 0.8 PF. Restore within 10 sec.

Deviation Factor: ≤ 0.1 .

2.3 GENERATOR CONTROL PANEL

Front access, assembled, wired, tested. Circuit breaker triple pole with adjustable releases. Instrumentation: LED/LCD for AC metering (Volts, Amps, Frequency, kW, kVA, kVAR, PF, kWh, kVARh) and DC metering (Battery Volts, Engine hours, Temperatures, Pressures, Speed, Fuel Level). Safety devices (A=Alarm, SD=Shutdown, TD adjustable): Engine over/under speed (A SD), Low lube oil pressure (A SD), High water temperature (A SD), Over/under voltage (A SD), Reverse Power (A SD), Low/High fuel level (A SD), Battery charger failure (A), Winding temperature high (A SD), Over crank (A SD), etc. Controls: Auto-Manual-Test-Stop, Lamp test, Alarm acknowledge, Emergency stop. Static battery charger for trickle and boost.

2.4 SYNCHRONIZING / LOAD SHARING PANEL AND ATS/AMF PANEL

Designed for: Mains failure (360-440V adjustable), D.G Sets start and synchronize. Open incoming ACB. Close D.G Set ACB. Synchronize Genset-1 and Genset-2, close ACB. Load sharing proportional. If total load $< 80\%$ of rating, one set shuts down after 5 min delay. If load increases or operating set fails, idle unit starts, parallels, shares load. Transfer load back to mains when voltage returns and persists for 3 min. Four-position selector switch (Test-Manual-Automatic-Stop/Maintenance). Duty Selection Switch for Duty-I or Duty-II. Potential free contacts for remote indication.

2.5 GENERATOR NEUTRAL DISCONNECTING SWITCH

Motorized for each D.G. Set neutral earthing. Rated for max fault current.

2.6 TECHNICAL SPECIFICATION GENERATOR:

Supply, Installation & Testing at site of water cooled NEW diesel generating sets suitable for operation at 50°C and 90% relative humidity manufactured by any one of the manufacturers as specified in annexure "A" assembled in accordance with their provided drawings / manuals and consisting of painted welded steel bed plate frame work to accommodate engine alternator complete with electronic governor to give regulation to BS: 514 class A1, balanced flywheel, water jacket heaters energized by the incoming main supply, heavy duty starting batteries, battery charger, set of spare oil/fuel filters engine panel with oil pressure and water temperature gauge, alternator electronic voltage regulator, radio interference suppressors, electronic tachometer frequency meters voltmeter, Ammeters, hour runs meter, KWH meter, KW (total and per phase) KVA total and per phase.

Power factor (Ave, total and per phase. KVAR (total) KVAR hour % of rated load, emergency stop push button, radiator, with water level switch, fuel tank, piping works, consisting of black steel pipe schedule 40, fuel pump, exhaust system residential type silencer, suitable for following prime rating, 400 / 230 volts, 50 cycles/second, at 1500 rpm, for 3 phase 4 wire system, including cost of all necessary material/accessories alongwith sound proof canopy, day tank/piping with filters and RCC foundation pads as per specification of engineer incharge, complete in all respects.

PART 3 – EXECUTION

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3.1 INSTALLATION

Install at location shown. Concrete foundation pad (civil works coordinated by Contractor). Foundation bolts grouted with non-shrinkable material. Erect per manufacturer's instructions. Connect incoming/outgoing cables per cable manufacturer, cable armour connected to ground. Generator body connected to earth per Section 0620.

3.2 TESTING

Tests per Section 0490.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0510 – INDOOR POWER TRANSFORMER

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing, connecting and commissioning of complete Indoor Power Transformer.

1.2 APPLICABLE STANDARDS/CODES

IEC 60076-1,2,3,4,5,7,8,10,12; IEC 60296; IEC 60815; IEC 60137; DIN 42561; NFPA-70; ISO-12944.

1.3 WARRANTY

Min 2 years from OEM from Taking Over Certificate.

PART 2 – PRODUCTS

2.1 POWER TRANSFORMER CONSTRUCTION

Tank welded boilerplates, external radiating tubes. Anti-corrosive painting per ISO 12944 Corrosivity Category C2, Medium Durability (Epoxy primer, polyurethane top coat, RAL 7032 or 7035). Conservator tank with silica gel breather, oil level indicator. Core non-aging cold-rolled electrical silicon steel. Windings high-grade electrolytic copper. H.T. lead on porcelain insulator bushings, protective arcing horn spark gaps. L.T and neutral leads terminated at porcelain insulator bushings. Off-load tap changer on H.T side. Double float Buchholz relay.

Principal Data: Capacity per drawings/BOQ; 11000/415 Volts; 50 Hz; Dyn 11; Off load tapping +2.5%, +5%, -7.5%; 11 kV Delta; 415V with grounded star point; Temperature rise oil 40°C max, winding 50°C max; Impedance voltage 4-6% max; Regulation $\leq 2.5\%$; BIL 95 kV; Cooling mineral oil immersed ONAN.

Accessories: Oil drain valve, filling hole, conservator, oil level indicator, corrugated fins/cooling tubes, silica gel breather, inspection hole, bi-directional roller wheels, lifting lugs, earthing terminals (2 diagonally), stainless steel rating plate, "Electrical hazard" labels, off-circuit tapping links with padlocking, HV cable box, LV connections from above, marshalling box, double float Buchholz relay, max oil temperature relay, dial type thermometer, pressure release safety valve.

2.2 TECHNICAL SPECIFICATION TRANSFORMER:

No. of phases: 3

Frequency: 50Hz

Type of cooling: ONAN/ONAF

Rated Voltage (HV) : 11KV

Rated Voltage (LV) : 415V

System Highest Voltage(V) : 12KV

No load losses(V): As per IEC-60076-11

Load Losses(V) : As per IEC-60076-11

Method of connection-HV : Delta

Method of connection-LV : Wye

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Neutral grounding : Solidly Earthed

Method of connection-LV : Wye

No. of bushings-HV : 3

No. of bushings-LV : 4

Impulse Withstand Voltage : 95KV (1.2/50 us)

Power Frequency Withstand Voltage : 36KV

Vector Group : DYN-11

Impedance Voltage At Rated Current : 6%

Efficiency At Rated Load & Unity Power Factor : Per IEC

Efficiency At 75% Load & Unity Power Factor : Per IEC

Note: It is important to understand before the quoting of the price of the Tx; that supplier shall be responsible to check & verify the standards and other related parameter at the testing floor of the manufacturing industry prior to despatch of the consignment to the site or consignee. In this regards the said expenses of boarding & lodging arrangements for bringing the concerned verification authorities (atleast 2 persons) to the manufacturing floor shall be borne by the supplier .

PART 3 – EXECUTION

3.1 INSTALLATION

Install and anchor on concrete bases per manufacturer's instructions and seismic codes. Permanently fitted lifting lugs. Removable bi-directional or steerable rollers, lockable. Connection methods per IEC 60076. HV and LV cable boxes on opposite sides. Earthing terminal on supporting steel work. Terminal marking per IEC 60076.

3.2 RATING PLATES

Per IEC 60076-1

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0520 – HIGH TENSION SWITCHBOARD / RING MAIN UNIT (RMU) / KIOSK TYPE SUBSTATION

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing, connecting, commissioning of complete HT Switchboard, Ring Main Unit (RMU), and KIOSK type substations.

1.2 GENERAL

Sheet steel fabricated, cubicle type, totally enclosed, dust tight vermin proof. Type-tested per IEC 62271. Loss of service continuity LSC 2B, partition class PM, Internal Arc Classified IAC. Front operation only. Incoming/outgoing connections from bottom. Rear accessibility. Anti-condensate heater in each enclosure. Stainless steel name plate.

Capacity and Basic Data: As shown on drawings; 50 Hz; 11 kV; Power frequency withstand 28kV for 1 minute; Short circuit capacity 500 MVA at 11kV; Short time withstand 25kA/1 sec; Peak withstand 63kA; Breaking/Making 25kA/63kA; Ambient 45°C; Impulse withstand 95kV; IP-4X; LSC2B; PM; IAC; Control voltage 110V DC (indication/metering and tripping), 220V AC (heaters/audible).

1.3 APPLICABLE STANDARDS/CODES

IEC 62271-1,-100,-101,-102,-103,-105,-200; IEC 61869-1,-2,-3; IEC 60051-2,1,3,4,8,9; IEC 60099-4; BS EN 13601; ISO 12944.

1.4 WARRANTY

Min 2 years from OEM from Taking Over Certificate.

PART 2 – PRODUCTS

2.1 HT SWITCHBOARD – SHEET METAL WORK

Angle-iron framework, 12 SWG sheet steel or as per type-tested design. Protective paint per ISO 12944 Category C2 (indoor) or C3 (outdoor), Epoxy primer, polyurethane top coat RAL 7032/7035.

Compartments: Busbar, H.T cable connection, low voltage for instruments. Earth bar full length, doors grounded by flexible copper braid. Mimic diagram on front of each cubicle (busbars, circuit breakers, earthing switch, transformer symbols).

Bus Bars: 99.99% pure electrolytic tinned copper, completely insulated by heat shrink coloured sleeves (red, yellow, blue). Porcelain/epoxy resin insulators.

Circuit Breaker: Triple pole, withdrawable, vacuum arc interruption. Motor spring operating mechanism. Rollout trucks, safety shutters. ON/OFF/TRIPPED/TEST POSITION indication. Luminous LEDs. Min 3 NC and 3 NO auxiliary contacts.

Earthing Switches: Triple pole make-proof type, interlocked with circuit breaker. Type tested per IEC 62271-102.

Instrument Transformers: Type tested per IEC 61869-2 (CT) and -3 (PT). CT accuracy 5P20 (protection) and 0.5M5 (metering). PT accuracy 1.0.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Protective Relays: Numerical static type, inverse definite minimum time, draw-out feature. Self-powered. Phase fault setting 50-200%, instantaneous 200-800%, ground-fault 20-80%.

Capacitor Shunt Trip Unit: 110V DC trip coils, fed from PT, capable of two successive trips within five minutes.

Meters: Operating hours counter, switching frequency meter, ammeter (0-15kV), voltmeter, kWh and kVArh meters. Selector switches R-Y-B-OFF.

Surge Protection: 11 kV surge arrester (12 kV rms, $11/\sqrt{3}$ kV rms).

Tools: Complete set for routine operation, setting, maintenance.

Insulation Mat: 1m wide, 6mm thick, 15kV working.

2.2 RING MAIN UNIT (RMU) – OUTDOOR

Fixed type. Enclosure lockable. Protective paint per ISO 12944 Category C3, Epoxy primer, polyurethane top coat.

Switches: Maintenance-free, low pressure SF6 gas, three positions (open-disconnected, closed, earthed). Natural interlocking. Fuses in sealed chambers, striker pin causes three-phase opening.

Circuit Breakers: Withdrawable, SF6, vertical mount. Sealed pressure system, 30 year life. Stored energy operating mechanism.

LV Compartment: For motor mechanism and auxiliary equipment.

Earthing Switch: Short-circuit making capacity per IEC 62271-102, visible through transparent covers.

Protective Relay: Integrated electronic/micro-processor, self-powered, phase-phase and phase-earth overcurrent.

Voltage Indicators: Per IEC 62271-206. Fault Passage Indicator (FPI) for short circuit and earth faults.

Cable Insulation Testing: Test voltage 42 kV DC for 10 min.

2.3 KIOSK TYPE SUBSTATION

Outdoor metal works per ISO 12944 Category C3. Includes MV Compartment (11kV 400A load break switches), Transformer Compartment (mineral oil immersed power transformer per Section 0510), LV Compartment (circuit breakers with thermal/magnetic tripping). Control voltage from 110V secondary of PT and 110V DC from capacitor trip unit. Relays self-powered.

PART 3 – EXECUTION

3.1 INSTALLATION (H.T SWITCHBOARDS, RING MAIN UNIT AND KIOSK TYPE SUBSTATION)

Install at location shown. Cable trenches civil works. Contractor coordinates foundation details. Foundation bolts grouted with non-shrinkable material. Erect per manufacturer's instructions. Cable termination kits per recommendations. Cable armour connected to earth. Body earthed per Section 0620. Testing per Section 0490.

PART 4 - MEASUREMENT AND PAYMENT

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0530 – LOW TENSION SWITCHBOARDS / LT OUTDOOR DISTRIBUTION BOARDS

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing, connecting, commissioning of LT Switchboards/LT Outdoor Distribution Boards.

1.2 GENERAL

Factory manufactured/assembled/routine tested per IEC 61439, Form-3b (or as approved). Designed to be fully compatible with Solar Power System (third party validation by AEDB listed qualified vendor). Sheet steel fabricated, floor/wall mounting, cubicle type. IP54 indoor, IP65 outdoor. Protective paint per ISO 12944 Category C2 (indoor), C3 (outdoor), Epoxy primer, polyurethane top coat RAL 7032/7035.

Design verification per IEC 61439: Temperature rise, short circuit withstand strength, etc.

1.3 APPLICABLE STANDARDS/CODES

IEC 61439 (all parts), 60947-3, 60947-2, 60831, 60073, 61869-2, 61869-3, 60051-1,2,3,5,8, 60898-1, 60871-1, 60947-4-1; BS EN 60529, 13601; BS 88-2; ISO-12944-2.

PART 2 – PRODUCTS

2.1 SHEET METAL WORK

14 SWG MS sheet, angle iron framework. Suitably divided into panels/compartments. Earth bar, two external earth terminals. Doors earthed by flexible copper strip. Cabling numbered and harnessed.

2.2 COMPONENTS

Bus Bars: 99.99% pure electrolytic tinned copper, heat shrink coloured sleeves (red, yellow, blue, black, green). Temperature rise $\leq 30^{\circ}\text{C}$. Neutral same cross section as phase; earth half cross section.

Circuit Breakers: Triple/four pole, current limiting, manually or motor operated, spring charged. Incoming: Air Circuit Breaker or moulded case; outgoing: moulded case. LSIG protection for ACB. Withdrawable type entire main LT Switchboard. ON-TRIP-OFF indication.

Switch-Fuse Units: Triple pole on load isolating switch with HRC fuses to BS-88 Class Q1.

Three Phase Energy Meters: 50 Hz, accuracy class 1.0, dust proof case.

Ammeters and Voltmeters: Flush mounting, moving iron, spring controlled, 96x96mm, accuracy class 1.5.

Current Transformers: Ring type, accuracy class 1.0, 5A secondary.

Selector Switches: R-Y-B-OFF for ammeters, RY-YB-BR-RN-YN-BN-OFF for voltmeters.

Air Break Contactors: Triple pole 400V AC, utilization Category AC3 (AC6b for capacitor switching). 230V AC operating coil.

HRC Fuses: Per BS 88, Class Q1.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Power Factor Improvement Plant: Automatic-cum-manual. Blocked during DG Set operation. Capacitors 440/415V, 50 Hz, self-cooled. Control panel with main circuit breaker, multi-stage correction relay, PF indicator, CT. Each bank: triple pole contactor AC6b, detuned harmonic filter reactor (resonance frequency 189Hz, $p=7\%$), HRC back-up fuses, selector switch, ON/OFF lamps.

2.2 TECHNICAL SPECIFICATION

Fabrication, supply at site, installation at designated location, testing and commissioning of Main Panel Board (MPB) comprising of cubicles, frame made of sheet steel 12 SWG and doors of 14 SWG, with flexible earthing straps, degreased and de-rusted, finished with electro-static powder coating of 50 micron thickness in approved color panel housing to comply with protection class IP-54, indoor floor mounting, in free standing design, with hinged door, lockable handle, all auxiliaries, internal wiring, designation labels on MCCBs, earthing bar, numbering beads on the control wires, panel suitable for system Voltage 415 V, 50 Hz, 3 Phase and neutral bus bars of 99.8% purity electrolytic copper with tin plating, including cost of cable termination lugs, brass cable glands for incoming & outgoing cables, wiring from breakers, indication lamps, instruments and control all accessories complete in all respects. All incoming and outgoing breakers shall be accessible by opening the front door having additional M.S. sheet cover. Gaskets shall also be provided where necessary. All MCCBs shall be suitable to operate without any de-rating at 50°C ambient temperature and shall be of one make only and not a mixture of more than one make. The front and back sides of MPB shall also have louvers at bottom and sides of panel for hot air exhaust. The panel shall have a front access. Circuits layout shall conform to the single line diagrams. Main Panel Board shall be manufactured by any one of the manufacturer as mentioned in List.

Also note that For Control Purpose 2Amps SP MCBs should be used & RS-485 Terminals should be provided for remote monitoring through EAs.

Surge Protection: 440V rms, 400/1.732 kV rms per IEC.

PART 3 – EXECUTION

3.1 INSTALLATION

Install at location shown or as advised. Concrete pedestal per civil works. Foundation bolts grouted with non-shrinkable material. Erect per manufacturer's instructions. Loose parts installed per assembly drawing. Connect incoming/outgoing cables per cable manufacturer, colour sleeves on lugs, cable armour connected to ground. Control system installed per manufacturer. Tested prior to energizing per Section 0490.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0540 – LOW TENSION DISTRIBUTION BOARDS

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing, commissioning of LT Distribution Boards.

1.2 GENERAL

Sheet steel fabricated, surface/recessed mounting on wall or floor standing. IP54 indoor, IP65 outdoor. Protective paint per ISO 12944 Category C2 (indoor), C3 (outdoor). Front operation. Rated service short circuit breaking capacity (Ics) at 400V per IEC 60947-2.

1.3 APPLICABLE STANDARDS/CODES

IEC 61439, 60947-2, 60073, 60831, 60051-1,2,3,5,8; BS 88; BS EN 61869-2, 60529, 13601; IEC 60898-1, 60269; ISO-12944-2.

PART 2 – PRODUCTS

2.1 SHEET METAL WORK

16 SWG sheet steel. Component mounting plate, screw front plate, rubber gasketing, lockable hinged door with cam fastener. Earth bar connected to body at two points.

2.2 COMPONENTS

Bus Bars: 99.9% pure electrolytic tinned copper, temperature rise $\leq 30^{\circ}\text{C}$.

MCCB/MCB: Triple pole 440V or single/double pole 250V. Fixed magnetic short circuit and adjustable/fixed thermal overload. MCB to IEC 60898.

Energy Meters: Same as Section 0530.

Ammeters/Voltmeters: Same as Section 0530.

Current Transformers: Same as Section 0530.

Selector Switches: Same as Section 0530.

Air Break Contactors: Same as Section 0530.

Push Buttons: Illuminated, momentary or latch type.

Indicating Lamps: LED, flush mounting.

Surge Protection: Same as Section 0530.

PART 3 – EXECUTION

3.1 INSTALLATION

Actual location determined at site. Recessed mounting: installed before plastering, door flush with wall. Outdoor distribution on pedestal. All screws/nuts/bolts galvanized. Cable entry from top or bottom as approved. Testing per Section 0490.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0550 – MOTOR CONTROL CENTRES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing, connecting, commissioning of complete Motor Control Centres (MCCs).

1.2 GENERAL

Sheet steel fabricated, floor/wall mounting, cubicle type, totally enclosed. IP54 indoor, IP65 outdoor. Protective paint per ISO 12944 Category C2 (indoor), C3 (outdoor). Front operation. Rated Ics at 400V per IEC 60947-2.

1.3 APPLICABLE STANDARDS/CODES

Same as Section 0530 plus IEC 60947-4-1 for contactors and motor-starters.

PART 2 – PRODUCTS

2.1 SHEET METAL WORK

14 SWG MS sheet, angle iron framework. Cable clamping channels, brass cable glands. Earth bar, two external earth terminals.

2.2 COMPONENTS

Auxiliary relays (230V AC), programme selector switches, operation hour counters, alarm hooter. **Air Break Automatic Star-Delta Starters:** line contactor, star contactor, delta contactor, time element. Delayed thermal overcurrent relay or electronic overcurrent relay (EOCR). Utilization category AC3, Type-2 coordination. **Direct-On-Line (DOL) Starters:** for full voltage starting, Type-2 coordinated. **Circuit Breakers:** Moulded case, ON-TRIP-OFF indication. **HRC Fuses:** per BS 88 Class Q1.

2.3 FIELD SENSOR / LEVEL TRANSMITTER / FLOAT SWITCHES

Control cabling from field devices to MCC in suitably sized surface mounted steel conduit. Level transmitter (230V AC, 50Hz, ≥ 3 switch-contacts). Float switch (SIEMENS type 6KCI or approved, IP65).

2.4 LOCKABLE MUSHROOM SWITCH

Inside MCC or remote location. IP65 casing. Red push button min 30mm dia, rotor lock-turn reset.

2.5 SEQUENCE OF OPERATION

For MCC-FW/MCC-PW coordinated with relevant specialty drawings.

2.6 WARRANTY

Min 2 years from OEM from Taking Over Certificate.

PART 3 – EXECUTION

3.1 INSTALLATION AND TESTING

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Install per Section 0540. Loose parts per assembly drawing. Level transmitter, float switch, pressure switch properly aligned and adjusted. Sequential testing in presence of Engineer.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0560 – LIGHT FIXTURES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of light fixtures and accessories.

1.2 GENERAL

Submit certified photometric data and type test certificates. Submit at least one sample of each fixture. All fixtures finished in standard color schemes per manufacturer's catalogue. Warranty min 2 years from OEM from Taking Over Certificate.

1.3 APPLICABLE STANDARDS/CODES

IEC 60598-1,2-1,2-2,2-3,2-5, 62471, 62031, 62262; BS EN 55015, 61547, 61000-3-2, 61000-3-3, 62493; LM79/LM80/LM82; BS 5266.

LED Driver Standards: BS-EN 61347-1, 61347-2-11/13; BS EN 62384.

PART 2 – PRODUCTS

2.1 LED WEATHER-PROOF BATTEN LIGHT FIXTURE

IP rating as per drawing. CCT 4000K, CRI >80, colour consistency <3 SDCM. Lumen maintenance L70B50, useful life ≥50,000 hours. Housing and optic polycarbonate. IK08 impact.

2.2 LED BATTEN TYPE LIGHT FIXTURE (INDOOR)

Housing SPCC cold rolled steel, optic polycarbonate opal finish. CCT 4000K, CRI >80, colour consistency <5 SDCM. IK03.

2.3 LED WALL/BULKHEAD LIGHT FIXTURE

Polycarbonate housing with frosted diffuser. CCT 4000K, CRI ≥70, colour consistency <6 SDCM. Life ≥30,000 hours. IK06.

2.4 CORROSION RESISTANT LED FLOOD LIGHT FIXTURE (FACADE LIGHTING)

Submit Natural Salt Spray Test Report. CCT 3000K, CRI >80, colour consistency <4 SDCM. Life ≥50,000 hours, ambient up to +50°C. Die cast aluminium housing, PMMA lenses, silicon gasket, tempered glass. IK06.

2.5 CORROSION RESISTANT LED FLOOD LIGHT FIXTURE (OUTDOOR)

Salt spray tested. CCT 4000K, CRI >70, colour consistency <5 SDCM. Non-corrosive aluminium die cast, polycarbonate lens. 15kV built-in surge protection. IK08.

2.6 CORROSION RESISTANT LED STREET LIGHT FIXTURE

Salt spray tested. CCT 4000K, CRI >70. Life ≥100,000 hours. Programmable driver. IK08.

2.7 LED EMERGENCY LIGHT FIXTURE

Maintained type, self-contained Ni-Cd battery, backup ≥3.0 hours. Polycarbonate body with clear diffuser.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

2.8 LED PANEL LIGHT FIXTURE

CCT 4000K, CRI ≥ 80 , colour consistency ≤ 4 SDCM. Life $\geq 50,000$ hours, ambient up to $+45^{\circ}\text{C}$. Aluminium housing, polystyrene optic. IK03.

2.9 LED SURFACE MOUNTED DOWN LIGHT FIXTURES

Die cast aluminium rear housing, polycarbonate front. CCT 4000K, CRI > 80 . IK02.

2.10 LED RECESSED DOWN LIGHT FIXTURES

CCT 4000K, CRI > 80 , colour consistency ≤ 5 SDCM. Die cast aluminium with polycarbonate diffuser. IK02.

2.11 LED RECESSED CANOPY / HIGH-BAY LIGHT FIXTURE

CCT 4000K, CRI > 80 . Die cast aluminium, polycarbonate optic, tempered glass. IK07.

2.12 LED STRIP LIGHT FIXTURE FOR COVE LIGHTING

CCT 3000K, CRI ≥ 70 . Ambient -20°C to $+40^{\circ}\text{C}$.

PART 3 – EXECUTION

3.1 INSTALLATION

Mounting heights per drawings. Uniform installation with respect to dimensions. Modifications approved by Engineer. Wiring with 3-core 1.0/1.5 sq.mm flexible copper conductor. Internal wiring with heat resistant cables. All fixtures earthed.

Surface/Wall Mounted: Back flush with ceiling/wall surface, nylon plugs and galvanized bolts.

Recessed Mounted: Installation coordinated with false ceiling design, weight not transferred to false ceiling.

Flood Light Fixture: On lighting poles or roof as shown, hot dipped galvanized MS poles, corrosion resistant brackets.

Street Light Fixture: On poles with high-performance epoxy paint.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0570 – UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of Uninterruptible Power Supply (UPS) system.

1.2 WARRANTY

Min 2 years from OEM from Taking Over Certificate.

1.3 APPLICABLE STANDARDS/CODES

EN 50091; BS EN 62040; IEC/EN 62040-1, 60950; IEC 60947-2; BS EN ISO 1461; BS EN 15630; ISO-12944-2.

PART 2 – PRODUCTS

2.1 UPS SYSTEM OPERATION – DOUBLE CONVERSION ON-LINE

Normal: Rectifier/charger draws AC power, supplies DC to inverter while float charging battery. Inverter supplies clean AC to load.

Emergency: Inverter continues from battery without interruption.

Battery Recharge: When mains restored, rectifier/charger supplies inverter and recharges battery.

Automatic Bypass: Static bypass transfer switch transfers load to bypass source without interruption on overloads or inverter shutdown.

Manual Bypass: Mechanical bypass for maintenance, isolate inverter and static switch while maintaining load power.

Operation Without Batteries: Circuit breaker to isolate battery for maintenance; UPS continues to supply load except during mains outage.

2.2 ELECTRICAL CHARACTERISTICS

Input Power (Three Phase): 380/400/415V AC $\pm 10\%$, 3 phase 4 wire + earth, 50 Hz $\pm 5\%$, PF 0.8.

Input Power (Single Phase): 220/230/240V AC $+10\%/-15\%$, 1 phase 2 wire + earth, 50 Hz $\pm 5\%$, PF 0.8.

Rectifier/Charger: “Soft start” power walk-in in 10 seconds. Charging current self-limited. DC voltage regulated $<1\%$.

Battery Panel: Lead acid, maintenance-free, matching enclosures. Sizing based on operating temperature up to 40°C .

Inverter: Rated load at least 0.9 pf. Voltage regulation steady state $\pm 1\%$, transient $\pm 5\%$ for 100% load step. Voltage distortion with linear load $<1-2\%$, with non-linear load $<3\%$ phase-phase, $<5\%$ phase-neutral. Output frequency 50 Hz, synchronised to bypass within ± 0.5 Hz, free-running $\pm 0.1\%$. Overload: 110% for 10 min, 125% for 1 min.

Static Bypass: Independent, zero millisecond synchronized transfer, 20 ms unsynchronized.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Mechanical Features: Sheet steel enclosure, protected against corrosion. Space saving modular, removable panels. Cable entry bottom/rear. Ventilation fans with low noise, standby fans with failure annunciation. Max sound level 65 dBA at 1m.

2.3 CONTROLS, INDICATIONS, PROTECTION

Controls: UPS to BYPASS switching, Rectifier/Charger ON/OFF, Inverter ON/OFF, Self-test, remote control.

Indications/Alarms: Mains status, battery status, rectifier/charger ON, load on inverter, load on bypass, charger fault, inverter overheating, fan fault, battery overloading/autonomy, bypass defect, overload.

Protection: Input over voltage, load short circuits, over temperature, emergency stop from fire alarm control panel (signal), DC voltage low.

Metering: Mains input voltage, rectifier/charger current, battery voltage and current, inverter output voltage/frequency/current.

2.4 TECHNICAL SPECIFICATION

Supply at site installation at designated location, connection of cables, testing and commissioning of Online-Inverter (UPS) with Dry Batteries Bank (as specified below) suitable for operation at 50° C (Max) and 90% relative humidity manufactured by any one of the manufacturers as specified in LAM assembled in accordance with their provided drawings / manuals and consisting of painted welded steel bed plate frame work to accommodate (built-in) power transformer complete with electronic safeties to give standard regulation, energized by the in coming main supply, battery charger, set of spare Copper battery thimble, radio interference suppressors, voltmeter displays and other allied safeties.

Suitable for 400 / 230 volts, 50 cycles/second, including cost of all necessary material / accessories, conforming to technical specifications mentioned below.

Technical Specification of Inverter:

Prime Rating:

On-Line, Normal and Bypass AC inputs, Interface Port

Output:

Efficiency at Full Load :=(should not less than) >92%

Load Power Factor: =(should not less than) >0.9

Output Voltage Distortion :Less than 2%

Output Frequency (sync to mains) :50/60 Hz +/- 3 Hz user adjustable +/- 0.1

Output Voltage Regulation: +/-1%

Waveform Type :True Sine wave

Efficiency at full load: =(should not less than) >90%

Bypass :Internal Bypass (Automatic and Manual)

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Input

Total Harmonic Distortion Index < 3%

Bypass :Internal Bypass (Automatic and Manual)

Input

Batteries & Runtime

Battery Type :Maintenance-free sealed deep discharged GEL Type built-in battery built-in

Control panel

LED status display

Alarm when on battery : distinctive low battery alarm : overload continuous tone alarm

Emergency Power Off (EPO) :Yes

Rack Height :6U

Surge Protection & Filtering

Warranty:Minimum 1 Year

PART 3 – EXECUTION

3.1 INSTALLATION

Per manufacturer's recommendations. All earthing, power and control cables, conduit, trunking provided by Contractor. Angle iron supports at base for UPS and stabilizer.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0580 – HIGH TENSION CABLE

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of High Tension (HT) cable and accessories.

1.2 GENERAL

15kV cable: three core, copper conductor, XLPE insulated, shielded, armoured or unarmoured as required. Continuous operation at conductor temperature $\geq 90^{\circ}\text{C}$, 8.7/15 kV, 50 Hz, three phase grounded system per IEC 60502. Airfield primary cable: 5kV to earth, copper conductor, XLPE insulated, screened, shielded, overall sheathed. Vermin proofing.

1.3 APPLICABLE STANDARD/CODES

IEC 60502, 540; ICAO Aerodrome Design Manual Part5; FAA L824 AC 150/5345-7; FAA L823 AC 150/5345-26 (Class A & B); IEC 60228, 60332-1-2, 60332-3, 60227, 60446; BS EN 50266.

PART 2 – PRODUCTS

2.1 15kV CABLE

Conductor: Stranded copper per IEC60228.

Insulation: XLPE, colour coded red, yellow, blue, nominal thickness $\geq 4.5\text{mm}$ per IEC 60502.

Screening: individual cores – conductor screen (extruded semi-conducting compound) and insulation screen (non-metallic semi-conducting layer + metallic layer).

Shielding: bare copper tape over semi-conducting insulation.

Assembly: three insulated conductors with PVC or non-hydroscopic filler, bounded with tape.

Aarmor: single layer galvanized steel wire.

Oversheath: PVC jacket $\geq 2.5\text{mm}$, black. Embossed marking every 3m: manufacturer, year, size, voltage grade, Cu/XLPE/SWA/PVC.

2.2 AIRFIELD PRIMARY CABLE

Per FAA L824 AC 150/5345-7 and ICAO Design Manual Part5. Stranded tinned copper, 6 sq.mm/7 strands, single core. Insulation XLPE 5kV/2.3mm. Shielding brass tape 0.08mm, concentric brass braid. Over sheathing PE 1.2mm, black, termite repellent. Marking every 0.6m.

2.3 STRAIGHT-THROUGH CABLE JOINT

Only in pits/trench, not in ducts. Prior permission required.

2.4 JOINT BOXES

Horizontal, straight through, split type. Ground straps on inside.

2.5 TERMINATION KITS

Indoor/outdoor, hot or cold shrink, per IEC 60060, 60230, 60270.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

2.6 CABLE MARKERS

2.7 TECHNICAL SPECIFICATION

Supply, installation, testing and commissioning of XLPE insulated, Aluminum tape screened PVC / SWA / PVC, 15 KV-Aluminum conductor cable manufactured by any one of the manufacturers Pakistan Cable, Fast Cable & Newage Cable to be laid in prepared trenches / in pre-laid conduits including cost of connections. Actual length of cables to be installed shall be practically measured at site by the Contractor, duly authenticated by the employers electrical engineer before placing the order with the manufacturer, however, approximate length of cables are shown herewith. Payments shall be made as per actual length installed.

Reinforced concrete Grade-25, at max 100m intervals along straight trench, each bend and joint box. Letters and symbols engraved. At joint box, symbol beneath letters. Dimensions per drawing.

PART 3 – EXECUTION

3.1 INSTALLATION

Underground Cables: Depth 900mm min below finished ground level. Trench bed: 100mm fine sand (max particle 1.3mm). Covers: fine sand 100mm above cable, then concrete protective bricks (Class-C, 50mm thick, 300x300mm) or good quality bricks. PVC warning tape yellow with black danger/voltage marking at 300mm below ground level. Cable identification tags water resistant at max 20m intervals. Slack ~3% extra length.

Cable Markers: On finally compacted trench at mentioned distances. On airside (runway/taxiway/apron): flat in ground, top ≈2.5cm above grade, 60m spacing straight runs, each change in direction and each splice. Painted bright orange after 24hrs.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0590 – LOW TENSION CABLES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of Low Tension (LT) cables and accessories.

1.2 GENERAL

Multi-core/single core PVC insulated and sheathed cables for light/socket circuits: 300/500V. Single core PVC insulated non-sheathed: 450/750V. Power cables (main feeders, power equipment): 600/1000V, armoured or unarmoured. Conductors stranded high conductivity soft annealed copper. All cables vermin proofed.

1.3 APPLICABLE STANDARDS/CODES

BS 6004, 6346, 7846, 7889; IEC 60227, 60332; BS 6746; BS EN 60228, 50525, 61386, 50618; ICAO Aerodrome Design Manual Part5; FAA L824 AC 150/5345-7.

PART 2 – PRODUCTS

2.1 CABLE TYPES

Conduit or Channel Wiring: single core PVC insulated.

Surface/Concrete Trenches/Trays: single or multi-core PVC insulated and PVC sheathed.

Solid Bottom M.S Trunking/Under Floor Metal Trunking: 3 core PVC insulated PVC sheathed, high temperature resistant (red phase, black neutral, green/yellow earth).

Inside Lighting Column: 3 core as above.

Underground: PVC insulated, PVC sheathed, armoured with galvanized steel/aluminium wire.

2.2 AIRFIELD SECONDARY CABLE

Per FAA L824 AC 150/5345-7. Stranded tinned copper, 2.5/4.0 sq.mm, 2 core. Insulation Ethylene propylene rubber (EPR). Outer sheath polychloroprene (PCP). Temperature 90°C. Marking every 0.6m.

2.3 DC CABLE FOR SOLAR POWER SYSTEM

Tinned fine copper strands Class 5 per IEC 60228. Insulation XLPO, flame retardant, halogen free. Outer sheath XLPO, flame retardant, halogen free, UV/weather resistant. Temperature -40°C to +120°C for 20,000 hrs. Rated 1500VDC, max 1800VDC.

2.4 CABLE MARKERS

Same as Section 0580, letters “LV”.

2.5 TECHNICAL SPECIFICATION

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Supply at site, installation, testing and commissioning of PVC insulated PVC sheathed non armoured copper conductor power cable 600 / 1000 Volt grade manufactured by any one of the manufacturers as mentioned in Annexure in preinstalled cable tray / trenches cables to be installed as per routes shown on drawings including cost of all necessary materials, connections of cables and identification tags at both ends, cables lugs properly crimped at both ends for the following sizes complete in all respects. Actual length of cables to be installed shall be practically measured at site by the Contractor, duly authenticated by the employers electrical engineer before placing the order with the manufacturer, however, approximate length of cables are shown herewith. Payments shall be made as per actual length installed.

PART 3 – EXECUTION

3.1 INSTALLATION

Conduit or Channel Wiring: Pull wires with care, no lubricant unless approved. All wires of same circuit in one conduit. No joints. Min 150mm extra length at each termination.

Surface/Trenches/Trays/Ladders: Fix to surface with galvanized steel clips secured to steel channel. Distance between clips to support weight, clearance between cables and surface $\geq 50\text{mm}$.

Underground Cables: Same as Section 0580.

DC Cable for Solar Power System: Run in appropriately sized cable trays/trunkings on roof, fixed with saddles, min distance equal to cable diameter.

Airfield Secondary Cables: In PVC protective pipes/saw cuts from transformer pit/housing to light fixtures in runway/taxiway/apron. **In Saw Cuts (existing pavement):** Diamond blade saws, cut not less than 1cm wide, 2cm deep. Sandblast to remove foreign material, flush with high-speed water/steam jet, dry with air. No splicing. Wedges/clips spaced $\sim 1\text{m}$ apart. Cables encased in polyethylene flexible tubing $\geq 0.3\text{m}$ at pavement joints. Seal saw cut with adhesive compound (min elongation 45%). **In Pipes (new pavement):** pipes from shallow base to transformer housing. 2-pole secondary receptacles and plugs per FAA.

Cable Marker: As Section 0580.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0600 – WIRING ACCESSORIES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, commissioning of wiring accessories including switches, switch sockets, etc.

1.2 APPLICABLE STANDARDS/CODES

BS 7671; BS EN 60669-1; IEC 60309; BS EN 60384-14; BS 67, 546, 1362, 4573; IEC 60884-1; CEE 7; BS EN 60529.

PART 2 – PRODUCTS

2.1 SWITCHES/BLANK FACE PLATES

Single pole, rated 10A, 250V AC. Thermoplastic body, flush mounting. Gang type with silver tipped contacts, snap action. Weather proof or metal front plates where specified.

2.2 13A/16A INTERNATIONAL SWITCH-SOCKET OUTLETS

13/16 Amps 250V AC, heavy-duty, sheltered live contacts. Weather proof: polycarbonate, IP65 min.

2.3 16A SCHUKO SOCKET OUTLETS

2 pin + earth German type, heavy-duty.

2.4 1-PHASE 3-PIN / 3-PHASE 5-PIN INDUSTRIAL SOCKET OUTLETS

250V/500V, weather proof per IEC, heavy-duty, polycarbonate enclosure, gasketed cover, captive cover screw. Supplied with matching plugs.

2.5 CONNECTION UNIT

13A/20A, 250V AC spur outlet with neon lamp indicator (if required). 20A Double Pole Switch with brass/phosphor bronze contacts, neon indicator.

2.6 FAN DIMMERS

Low voltage electronic components, radio frequency compressor. Smooth speed control. Same make/colour as approved wiring accessories.

2.7 SHEET STEEL BACK BOXES

16 SWG sheet steel. Earth terminal for at least three 4-sq.mm earth wires. For surface wiring: cover plates same gauge, counter sunk screws, powder-coated.

2.8 CEILING ROSES

5 amps 250V, white plastic moulded base plate, copper/brass terminals suitable for at least two 2.5 sq.mm wires.

2.9 15 AMPS SWITCH SOCKET OUTLETS

Round 3 pin, 15 Amps, 250V AC, polycarbonate, neon indication.

2.10 UNDER FLOOR SERVICE BOX

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Heavy duty stainless steel, pre-galvanized steel infill plate. Types: A (2x16A Schuko, 1xRJ-45 simplex, 1xRJ-45 duplex); B (2x16A Schuko, 1x duplex fiber optic); C (blank plate). IP30, perforation for trunking/knockout holes, disposable lid.

PART 3 – EXECUTION

3.1 INSTALLATION

Mounting heights per drawings. All wiring accessories installed on 16 SWG sheet steel box recessed in wall/column/floor. Faceplate fixed with flat head galvanized/brass screws sunk flush. Matching screw caps. Industrial sockets in polycarbonate enclosure on wall/floor. Floor outlet box on floor as shown.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0610 – CONDUITS AND PIPES

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, commissioning of conduits and pipes.

1.2 APPLICABLE STANDARD/CODES

BS 61386; BS 4607; BS EN ISO 1452-1:2009; IEC 60614; BS3505.

PART 2 – PRODUCTS

2.1 GALVANIZED IRON (G.I.) CONDUITS AND ACCESSORIES

Medium gauge mild steel, hot dip galvanized inside and outside. Threaded ends. Round junction boxes: ceiling – 64mm dia x 64mm depth; wall – 64mm dia x 40mm deep. One piece cover plate with brass screws.

2.2 PVC CONDUITS AND ACCESSORIES

PVC bends with enlarged ends. Round PVC junction boxes: ceiling – 63mm dia x depth; wall – 63mm dia x 38mm deep. PVC cover plate with brass screws.

2.3 INSPECTION/PULL AND ADAPTABLE BOXES

Inspection/Pull Boxes: Rectangular 16 SWG sheet steel, painted inside/outside red oxide primer. Surface type cover same gauge; concealed type white plastic sheet cover.

Adaptable Boxes: 16 SWG sheet steel. Depth: conduits $\leq 25\text{mm} - 50\text{mm min}$; $\leq 32\text{mm} - 65\text{mm min}$; $\leq 50\text{mm} - 90\text{mm min}$; $> 50\text{mm} - 2\text{x dia}$.

2.4 uPVC PIPES AND FITTINGS

Class D (WP 12 bar) and Class-B (WP 6 bar) per BS EN ISO 1452-1:2009. Smooth bends only. Hard PVC pipe range spacers with locking, distance $\leq 2\text{m}$.

2.5 PIPE END MARKER

Concrete slab marker. Information impressed: word 'PIPE', number of layers X number of pipes in each layer (diameter).

PART 3 – EXECUTION

3.1 G.I. CONDUITS (SURFACE)

Install parallel/perpendicular to surfaces. C.I. saddles and clamps, supported at max 1m spacing horizontal/vertical.

3.2 PVC CONDUITS (CONCEALED)

Minimum 32mm cover of concrete from top of conduit to finished surface. In RCC, laid before pouring concrete. No chases in RCC after pouring. Conduit on top of bottom reinforcement. Outlet boxes flush with soffit. Termination ends plugged. Under floor: min 50mm depth, installed empty with 18 SWG steel wire.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

3.3 PVC CONDUITS (SURFACE)

PVC saddles and clamps, supported at max 1000mm spacing.

3.4 uPVC PIPES (UNDERGROUND)

Depth: under roads/pavements 900mm below finished surface; under drain/culvert 1000mm below bottom slab; crossing other services 250/500mm vertical/horizontal. Trench bottom leveled, 100mm fine sand bed. Clearance between pipes ≥ 50 mm using pipe range spacers. Backfill with sand ≥ 100 mm above topmost pipes, then selected earth in layers compacted. Warning tape at 300mm depth. End caps watertight.

3.5 PIPE END MARKERS

Installed flat in ground, top ≈ 5 cm above finished grade. After 24hrs, top surface painted bright orange.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

PART 5 – TECHNICAL SPECIFICATION OF CABLE TRAY

Fabrication, supply at site and installation of perforated cable tray made of M.S. sheet 14 SWG 8 ft. to 10 ft. long with sides 4" high with cover of cable tray made of 18 SWG M.S sheet to be installed on wall, or in vertical, or above false ceiling in horizontal position or as shown on drawing, including cost of the following:-

- 2 M.S threaded hanging rod 1/2" dia. Length 12" or as required as per site.
- M.S strip 2" wide x 1/4" thick.
- Hilti rawal bolts as per required quantity & size.
- 2 coats of antirust paint.
- 2 coats of enamel paint (Oven hot) or powder coating of approved colour.
- Complete hanging system shall be installed at every 36".

SECTION 0620 – EARTHING / GROUNDING SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of complete Earthing system.

1.2 GENERAL

Dedicated earthing grid underground in vicinity of buildings/structures. All mechanical and electrical systems solidly connected. Main distribution, connection pit, earth connecting point, lightning protection system integrated. Overall earthing resistance ≤ 1 ohm.

1.3 APPLICABLE STANDARDS/CODES

BS 7430, 951; BS EN 12163, 50522, 13601, 60228, 12164, 12167; IEEE Std.80; BS 6346, 6004; BS EN 62561-5.

PART 2 – PRODUCTS

2.1 EARTH ELECTRODES

Plate Type: 600x600x3mm 99.9% pure high conductivity electrolytic copper, tinned. Four terminals. 50mm dia G.I. pipe from inspection chamber to earth plate with 10mm dia holes at 500mm centers. Concrete inspection chamber with cast iron cover, hinged, flush with ground.

Copper Clad Steel Rod Type: 3m long, 19mm dia, flat head at drive end, pointed conical tip hardened. Brass clamp for bolted connections.

2.2 EARTHING LEADS

Stranded electrolytic copper, bare tinned or PVC insulated (green or green/yellow).

2.3 EARTH CONTINUITY CONDUCTORS (ECC)

Stranded bare tinned copper or single core PVC insulated copper (green or green/yellow). Thimbles, lugs, sockets, nuts, washers included.

2.4 COUNTERPOISE CONDUCTOR

Hard drawn high conductivity bare stranded copper, 16 sq.mm.

2.5 EQUIPMENT GROUND LEAD

10 sq.mm single core stranded copper PVC insulated. Connected per ICAO Aerodrome Design Manual Part5, equipotential method.

2.6 EARTH CONNECTING POINTS (ECPs)

Tinned copper bar, rectangular 50x6mm, 300mm long, min six terminals. Brass or tinned copper bolts, nuts, washers.

2.7 ELECTROMAGNETIC PROTECTION NETWORK

Building perimeter ground loop: flat bare copper wire buried 1m deep, 1m from building wall, 3m x 19mm copper-clad steel ground rods every 6-12m. Building steel bonded at every column.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Data center grounding infrastructure (CBN per IEEE 1100): Copper conductor, insulated, size as shown. Electrically continuous access-floor system bonded. Each equipment cabinet/rack grounding connection with two-hole lugs, bare metal-to-metal contact, antioxidant.

PART 3 – EXECUTION

3.1 INSTALLATION

Earth resistance ≤ 1 ohm. All connections with copper brazing (no soldering) using copper or brass sockets, thimbles, lugs. Copper brazing with oxide inhibiting compound. No twisting of earth conductors. Alternative path to earth when disconnecting for testing.

Plate Type Electrode: Installed at min depth 16.5 ft (5m) or 4 inches below permanent water level. Min horizontal distance between electrodes 10 ft (3m). Lime and charcoal mixture buried with plate.

Copper Clad Steel Rod Type: Hammered in soil until top ~300mm below finished ground level, or pit excavated and backfilled in 500mm layers compacted.

ECC: Installed along cable runs, connected to earthing bar/terminals in equipment. Bodies of equipment and switchboards connected.

Counterpoise Conductor: Along airfield primary cable route between earth's surface and underground cables. Continuous, connected to earth terminal on transformer housings, cable tray inside transformer pits, secondary earthing terminal of isolating transformer, and earth electrodes.

Equipment Ground Lead: In pipes/conduit/saw cuts from earth point on cable tray in transformer pit/earth terminal on transformer housing to earth terminal on isolating transformer, light monitoring switch, light bases, mounting stakes/poles/baseplates.

ECPs: On wall surface with brass screws, nuts, washers, porcelain insulators.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0630 – LIGHTNING PROTECTION SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of complete Lightning Protection System.

1.2 GENERAL

Earthing resistance ≤ 10 ohms at any point. Roofs equipped with lightning arresters/air terminals/roof conductors. Inspection/measuring joints in down conductors. Integrate lightning protection system to reinforcement bars of column and foundation. Submit Risk Assessment per IEC 62305 compliant software. Rolling sphere method & protection angle method analysis.

1.3 APPLICABLE STANDARDS/CODES

IEC 62305-2; BS EN 62561-1,2,4; BS EN 13601; BS 6346; BS EN 60228; BS 7884, 6004.

PART 2 – PRODUCTS

2.1 LIGHTING ARRESTOR/AIR TERMINAL SYSTEM

Solid tinned copper 2m long, 10mm dia (or as per rolling sphere/protection angle analysis). Base suitable for roof/down conductors.

2.2 DOWN / ROOF CONDUCTORS

Tinned copper strip. Cad welded at top/bottom with reinforcing bars. Structure's concrete column reinforced steel bars used as down conductors. Reinforced concrete foundations as earth termination network.

2.3 TESTING TERMINALS

For each tinned copper strip down conductor and every third reinforcement bar used as down conductor, installed 1.5m above finished floor. Removable connections. Enclosed in 16 SWG MS Powder Coated enclosure box with protective cover.

2.4 GROUNDING CONDUCTOR MESH

Stranded circular bare tinned copper conductor or tinned flat copper strip. Cad welded at intersections. Connected via PVC insulated stranded copper conductor to ECP at 300mm above finished floor.

2.5 EARTH ELECTRODE (COPPER CLAD STEEL ROD TYPE)

3m long, 19mm dia, copper clad (1.5m sections with copper coupling). Brass clamp. Concrete inspection pit with C.I. cover (Medium/Heavy Duty).

2.6 EXOTHERMIC CAD-WELDING CONNECTIONS & ACCESSORIES

Connections: Bar to Bar (Straight, T, Cross), 25x3mm flat copper strip to 70 sq.mm conductor, Bar to Cable T joint, Bar to Rebar, Cable to Rebar. Exothermic powder, handle clamps, moulds, tools.

2.7 TECHNICAL SPECIFICATION

Supply, Design & Testing of Prevelectron type 3rd Generation Controlled Early Streamer Emission (CESE) 2nd edition (UNE21186:1996) lightning conductor equipped with a tinned copper central pick

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

up rod. Full electrical continuity between the tip and the earth point shall be ensured. Fully autonomous (no battery, no external power supply required) which shall collect ambient energy through a lower series of electrodes. Timing of the streamer emission controlled with an electronic device that detects the lightning and triggers a streamer (3.5 KV and 20 A).

Manufactured as per NFC 17-102.

A tester/ testing process corresponding specifically to the airterminal shall be available for the maintenance and ensure the healthiness of the unit.

Protection Radius = 45 meter

Level of Protection: Level 1

The base of the down conductor should be protected from accidental knocks and other damage by means of a 2 meters stainless-steel or PVC protection sheath fixed to the structure.) (5meter ht. considered

PART 3 – EXECUTION

3.1 INSTALLATION

Lightning Arrestor/Air Terminal: Installed by specialist supplier. Base properly fixed to roof.

Down Conductor: Shortest possible route from roof to earth electrode. Fixed with Omega type pads in tinned copper by stainless steel screws. Continuous – no joints; if necessary, straight joints bolted with anti-corrosive paint. Reinforcement bar connected to roof conductor with pre-welded tails (500/1000mm long) and 2x70sqmm PVC insulated copper cable. All metallic projections on roof bonded. Flexible copper braids (25x3mm) at expansion joints.

Testing Terminals: Removable terminal at ~1.5m height from finished ground level at every third column with reinforced steel bars and at every tinned copper strip down conductor.

Grounding Conductor Mesh: Laid in soil below foundation reinforced steel bars at same depth as earth pits. Connected to ECP via PVC insulated stranded copper conductor raised along columns.

Earth Electrode (Rod): Hammered in soil until top ~300mm below finished ground level, or pit excavated and backfilled in 500mm layers compacted.

Exothermic Cad-Welding: Installed by specialist qualified supplier.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0640 – MISCELLANEOUS ITEMS

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, testing and commissioning of Miscellaneous Items.

1.2 WARRANTY

Ceiling Fans and Wall Bracket fans: min 2 years from OEM from Taking Over Certificate.

1.3 APPLICABLE STANDARDS/CODES

IEC 60947-3; BS EN ISO 1461, 15630, 50085, 61537, 4678-2; IEC 61084-2-2; BS EN 60335-2-80, 124; ISO-12944-2; BS EN 60529.

PART 2 – PRODUCTS

2.1 CEILING FAN

Capacitor type, 250V AC. Air displacement 12,000 cfm for 56" sweep, 10,000 cfm for 48" sweep. Fan regulator low voltage electronic. Fan hook: 16mm dia mild steel rod, loop ~75mm long, 50mm wide, extensions ≥200mm. Fan rod G.I 20mm dia.

2.2 WALL BRACKET FAN

Capacitor type, 250V AC. Regulator in fixed portion. Rotating mechanism for swinging on vertical axis.

2.3 SWITCH DISCONNECTOR / LOAD BREAK SWITCH IN WEATHERPROOF ENCLOSURE BOX

Triple pole 500V / single pole 250V. AC-23 utilization category. IP65. 16 SWG sheet steel weather proof box. Copper/brass links for earth/neutral. Door cam locks, hinge type. Protective paint per ISO 12944 Category C3, Epoxy primer, polyurethane top coat RAL 7032/7035.

2.4 HOT DIPPED GALVANIZED M.S. CABLE TRAYS / TRUNKING / LADDERS WITH PROTECTIVE PAINT SYSTEM

14 SWG M.S. sheets. Fabricated in sections ≤3m. Flexible expansion couplers at building expansion joints. Indoor: ISO 12944 Category C2; Outdoor: Category C3. Etch primer for galvanized surfaces.

2.5 UNDER FLOOR METAL TRUNKING

Pre-galvanized sheet steel, 1.2mm thick, ≥2 compartments (power & telecom). Tested to 30 kN concentrated load. Channel method construction. Accessories: floor pedestal boxes, round grommets, extension screw terminals, offsets, clamping saddles, connecting saddles. Sections ≤2.3-2.44m.

2.6 MANHOLES/HANDHOLES WITH COVER & FRAME

Per Civil Specifications. Covers roughened, watertight. Label "E" (Electrical), "T" (Telecommunication), "AFL" (Airfield Lighting). Loading capacity per BS EN124.

2.7 STREET LIGHTING COLUMN

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Steel tubular tapered/octagonal per BS EN 40-5, longitudinally welded (no circumferential weld). Hot dip galvanized full bath, then protective paint ISO 12944 Category C3. Anchor bolts threads re-cut and greased after galvanizing. Door lockable (tamper proof), size 120x350mm min. Inside: baseboard with channel for cable termination and circuit breaker/MCB block. Earth terminal screw M8 min.

PART 3 – EXECUTION

3.1 CEILING FAN

Fan hooks installed in RCC ceiling before pouring concrete. Down rod with long threads, check nuts, split pin at fan body end and clamp. Wiring between ceiling rose and fan terminals with ≥ 3 core 1.0 [sq.mm](#) PVC insulated PVC sheathed flexible cable.

3.2 WALL BRACKET FAN

Install on wall with flat head galvanized screws. Wiring as above.

3.3 SWITCH DISCONNECTOR / LOAD BREAK SWITCH ENCLOSURE

Installed inside 16 SWG sheet steel box, fixed with screws. White faceplate fixed with flat head galvanized screws flush with wall.

3.4 CABLE TRAYS / TRUNKING / LADDERS

Installed on supports fixed to wall/ceiling/trusses with Rawl bolts. Span ≤ 2 m. Supports at each bend/change of direction. Straight joints, bends fixed without sharp edges. Copper earth braid with lugs at each joint and bend.

3.5 UNDER FLOOR METAL TRUNKING

Floor slab level and smooth. Humps hacked to level to maintain min screed thickness 38mm over trunking. Use layout drawing to select starting point. Use connecting/clamping saddles to secure. Box covered with disposable lid, taped to prevent cement ingress. After screed dried, remove lid, fit interiors, use levelling system to adjust height.

3.6 MANHOLES/HANDHOLES

Construct per Civil Specifications. Proper curing ≥ 15 days. Submit shop drawing for approval. Cement sulfate resistant.

3.7 STREET LIGHTING COLUMN

Foundation reinforced concrete Class 'B' (grade 25) per structural calculation. Submit civil drawing for approval. Cable opening and gaps filled with watertight material. At least 10 setting templates for each size.

3.7 TELEPHONE EXCHANGE TECHNICAL SPEC

PABX (4 Trunk lines and 100 extensions).

2 extension interfaces for multi-line executive telephone sets.

1 x Operator console with 2 lines LCD display, 15 programmable keys, USB interface, powered from the PABX.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Maintenance free batteries for power backup.

Music on hold with auto-reverse cassette player.

Integrated UCD functionality.

Integrated Ethernet interface for LAN based administration.

Servo motor controlled voltage stabilizer.

Make Panasonic / Samsung.

PART 4 - MEASUREMENT AND PAYMENT

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SECTION 0650 – STRUCTURED CABLING NETWORK

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, connecting, programming, configuring, integration, testing, commissioning, training and completion for Structured Cabling Network.

1.2 GENERAL

Passive equipment from one manufacturer. System supports Gigabit and 10 Gigabit Ethernet. Star topology: horizontal cable, consolidation point cable (CP), Multi-user Telecommunications Outlet (MUTO), Telecommunication outlet (TO). Ensure compatibility of active equipment with existing makes.

1.3 APPLICABLE STANDARDS AND CODES

ISO/IEC 11801, 8802-3, 61935-1; IEC 60364-1, 60950; EN50173, 50174-1, 50174-2; ANSI/TIA/EIA-568, -569; TIA/EIA TSB-72, TSB-75.

1.4 WARRANTY

Min 1 year warranty after TOC for Ethernet & Fiber Switches, Transceivers, Wireless Controller, Network Security Firewall, Wireless Access Point.

PART 2 – PRODUCTS

2.1 LAYER-3 MANAGED MODULAR FIBER SWITCH

Min 8 slots for up to 4 line cards. Communication Manager/Routing Engine Module Line Card min 32 x 10G SFP+ Ports. Backplane capacity up to 4 Tbps, up to 1.5 Tbps (full duplex) per slot fabric capacity. 1+1 fabric redundancy. 1 million IPv4 RIB, 1 million IPv6 RIB. Routing: RIP v1/v2, OSPF v1/v2/v3, VRRP, BFD, BGP, IS-IS, GRE tunnels, MPLS, Ethernet VPNs. Multicast: up to 256k IPv4/IPv6 routes, IGMP v1/v2/v3. Min 16k policers for QoS. Dual power supply, fans.

2.2 LAYER-2 MANAGED ETHERNET SWITCH (24 PORT)

24 x 10/100/1000 ports PoE+, 4 x 1G/10G fixed uplinks, 2 x 40G QSFP stacking ports. Switching capacity 144 Gbps, processing 214 Mpps. Stacking up to 10 units. 32000 MAC addresses. VLAN IDs 4000. Features: LACP, MSTP, IEEE 802.1w, 802.1x, 802.3ad, 802.3at PoE+, 802.3af, 802.1d, 802.1p, 802.1q, LLDP, Jumbo frames 9198 bytes, port security, SNMP v1/v2/v3, NTP, DHCP relay, RIP v1/v2, OSPF v2.

2.3 FIREWALL

8x GE SFP slots, 2x 10 GE SFP+ slots, 20x GE RJ45 ports, 2x GE RJ45 management ports, console port. Firewall throughput 36 Gbps, NFFW throughput 4 Gbps, Threat Protection throughput 3 Gbps. TLS 1.3 support. IPS, SSL inspection, AI-powered threat protection, dynamic WAN path steering, cloud-on-ramp, DNS filtering.

2.4 WIRELESS CONTROLLER

4 x Gigabit Ethernet ports. WPA, WPA2, 802.1H, TKIP, AES. L3/4 based. Supporting up to 1,024 APs, 25,000 clients per device cluster up to 4 units (3+1). Rogue AP detection, interference detection, band

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

steering, airtime fairness, role-based user policies, per-user rate-limiting, hotspot, guest networking. Capacity-based client admission control, band balancing, internal captive portal (Radius, AD, LDAP, Local DB).

2.5 WIRELESS ACCESS POINT

2 x 1GbE ports, PoE in. 802.11a/b/g/n/ac Wave 2. MU-MIMO 2x2. WPA-PSK, WPA-TKIP, WPA2 AES, WPA3, 802.1H, Dynamic PSK. WIPS/WIDS, captive portal, 802.1Q, VLAN pooling, port-based, tunnel L2TP/GRE. Operating temperature 0°C to 50°C, max power 12.6W.

2.6 COPPER CONNECTORS (RJ45 JACKS)

EN 60603-7 and EN 28877. Insulation displacement, 0.50-0.65 solid and 7x0.15-0.20 mm stranded. Tool less assembly, 568B/568A, Category 6A, integral shutter. Performance at 500 MHz: Attenuation <11.2dB, Return loss ≥12.6dB, NEXT ≥32.3dB.

2.7 FIBER CONNECTORS

IEC 61754. Small form factor, duplex, high density, field terminated under two minutes, integral shutter.

2.8 TELECOMMUNICATION WALL OUTLETS

RJ45 / Duplex LC Fiber Connectors, flush mounting, space for labelling.

2.9 PATCH PANELS

19" panels. Copper: 16/24 per panel. Fiber: 12,24,48 per panel (sliding or front loading). Cable management, slack storage, labelling. Colored identifiers for jacks/sockets.

2.10 PATCH CORD MANAGEMENT

1U with min 5 rings to accommodate up to 72 patch cords.

2.11 PATCH CABLES

RJ-45 copper: Category 6A, stranded wires. **Fiber:** duplex ruggedised, core/cladding sizes matching permanent link.

2.12 COPPER CABLE (CATEGORY 6A)

100 Ohm. Conductor 24 AWG (0.560mm), resistance <98.6 Ω/km, dielectric strength 1kV/1 min, insulation resistance >5000 MΩ/km, characteristic impedance 100±15% from 1 to 100 MHz. LSZH sheath.

2.13 OPTICAL FIBER CABLE

50µm/125µm Multimode (OM4) LSZH or 9µm/125µm Single mode (OS2) LSZH indoor. Single mode performance at 1310/1550nm: attenuation <0.4/0.4 dB/km. Multimode at 850/1300nm: <2.7/0.8 dB/km. Min bend radius: indoor 20x cable diameter (install), 10x (after); indoor/outdoor 25x (install), 20x (after). TO min bend radius 20mm. Operating temp -10 to +60°C.

2.14 19" CABINET

Colour black or as required. Plexiglass door. Frame thickness 2mm, mounting rail 2mm, roof 1.63mm, rear door 1.63mm, side panels 1.2mm. At least two cooling fans. Cable entries top and bottom. Cabling guide system inside. Earthing point. Door lock with key. Power distribution unit (PDU): ≥2 extra sockets, industrial male plug, two PDUs per rack for dual power supply equipment.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

PART 3 – EXECUTION

3.1 INSTALLATION

Per manufacturer's guidelines and relevant specification. Provide test report to ensure cabling meets Class E. No distribution cabling alongside power lines. Correct cable baskets/trays per IEC 50174-1. Pulling tensions not exceeded. Plug conduits/entrance holes with re-unutterable duct seal or flame retardant putty. Proper grounding, bonding to main electrical ground.

3.2 INSTALLATION HANDOVER

Documentation includes evidence of conformance, delivery information, cable acceptance test records.

3.3 FINAL CABLE DOCUMENTATION

Site plans, as-built information (nodal, route, cable connectivity), installed cabling acceptance test records, evidence of conformance to installation specification, handover certificate, earthing/equipotential bonding details.

3.4 TESTING AND COMMISSIONING

Horizontal copper cabling (Level II field tester per ISO/IEC 11801): Headroom report, wire map, resistance, link length, insertion loss, return loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, ACR, PS ACR, delay skew, impedance, DC loop resistance.

Fibre permanent links: Light source/power meter or OTDR at 850nm and/or 1300nm. 100% of installed links tested. Confirm continuity, link length, radius of curvature, cable preparation, cable ties, insulation continuity, earthing and bonding.

Labels: Computer generated or typewritten.

Commissioning: After handover, probationary period. All components from one manufacturer to guarantee Category-6A performance end-to-end.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0660 – INTELLIGENT ADDRESSABLE FIRE ALARM SYSTEM

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, configuring, programming, integration, testing, commissioning, training for Fire Alarm System complete in all respect.

1.2 GENERAL

System operates on 24 VDC from battery charger with standby batteries. Incoming supply 230 VAC from emergency circuit. All active items product of single manufacturer. Provide wall chart near FACP (layout, standby battery spec, operating/maintenance instructions in black, emergency instructions in red, servicing contractor's name/address/phone). Interface with Public Address / Voice Alarm System (per Section 0651 and EN 54-16) and the Access Control System (per Section 0652). The FACP shall be provided with a remote-parallel-monitoring interface for connection to the ATC operational annunciation panel. The Contractor shall coordinate the routing of all FACP and BMS interface cabling with the Engineer and with the Pakistan Airports Authority (PCAA) operational staff for the airside cable trench provision.

1.3 APPLICABLE STANDARDS/CODES

BS 5839; NFPA 72; NFPA 101. All items LPCB/EN54 approved or British Standard.

PART 2 – PRODUCTS

2.1 ANALOGUE ADDRESSABLE FIRE ALARM CONTROL PANEL (FACP)

Functions: Supervise all intelligent addressable detectors/modules. Detect activation, location, operate notification appliances and auxiliary devices. Visually/audibly annunciate trouble/supervisory/alarm conditions. LCD display, local audible device, printing/history storage. Acknowledge switch (silences local panel piezo, changes LEDs from flashing to steady). Signal silence switch (programmable). Drill switch (activates all programmed notification circuits). System reset switch. Lamp test. Scroll display keys for FIRE ALARM, SECURITY, SUPERVISORY, TROUBLE, OTHER EVENTS. Print screen.

System Capacity: Each module loop supports min 127 analog/addressable devices. Backlit LCD, QWERTY keypad. Programming without special equipment, without interrupting alarm monitoring. Automatic smoke detector test function per NFPA 72. On-line or off-line programming. History file (alarms, troubles, operator actions, programming entries). Drill (activate all silenceable fire output circuits). Two password levels (master, user), min 4 user passwords. Environmental drift control (maintenance alert/urgent warning).

Loop Control Module: monitors/controls 127 devices, contains own microprocessor for local/degrade mode. Single pair of wires, NFPA Style 4 (Class B). Receives analog/digital information from detectors, adjusts for environmental factors, dust accumulation.

Enclosures: 0.060 steel, key lock, transparent opening for indicators, modular structure.

Power Supply: 230 VAC, 50 Hz. Battery charger for 24 hours standby (48 hour recharge). Very low frequency sweep earth detect circuit.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Printer: Automatic, printing code, time, date, location, category, condition. 80 characters per line. Strip printer can be mounted in main FACP enclosure (alarms in RED, other messages in BLACK). Adequate printer paper rolls.

Field Programming: Programmable, configurable, expandable without special tools or laptop. Via standard FACP keyboard. Non-volatile memory.

2.2 NOTIFICATION APPLIANCES

Audible visual sounders 24 VDC. Field programmable, ≥ 10 dBA above ambient noise. Strobe lights per ADA, UL 1971, fully synchronized. Max pulse duration 1 second.

2.3 ADDRESSABLE DEVICES – GENERAL

Address-setting via rotary decimal switches. Analog and addressable. Integral short circuit isolator (isolate fault in < 1 sec). LED flashes normal, steady on alarm. Detector sensitivity adjustment field programmable; automatic compensation for dust accumulation. Detectors listed by UL for calibrated sensitivity test (NFPA 72 Chapter 7). Ceiling-mount with twist-lock base (tamper proof). Bases: sounder base (85 dBA min), Form-C relay base (30VDC, 2.0A), isolator base. Test means: magnetic switch at detector or remote command from panel.

Addressable Manual Call Station: Key operated test-reset lock. After emergency operation, cannot be restored without key. Lexan, operating instructions on cover. "FIRE" in raised letters, 44mm or larger.

Intelligent Addressable Multi Optical and Heat Detector: Photoelectric and thermal technologies in single device. Microprocessor to determine environment and choose sensing settings. Sensitivity 1-4% per foot obscuration. Combine thermal and photoelectric signals for fire detection; distinguish false alarms.

Intelligent Addressable Thermal/Heat Detector: 135°F (58°C) fixed, rate-of-rise 15°F (9.4°C) per minute.

Flame Detector: Class 1 per BS EN54-10:2002 high sensitivity. Detection range 25m, 90° cone. Loop powered interface module.

Addressable Dry Contact Monitor Module: Connects one supervised IDC zone of conventional alarm initiating devices (N.O. dry contact) to SLC. Mounts in 4" square, 2-1/8" deep box. LED flashes normal.

Addressable Control Module: Supervises and controls one conventional NAC (24VDC). For fan shutdown, can operate as dry contact relay (Form-C, rated ≥ 0.6 A at 30VDC).

Addressable Relay Module: Form C, min 2.0A resistive or 1.0A inductive. Magnetically latched.

Agent Release Module (ARM): Allows Gas Cartridge Actuators for Clean Agent containers to be wired in parallel, Class A or B wiring.

Abort Switch: Within protected area, near egress. Requires constant manual pressure to cause abort. Manual control overrides abort. Audible and visual indication of impairment.

Zone Disable Switch: Momentary push button, delays agent release circuit when operated prior to circuit actuation.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Manual Release Station: Dual actuation, pull spring clip safety pin (breaking seal) and depress button. Remains engaged until unlocked with key. Stainless steel housing, red plastic release button with black trim.

LCD Alphanumeric Display Annunciator: Supervised, back-lit LCD, min 160 characters. Displays all alarm/trouble conditions. Up to 32 annunciators per EIA 485 interface. Mimics main control panel 80 character displays. Switches for Global Acknowledge, Silence, Reset (can be disabled or key lockout).

2.4 BATTERIES AND EXTERNAL CHARGER

Batteries: 12 volt, Gell-Cell. Capacity for 24 hours + 5 minutes alarm upon AC power failure. Maintenance free. External Battery Charger: Automatic, constant potential. 120/240V 50/60 Hz. Fully charge discharged battery within 48 hours while supplying loads. Overload and short circuit protection.

2.5 WIRING AND CABLING

1.5 mm² / 2.5 mm² fire resistant enhanced (120 min) cables with LSZH outer sheath. All wiring on terminal blocks. Cable joints only on detector bases.

PART 3 – EXECUTION

3.1 INSTALLATION

Per manufacturer's instructions. Testing per relevant standards: operational safety, regular functioning, protection against false alarms. Detectors subjected to basic tests and sensitivity tests.

3.2 TRAINING

By fully qualified representative of equipment manufacturer/supplier. Training includes: wall chart explanation, function of each control switch, periodic operational testing, maintenance of fire log book, actions upon signals (false alarm, trouble, common alarm/trouble, low battery), field modifiable programming.

3.3 WARRANTY

Min 1 year after TOC for all detectors, sounders, modules, control panel, repeater panel, computer, software.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0670 – CLOSED CIRCUIT TELEVISION SYSTEM (CCTV)

PART 1 – GENERAL

1.1 SCOPE OF WORK

Supplying, installing, connecting, configuring, programming, testing, commissioning and training for complete IP CCTV system.

1.2 GENERAL

All active items product of single manufacturer. Power to rack from UPS with min 30 minutes autonomy. Open standard based integrated system with IP network centric architecture. Colour Video Cameras with individual IP address, Fixed or P/T/Z Lens, Server, Network Attached Storage (NAS)/Raid backup, Application Software, Colour Video displays, Keyboards with Joystick Controllers, software based Video Matrix Switcher, Workstation for System Administration/Management/Maintenance. Central Management Server and Network Storage management for video stream and storage management. Recording frame rate & resolution programmable. Recorded video cannot be altered (audit trail). Storage calculation: H.264/H.265 compression, 1080p recording at 30 fps, 24 hour operation, 30 days storage, 25% expansion capacity. Video analytics for abandoned object, intrusion, wrong direction, loitering, object removal, camera sabotage, tail-gating, unattended baggage, queuing analysis, intruder detection. Watermarking/digital certificate for tamperproof recording. Camera ID, location/area, date/time stamp programmable by system administrator. Triplex (Viewing, Recording, Reply simultaneously). Export clipping to portable hard drive, viewable on standard PC. PTZ cameras 64+ pre-defined positions. LAN connectivity for remote monitoring anywhere in Airport. All control equipment in standard 19" racks.

1.3 APPLICABLE STANDARDS AND CODES

IEC 801-2 (Electrostatic discharges), 801-3 (Radiated EMI), 801-4 (Voltage transients). Dust/rain resistance IP67 for outdoor cameras. Salt mist per IEC 68-2-11, Vibration IEC 68-2-6, Bump test IEC 68-3.

PART 2 – PRODUCTS

2.1 IP FIXED COLOUR BULLET VARIFOCAL CAMERA

1/2.9" CMOS, 3072(H)x1728(V) 5MP or better. Built-in varifocal auto iris, 3.2-10mm or better. 25 fps, 0.0 lux with IR. SNR >55dB, WDR 120dB. H.265/H.264. PoE. IP rating per BOQ.

2.2 IP FIXED COLOUR DOME VARIFOCAL CAMERA

Same specs as bullet.

2.3 IP PTZ DOME COLOUR VIDEO CAMERA

1/2.8" CMOS. Focus 4.5-135mm, optical zoom 30x, digital 12x. Resolution 1920x1080 (2MP). 0 lux with IR. Pan 360° continuous, 256 presets. H.265/H.264/M-JPEG. WDR 90dB. IP rating per BOQ.

2.4 CENTRAL MANAGEMENT SERVER on H.264/H.265 Compression

Simultaneous playback and recording full duplex. Windows/Linux OS. User management for security level control. Latest generation processor, redundant hot pluggable power supply. Network protocols: TCP/IP, CIFS, NFS, HTTP/HTTPS, FTP, NTP, SNMP, SMTP, DHCP, DNS. KVM switch.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

2.5 WORKSTATION

Latest industrial standard, 21" LED display, wireless keyboard/mouse, video/sound card, 10/100/1000 Base-T Ethernet port, latest OS, CCTV software, antivirus.

2.6 NETWORK VIDEO STORAGE on H.264/H.265 compression

As per manufacturer's recommendation for operation of CCTV system.

2.7 CAMERA HOUSING & MOUNT

Same make as camera or with manufacturer's authenticity document. Compact, indoor/outdoor as required. Support weight in any position.

2.8 SPEED DOME CONTROLLER / PTZ CONTROLLER

Variable speed joystick, LCD display for programming.

2.9 FULL HIGH DEFINITION (FHD) LED DISPLAY

42" Colour LCD. Resolution 1928x1080, contrast 4000:1, 16:9, luminance 500 cd/m². HDMI, DVI, VGA.

2.10 CONSOLE

Ergonomic design, adjustable work surface. High-pressure plastic laminate veneer. Static load 50 lb/linear ft (max 250 lb per surface). Frame assembled profiles with angle brackets. Integrated screens, PTZ controller, mouse, telephone, keyboards drawers, headset panels, lighting panel.

PART 3 – EXECUTION

3.1 VIDEO SURVEILLANCE APPLICATION SOFTWARE

Open architecture for integration with perimeter safety, access control, public address, fire/safety systems. Display and manage entire system. Flexible windows split (1/2/4/16) on 42" screen. PTZ control, iris, focus, color balance, presets, video tour. Reports of stored device configuration. Alarm and alarm log. User authority configurable per device or group. User activity log (audit trail). Administrator add/edit/delete users with rights. Minimum 3 hierarchical security levels. Recording modes: continuous, manual, programmed (date, time, camera-wise). Search and replay by date, time, camera. Motion detection area-wise. Pre-record duration 0 seconds to 5 minutes. Browser-based system for remote users. Retrieval instantaneous or via search. Backup on CD/DVD/Blue Ray or other device. Storage for 24 hour operation, 30 days recording, all cameras at 1080p, 30 fps, H.264/H.265, 25% expansion. Artificial intelligence: image tracking, stationary object detection, abandoned object, intrusion, wrong direction, loitering, object removal, camera sabotage, vehicle detection, tail-gating, unattended baggage, queuing analysis, intruder detection.

3.2 INSTALLATION

Per manufacturer's recommendations.

3.3 TRAINING

By fully qualified representative of equipment manufacturer/supplier.

3.4 WARRANTY

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Min 1 year after TOC for all cameras, LED display, computer with software, NVR, CMS, PTZ controller, Ethernet switches, transceivers.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0680 – FUEL STORAGE AND SUPPLY SYSTEM TO DG SETS

PART 1 – GENERAL

1.1 GENERAL

Fuel storage and supply system to DG sets. Contractor engages specialized Sub-Contractor/Authorized Distributor ('Supplier'). Submittals: technical data sheets, outline drawing, printed technical literature.

1.2 DESCRIPTION

Fuel transferred in underground storage tank (UST) via fuel bowzers. UST filling: operator sees level on indicator at fuel filling cabinet. Fuel transferred from UST to D.G. set day/base tanks using fuel transfer pumps (duty + standby) through piping with valves, instruments, accessories. Transfer pumps with automatic controls: start pumps and open solenoid valve when low level sensed in day/base tank; shut-off when high level achieved.

1.3 SCOPE OF WORK

Fabrication, supply, installation, testing & commissioning of USTs and aboveground day tanks. Supply, installation, testing of fuel transfer pumps (1 duty + 1 stand-by) with explosion proof motors. Fuel supply piping network (pipes, fittings, supports, drains, gauge stick port cap, painting, coating, wrapping, vents with bird screen). Valves (ball, gate, foot, check, strainer, solenoid, pressure relief). Instrumentation (level transmitters, flow switches, flow meters, pressure gauges). Fuel filling point cabinet (SS cabinet, filling pipe with coupler & cap, level indicator, alarm system). Fuel monitoring & control panel + pump/motor control panel. Labour, materials, equipment for complete installation. Design & execution of related civil & electrical works (pump foundation, day tank foundations & dike/bund wall, pipe supports, caution signs, power & control wiring in conduits).

1.4 ORIGIN OF SUPPLY

Complete equipment/instruments (pumps, valves, strainers, flow switches, flow meters, pressure gauges, level sensors, level indicators, alarm system, breakers, PLC, relays, contactors, selector switches, HMI) imported from USA, Europe, Korea or Japan. Steel storage tanks fabricated locally. Electric control panel steel box/enclosure, fuel filling point steel cabinet may be local. Steel pipes may be local.

1.5 CODES AND STANDARDS

ANSI B16.5, B16.22, B16.39; API 5L, 6D, 610, 674, 676, 1104, 1110; ASTM A53, A126, A234; ASME B31.3, ASME Code Sec VIII Div.I, Sec IX; DIN 6608, 6616; NFPA 30.

PART 2 – PRODUCTS

2.1 FUEL STORAGE TANK

Design: UST per DIN 6608. Aboveground per DIN 6616. Connection nozzles for fuel filling, supply, vent, instruments, drain. Inspection manhole and dip stick. Lifting eyes. Steel access ladder with bolts/nuts where necessary. Thickness increased by 2mm for corrosion allowance. Nameplate per code: manufacturer, year, serial number, design/test pressure, design temperature, code stamp, fluid, capacity, dimensions.

Welding: Butt welded with full penetration. Non-destructive testing per ASME Code Sec VIII DIV-I.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Surface Preparation and Painting: Commercial sandblast per SSPC-SP5. **Internal Coating:** Fuel resistant primer or anti-corrosive material if specified. **External Coating (Above Ground):** Polyamine cured epoxy mastic primer (200µm DFT) + Polyurethane Top Coat (50µm DFT) – total 250µm min. **External Coating (Underground/Buried):** Epoxy Primer (75µm), High Build Epoxy (175µm), Coal Tar Epoxy (200µm) – total 400µm min.

Tank Calibration: Provide calibrated dip stick with graduations and calibration chart.

Installation: UST buried inside RCC pit with pedestals, suitable slope. Concrete beams/saddles or hold-down straps to resist flotation. Aboveground tank on RCC pedestals or steel support structure with slope. Spill/leakage containment bund of 110% capacity. Spill containment ditches below drain valves, fuel supply/filling connection points. Security fence with access gate and sign boards.

Testing: NDT of ≥10% weld length by radiography. Hydrostatic testing per DIN or ASME. Holiday test for external coating. DFT measurement.

2.2 FUEL DAY TANK

Skid Mounted Base Tank: Coordinate with generator set manufacturer for high/low level sensors.

Free Standing Day Tank: Supported over fabricated steel structure or saddles. Connections for filling, supply, return, overflow, vent with bird screen, instruments, drain. Lifting eye, inspection cover, emergency vent, glass sight gauge (if applicable), graduated dip stick, access ladder (if applicable). Level sensors with level indicator. Fabrication, coating, calibration, installation, testing as per aboveground storage tank. Dike/bund walls around day tanks for 110% of total diesel stored. Vent pipe extended to outside of room.

2.3 FUEL PIPING NETWORK

Lines: filling, vent (UST and AST), pumps suction, pumps discharge, overflow, pumps relief, drain point, fuel supply to DG sets, fuel return from DG sets, solenoid bypass, day tank drain. Full flow Y-strainer before suction of each pump. Filling hose coupler in filling point cabinet, locking arrangement.

Materials: Black steel schedule 40 seamless ASTM A53 Type-S Grade-B or API-5L Grade B. Threaded fittings up to 1½" forged steel; 2" and larger socket/butt-welded per ASME B16.9, ASTM A234 Gr. WPB. Elbows long radius 1.5D. Steel flanges ASME B16.5, ASTM A105, Class 150, Slip-On or Weld Neck with Raised Face. Flanged ball and check valves per data sheet. Flanged Y-type strainers per data sheet. Vent terminals full size, recessed cast bronze, bird/insect screen, weatherproof vent cap. Filling hose coupler stainless steel. Foot valve per data sheet. Flow meter with totalizer.

Installation: Per ASME B31.3. Underground or aboveground with min 0.5% slope. Automatic air release valves at high points. Buried pipe ≥300mm below finished ground level in non-traffic areas; ≥1000mm in traffic areas. Minimum 300mm from other services. Soft sand padding below/above pipelines in rocky soil.

Surface Preparation and Painting: Underground: primer + three ply polyethylene tape + two ply polyethylene tape. Above ground: epoxy primer coat + high build epoxy.

Testing: Hydraulic test to 1.5 x working pressure per API 1110. Welding per API 1104.

2.4 FUEL TRANSFER PUMP

Electric Motor Operated Pump: Skid mounted positive displacement (PD), capacity/head per drawings/BOQ. Data sheet per clause 12.1.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Hand Operated Pump: Stand-by, capacity to refill empty day/base tank within two hours.

Installation: On concrete foundation with spill containment. Priming arrangement if non-self priming. Pressure Relief Valves inline at pump discharge, outlet routed back to fuel supply tank/suction line. Strainers on pump suction. Pressure gauges 4" dia, dial graduated to 1.5 x working pressure, with isolating plug/ball valve. Eccentric reducers if connection sizes differ.

Pump Operation: Duty pump selectable via selector switch. Stand-by. Automatic duty change on each start/stop cycle. Pump starts when low level sensor in day/base tank activated; stops when high level sensor activated. Pump not start (alarm) if low level sensor in UST activated.

2.5 CONTROLS AND EQUIPMENTS

Level transmitter (continuous) for UST with indicators on control panel in generator room and fill point cabinet (% full display), audible/visual alarm. Level transmitter for day tanks with indicator on control panel, audible/visual alarm. Pump Control panel & Fuel Monitoring Panel. Control cabling with conduits.

Operation Scheme & Interlocks (per table):

- UST filling: high level – warning (visual+audible) at panel + filling point.
- Decanting UG to Day: low level in UG – pumps shutdown + alarm; high level in day tank – pumps shutdown + alarm; high level + pump shut-off failure + overflow – pumps shutdown.
- Fuel transferring Day to DG: low level in day tank – pumps start & solenoid valve open; low level + pump start-up failure – alarm only.

Pump Control Panel: Per manufacturer's recommendation. Motor control, safeties, automatic duty changeover, operational status display, manual operation switches, emergency stop.

Fuel Monitoring Panel: PLC controlled with HMI for digital indication of tank contents (liters) for each tank. Alarm sounder/horn for events per operation scheme. Indication lamps, test/reset buttons. Interfaced with pump control panel. Features: power supply module, main circuit breaker, CPU, memory card, PLC, digital/analog I/O modules, HMI/touch panel 9" LCD, alarms/sounders, software, internal cabling. Enclosure: surface or semi-flush, corrosion protected, 14 gauge SMG steel, key lock with 9" touch LCD, IP54, pocket for documents.

Fuel Filling Cabinet: Outdoor near UST. Stainless steel ASTM A316, 12 gauge, size 800x600x300mm (or approved), satin/hairline finish. Partial glass/polycarbonate front door. Lockable, side hinged. Single point 45° angular filling coupler of 65mm with SS filler cap. Bottom entry. Lever ball valve 65mm threaded. Removable drip tray. Dial Type Contents Gauge (% filled). Overfill alarm at 90% (also to control panel). Grounded per NFPA 780.

2.6 DATASHEETS (summarized)

Pumps (P-201, P-202): Quantity 2 with motors. Rotary vane/gear positive displacement, self-priming, horizontal. Housing cast iron, gears stainless steel/bronze, mechanical seal. Capacity 100 L/min. Internal relief valve. Motor explosion proof, TEFC, 400VAC or 230VAC, 50Hz.

UST (V101): 25,000 liters, DIN 6608, horizontal with 2:1 elliptical dish head, atmospheric. Material HR235/ASTM A36, shell/dish head thickness 8mm. Test pressure 1.5 bar hydrostatic.

Aboveground Day Tank (V301, V302): 3,000 liters each, DIN 6616. 1,250x2,600 mm, shell/dish head 6mm.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Pressure Gauge (PI301): IP55, ASME B40.100, direct reading, SS316 case, 4" dial, ½" NPT male, Bourdon tube, 0-2 bar/0-30 psi, glycerin filled. With ball valve + snubber + pressure limiting valve.

Flow Meter with Totalizer (FQI301): ATEX/IEC Ex, CE, explosion proof IP65. Turbine type, SS316 body. Range 5-250 L/min, LCD display, totalizer. Flange type ANSI 150# RF or threaded, 40mm.

Flow Switch (FS): ATEX/IEC Ex, CE, explosion proof IP65. Paddle type, gives signal to panel when flow detected. Horizontal pipe, lower mount, plastic/metal case, SS316 paddle, threaded 40mm.

Level Transmitters/Sensors (LT): ATEX/IEC Ex, CE, explosion proof IP68. Submersible continuous leveling. SS316 housing, SS316L cells. Accuracy $\pm 0.5\%$ FS. Output 4-20mA. For UST (2500mm range) and AST (1250mm range).

Solenoid Valves (SV1, SV2): ATEX/IEC Ex, CE, explosion proof IP65. Direct acting, normally closed. 2 ports/2 switching, 40mm threaded, operating pressure 0-4 bar. Body CSteel ASTM A216 WCB or SS316. Seal FKM. Max flow 250 L/min.

Strainers (YS1, YS2): Y Type, before pump suction. 50mm flanged RF, ANSI 150#, SS316 filter (400µm). Body CSteel ASTM A216 WCB or SS316.

Check Valves (CV1-CV5): Swing type, 40mm female threaded. CSteel or SS316.

Foot Valve (FV1): Spring loaded type, double poppet, 50mm female threaded. CSteel or SS316 with strainer.

Ball Valves: 50mm (flanged RF, full bore, lockable handle), 40mm/25mm/20mm (female threaded), 65mm (female threaded). CSteel or SS316, reinforced PTFE seat.

Gate Valve (GV1): Non-rising stem, multi turn, 25mm female threaded.

Relief Valve (PRV1, PRV2): Spring loaded, auto inline, 40mm female threaded. Body CSteel or SS316, seat/disc SS316. Operating pressure approx 2.5 barg, max flow >250 L/min.

PART 3 – EXECUTION

3.1 TESTING & COMMISSIONING OF FUEL SUPPLY NETWORK

Field tests in presence of Engineer. Contractor records all values, provides 3 certified copies.

3.2 TRAINING REQUIREMENTS

Operational training to each shift of Employer/End user: Control Panel operation, manual and abort functions, trouble procedures, supervisory procedures, auxiliary functions, emergency procedures.

3.3 OPERATION AND MAINTENANCE MANUALS

Four copies. Piping isometrics, written description, checklists, troubleshooting.

3.4 AS-BUILT DRAWINGS

Four copies. One reproducible engineering drawing.

3.5 WARRANTY

Min 1 year replacement warranty for equipment including motors, pumps, valves, strainers, flow meter, sensors, flow switch, pressure gauge, control. After-sales service, trouble shooting, parts replacement included.

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0690 – LIFTS

PART 1 – GENERAL

1.1 GENERAL

Lifts as indicated. Contractor engages specialized Sub-Contractor/Authorized Distributor ('Supplier'). Submittals: technical data sheets, outline drawing, printed technical literature.

1.2 SCOPE OF WORK

Two lift (Duplex arrangement). Capacity 1000kg, 11 stops/11 openings, speed 1 m/s, cabin size 1600×1400×2300mm (W×D×H), entrance width 900mm, approx. total travel height 42m. MRL type, indoor type suitable for ambient condition of 45°C. Scope includes design, supply, installation, testing, commissioning, maintenance during defect liability period: hoisting machinery, sheaves, girders, controller, car, ropes, counterweights, supports, brackets, guides, car & landing doors, door operator, switches & control, safety devices, signals, governor, safety gears, buffers, pit screens, separator beams, well trimming girders, pit access ladder. All labour, erection plant, tools, embedded parts. Civil works for embedded parts and making good. Electrical cabling from designated power supply point. Maintenance during defect liability period. Training. Operating and Maintenance manuals (3 copies each).

1.3 APPLICABLE CODES AND STANDARDS

BS 5655/EN 81 Parts 5,6,8,9,10 with Appendices, EN 81-20, 81-50 and 81-70; ISO 4190-1; AWS B3.0, D1.1; NEMA-1CS6; NFPA 70, ANSI-A17.1; AISC Manual; Building Code of Pakistan (Seismic Provisions 2007) Chapter 11; International Building Code (IBC) Chapter 30.

1.4 ORIGIN OF SUPPLY

KONE, SCHINDLER, OTIS, DOPPLER, THYSSENKRUPP. Major components manufactured in manufacturer's own plants.

ORIGIN: WESTERN EUROPE

PART 2 – PRODUCTS

2.1 PAINTING

Preparation: Blast cleaning to remove rust/grit. Stainless steel, aluminium, bronze, machined surfaces protected. **Application:** Dry, dust-free, temperature $\geq 45^{\circ}\text{F}$. First coat immediately after cleaning. Each coat thoroughly dried before next.

2.2 MATERIALS & WORKMANSHIP

Highest grade, unused. Workmanship per best modern practice. All parts accurate to American Standard or approved gauge.

Structural Metal Work: Per AISC Specifications. Surface finish ANSI B64.1. No sharp kinks, bends. Shearing accurate. Re-entrant cuts filleted. Bends with approved dies or rolls. Low-carbon steel may be flame-cut.

2.3 LIFT CAR

Construction of New Air Traffic Control Tower (ATCT), Fire Station and Allied Facilities at Skardu International Airport, Skardu.

Car Frame & Platform: Welded or bolted steel channel sections. Deflection under contract load $\leq 1/1000$ of span under static conditions. Guides mounted on car frame. Platform fabricated frame, sheet steel underside. Rubber pads for sound/vibration isolation. Aluminum sill with grooves, toe-guard.

Car Body Work: Steel construction. Roof withstand weight of two men without deformation. Roof trap door with micro-switch, emergency communication. 3 pin socket outlet on car top, two outdoor protected lights at bottom and top operated via MCB.

Finish: Recessed kick plate 100-150mm stainless steel on three walls. Floor sheet steel sound-isolated platform with granite flooring. Rear wall laminated safety glass 12.5mm where required. Ceiling removable with modular light fittings, emergency exit with safety switch. Handrails on side walls stainless steel hollow section. Protective padded canvasses for cargo lift (hook-on type) with stainless steel hooks.

Telephone: Telephone compartment in front return panel above car operating buttons. Stainless steel satin/hairline finish, hinged door. Telephone set connected to control room via controller (or intercom with auto dialing).

Car Ventilation: Motor-driven propeller fan, discharge through concentric ring louver in ceiling center. Rubber mounting. Fan motor 220V, 1Ph, 50Hz with manually operating switch in car station.

2.4 LANDING DOORS

Two-panel centre or side opening stainless steel doors per technical data sheet. Frames and architrave stainless steel satin/hairline finish. Fire resistance rating ≥ 1 hour. Toe-guard apron at hoistway entrance (sheet steel, ≥ 16 gauge, extends ≥ 50 mm beyond jamb each side, ≈ 600 mm deep). Frames 14 SWG min, panels/fascia/toe-guards/hanger covers 16 SWG. Interlock per code, prevents movement until doors locked, prevents opening from corridor side unless car at landing or in leveling zone. Unlocking device per ANSI A17.1 or BS 5655 part 1.

2.5 CAR DOORS

Two-panel centre or side opening stainless steel. Door-gear operated by VWF AC drive. Retractable car door coupling. Door frame stainless steel satin/hairline. Full Width Light Curtain: from 25mm above floor to 1600mm, transmitter/receiver strips, reverses door motion if any ray interrupted; self-calibration. Door opening timing feature (adjustable reduced hold open time; buzzer and reduced speed close if door remains open). Door operator variable speed variable voltage, smooth acceleration/retardation, no dashpots. Closing force per BS 5655 Part 1.

2.6 HOISTING EQUIPMENT

MRL type. Permanent magnet gearless drive with motor, brake, other parts on steel bed plates. Manual operation with smooth-rimmed detachable spoke-less wheel.

Motor: VVVF, duty cycle min 180 starts per hour. Drip proof enclosure, force ventilated if needed. Leveling accuracy ± 5 mm.

Brakes: Spring actuated, electrically released. Two self-aligning shoes. Instantly applied on power interruption. Capable of bringing car to rest smoothly at max load and speed, sustain static load 150% of contract load.

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Controller: Fully microprocessor based, full collective mode. Features: correction drive, phase failure detection, recall drive, drive time supervision, door zone indication, elevator position synchronizing, accurate re-leveling, stuck push button supervision. Meets EN-81.

2.7 HOIST-WAY EQUIPMENT

Suspension Ropes: High-grade steel per BS EN 12385-5, material per BS EN 10264-1. Rope terminals per BS 461. Independent adjustment for each rope. Automatic device for equalizing tensions.

Guides: High quality T section steel. Joints spigotted, machined steel fish plates. Securely fixed by steel brackets bolted to metal inserts. Deflection $\leq 3\text{mm}$ under normal operation.

Counterweight: Weight equal to car + 40-50% specified load. Structural steel frame, cast iron weights. Guide shoes.

Safety Gear and Governor: Friction type progressive safety-gear actuated by centrifugal over speed governor, bolted to car frame under platform. Governor wire rope $\geq 8\text{mm}$. Tension weight with electrical safety device. Two electrical switches: first reduces speed, second cuts off power and applies brakes if speed not controlled. Mechanical trip causes governor jaws to grip rope, bringing safety gear into operation, bringing car to rest gradually.

Buffers: Oil buffers of spring-return type in pit under car and counterweight. Stroke based on retardation of 10 m/sec^2 at 115% contract speed. Max retardation 25 m/sec^2 . Mounted on continuous channels anchored to pit floor. Self-setting with safety device.

Final Limit Switches: Automatic device to bring car to stop at terminal landings independent of regular operating devices. Conform to BS 5655 Part I.

2.8 CONTROL SYSTEM

Microprocessor based electronic solid state. Operational mode per technical data sheet with emergency operation and fireman switch. Parking feature returns car to main floor when no calls. Load weighing: dispatching in advance when car filled to $\sim 80\%$ capacity; buzzer for overload. Automatic leveling within $\pm 6\text{mm}$. Independent operation from car buttons only (key operated switch). Emergency features: emergency power transfer (stand-by generator), intercom with control room, earthquake control (seismic detector brings cars to stop at next floor, opens doors), automatic power evacuation device (brings car to next floor, opens doors on power failure), hand winding system for manual operation, fireman switch at ground floor lobby (cancels all calls, stops at designated parking floor, opens doors, alarm sounds).

2.9 SIGNALS & FIXTURES

Integrated Hall Indicator: Digital car position indicator, illuminated/digitalized arrows, two-tone electronic gong.

Landing Call Station: Call buttons micro-movement, stainless steel pressel, translucent surround illuminates on call acceptance. Faceplate stainless steel 2mm thick, tamper resistant screws.

Car Station: Integral with front return, 1.6mm stainless steel satin/hairline. Hinged full height front panel with secret release. Features: alarm button, floor buttons for each floor, open door/hold-on button, key operated car independent service switch, key operated fan switch, digital car position indicator and direction arrows. Car call cancellation feature (press floor button twice).

2.10 TECHNICAL DATA (per lift type)

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Lift Type: Traction type passenger lift, Duplex, MRL. Quantity: 2 Nos. Capacity: 1000 kg. Cabin Size: 1600×1400×2300mm (W×D×H). Speed: 1 m/s. Stops/Openings: 11/11. Approx. total travel height: 42m. Entrance width: 900mm. Machine: Permanent magnet gearless VVVF drive. Control System: Microprocessor based, full collective. Standards: EN 81-20, EN 81-50, EN 81-70. Ambient design condition: 45°C (indoor). Shaft Ventilation & Cooling: Air conditioning unit of 2 TR cooling capacity per lift shaft, operable at ambient temperature of 50°C (Make: Trane/Mitsubishi/Samsung); propeller-type exhaust fan of 800 CFM per lift shaft.

PART 3 – EXECUTION

3.1 INSTALLATION

Comply with applicable standards, manufacturer's instructions. Electrical work per NFPA 70 or approved equivalent. Civil works: cutting holes, chases, openings, making good. Supports, beams, ladders for machinery, guide brackets, doors, buffers. Cement/concrete for grouting-in brackets, bolts. Scaffolding and protection. Welded construction for installation unless bolted connections required. Welding per AWS. Rotating/vibrating equipment on vibration-absorption mounts. Lubrication per manufacturer. Alignment of hoistway entrances with guide rails. Sill unit set accurately aligned, slightly above structural floor. Painting, retouching, refinishing after installation.

3.2 TESTING AND INSPECTION

Per BS 5655 Part 10. Tests include: functioning of all systems/devices and controller, operational test of all safeties, motor test, earth fault test, insulation resistance test. Periodic re-examination during defect liability period.

3.3 WARRANTY

Min 1 year replacement warranty from TOC for complete equipment including machine, controls, other components.

PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0700 – FM-200® FIRE SUPPRESSION SYSTEM AND FIRE ALARM & DETECTION SYSTEM

PART 1 – GENERAL

1.1 GENERAL

FM-200® Fire Suppression System and Fire Alarm & Detection System. Contractor engages specialized Sub-Contractor/Authorized Distributor ('Supplier'). Submittals: technical data sheets, outline drawing, printed technical literature.

1.2 SCOPE OF WORK

Fire Alarm & Detection System complete with control panel, automatic detectors, manual pull station, notification appliances, abort switch, zone disable switch, manual release station, agent release module, relay module, monitor module, remote alarm LED. FM-200® or HFC-227ea total flooding fire suppression system complete with cylinder assembly, cylinder manifold, factory filled containers equipped with discharge valve, safety plug/burst disc, fill port, impulse valve operator/solenoid valve, low pressure supervisory switch, discharge pressure switch, liquid level indicator, pressure gauges, discharge nozzles, black steel schedule 40 piping with accessories, painting/finishing, caution signs, performing room pressurization tests, coordination with general contractor for closure of openings/leakages and sealing of protected spaces.

1.3 APPLICABLE STANDARDS AND PUBLICATIONS

NFPA 2001 (Clean Agent Fire Extinguishing Systems), NFPA 70 (National Electrical Code), NFPA 72 (National Fire Alarm Code), NFPA 101 (Life Safety Code), FM Approvals, Underwriters Laboratory.

1.4 QUALITY ASSURANCE

Manufacturer: Min 10 years experience. All devices/equipment UL listed or FM approved. Locks for all cabinets keyed alike.

Installer: Trained by supplier. Certified special hazard designer. Min 5 years experience. Access to clean agent recharging station. Authorized stocking distributor. 24/7 emergency service.

1.5 SUBMITTALS

Field installation layout drawings (scale $\geq 1/8"=1'-0"$). Separate layouts for each level. Isometric details of agent storage containers, pipe runs, sizes, material, gauge. Hydraulic flow calculations from UL/FM Approved Flow Calculation Program (total discharge time by zone). Description of occupancies and hazard. Electrical layout drawings with point-to-point conduit runs. Internal control panel wiring diagram. Battery standby power calculation. Sequence of operation. Submit to local Fire Prevention Agency and authorities having jurisdiction.

1.6 ORIGIN OF SUPPLY

Imported from USA, Western Europe or Japan, or license from same with guarantee. All devices UL listed or FM approved.

PART 2 – PRODUCTS

2.1 FM-200® FIRE SUPPRESSION SYSTEM

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System Description: Total flooding, uniform concentration per NFPA 2001. Minimum design concentration 8.1% by volume, max 10.5% in occupied spaces unless evacuation provided. Includes agent storage containers, FM-200® agent, system actuation equipment, discharge nozzles, pipe and fittings, caution/advisory signs, functional checkout, testing, training. Capable to shut down HVAC power, HVAC dampers, ventilation, lighting, electronics per NFPA-2001. Minimum two inspections in first year (6 month intervals). Contractor responsible for sealing protected spaces against agent loss during 10 minute “hold” period.

Sequence of Operation:

- One detector: “ALARM” lamp, alarm bell/visual indicator, auxiliary functions (door closures, signal to fire alarm system, HVAC shutdown).
- Second detector: “PRE-DISCHARGE” lamp, pre-discharge horn/strobe, HVAC shutdown, time-delay sequence (≤60 seconds), abort enabled.
- After time-delay: “RELEASE” lamp, shutdown of high-voltage equipment, visual indicator outside hazard, “System Release” audible.
- Manual actuation bypasses time delay and abort functions. Manual discharge station electrical actuation type, supervised.
- “PRE-ALARM” feature for early warning.

Parameter	Specification
Agent	FM-200 (HFC-227ea) — Clean Agent per NFPA 2001
Protected Areas	ARFF Cab (Drawing FF-06) and ATCT Cab (Drawing FF-07) — both circular plan areas
Application Method	Total flood system for specified enclosed spaces
Scope	Supply, installation, testing and commissioning — complete system
Pre-discharge Alarm	Minimum 30-second pre-discharge alarm with manual abort at each protected space
Compliance	NFPA 2001 — Standard on Clean Agent Fire Extinguishing Systems

Material and Equipment: Pipe: ASTM A106 Gr. B, Schedule 40, seamless black steel. Fittings: ASTM A-105/A-234 standard, Class 300. Nozzles: manufacturer’s standard stainless steel or aluminum, 360° or 80° pattern, UL/FM/LPCB approved. Signs: instruction signs per NFPA, durable plastic with adhesive.

FM-200® Storage and Distribution: Each protected area separate supply. Welded steel painted containers, UL/FM approved. Discharge valve assembly with fast acting rupture disc, safety plug, fill port, pressure gauge, low pressure supervisory switch, discharge pressure switch, level indicator. Steel retaining brackets. Discharge nozzles distribute agent. Piping per NFPA, securely supported with UL listed hangers. Reducing fittings only (no reducing bushings). All pipe reamed, blown clear, swabbed with solvents before assembly.

Caution and Advisory Signs: Entrance sign at each entrance, Manual Discharge sign at each manual discharge station, Flashing Light sign at each exit from protected space.

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Room Data Sheet: Primary Data Center (Level-2 including room void & ceiling void), Secondary Data Center (Level-2 including room void & ceiling void).

2.2 FIRE DETECTION AND ALARM SYSTEM

Addressable Fire Alarm & Fire Suppression Control Panel: Supervise monitors detectors and modules. Detect activation location, operate notification appliances and auxiliary devices. Annunciate trouble/supervisory/alarm. Acknowledge, signal silence, system reset switches. Expandable, each loop supports min 127 analog/addressable devices.

Enclosures: UL-listed cabinet, 0.060 steel, key lock, transparent opening, right or left hinged, modular. Power Supply: 230V AC, 50 Hz. Battery charger for 24 hours standby (48 hour recharge). Low frequency sweep earth detect circuit. Remote alarm and fault monitoring at main fire alarm control panel.

Notification Appliances: 24 VDC, field programmable, ≥90 dBA at 10 ft. Strobe lights per UL 1971, fully synchronized, max pulse duration 1 second.

Addressable Devices – General: Rotary decimal address switches. Analog and addressable. Integral short circuit isolator (isolate fault in <1 sec). Status LED (flashes normal, steady on alarm). Detector sensitivity adjustment field programmable; automatic compensation for dust accumulation. Listed by UL for calibrated sensitivity test per NFPA 72 Chapter 7. Ceiling-mount with twist-lock base (tamper proof). Test via magnetic switch at detector or remote command.

Intelligent Photoelectric Smoke Detector: Photoelectric (light-scattering) principle.

Intelligent Thermal Fixed Plus Rate of Rise Detector: 135°F (58°C), rate-of-rise 15°F (9.4°C) per minute.

Addressable Monitor Module: Connects one supervised IDC zone of conventional 2-wire smoke detectors or N.O. dry contact devices. 4" square box. Class A or B (Style D or B). LED flashes normal.

Addressable Control Module: Supervises and controls one conventional NAC of 24VDC polarized audio/visual appliances. For fan shutdown, can operate as dry contract relay. 4" square box. NAC Style Z or Y (Class A/B), up to 1A inductive, 2A resistive. Relays Form-C, magnetically latched.

Addressable Relay Module: Form C, min 2.0A resistive or 1.0A inductive. Magnetically latched.

Agent Release Module (ARM): Allows Gas Cartridge Actuators for Clean Agent containers wired in parallel, Class A or B.

Abort Switch: Within protected area near egress, requires constant manual pressure. Manual control overrides abort. Audible and distinct visual indication of impairment.

Zone Disable Switch: Momentary push button, delays agent release circuit when operated prior to circuit actuation.

Manual Release Station: Dual actuation, pull spring clip safety pin (breaking seal), depress button, remains engaged until unlocked with key. Stainless steel housing, red plastic release button with black trim.

LCD Alphanumeric Display Annunciator: Supervised, back-lit LCD, min 160 characters. Displays all alarm/trouble. Up to 32 annunciators per EIA 485 interface. Switches for System Acknowledge, Silence, Reset (programmable for control).

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2.3 BATTERIES AND EXTERNAL CHARGER

Same as Section 0660.

2.4 WIRING AND CABLING

1.5 mm² fire resistant cables with LSZH outer sheath, 120 minutes in fire condition.

2.5 ROOM DATA SHEET

Same as suppression system: Primary and Secondary Data Centers.

PART 3 – EXECUTION

3.1 SYSTEM INSPECTION AND CHECKOUT

Entire system checked out, inspected, functionally tested by qualified trained personnel per manufacturer's procedures and NFPA. All cylinders and distribution piping checked for proper mounting and installation. Complete system functionally tested in presence of Employer/Engineer at least 5 days prior to final acceptance tests. Testing of fire alarm equipment per relevant standards (operational safety, regular functioning, protection against false alarms). Detectors subjected to basic and sensitivity tests.

3.2 TRAINING REQUIREMENTS

Operational training to each shift: Control Panel operation, manual and abort functions, trouble procedures, supervisory procedures, auxiliary functions, emergency procedures. Detailed explanation of wall charts, function of each control switch, periodic operational testing, maintenance of fire logbook, actions upon signals (false alarm, trouble, common alarm/trouble, low battery, field modifiable programming).

3.3 OPERATION AND MAINTENANCE MANUALS

Four copies. All aspects of system operation and maintenance detailed, including piping isometrics, written description, checklists, troubleshooting.

3.4 AS-BUILT DRAWINGS

Four copies, plus one reproducible engineering drawing. Show actual installation details, equipment locations, piping and wiring details, room/facilities modifications.

3.5 ACCEPTANCE TESTS

Submit Test Plan with step-by-step description, type and location of test apparatus. Room pressurization test in each protected space using Door Fan system with integrated computer program per NFPA 2001. If openings found, contractor coordinates with general contractor for sealing. Additional tests at no cost until successful.

3.6 WARRANTY

Min 1 year replacement warranty from TOC for cylinders, valves, switches, sensors, pressure gauges, indicators, detectors, monitor modules, controls, all components.

3.7 SYSTEM INSPECTIONS DURING WARRANTY

Two inspections (6 month and 12 month intervals) per manufacturer's guidelines and NFPA 2001. Certificates submitted.

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PART 4 - MEASUREMENT AND PAYMENT

No payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein. The cost thereof shall be deemed to have been included in the quoted unit rate of other items of the Bill of Quantities.

SECTION 0710 – SPECIAL PROVISIONS (HVAC)

SP-01 GENERAL

SP-01.1 Location of Project

The HVAC system shall be installed at Skardu Airport, Skardu, Pakistan.

SP-01.2 Building for the Project

The building is under construction and HVAC Contractor shall be responsible to point to engineer any omission during Civil Construction with respect to provision of space, Openings in walls floors and roof slabs, false ceilings, drain points and electrical requirements for HVAC Works.

SP-01.3 Use of Building

The Skardu Airport building will have offices, Meeting Rooms, Cafeteria, Executive offices, Non-AC areas, Parking Garages (Fire-Trucks).

HVAC Central Plant Room(CPR) shall be located in another building near the ATCT building, within the utilities building as shown on drawing.

The Contractor is advised to study the architectural, structural electrical and plumbing drawings along-with the specification documents to familiarize himself with the Building Plans/Layout.

SP-01.4 HVAC System Concept

Type of System

The HVAC system for ATCT building is consisting of following HVAC Systems.

a. Water Cooled Water Chiller-Electric (Summer)

The building will be served by a central chilled water system utilizing water-cooled electric chillers during the summer season. This system will provide chilled water to Fan Coil Units (FCUs) and Air Handling Units (AHUs), ensuring consistent and efficient cooling throughout the facility.

b. Hot-Water Generators(HWG)

Given the project's exposure to extreme winter conditions, a hot water generation system will also be incorporated to support heating requirements. During winter operation, hot water will be circulated through the same FCUs and AHUs, maintaining comfortable indoor conditions despite low outdoor temperatures.

The integration of both chilled and hot water systems allows the building to operate efficiently across all seasons. This approach ensures thermal comfort, system flexibility, and reliable performance by using centralized distribution to airside equipment for both cooling and heating functions

c. Ventilation Fans

All Non- AC areas will be ventilated through Supply and exhaust air fans with air ducts.

d. Parking Ventilation

The project location have an extreme winter history, considering this historical weather data the parking is equipped with the FCU;s to maintain indoor temperature slightly higher for vehicle garage,

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to maintain the temperature and vehicle exhaust keeping out of the area, special exhaust system shall be provided to remove the vehicle smoke directly connected with the vehicle exhaust.

This project incorporates a dedicated vehicle exhaust extraction system, commonly used in garage and maintenance workshop applications, adapted here for the airport control tower and fire truck parking areas.

Considering the site's history of extreme winter conditions, the parking facility is equipped with Fan Coil Units (FCUs) to maintain indoor temperatures slightly above ambient levels, ensuring reliable vehicle readiness and operational efficiency.

To maintain acceptable indoor air quality alongside temperature control, a specialized exhaust extraction system will be provided. This system will be directly connected to vehicle exhaust outlets, allowing for the effective removal of fumes at the source and preventing the buildup of harmful emissions within the enclosed space.

This integrated approach ensures both thermal comfort and a safe, well-ventilated environment within the facility.

System Operation

The system will operate from dawn to dusk.

SP-01.5 Service Conditions for Auxiliaries

a) Power Supply

Electrical Circuit Voltages:

Nominal, 3-phase: 415 volts.

1-phase: 240 volts.

For equipment ratings, 3-phase: 400 volts.

1-phase: 230 volts.

Fluctuation in voltage applied (+/-) 10%

to equipment of equipment rated voltage.

Frequency: 50 HZ.

b) Water Supply will be available as directed by the project engineer.

c) Water Disposal: Floor drains provided by others will be connected to sewerage system of the Building.

SP-01.6 Units

The units used in these specifications are as under:

Unit System: British

Gauge: U.S. Gauges as per ASTM

TR: Ton of refrigeration equivalent to 12000 BTUH.

SP-02 WORK BY CONTRACTOR

SP-02.1 Scope of Work

- a) The work under this Contract comprises of all HVAC works including supply, installation, commissioning, balancing, testing and operation /maintenance during Defects Liability Period.
- b) The Contractor shall furnish all labour, materials, equipment, tools, appurtenances, services, temporary work and storage necessary to completely supply, install, commission, test, operate and maintain the heating, ventilating and air-conditioning (HVAC) system and associated works, all in perfect operating condition in accordance with these Specifications and Drawings. The Contractor shall also adjust, balance, and readjust all the air and water systems as specified and shown. The Contractor shall operate and maintain all the system for a period specified elsewhere in these Specifications under Defects Liability Period.
- c) Coordination with other contractors/agencies.
- d) The contractor shall not withhold or delay any of the HVAC works which is independent of the other building trades without prior approval of the Engineer and ensure to swiftly complete the activities during the execution.
- e) Specifications are only general guidelines and by no means cover detail of each equipment. These only spell out the intent of the requirement. The details have to be provided by the Contractor along with details of performance, construction and technical literature with the Tender. The specifications are to be read in conjunction with Drawings.
- f) All equipment and materials shall be brand new bearing stamped ratings as required by Equipment Schedules and must be approved by the Engineer prior to their use. Any doubts about the practicability and implementation of Specifications and details shown in Drawings must be expressed along with submission of Tender. Inability of the Contractor to implement these specifications after the acceptance of the Contract shall be considered breach of Contract.
- g) Following information shall be provided with tender document for Technical evaluation.
 - a. Computer Selection Sheet with Details Listed Below
 - 1. Model Number and Series
 - 2. Power Consumption (Actual)
 - 3. Energy Efficiency Ratio (EER)
 - 4. Seasonal Energy Efficiency Ratio (SEER)
 - 5. Ambient Temp
 - b. Make of Equipment
 - c. Country of Manufacture

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- d. Model Series
- e. Dimensions of Foot Print & Height
- f. Nominal Power Consumption, kW
- g. Energy Efficiency Ratio (EER)
- h. Compliance Sheet shall be furnished, with reference to Specifications and Equipment Schedule, Clause by Clause Compliance Statement with list of deviations if any
- i. Confirmation that detailed technical submittal as specified hereunder will be furnished after Acceptance of Offer for approval by the Consultant.

II. Technical information Required After Award

- a. Technical Submittal for approval
- b. Foundation requirements & sketch
- c. CFD analysis for Parking Ventilation and Smoke Clearance system.

SP-02.2 Services by the Contractor

- a) Erection Supervisor

The Contractor shall provide competent HVAC Erection Supervisor to direct and be responsible for the erection, starting and operation of the Equipment supplied by the Contractor until issue of Substantial Completion Certificate. Further details concerning Erection Supervisors are covered in Clause SP-17, Erection Supervisors and operating staff".

- b) Operation During Defect Liability Period:

If so desired by the Employer, the Contractor shall operate service and maintain complete HVAC system for a period mentioned in and as per requirements of Clause SP-22, Defect Liability Period. The Contractor shall provide all personnel for operation and maintenance including one HVAC Supervisor. Qualifications and experience and number of all these personnel shall be subject to Engineer's approval.

SP-02.3 Erection Plant

Under this clause Contractor will provide erection plant and tools for his own use during erection period only, he would take back these tools on completion.

Tools for maintenance after completion are to be provided under clause TP-10-04, if so desired by the Employer.

The Contractor shall furnish special erection plant and tools in accordance with the requirements of Clause SP-15, "Installation Erection and Maintenance Plant and Tools".

SP-02.4 Related Works

The Contractor shall provide all works related to HVAC system, whether specifically mentioned or not, except those specifically stated in exclusion Clause SP-03, "Work Not Included". These related works shall include, but not limited to :

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- a) Power supply and earthing shall be provided by the Employer and incoming power feeders and earth continuity conductors shall be terminated at location as shown on Drawings and/or as stated in Technical Provisions, Section 7, Electrical Equipment and Controls. All electrical works from these points onward shall be the responsibility of the Contractor including electrical works for Employer-Furnished Equipment.
- b) Water supply shall be provided by others from overhead tank or city water main, in each AHU room and at roof.
- c) All works related to water and cooling coil condensate disposal from HVAC system up to nearest floor drains shall be the responsibility of the Contractor.
- d) Cutting, patching and repairing in accordance with Section 1.0 of Technical Provision (except cutting in concrete walls, floor or roof slabs).
- e) Providing written information regarding location and sizes of door louvers, where required, to the persons responsible for door louvers, through the Engineer. This information shall be provided within 7 days of issue of Engineer's Order to Commence Work.
- f) All wood-work required for satisfactory completion of the project as specified except decorative wood work provided to conceal HVAC equipment. the wood shall be anti-termite treated and should be of suitable type and strength to serve the required purpose with degradation and deterioration under climatic effect.
- g) Providing shop drawings at scale 1/4"=1 Ft (1:50). Design Drawings are indicative only and for bidding purpose. These are not meant for construction / fabrication / installation.
- h) Providing steel frames for inertia pads.
- i) All foundations for HVAC equipment including concrete foundations, housekeeping pads and inertia pads (where required) shall be provided by the HVAC Contractor. Engineer's approval shall be obtained on foundation drawings before construction of foundations. Catalogue cuts showing foundation details will not be accepted.
- j) Coordination with other contractors/agencies.
- k) Contractor shall be responsible for completing and isolating the identified HVAC zones by providing and installing the required hidden minor partition walls etc. Any major and substantial such omission/s shall be timely identified and brought into the knowledge of the Engineer for handling the matter.

SP-03 WORK NOT INCLUDED

Work listed here under which may be required for satisfactory completion of the Project are not included in this Contract and will be provided by the Employer or other contractors appointed by the Employer:

- a) Decorative concealment of HVAC equipment and wood paneling.
- b) Door Louvers

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- c) Protective fencing around HVAC equipment, if required.
- d) Provision of Chases in Concrete Walls/Floors.

SP-04 DEFINITIONS

Not Used

SP-05 DRAWINGS, EQUIPMENT SUBMITTALS, INFORMATION MANUALS, SAMPLES AND CONTRACTOR'S OTHER SUBMISSIONS

SP-05.1 General

All drawings, other information and samples must be supplied to the Engineer as laid down in these Specifications and as and when agreed during site meetings, in the Progress Chart or as instructed by the Engineer.

The Contractor shall submit, for approval, detailed submittals as specified and no material or equipment may be delivered to the job site or installed until the Contractor has in his possession the approved Data Sheet, Catalogue cuts or samples of particular material. Approval rendered on submittals shall not be considered as a guarantee of measurements or building conditions.

Where submittals are approved, said approval does not in any way relieve the Contractor from his responsibility for necessity of furnishing material or performing work as required by the Drawings and Specifications.

Failure of the Contractor in providing submittals in ample time for checking shall not entitle him to an extension of Contract time and no claim for extension by reason of such default will be allowed.

SP-05.2 Omitted Particulars

All works and matters omitted from the Contract but which may reasonably be implied or inferred from them and in the opinion of the Engineer obviously are necessary for the efficiency, stability, completion and maintenance of the works and which are ordered by the Engineer to be carried out shall be executed by the Contractor accordingly as if they had been expressly described in or shown on the Contract documents and the costs thereof shall be deemed to be included in and covered by the Contract Price.

SP-05.3 Drawings

The Drawings show the Scope of Work to be performed by the Contractor. These Drawings shall not be used as a basis for fabrication, construction or installation but shall be used for estimation for bidding purpose only. These drawings are not to be considered defining the design of HVAC equipment to be furnished or defining the exact details of the installation under this Contract, but are only illustrative of the Specifications and HVAC System and show the general layout of the equipment forming part of HVAC System and schematic diagrams explaining the system flow, controls and sequence of operation. These drawings are not to be scaled.

These Drawings do not show every offset, bend or elbow which may be required in the piping or ductwork for installation in the space provided. The routes and sizes (if shown) of ductwork, piping, air inlets and outlets shown on these Drawings are subject to change depending upon the make of major HVAC equipment to be provided by the Contractor. These design parameters shall be adjusted at the shop drawing stage.

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Work shown on the HVAC Drawings and not mentioned in the Specifications, or described in the Specifications without being shown on HVAC Drawings shall nevertheless be held to be included in the Contract in the same manner as if they had been specifically shown upon the Drawings and described in the Specifications.

SP-05.4 Drawings Supplied by Engineer

The Engineer may supply to the Contractor after signing the contract working drawings/detail drawings and instructions as may be necessary for preparing shop drawings and for the guidance of the Contractor in the construction, completion and maintenance of the works, and the Contractor shall execute, obey and be bound by the same.

The Contractor shall not be entitled to any payment in addition to the Contract Price in respect of any work shown or directed to be done by such working/detail drawings or instructions unless the Engineer shall have given and approved a variation order for the same.

Any additional drawings found necessary or desirable by the Contractor to show different combinations of drawings supplied by the Engineer shall be prepared by the Contractor at his own expense. The Contractor shall carefully check all drawings and advise the Engineer of any errors or omissions discovered. The Contractor shall be furnished with one copy of all detail drawings and graphic instructions prepared by the Engineer. Additional copies, within reasonable quantity, will be furnished to the Contractor, upon request, at cost.

The Contractor shall be furnished with one copy of all textual instructions as may be issued by the Engineer.

SP-05.5 Shop Drawings

The Contractor shall make detailed analysis of the requirements of work. Based upon such analysis and working drawings supplied by the Engineer, he shall revise and amplify the Drawings and shall prepare detailed Shop Drawings at his own cost for complete HVAC System and Equipment. Initially he shall submit 2 preliminary copies each of all such Shop Drawings to the Engineer for obtaining approval. Once basic agreement is reached with the Engineer regarding the details then the Contractor shall submit 6 copies each of all such Shop Drawings and one reproducible to the Engineer for record/distribution by the Engineer. After obtaining approval and after having in possession these approved Shop Drawings, the Contractor shall use these Shop Drawings for fabrication, construction and installation.

The work described on any shop drawing submitted shall carefully be checked by the Contractor for all clearances, field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. To this end, the Contractor during the shop drawing stage, shall ensure that he receives drawings of all other trades that might interfere with the proper installation of his work. No payment shall be made for any variations or alterations on site due to lack of knowledge of other trades. Any unresolved conflict between trades shall be referred to the Engineer for decision.

Equipment layout is to be detailed on shop drawings, showing the exact method of installing and clearly illustrating components to be used in making all connections.

The Contractor shall submit shop drawings of all sheet metal work for approval, before work is fabricated and installed. All dampers, splitter dampers, fresh air inlets, exhaust outlets, connections to equipment and methods of support and any other details necessary for the satisfactory installation of the system must be indicated. Each type of grille, register, diffuser and louver is to be referenced in a

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schedule and the type and size clearly indicated at each location. Taper and flat sides of ductwork at all transitions must be indicated, and all equipment piping and ductwork must be located exactly by showing exact dimensions with column lines or other reference lines.

Ductwork drawings must show Clearances between ductwork and masonry. Duct bottom and piping centre-line height from finished floor level shall be marked with every change in level.

Position of hangers and supports with type and method of installation of each hanger shall be given, detailing the type of hanger fixing with a reference number for each type.

Piping drawings must be fully detailed, showing all piping in double line and indicating the precise size of fittings, valves and equipment. Positions of hangers and supports with reference numbers must be given showing the type and method of installation of each hanger detailing the type of hanger fixings with a reference number for each type.

All general layout drawings shall be drawn to 1:50 scale. Details of hangers, methods of fixing of pipes and ducts, detailed cross section of pipe, ducts and risers, details of control and piping hook-ups to equipment shall be drawn to 1:10 scale.

The Contractor shall prepare Drawings and Schedules showing precise details of holes in concrete, masonry, etc. and necessary sleeves required for passage of ducts and pipes and fitting of grills, register diffusers. Louvers, plant, plant supports etc. Drawings and Schedules, approved by the Engineer must be available before any structural work requiring holes or other modifications, is constructed.

Signed and approved drawings shall not be departed from unless a signed variation order or site instruction is issued in writing by the Engineer. Drawings returned to the Contractor for alteration or amendments are to be resubmitted for approval. Amended or altered drawings shall show the nature of the amendment or alteration in a revision block on the drawing, together with revision number or letter and the date of the revision.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other particulars supplied by him whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors, or omissions are not due to inaccurate information or particulars furnished in writing to the Contractor by the Engineer.

SP-05.6 As-Built Drawings /Documents

Before issuance of Substantial Completion Certificate the Contractor shall supply to the Engineer a set of "As-Built" drawings showing the Contract works as installed, together with any other information necessary for operation and maintenance. Six copies of each drawing and other information to be supplied, along with a soft copy (ACADD Format). The Contractor shall also submit 3 sets of bound copies the following for all equipment installed by him:

- 3 sets of bound copies of Manufacturers Equipment DATA/catalogues with final Site settings / adjustment data, Addresses of Source of spare parts and operating parameters and other relevant information
- System Start up Sequence (Summer & Winter)
- Electrical Data / power consumption of each equipment
- Power ratings of each device installed in ACPs / MCCs

- Preventive Maintenance Schedule

SP-05.7 Manufacturer's Data

Manufacturer's performance data, certified factory drawings and/or curves of apparatus giving full information as to capacity, performance at different operating and ambient conditions, dimensions, materials electrical data and all information pertinent to the adequacy of the submitted equipment shall be submitted for approval. One original and 5 copies of catalogues and other information shall be submitted.

Manufacturers' names, sizes, catalogue numbers and/ or samples of all materials shall also be submitted for approval.

Orders for equipment submitted for approval must be accompanied by relevant drawings, curves, technical data, catalogues and samples. Where data, certified drawings or other required information is not available until after orders have been placed, the Engineer shall give provisional approval until all requested drawings and information have been supplied to the Engineer and approved by him. It is the Contractor's responsibility to ensure that all necessary information is supplied to the Engineer in accordance with the progress of works.

Should the Engineer give provisional approval only for an order due to lack of complete information and should the missing information not eventually meet with the approval, the Engineer shall not be held responsible for any delay incurred. For equipment where information from the manufacturers is likely to be delayed, it is essential that the contractor places provisionally approved orders at the earliest possible date so as to ensure approval of orders in complete conformity with the progress of the works.

Submittals and shop drawings should, as far as possible, be complementary so that drawings and submittals can be cross-checked.

SP-05.8 Samples

Contractor shall provide at his cost, samples of materials, instruments, gauges and electrical items, for approval by the Engineer before order is placed for the same. Engineer may waive this requirement, if detailed published catalogues submitted by the contractor, provides sufficient information for approval. These samples shall include, if specified, but not limited to:

- i) G.I. Sheet, each gauge to be used.
- ii) Pipes and Fittings.
- iii) Valves, strainers, pressure gauges, thermometers
- iv) Duct insulation, liner and covering.
- v) Pipe insulation, and covering.
- vi) Insulation adhesive and tapes.
- vii) Diffusers, grilles and registers
- viii) OA/EA Louvers.
- ix) All types of dampers.
- x) Power and Control Cables.

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- xi) Electrical items; push buttons, HOA and toggle switches, pilot lamp.
- xii) Vibration isolating springs, pipe hangers and rollers.
- xiii) Flexible duct connections.
- xiv) Pipe flexible connection/expansion joints (when specified local)
- xv) Air filters (when specified local)
- xvi) Electrical conduits and fittings.
- xvii) Paints
- xviii) Anchor bolts, studs, etc. for hanging arrangements.
- xix) Any other item required by the Engineer

SP-05.9 Copies of Drawings and Specifications

One set of Tender Documents and Drawings will be issued by the Employer to the Contractor free of cost after award of Contract. Additional sets will be provided at cost upon written request to the Engineer by the Contractor. Soft copies in PDF format will also be issued, however copies in A-CAD format will not be issued

SP-05.10 Sound Absorption Data

The Contractor shall provide data for sound from HVAC machinery, air terminals, etc.

SP-05.11 Photographs and Progress Reports.

The Contractor shall arrange, at his cost, colour photographs of Works in progress at Site. At least six photographs per month shall be taken from approved locations, commencing with the first month up to the completion of The Works. A professional camera shall be used. The Contractor shall submit, not later than seventh of each month, a soft copy and six prints of 250x200 mm of each photograph taken during the previous month, with brief report indicating progress of Works to date.

SP-06 APPROVAL OF MATERIALS AND EQUIPMENT

As soon as practicable after award of Contract, the Contractor shall submit for the approval of the Engineer specifications, drawings, catalogue - cuts, diagrams and other descriptive data for all materials, components and equipment which the Contractor proposes for use under this Contract. For certain materials and equipment, data may be required to be submitted in accordance with a detailed form furnished by the Engineer. Items submitted shall be properly labeled to indicate the Contract number, project, manufacturer, source of supply, Contract Item number, and other data required by the Specifications. All items shall be submitted in sufficient time to permit proper consideration and action thereon without delaying the construction schedule.

SP-07 TIME FOR DELIVERY

All equipment plant and machinery shall be delivered at Site on such dates so as to ensure adherence to scheduled dates stated in program of works submitted by the contractor and approved by the Engineer subsequent to award of contract. The Contractor shall keep the Engineer informed of the progress of the shipment and notify them approximately 2 weeks in advance, in writing, as to when the equipment will be ready for inspection at Site by the Engineer and shall supply lists covering each

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consignment in sufficient detail to enable Engineer to check the contents of the packages, if he so desires.

SP-08 STANDARDS AND CODE REQUIREMENTS

SP-08.1 All equipment and materials under HVAC Scope of Works shall be furnished in conformity with latest edition of Applicable Standards of ASME, ASHRAE, ARI, SMACNA, TIMA AMCA CTI and applicable Government and Local Codes governing the same. In case of conflict, the stricter requirements shown/specified shall govern.

SP-08.2 Abbreviations for Codes and Standards referred in the Contract are as under:

ASME - American Society of Mechanical Engineers

1. ASTM - American Society for Testing & Materials
2. ASHRAE - American Society of Heating, Refrigerating and Air-conditioning Engineers
3. NFPA - National Fire Protection Association, USA
4. AHRI - Air-conditioning, Heating and Refrigeration Institute, USA
5. CTI – Cooling Tower Institute
6. SMACNA - Sheet Metal and Air-conditioning Contractors National Association, USA
7. GOVERNMENT- Government of Pakistan
8. LOCAL - Local authorities of the city where Project is located
9. I.E.E. - Institute of Electrical Engineers, London
10. NEMA - National Electrical Manufacturers Association, USA
11. AMCA - Air Moving and Control Association Inc., USA
12. P.S. - Pakistan Standards.
13. B.S. - British Standards.
14. TIMA - Thermal Insulation Manufacturer's Association, USA

SP-09 STANDARDS OTHER THAN THOSE SPECIFIED

Where the specifications provide requirements for material or equipment by specifying a standard such as for example, one of the American Society of Heating, Refrigerating and Air conditioning Engineers which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. Other standards, including standards of other countries, will be accepted provided the requirements thereof, in the sole opinion of the Engineer are at least equal to the requirements of the standards specified. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standards and all other information to demonstrate and prove his proposed standard is equivalent in all significant respects to the standard specified. All submissions must be made in the English language.

SP-10 PERMITS

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The Contractor shall secure and pay for any necessary approvals, permits and inspections from Government or other controlling agencies where applicable as required by law, before commencing any work so as to avoid all delays during erection and turn over the official records of granting of permits to the Engineer. No reimbursements shall be made for such payments.

SP-11 SHOP INSPECTION AND MATERIAL ORDERS

SP-11.1 Inspection

All major equipment to be supplied under this Contract which has been manufactured or shop-assembled in or outside Pakistan shall be subject to inspection (if the Employer so desires) by Employer or its authorized representative at its point of original manufacture or final shop assembly before its dispatch to SITE. The Contractor shall make necessary arrangements and provide all the facilities required for such inspection. Responsibility for the cost of travel, boarding and lodging of Employer, his authorized representative or the Engineer shall be as stated in the Contract.

SP-11.2 Material Orders

Triplicate copies of material or equipment orders required in this Contract shall be furnished to the Engineer. All orders shall state the specification designation under which the material is to be furnished and shall bear reference to the drawing number, if any, pertinent thereto. Orders shall also state that material is subject to inspection and testing and shall show the required date of delivery of the material to destination.

SP-11.3 Acceptance of Materials

The acceptance of any material or equipment prior to shipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective.

SP-11.4 WITNESSING FACTORY TESTS

The Employer will nominate two inspectors to witness the factory tests of following imported equipment in the country of their manufacture:

- Water Cooled Chiller
- Hot-Water Generator
- Cooling Tower (Closed Circuit)

Please refer to Section 0010 for further details.

SP-12 NAMEPLATES

The Contractor shall ensure affixation of the OEM nameplate to each major piece of equipment, a SS metal name and rating plate to be approved by the Engineer, giving the name and address of the manufacturer, the date and rating data. All ratings shall be in the British system. Large lettering on any of the parts will not be permitted.

SP-13 DIRECTED AND REQUIRED ETC.

Unless otherwise stated, wherever in the Specifications or upon the Drawings the words, "directed", "required", "permitted", "ordered", "designated", "prescribed" or words of like import are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription of the Engineer is intended, and similarly the words "approved", "accepted", "satisfactory", or words of like

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import shall mean approved by, or acceptable or satisfactory to the Engineer unless otherwise indicated.

SP-14 SEQUENCE OF ERECTION

The sequence of erection of the Equipment shall conform to the requirements of the civil construction and of the Erection Instructions. Such information will be furnished to the Contractor by the Engineer upon request.

SP-15 FABRICATION, ERECTION, TESTING AND MAINTENANCE TOOLS PLANT & INSTRUMENTS

SP-15.1 The Contractor shall furnish special plant and tools for the complete and proper fabrication erection and maintenance tools, plant and instruments of the HVAC Equipment. Tools shall include the type of tools not normally available in the market as standard tools and is generally manufactured especially for use with the HVAC Equipment. All lifting devices shall be accurately machined to fit the parts to be handled. The wrenches and tools for maintenance, insofar as practicable, shall be mounted on a suitable hardwood or steel board arranged for wall mounting and provided with means for ready identification. The Contractor shall also provide refrigerant charging Plant/ vacuum pump if and when required. No separate payment shall be made for providing Plant and Tools and the Contractor may withdraw the Plant and Tools after its use.

SP-15.2 The Contractor shall furnish and install sign board showing information about the project, name of Employer, Consultant, Engineer and the Contractor, as directed by the Engineer.

SP-16 MATERIALS AND EQUIPMENT TO BE IMPORTED

Not Used

SP-17 ERECTION SUPERVISORS AND OPERATING STAFF

SP-17.1 General

The Contractor shall provide the services of Erection Supervisors and Operating Staff in accordance with the requirements of the Conditions of Contract, of sub- clause SP-02.2 Services by the Contractor, and as specified herein.

SP-17.2 Work by Erection Supervisor

- a) The Erection Supervisor shall direct the activities of Contractor's employees as they concern the installation, commissioning balancing and testing of the Equipment furnished under this Contract and Employer-Furnished Equipment. The Contractor through his Erection Supervisor shall cooperate with other Contractors to whatever extent is necessary to produce an installation satisfactory to the Engineer in accordance with the requirements of the time schedule, the Drawings and the Specifications.
- b) Erection Supervisor shall be present from the Commencement of Work and remain on Site until the issuance of substantial completion certificate by the Engineer.
- c) Should a disagreement arise between other Contractors and the Erection Supervisor, the matter shall be submitted without delay to the Engineer for his decision. Upon such decision, the Erection Supervisor shall proceed with the work in accordance therewith, immediately.

- d) Erection Supervisor shall be a graduate HVAC or mechanical engineer, registered with Pakistan Engineering Council, having at least 7-8 years' experience in HVAC installation works of similar nature.
- e) If the Contractor fails to fulfil his obligations under clause SP-02.2(a) and also fails to provide the Services of the Erection Supervisor having the minimum qualifications as stated in sub-clause (d) of this Clause then the Contractor would be obligated to pay to the Employer an amount of Rs 50000/- per day for the number of days when the services of such Erection Supervisor are not provided. The Employer would be entitled to deduct the amount due from the Contractor in this regard from his running Bill/any payable sums.
- f) Provision of (e) above shall not apply when the Erection Supervisor is on authorized legal leave (casual) , sick leave and official holidays only. His absence upto a period of 10 (ten) days will also be allowed when the contractor intends to replace the Erection Supervisor with the consent of the Engineer.

SP-17.3 Operating Staff

The Contractor shall provide staff to operate the HVAC system continuously for 24 hours a day during the Defect Liability Period including weekly and other gazetted holidays. Operating supervisor shall be a graduate HVAC or mechanical engineer, registered with Pakistan Engineering Council having at least 5 years experience in HVAC operation of similar plant or a 3-year diploma holder from Government College of Technology in HVAC Technology having at least 10 years experience of similar plants with DDC controls. A separate operator of DDC Controls shall also be provided The Contractor shall also arrange to provide proper and complete training comprising of theory class and hand-on practical sessions to Employer's staff to operate, maintain, diagnose and find faults, troubleshoot and repair the HVAC system to the entire satisfaction of the Employer. The training manuals/ course details and the qualified trainers details should be provided to Employer for prior approvals. All costs incidental to providing operating staff including staff salaries shall be deemed to be included in relevant item of Bills of Quantities. No separate payment shall be made to the Contractor for fulfilment of his obligations under this clause.

SP-18 RIGHT TO OPERATE PLANT

The Employer reserves the right to operate any and all Equipment after it has been Commissioned and prior to substantial completion of whole Works. All repairs or alterations found to be necessary during such operation, and required of the Contractor, shall be made by the Contractor at such time as directed by the Engineer. The repairs or alterations shall be made in such a manner and at such a time as will cause the minimum interruption in the use of the Equipment by the Employer.

All operator, maintenance and administrative level passwords shall be shared with Employer.

SP-19 ERECTION INSTRUCTIONS

Erection Instructions in form of published installation manual, as furnished by the manufacturer of all HVAC equipment (when specified) listed hereunder shall be provided by the Contractor.

- 1) Water-Cooled Water Chillers
- 2) Cooling Towers (Close-Circuit)
- 3) Hot Water Generators (HWG)

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- 4) Pumps
- 5) Pressure Boosting System
- 6) Air Handling Units (AHUs)
- 7) Fan Coil Units (FCUs)
- 8) Parking Jet fans
- 9) Fans.
- 10) Automatic Controls

These instructions shall include full and detailed instructions for the guidance of the Erection Supervisor as to all procedures and precautions to be observed in erecting, assembling and adjusting the Equipment and as to the use of the Erection Plant. It shall include or be accompanied by drawings, clearly showing erection marking and particularly any matchmaking and shall embody in particular a full statement as to erection tolerances to be observed.

These shall also include full instructions for the complete operations and maintenance of the Equipment not only during the period of Contractor's liability but more particularly during its operating life. The directions shall be set out simply, clearly and systematically. In particular this section shall include a full list of all routine checks and their timing, directions as to fault finding, detail of all routine attentions (such as greasing), in the form of check sheets for daily, weekly, monthly, quarterly, half-yearly, yearly and any other periodic checks recommended by the manufacturer. This section should also provide detailed and complete instructions for trouble shooting, maintenance and all necessary adjustments to the Equipment Technical leaflets and brochures in respect of all equipment supplied under the Contract including all relays, instruments, switches, controllers, regulators, software, hardware etc., should be supplied with the erection instruction. This should also include complete catalogue of spare parts with exploded views of the equipment and relevant part numbers to facilitate identification and ordering of spares throughout the operating life of the Equipment. The set of operational parameters lists comprising of normal ranges, alert and alarm/ tripping thresholds shall be provided to Employer.

The Contractor shall submit 3 copies to the Engineer for approval.

SP-20 WATER, POWER AND GAS DURING ERECTION AND TESTING

Water, and power supply FOR ERECTION AND Preliminary TESTS shall be the responsibility of the Contractor unless otherwise stated in conditions of Contract. Water, power and gas supply for Balancing & Commissioning, Performance Tests and Reliability Trial Tests and operation during Defects Liability Period will be provided by the Employer. Contractor shall be responsible for the efficient and scarce utilization of these resources.

SP-21 SPARE PARTS

The Contractor shall furnish the essential spare parts as directed by the Engineer and agreed by the Contractor before award of the Contract. The Contractor shall also furnish recommended spare parts selected by the Employer at the applicable unit rates, from the lists provided by the Tenderer. Payment for recommended spare parts will be made from the amount set out in Bill of Quantities against items "Provisional Sum for Recommended Spare Parts". The spare parts listed shall serve all Equipment furnished.

These spare parts shall not be used during Defects Liability Period, or earlier.

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The Contractor shall supply, at his own cost any spare parts required during the Defects Liability Period.

The contractor shall also submit the list of OEM's recommended and critical spares of the plant equipment, mentioning Ex-factory prices to Employer whenever demanded.

SP-22 DEFECT LIABILITY PERIOD

The Contractor shall operate, service and maintain complete HVAC System in accordance with OEM instructions and best engineering practice for a period of 365 days after date of issuance of Certificate of Completion as per directions of the Employer. The plant shall be operated in accordance with provisions of Clause SP-02.2(b), SP-17.3 and as specified herein, and shall include supply of operating staff, consumables, all necessary adjustments, greasing, oiling and cleaning and the furnishing of necessary tools, instruments supplies and parts to keep the system in perfect operation, except such parts made necessary by misuse or neglect not caused by the Contractor. All costs incidental to the above specified Servicing and Maintenance shall be deemed to be included in other items of the Bill of Quantities and no separate payment shall be made to the Contractor for fulfilment of his obligations under this clause with respect to Servicing and Maintenance. The Contractor may withdraw maintenance tools and instruments at the completion of Defects Liability Period.

The cost of operating the plant during Defect Liability Period shall be paid by the Employer to the Contractor under BOQ item named "HVAC System Operation During Defects Liability Period As specified"

SP-23 LICENSE FROM GOVERNMENT

The Contractor shall arrange and be responsible for all tests, test reports and approvals regarding electrical works under this contract, any other works under this Contract requiring tests/Government approvals. All the requirements to be completed for this purpose, whether specified or not shall be at the cost of the Contractor. The Contractor shall handover all test results and approval certificates to the Engineer within one week of obtaining such approval.

SP-24 PERFORMANCE GUARANTEE:

The Contractor shall be required to furnish a Performance Guarantee in accordance with Conditions of Contract.

SP-25 SITE FACILITIES

Except for the Site facilities specifically stated in Conditions of Contract and/or Special Provisions, no other site facility shall be provided by the Employer to the Contractor.

SP-26 SUFFICIENCY OF RATES AND CURRENCY FOR PAYMENT

All the rates and amounts filled in BOQ of the Tender and Appendices by the Contractor shall be deemed to include but not limited to, the cost of items, Import duties taxes and surcharges, Freight, Insurance, local duties taxes and surcharges, clearance charges, inland transportation and insurance, Octroi etc. All payments whatsoever to the Contractor shall be made in Pakistani Rupees, except that letter of Credit for following equipment will be established by the Employer and the equipment will be delivered to the Contractor at site for incorporation in permanent works

- Chiller
- Cooling Towers

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- Hot Water Generators
- Air Handling Units
- Controls
- Pumps
- Fan Coil Units
- Parking Ventilation System
- Staircase Pressurization System

SP-27 IMPORT LICENSE

The Contractor will arrange the import licenses if required for all the imported Equipment, Plant, Tools and Machinery to be incorporated in permanent works except for the items listed in SP-26. All the costs and charges for arranging import licenses for items to be imported by the Contractor will be paid by the Contractor.

SP-28 GUARANTEES AND WARRANTIES

SP-28.1 Performance Guarantee

The contractor shall guarantee the performance of the complete HVAC system, viz.-a viz. his workmanship for the work executed at site, and quality of material, as specified. He shall replace the material/workmanship, whenever found not meeting the specified requirements, at his own cost.

SP-28.2 Manufacturer's Warranties

- a) The contractor shall obtain manufacturer's standard warranties for all equipment extended for a period up to completion of Defects Liability Period at his own cost. In case the completion of Defects Liability Period is delayed, the contractor should obtain further extension of warranties. The contractor shall be responsible for cost of such extension, if the delay is due to his fault, otherwise the cost of such extension shall be reimbursed to him on production of acceptable documentary evidence of such costs.

SP-29 INSPECTIONS AND TESTS

SP-29.1 Inspection by Engineer at Site

The Engineer shall inspect the works in progress at site as and when considered necessary by the Engineer and the Contractor shall provide full access and assistance to the Engineer for carrying out inspection to verify the conformity of works to general lay-out of HVAC System as designed and as shown on Drawings and as specified. Such inspection if made shall not relieve the Contractor from any obligations under the Contract.

SP-29.2 Tests

- A) General
 - i) All Tests as specified shall be carried out unless otherwise specified. The Engineer shall witness the tests.

- ii) All the equipment related testing shall be carried out in the neat and clean environment. Contractor shall be solely responsible for ensuring the required site readiness and environmental conditions to prevent any damage or contamination of the system being tested.
 - iii) Any type of filters soiled or contaminated during testing shall be replaced or made good without any addition cost.
 - ii) The Contractor shall give the Engineer at least seven days' notice in writing of the date on which any equipment will be ready for inspection and/or testing as provided in the Specifications and unless the Engineer shall attend within seven days of the date which the Contractor has stated in his notice the Contractor may proceed with the tests in the Engineers absence and shall forthwith forward to the Engineer five duly certified copies of test readings, on the forms prescribed by the Engineer. The Engineer shall give twenty-four hours' notice in writing of his intention to attend any test.
 - iii) The Contractor shall provide all labour, materials, electricity, fuel, stores, apparatus machines and instruments as may be necessary to carry out tests, unless otherwise specified.
 - iv) The cost of all tests carried out by the contractor under this Clause shall be borne by the Contractor if such tests are clearly intended by or provided for in the Specifications or Bill of Quantities.
 - v) As and when any equipment or HVAC System or part thereof shall have passed any inspection/test the Engineer shall furnish to the Contractor a certificate in writing to that effect.
 - vi) The Engineer may reject any part or parts of Equipment, and HVAC System which he shall after inspection/ testing decide is not in accordance with the Specifications and Drawings and he shall give to the Contractor within fourteen days of such inspection/ testing notice in writing of such rejection stating therein the grounds upon which his decision is based.
 - vii) The test results shall be filled out by the Contractor in the forms proposed by the Contractor and approved by the Engineer. Six copies of filled out forms shall be submitted to the Engineer for review and approval.
 - viii) In case any re-testing is required, same should be conducted as per testing requirements without any additional cost.
- B) Once the inspection/test certificate has been obtained by the contractor, as stated in A(v) above, the contractor shall test and balance the system in accordance with NEBB (National Environmental Balancing Bureau), USA, code of practices. The Contractor shall be responsible for all remedial measures if any, required. The Contractor shall also be responsible for the following:

- i) Supply and fixing of any test hole covers, paint, gauges, gadgets, testing and balancing instruments, or any such thing which is necessary to carry out this work.
- ii) To provide all supervision, labour and materials required to carry out these balancing works.

C) Preliminary Inspection & Tests

Preliminary Inspection/Tests as specified in Technical Specifications shall be carried out on all or any major HVAC equipment (including Employer-Furnished Equipment) and such other equipment as the Engineer may require, on completion of installation of that equipment or at such time which the Engineer may require.

D) Balancing & Commissioning

Balancing and Commissioning shall be carried out on all or any major equipment (including Employer-Furnished equipment), as Specified in Technical Specifications, when such is ready for operation.

E) Performance Tests.

These tests as specified in Technical Provisions shall be carried out on each equipment of HVAC system after successful completion of Commissioning of that equipment, during appropriate season, on the dates proposed by the Contractor and approved by the Engineer. The Engineer keeping in view the weather conditions may fix the test date on any equipment of HVAC system within 6 months of Completion of Commissioning of that equipment.

F) Reliability Trial Tests

- i) During the Defects Liability Period the Contractor shall inform the Engineer in writing of his readiness to commence the Reliability Trial Test of HVAC System or part thereof. Cooling or Heating Tests shall be carried in appropriate season and the Engineer shall, within fourteen days of receipt of such information shall forward his consent for commencement of Reliability Trial Test as specified in Technical Specifications, after having satisfied that all the requirements for such Tests have been completed.
- ii) If any Reliability Trial Test be not fulfilled to the satisfaction of the Engineer, such test shall be repeated at such time as the Engineer may direct.

SECTION 0720 – TECHNICAL PROVISION (HVAC)

SECTION 1 - GENERAL REQUIREMENTS

1-01 MATERIALS

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated, conforming to the requirements of the latest issue of the appropriate specifications cited herein. All materials, supplies, and articles forming part of major equipment and not fabricated by the principal manufacturer of the equipment, shall be the products of the recognized reputable manufacturers.

1-02 WORKMANSHIP

Workmanship and general finish shall be of the highest grade, in accordance with the requirements specified herein, and the best modern standard practice.

1-03 EQUIPMENT

For equipment requirements refer to clause Section 2

1-04 CHASSES AND OPENINGS

The Contractor shall provide shop drawings, templates or details for chases and openings to be left in concrete walls, concrete partitions, floor, and roof slabs to accommodate work under HVAC scope of works. Chases and openings in masonry walls shall be provided and closed by the Contractor.

1-05 PROTECTION

The Contractor shall keep pipe, duct and other openings closed to prevent entry of foreign matter. All fixtures, equipment and apparatus shall be covered and protected against dirt, water, chemical or mechanical damage, before and during the construction period. All fixtures, apparatus, or equipment damaged including damaged shop coats of paint shall be restored to original conditions prior to Commissioning and also again prior to Final Acceptance. All bright finished shafts bearings housings and similar items shall be protected until in service: no rust will be permitted.

1-06 CUTTING, PATCHING AND REPAIRING (EXCEPT CUTTING IN CONCRETE)

Required for proper installation and completion of HVAC works, including masonry work, carpentry work, painting and re-painting shall be performed by skilled craftsmen in respective trades, at expense of the Contractor. Construction shall be cut only after obtaining written permission from the Engineer.

1-07 LINES AND LEVELS

The Contractor shall check dimensions at the building site and establish lines and levels for work specified in Specifications. The Contractor shall check work of other trades to ensure proper clearance of piping, ductwork, conduit and other HVAC items, and report to the Engineer in case he foresees any potential problem in executing his work

1-08 MACHINERY GUARDS

All moving parts of machinery are to be protected by strong guards to adequately protect all personnel working on or in the vicinity of equipment.

Wherever possible, moving parts should be protected by guards supplied by the equipment manufacturer. All guards must be strongly attached to equipment and should be designed for easy removal for access, servicing, adjustment and maintenance.

1-09 not used

1-10 ACOUSTIC TREATMENT

The noise criteria for different areas as per ASHRAE recommendations are to be obtained.

Sound measurements will be made at approximately 1.50 meters above floor level in the occupied area served and not more than 1.50 meters from the grills, diffusers or other air devices being tested. Instruments for sound measurement shall be provided by the Contractor.

All equipment installed should not be audible inside the occupied areas and the Contractor must ensure that all equipment he is offering is quiet and have satisfactory sound levels.

Provision is to be made to minimize noise and vibration. However, different manufacturers equipment have varying sound and vibration characteristics and it is, therefore, the responsibility of the Contractor to ensure that the requirements in these specifications are fully met by the equipment he is offering. If the Contractor has any requirements for additional vibration or sound isolation to meet specified noise criteria, these must be incorporated into the price quoted. Where silencers are required, these must be incorporated into the price quoted.

1-11 ACCESS PANELS

The Contractor shall mark locations of, and give sizes of, access panels required in false ceiling and wall panelling (where applicable) for adjustment and maintenance of HVAC Equipment, such as Dampers, Fire Dampers, valves, ceiling-hung equipment, etc. This information shall be provided to the Engineer before commencement of false ceiling work by the concerned persons.

1-12 SEALING OF OPENINGS

The contractor shall seal all openings in external walls and roof where HVAC ducts/pipes penetrate in external membrane. The sealing shall be air tight and water tight and non-deteriorating type to prevent penetration of outside air and water into building. The method and materials for sealing shall be subject to Engineer's approval. All these sealings shall be subjected to wet testing and satisfactory performance.

SECTION 2 - EQUIPMENT

2-01 GENERAL

2-01.1 General Requirements

All equipment shall be of such overall dimensions, operating weights, service area requirements and configuration that it can be located where shown on the plans without any adverse effect on its performance and clearance requirements. Any change in other trades work, anticipated by offering alternate equipment, shall be estimated by the Contractor and its cost shall be included in the quoted price for HVAC Works.

Provision for clearance and service spaces shall be made around all mechanical equipment as recommended by equipment manufacturers.

All equipment supplied under this section shall be brand new, factory manufactured and factory assembled (unless otherwise specified) and complete in all respects. The type, characteristics, capacity ratings, component sections of all equipment shall be as Scheduled.

All equipment furnished by the Contractor shall include vibration isolation mounting pads, anchor bolts, frames or any other mounting or supporting accessories.

All power-driven equipment shall include drives, motors and adjustable motor foundation bases and accessories including machinery guards where applicable.

All equipment shall be complete with all accessories necessary to serve the intended purpose, whether specified or not.

All equipment installed on roof or intermediate floors shall include suitable vibration isolators to prevent any vibration traveling to building structure.

The Heating, Ventilation and Air Conditioning (HVAC) systems shall be designed, selected, and installed to operate satisfactorily under the climatic and environmental conditions prevailing at Skardu International Airport, ensuring continuous, reliable, and energy-efficient operation throughout the year. All HVAC equipment capacities and performance ratings shall be corrected for the reduced atmospheric pressure and air density associated with the project site elevation. The minimum outdoor design conditions shall be as follows:

Summer Design Condition

- Dry Bulb Temperature: 34°C
- Wet Bulb Temperature: 18°C
- Mean Daily Range: 16–18°C
- Relative Humidity: 25% (approx.)

Winter Design Condition

- Dry Bulb Temperature: –18°C
- Wet Bulb Temperature: –18°C
- Relative Humidity: 50–60% (approx.)

Site Elevation: Approximately 2,230 m above Mean Sea Level

Indoor Conditions:

- Indoor Cooling Condition: 24°C ±1°C.

- Indoor Heating Condition: 22°C ±1°C.

All HVAC equipment shall be selected and rated for operation at the project site elevation. The Contractor shall submit manufacturer-certified performance data and capacity correction calculations demonstrating compliance with the specified design conditions. HVAC systems serving critical operational areas, including the ATC Operations Room, Equipment Rooms, UPS Rooms, and Communication Rooms, shall be designed for continuous 24/7 operation.

2-01.2 Equipment Requirements

- For ratings and characteristics of manufactured equipment, Equipment Schedule as appended to Technical Provisions shall be followed.
- All equipment shall be manufactured by companies which have had at least ten years previous experience in the design and manufacture of equipment of comparable type, capacity and operating conditions, having same distributor for last 5 years in Pakistan. Contractor shall procure all imported equipment through local distributor. The Engineer may issue a waiver to this clause if considered necessary by him
- Where the requirement of this Clause make any equipment proprietary or non-obtainable, the Engineer reserves the right to waive any portion or portions of it as required to obtain the intent of the technical specifications (s).
- When a manufacturer's product is specified by name, or equivalent, it shall be in the sole judgment of the Engineer as to acceptability of any product which is offered as equal to that specified.
- Where two or more units of the same class of equipment are furnished, product of the same manufacturers shall be used, unless otherwise approved by the Engineer: component parts of entire system need not be product of same manufacturer.

2-02 WATER COOLED SCREW TYPE WATER CHILLER

2.02.1 General

- The Water-Cooled packaged chillers shall be High Efficiency type robust construction units & shall consist to Twin Screw serviceable semi-hermetic rotary Screw CE listed compressors, factory mounted and tested variable frequency drive, cooler, condenser & Micro-processor based controls.
- All controls necessary for automatic operation shall be mounted, on each machine. Each machine shall be shipped completely charged with refrigerant & with lubricating oil.
- The chillers shall be suitable for installation in the spaces provided & spring vibration isolators supplied by the manufacturer of chiller shall be included.
- Each Chiller shall have independent refrigeration circuit. Refrigerant circuit shall have a removable core filter drier in the liquid line, moisture indicating sight glass & electronic expansion valves. The chiller's performance shall be AHRI or EUROVENT, ETL certified & should be tested at certified test bench. The Chillers to be charged with eco-friendly R-134a Refrigerant.

- e) Origin / country of manufacture & make of chiller shall be as specified / as scheduled unless otherwise approved by the consultant / Project Director. The chiller should have a capacity & characteristics as shown in equipment scheduled,
- f) All chillers shall be commissioned under supervision & guidance of commissioning engineer trained in chiller manufacturer factory & certified by manufacturer as commissioning engineer & should have capability to trained Project Director nominated personnel regarding operation of chiller through a minimum 10 days at site training program after successful commissioning of chiller.
- g) All chiller parts shall be painted using standard painting methods of the manufacturer.

2.02.2 Compressor

- a) The packaged chiller shall be furnished with Semi-hermetic Screw type compressor with part winding or star delta and shall have internal thermal contacts for overheat protection. Further the compressor, having improved efficiency, high reliability & lower sound level.
- b) The motor in each compressor shall be cooled by suction gas and shall have additional thermal contacts for motor overheat protection, Compressor shall include integral oil separation system, oil sump & oil filter.
- c) The oil differential pressure shall be controlled during operation to maintain proper oil lubrication throughout the lubrication system. An electric oil heater shall be supplied with each compressor to maintain oil temperature during shutdown period. The heater shall be energized when the chiller is switched off. Compressor shall have a sight glass, suction check valve, suction filter, suction service valve, a discharge check valve & a discharge service valve.
- d) Capacity control shall be step-less type fully automatic with manual option, and shall be fail-safe. Capacity control shall be operated through Modulating expansion valve. Machine shall shut down for oil pressure, chilled water low temperature, refrigerant low pressure, condenser high pressure, compressor discharge high temperature.
- e) Controls shall ensure through lubrication of compressor prior to start and during coast-down after machine stop. Motor shall be protected against drawing more than rated full load amperes.
- f) Controls shall prevent machine restart until after a safe pre-set time.
- g) All controls shall be in a weather tight enclosure, and shall include, but not limited to, power controls for starters, low-voltage control power transformers, terminal strip relays, high pressure and low-pressure controls, low temperature control, motor protection oil pressure control and chilled water temperature controllers.
- h) The compressor motor shall be hermetic refrigerant gas cooled, 2 pole, & squirrel cage induction type with class H insulation. Motor winding shall have thermistors embedded in the motor windings to protect motor from overheating. The thermistors shall be wired to the solid-state motor protection module.
- i) Compressor should have low noise & sound compartment to dampen the sound levels. Sound attenuation compartment should have removable insulated panels with minimum 1" thick insulation & powder coated on external side.

Following should be standard features of compressor.

- Integral high efficiency oil separator
- Suction check valve & service valve
- Integral lubrication system using pressure differential
- Discharge check valve
- Compressor vapor injection available

- Compressor oil sump heater(s)
- Compressor motor protector
- Optical oil level sensor
- Suction Filter

2.2.3 Cooler

- Evaporator vessel shall be ASME Stamped in AHRI case & PED, CE in Eurovent compliant cleanable shell & tube, Shell shall be fabricated from rolled carbon steel sheet with fusion welded seams or carbon steel standard pipes. End plates shall be of carbon steel with precision drilling, reamed in order to accommodate tubes. Intermediate tube support shall be in place to provide required tube support between tube sheets.
- Tubes shall be of copper, seamless, high efficient, internally enhanced & externally finned, mechanically expanded into fixed steel tube sheets. Tube dia shall be ¾ inch & thickness shall be 0.025 inch.
- The evaporator shall have a built in distributor for feeding refrigerant evenly under the tube bundle to produce a uniform boiling action & baffle plates shall be provided to ensure vapor separation. Water box /Head Plate shall be removable for tube cleaning, shall have stub out water connections with Victaulic grooves in compliance to ANSI. Evaporators to be two pass design. Vent & drain plugs are to be provided in water box. The shell side of the evaporator shall have pressure relief valve with provision for refrigerant venting.
- Evaporator's refrigerant side shall be designed constructed in accordance with the ASME, PED for Unfired Pressure Vessels. Evaporator shell side shall undergo pneumatic pressure test at 220psi, shall be designed for working pressure up to 200psi. Tube side shall undergo hydrostatic pressure test at 195psi, shall be designed for 150psi working pressure.
- The evaporator shall have an efficient & reliable oil recovery system. The oil recovery system will ensure the evaporator is operating at peak efficiency at all times & provide optimal energy efficiency during extended periods of part load. All low temperature surfaces shall be factory insulated with 25mm thick Polyethylene resin having K factor of 0.26 btu-in / hr – ft² – °F, Following should be standard features of Evaporator.
 - Evaporator Designed for higher capacity & easy maintenance
 - Cleanable integral fin copper tubes for easy serviceability
 - 1"thick PE foam closed cell evaporator insulation, thermal conductivity 0.040W/m.K at 40°C(0.28Btu in/hr.ft²F at 104 F .)
 - Removable water heads
 - Victaulic groove water connections
 - Drain & vent plugs
 - Carbon steel header ,shell & tube sheet

- The cooler shall be equipped with marine water box.

2.2.4 Condenser

- Condenser vessel shall be cleanable shell & tube. Shell shall be fabricated from rolled carbon steel sheet with fusion welded seams or carbon steel standard pipes. End plates shall be of carbon steel with precision drilling, reamed in order to accommodate tubes. Intermediate tube support shall be in place to provide required tube support between tube sheets.
- Tubes shall be of copper, seamless, high efficiency & externally finned, mechanically expanded into fixed steel tube sheets. Tube dia shall be ¾ inch & thickness shall be 0.025 inch. Water box/ Head shall be removable for tube cleaning, shall have stub out water connections with Victaulic grooves in compliance to ANSI / AWWAC-606. They are to be available in

one, two or three pass design as required on the drawings. Vent & drain plugs are to be provided in water box.

- i) The shell side of the condenser shall have pressure relief valve with provision for refrigerant venting. Condenser refrigerant side shall be designed, constructed in accordance with the ASME/PED Code for Unfired Pressure Vessels. Condenser shell side shall undergo pneumatic pressure test at 220psi, shall be designed for working pressure upto 200psi. Tube side shall undergo hydrostatic pressure test at 195psi, shall be designed for 150psi working pressure. The condenser shall be sized for full pump down capacity. Following should be standard features of condenser.
 - 1. Condenser Designed for higher capacity & easy maintenance
 - 2. Full pump down capacity in condenser
 - 3. Cleanable integral fin copper tubes for easy serviceability
 - 4. Removable water heads
 - 5. Victaulic groove water connections
 - 6. Drain & vent plugs
 - 7. Carbon steel header, shell & tube sheet.

Following shall be standard features of condenser.

- 1. Liquid level float control
 - 2. High Pressure relief valves
 - 3. Economizer usage to boost capacity
 - 4. Refrigerant charge
 - 5. Sight glass with moisture indicator
 - 6. Oil Charge
 - 7. V.I check valves on multiple compressor units
 - 8. Discharge check valves on multiple compressor units
 - 9. Replaceable core filter drier
 - 10. Automatic oil balancing control
 - 11. Charging & gauge connections
- j) The condenser shall be equipped with marine water box.

2.2.5 Refrigerant Circuit

- a) The refrigerant circuit shall include suction & discharge service valves (which facilitate compressor isolation), oil filter, replaceable filter drier on oil return line, sight glass on liquid line, economizer, pressure relief valves on the cooler & condenser, liquid line angle valve for refrigerant charging.
- b) The packaged chiller shall be furnished with electronic expansion valve for precise modulation of refrigerant flow control & improve efficiency by optimizing the suction & discharge superheat while protecting compressors. In addition, the refrigerant control system shall monitor the liquid refrigerant level in the evaporator & restrict refrigerant flow entering the evaporator upon a rise in the level, protecting the compressor from slugging liquid refrigerant. Fixed orifice control systems will not be acceptable. (Option Hot gas bypass shall be factory installed for operation down to approximately 10% of full load.)

2.2.6 Motors & Starters

Motors & Starters shall conform to the Electrical clauses of these Specifications. Full load operation of the motor shall not under any circumstances exceed nameplate KW rating. The chiller manufacturer

shall provide suitable part winding starter for the compressor motor in order to minimize the starting current. The starter shall be factory mounted, wired to the motor & controller. The starter shall be able to provide adequate starting torque & the required acceleration for the compressor during starting. NEMA-1 electrical panel compartment shall include following.

- Compressor MCCB & contactors
- Single point power connection
- Compressor solid state overloads
- Control circuit transformer
- Low voltage/phase failure/phase reversal relay
- Current transformer
- On-off switch in the unit control circuit & each compressor control circuit
- Under voltage/Phase Failure-Phase sequence relay.
- Indicating lights for Compressor overloads High pressure, low pressure, & freeze High motor temperature, Control power
- Safety Protections for High & low pressures, High discharge temperature, freeze protection, Low pressure differential, Low oil level, Compressor run error & over current, Chilled water flow loss, Compressor anti-recycle, Sensor error, Evaporator & condenser refrigerant pressure, Compressor amps (each compressor), Water sensor: Evaporator leaving -Standard sensor to provide temperature readout for water leaving the evaporator

2.2.7 Microprocessor Controller

- a) The packaged chiller shall be equipped with stand along proactive advance controller which adapts to abnormal operation conditions.
- b) Chiller microprocessor-based controller shall be Factory installed, wired & tested RS 485 serial interface with capability of communication with building automation, centralized systems and supervision networks
- c) The unit algorithm program & operating parameters shall be stored in flash-memory. Battery back-up is not acceptable. 115V Power supply to the controller shall be provided by a control transformer provided with the panel. External power source to the controller is not acceptable.
- d) The controller shall be equipped with a user-friendly terminal with color touch screen LED back lit graphical display & dedicated touch keys that provides easy access to the unit operating parameters, control set points & alarm history.
- e) There shall be dedicated physical buttons & touch keys enable user to access information, based on security level of password. There shall be min three level of password for operator, service personnel & for the critical manufacturer settings in order to protect the chiller controller from unauthorized access.
- f) The controller board shall be provided with a set of terminals that connected to various devices such as temperature sensors, pressure transducers, current transducers, solenoid valves, compressor contactors, electronic expansion valve, & controls relays. The controller should be able to configure & connected multiple unit that allow sequencing control without additional hardware.
- g) The controller shall be able to carry out all program operations; it shall be able to display unit operating parameters, compressor information, alarm history & shall able to modify the parameters.
- h) The controller shall be able to carry out its own diagnose test on the controller & the connected devices & alarm messages shall be displayed

automatically on faulty devices. All messages shall be displayed in English language & shall be displayed either in Imperial or SI units. Leaving chilled water temperature control shall be accomplished by entering the water temperature set point with accuracy to 0.8°F & placing the controller automatic control mode.

- i) The controller shall monitor all control functions & move the compressor slide valve to the calibrated position. The compressor loading cycle shall be programmable & shall be adjusted to the building load requirement. The loading adjustable range shall be from 0.1% to 0.4% per increment to prevent excessive demand hike at start up.
- j) The controller shall continuously monitor evaporator leaving water temperature, rate of change of chilled water leaving temperature, evaporator & condenser pressure; compressor amp draw; & discharge refrigerant temperature.
- k) In case of multiple chillers, the controller shall have provision of Master & slave option.
- l) The controller shall be complete with all hardware & software necessary to enable remote monitoring of all data through the addition of an optional web card if accessing the controller via web or network cards if linking chiller to the Building Management Systems. The controller shall be complete with a RS485 long distance differential communications port; the remote connection shall be established by a twisted pair of wire. The electrical control panel shall be wired to permit fully automatic operation during - initial start-up, normal operation, & shutdown conditions.
- m) The control system shall contain the following control, displays & safety devices:

Manual Controls

- Auto/Local/Remote switch
- Control circuit stop & start switches
- Compressor enable switch
- Compressor over current
- Compressor anti-recycle
- Programmable with Seven-day operation cycle

Automatic Controls

- Compressor motor increment contactors
- Start delay timer
- Anti-recycle timer
- Oil sump heater interlock relays
- Master & Slave

Refrigerant Flow Controls

- Refrigerant flow control shall be carried out electronically by a precision EEV
- Liquid refrigerant level sensor for evaporator
- Compressor loading & unloading solenoid valves
- Refrigerant isolation valve package.

Microprocessor Display information

- Leaving chilled water temperature
- Leaving chilled water temperature derivative
- Evaporator pressure
- Condenser pressure

- Compressor amps draw for each compressor
- Compressor elapsed run time of each compressor
- Compressor start status
- Oil level sensor status
- Water flow switch status
- External start/stop command status
- Trend graph for leaving chilled water temp
- Percentage of compressor capacity
- Electronic expansion valve percentage of opening.
- Fault Log & minimum four-week History

2.2.8 Accessories

Following accessories shall be included: -

- Spring vibration isolators for unit frame
- Suction & discharge gauges, oil pressure gauge
- Unit mounted disconnect switch
- Water side flow switch with communication cable
- Victaulic grove coupling for water side connections.
- Built-in pump down unit with complete isolation valve package or provide portable pump down unit with all high-pressure hoses, electric and water connections.
- Portable Compressor oil charging pump

2.2.8 Commissioning & Testing

- a) The pre-commissioning check list to be provided by the commissioning engineer prior commissioning to the installer for proper installation & pre-check the installation prior to start commissioning without any extra charge.
- b) The Contractor shall provide a factory authorized & trained commissioning Engineer, employed by the chiller manufacturer, to perform &/or supervise chiller pressure test (when required), Top-up chiller with refrigerant, place unit into operation, & calibrate all controls in accordance with the manufacture's written start-up, operating, & maintenance instructions.
- c) The Commissioning Engineer shall furnish a start-up log indicating that proper operation conditions, operating sequences & operating & safety control functions are obtained.
- d) The Commissioning Engineer of chiller may recommend specified tests & these test reports shall be submitted to the Consultants by the Contractor in suitable test forms.
- e) Once the chillers) shall be successfully commissioned & the report prepared by the factory authorized commissioning engineer, the final report handed over to the client shall be countersigned by the factory' engineer (placed in the manufacturing plant) for its performance authenticity as per the design performance requirements.
- f) Contractor will ensure that, after unit start-up has been performed & witnessed by client, the Authorized Commissioning Engineer shall be available on site for a period of instruction not to exceed accumulative 36 working hours to instruct the owner's personnel in the proper start-up, operating, & maintenance procedures & hands on training.
- g) All chilled water supply/return connections, power line connections, valves installation, valves & pipeline tagging, electric power & control wiring/cabling to be provided by the installation contractor.
- h) The start-up shall include detailed briefing to operators on chiller operations & maintenance as well.
- i) Installation contractor shall also be responsible to ensure all control interfaces complete in all respect to connect chillers, pumps, VFD's or with any related equipment etc.

2-03 Not-used

2-04 Not-used

2-05 CLOSED CIRCUIT COOLING TOWERS

2-05.1 GENERAL

Provide factory assembled closed circuit cooling towers
Provide factory assembled induced draft closed circuit cooling towers suitable for continuous outdoor operation. The cooling tower shall be complete with heat exchange coil, recirculating spray water system, axial fans, drift eliminators, air inlet louvers, casing, basin, pumps, access doors, and all accessories required for a complete operating system.

Automatic blow-down based on pre-defined TDS/ Salinity value and auto re-filling adjustable float arrangement should be provided with each individual tower. A suitable equalizer line with isolation provision shall be provided.

Units shall be induced draft evaporative fluid cooler type suitable for continuous outdoor duty.

Cooling towers shall comply with latest applicable standards:

- CTI STD-201 Thermal Certification
- CTI Acceptance Test Code
- ASHRAE Standards
- JCI/ JIS, SMACNA and AMCA applicable provisions

Thermal capacity shall not be less than 100% of published ratings under certified conditions.

2-05.2 Construction

Cooling tower casing, fan deck, access panels, and structural members shall be heavy gauge hot dip galvanized steel (minimum casing 14 SWG and galvanization thickness min. 700 g/ sq. meter) , stainless steel 304 or better, or FRP construction unbreakable under wind pressure of minimum 1500 Pa suitable for corrosive outdoor environment.

The unit shall be fully weatherproof and UV resistant.

Access doors shall permit inspection of coil, spray nozzles, drift eliminators, and basin.

2-05.3 Heat Exchange Coil

The cooling coil shall be continuous serpentine type fabricated from seamless steel tube hot dip galvanized after fabrication or stainless-steel construction.

Coils shall be designed for minimum 10 bar working pressure and factory hydrostatically tested.

Coil circuiting shall allow complete drainage and venting.

2-05.4 Spray Water System

Provide heavy duty non-metallic and UV resistant spray piping with removable non-clog polypropylene or ABS nozzles.

Spray pump shall be centrifugal type suitable for continuous operation.

Water distribution shall ensure complete wetting of the coil surface at all operating conditions.

2-05.5 Basin

Cold water basin shall include:

- Make-up connection
- Overflow
- Drain connection
- Strainer
- Anti-vortex suction outlet
- Equalizing connection for multi-cell towers

Basin shall be sloped for complete drainage and cleaning.

2-05.6 Drift Eliminators

Provide multi-pass PVC drift eliminators designed to limit drift loss to maximum 0.001% of circulating water flow.

Eliminators shall be removable for maintenance.

2-05.7 Fans and Motors

Fans shall be axial propeller type with adjustable pitch FRP or aluminium blades.

Motors shall be TEFC minimum efficiency class IE-4, weatherproof type suitable for 415V/3Ph/50Hz operation with Class-F insulation and IP55 protection minimum.

Drive system shall be direct drive or industrial gear drive type. Belt drive shall not be acceptable unless specifically approved.

2-05.8 Access Ladders

- a) An access ladder constructed of hot dipped galvanized iron (700 gm / sq. m) shall be provided for gaining access to the water distributing system & fans. In multiple cell towers where single point access is provided, a safety rail made of hot dipped galvanized iron shall be provided around the tower top periphery.
- B) Provide an access door adequately sized to allow entry into the tower. Alternative means of access shall be provided as appropriate to suit the tower configuration. In multi-cell Towers access door in internal partitions shall also be provided to access middle side cells for maintenance.

2-05.9 Freeze Protection

Provide basin heaters, electric heat tracing, and low temperature controls where ambient conditions require freeze protection.

Fan cycling or VFD control shall prevent icing during winter operation.

2-05.10 Sound Control

Cooling tower sound levels shall comply with project acoustic requirements.

Low sound fans, attenuators, or discharge silencers shall be provided where required.

2-05.11 EXECUTION

Install cooling towers in accordance with manufacturer recommendations and approved shop drawings. Provide adequate service clearances for maintenance and coil removal. Mount units on reinforced concrete foundations with vibration isolation supports where specified.

2-05.12 Performance criteria

- a) Contractor shall furnish manufacture certificate that relate performance of cooling towers will meet contract document requirements, stating entering air wet bulb temperature, entering & leaving condenser water temperature, water flow rates, fan KW (Horsepower), & pump head at base of tower, certification shall be made at the time of submittal.
- b) The cooling tower shall have been tested, rated & certified in accordance with cooling tower institute (CTI) standard 201 or latest JCI standard & shall bear the CTI / JCI certification label & shall be listed in the CTI directory of certified cooling towers.

2-05.13 Testing and Commissioning

Cooling towers shall be factory tested prior to shipment. Contractor shall verify:

- Water flow rates
- Fan rotation
- Motor current
- Basin operation
- Vibration levels
- Freeze protection controls
- Sound levels

Manufacturer shall submit certified performance data indicating:

- Entering and leaving fluid temperatures
- Wet bulb temperature
- Fluid flow rate
- Fan motor kW
- Pressure drop through coil
- Airflow rate

2-05.14 Warranty

Provide minimum five (5) years warranty for fan assembly, drive system, and structural components.

Coil shall be warranted against leakage and material defects.

2-05.15 Spare Parts

Provide manufacturer recommended spare parts list for minimum two years operation including:

Spray nozzles
Fan belts (if applicable)
Bearings
Float valves
Drift eliminator sections
Motor protection devices

2-06 Not-used

2-07 HOT WATER GENERATORS (HWG)

2-07.1 General

The Hot Water Generator (HWG) shall be a fully automatic, forced-draft, dual-fuel fired unit capable of operating on both Natural Gas and Light Diesel Oil (LDO), complete with automatic fuel changeover and all associated burners, controls, safety devices, and accessories. The HWG shall have the heating capacity as specified in the Equipment Schedule and Drawings and shall be factory assembled, tested, and suitable for continuous operation under the specified design conditions.

The HWG shall be of welded steel construction with high-efficiency heat transfer surfaces comprising water tubes or an equivalent approved design. The heat exchanger shall be designed for high thermal efficiency, ease of inspection, cleaning, and maintenance. All heat transfer tubes or equivalent heat exchange elements shall be individually replaceable without requiring major dismantling of the unit. The combustion chamber and heat transfer surfaces shall be readily accessible through removable access doors for inspection, cleaning, maintenance, and tube replacement, where applicable.

The complete hot water generation system, including the hot water generator, fuel storage and distribution system, piping, valves, controls, instrumentation, and all associated equipment, shall be provided with adequate freeze protection measures to ensure safe, reliable, and uninterrupted operation at ambient temperatures down to -25°C. Freeze protection shall include, as a minimum, thermal insulation, heat tracing, enclosure heating, and any other measures necessary to prevent freezing of water and fuel systems.

2-07.2 Trim

The H.W.G. trim shall consist of, but not be limited to, the following items:

- Low water cutoff.
- ASME rated relief valve.
- Automatic gas valve.

- Gas shut off controls in case of failure of ignition.
- Water temperature controls to regulate burner operation.
- Gas line shut off valve
- Gas Pressure Regulator
- Gas Strainer
- Gas Pressure Gauge

2-07.3 Heating Surface

H.W.G. shall be rated not less than 5 Square feet of heating surface per rated H.W.G. horsepower. H.W.G. shall be complete package ready for field installation.

2-07.4 Burner

The burner shall be dual fired and shall be suitable for natural gas with a calorific value of (915 Btuh/cu. ft) and Light Diesel Fuel. The burner shall be integral with the front head of the H.W.G. and shall be high radiant annular entry type for gas. The burner shall burn fuel without objectionable vibration or pulsation with no carbon monoxide in the flue gases. Burner shall have full modulation with automatic return to low fire position on every gas cutoff for re-ignition. The ignition/ pilot shall auto-ignite on the command.

2-07.5 Oil Burner

A single tip retractable nozzle is used for the low-pressure air atomizing burner. Flexible hoses allow easy removal of the nozzle for inspection when it is placed in the vice jaws located on the front door of the unit. The operation range of the oil burner shall be either automatically variable between 35 and 100 per cent of the hot water generator or be equipped with an automatic two or three stage power control, depending on the power demand of the hot water generator. This will result in a higher fuel efficiency during off-peak periods.

2-07.6 Oil Pump

An oil pump with a capacity of approximately twice the maximum burning rate is included. The oil pump is integral with the burner.

2-07.7 Oil Burner Piping

Fuel oil piping on the unit includes oil pressure regulating devices, oil metering controls, solenoid shutoff valves, pressure gauges and fuel strainer, all integrally mounted on the unit. Piping material shall be copper with hard soldered connections.

2-07.8 Diesel Oil Supply System and Safety Arrangement

Diesel valve shall be motorized controlled, spring loaded to close automatically in the event of power failure. The diesel train shall include manual shut-off valve, UV flame detector and diesel manifold pressure gauge. A pre-mix type diesel pilot with automatic electric ignition and

high-tension transformer shall be provided. An electronic detector shall prevent the opening of diesel valve in the absence of pilot flame. Low fire ignition interlock and air flow safety switch shall be provided. An emergency power shut-off switch shall be provided at the entrance door outside the H.W.G. room.

2-07.9 Gas Supply System and Safety Arrangement

Gas valve shall be motorized remote controlled, spring loaded to close automatically in the event of power failure. The gas train shall include manual shut-off valve, pressure regulator, and gas manifold pressure gauge.

A pre-mix type gas pilot with automatic electric ignition and high-tension transformer shall be provided. An electronic detector shall prevent the opening of gas valve in the absence of pilot flame. Low fire ignition interlock and air flow safety switch shall be provided.

2-07.10 Controls

H.W.G. controls to be of a manufacturer, which is adequately represented in Pakistan. A certificate to this effect from H.W.G. controls manufacturer and local agent shall be submitted. H.W.G. controls shall be suitable for intermittent start-stop operation of H.W.G. as the H.W.G. will not be operating 24 hours a day.

2-07.11 Flue Collar

H.W.G. shall have flue collar for connection to Bracing with structural angle flange and bolts.

2-07.12 Controls Panel

The control panel shall be factory fabricated supplied by the manufacturer of H.W.G., mounted on the H.W.G. panel shall include, but not be limited to, control circuit transformer, relays, starters, timers, terminal strip, control circuit fuse, internal wiring, on-off switch, indicating lights, meters for operating hours and number of starts.

2-07.13 Breaching / Stack

The Contractor shall provide welded steel breaching/ stack for size and configuration as required and as per recommendations of the manufacturer. Fabrication shall be by welding using no less than 6mm thick plate conforming to ASTM A36 or A283. Structural angle flanges for breaching and H.W.G. connection shall be provided. Stack shall be terminated as shown on the Drawings

2-08 Diesel Oil Storage and supply system

2-08.1 GENERAL

Provide a complete, fully integrated, factory-engineered Light Diesel Oil (LDO) storage and fuel oil transfer system intended for continuous and reliable operation of mission-critical heating and standby power

systems in severe cold climate and high-altitude environments with outdoor ambient temperatures down to minus 18°C or lower.

The system shall include underground bulk diesel storage tanks, duplex transfer pumps, fuel filtration assemblies, leak detection systems, day tanks, heat-traced piping networks, thermal insulation, controls, monitoring panels, fuel recirculation arrangements, emergency shutoff systems, venting systems, containment provisions, and all accessories necessary for safe, code-compliant, and uninterrupted operation.

The design intent is to maintain diesel fuel fluidity, pumpability, viscosity stability, and combustion reliability under sub-zero ambient conditions while minimizing risk of waxing, gelling, condensation, water contamination, fuel degradation, and operational interruption.

The Contractor shall provide complete design, engineering, coordination, fabrication, installation, testing, commissioning, and documentation in accordance with internationally recognized engineering practices, peer-reviewed industry guidance, manufacturer recommendations, and latest applicable editions of governing codes and standards.

Trace heating systems shall maintain minimum fuel temperature above diesel cloud point and pour point throughout all operational and standby conditions. Heat tracing shall be self-regulating electric type specifically listed for hazardous locations and low-temperature fuel oil applications.

2-08.2 APPLICABLE CODES AND STANDARDS

System shall comply with latest editions of:

1. NFPA 30 – Flammable and Combustible Liquids Code
2. NFPA 31 – Installation of Oil Burning Equipment
3. NFPA 70 – National Electrical Code
4. API 650 – Welded Steel Tanks for Oil Storage
5. API 2610 – Design and Construction of Terminal Facilities
6. UL 58 – Steel Underground Tanks for Flammable Liquids
7. UL 1746 – External Corrosion Protection Systems
8. ASME B31.3 – Process Piping
9. ASME B31.9 – Building Services Piping
10. IEC 60079 – Hazardous Area Classification
11. SSPC/NACE Corrosion Protection Standards
12. International Fire Code (IFC)
13. Local Environmental Regulations
14. Manufacturer's written recommendations

2-08.3 Fuel storage and tank engineering practices

2-08.4 SYSTEM DESCRIPTION

Supply, installation, testing, and commissioning of complete Light Diesel Oil (LDO) underground storage and distribution system including double-wall underground storage tank with leak detection and cathodic protection, duplex transfer pumps, indoor day tank, fuel piping network, self-regulating electric heat

tracing for sub-zero ambient operation (-18°C), thermal insulation, fuel filtration system, valves, controls, alarms, BMS integration, excavation, foundations, supports, commissioning, sizing and all associated accessories in accordance with project specifications, NFPA 30 requirements, and approved shop drawings.

2-08.4.1 UNDERGROUND STORAGE TANK

Provide double-wall underground diesel storage tank complete with:

- Interstitial leak monitoring
- Anti-corrosion coating
- Cathodic protection
- Manway access
- Emergency vent
- Normal vent
- Fill connection
- Level transmitter
- Overfill prevention valve
- Water monitoring probe
- Sloped bottom for drainage
- Thermal insulation where required

Minimum storage capacity shall not be less than 100 hours continuous full-load operation unless noted otherwise.

2-08.4.2 DAY TANK SYSTEM

Provide indoor insulated day tank with:

- Minimum 8-hour operational storage
- Duplex fuel transfer pumps
- Automatic refill controls
- High- and low-level alarms
- Emergency high-high shutdown
- Overflow return line
- Leak containment basin
- Local and remote indication
- Fuel polishing connection

Day tank shall be installed within mechanical room protected from freezing conditions.

2-08.4.3 HEAT-TRACED FUEL PIPING

All exposed diesel piping, valves, filters, pump casings, and accessories subject to low ambient temperatures shall be provided with electric self-regulating heat tracing and closed-cell insulation.

Heat tracing system shall:

- Maintain fuel temperature minimum 10°C above cloud point
- Operate continuously during winter mode
- Be suitable for hazardous classified areas
- Include thermostatic control
- Include circuit monitoring panel

- Include GFCI protection
- Prevent fuel waxing and viscosity increase

2-08.4.4 PIPING MATERIALS

- Underground piping: Double-wall HDPE or coated carbon steel
- Indoor piping: Schedule 40 black steel
- Flexible connectors: Stainless steel braided
- Valves: Full-port ball valves
- Insulation: Closed-cell elastomeric minimum 50 mm thick
- Jacketing: Aluminium weatherproof cladding outdoors

2-08.4.5 CONTROLS AND SAFETY

Provide complete automatic control and monitoring system including:

- Fuel leak detection
- Low temperature alarm
- Tank overfill alarm
- Pump failure alarm
- Emergency stop stations
- BMS integration
- Fuel level trending
- Redundant power supply
- Audible and visual alarms

System shall automatically maintain fuel circulation during extreme low ambient conditions to prevent localized fuel gelling.

2-08.4.6 TESTING AND COMMISSIONING

Contractor shall perform:

1. Hydrostatic and pressure testing
2. Leak testing of double-wall piping
3. Heat tracing continuity testing
4. Insulation resistance testing
5. Functional testing of alarms and controls
6. Fuel transfer performance testing
7. Full operational commissioning under simulated winter conditions

Submit complete commissioning reports, as-built drawings, fuel calculations, equipment data sheets, and O&M manuals prior to handover.

2-08.5 DAILY USE DIESEL STORAGE TANK

The tank shall be horizontal cylindrical storage type with dished heads. The daily use tank shall be mounted on saddles.

Provide a 2700 Liters capacity cylindrical type daily use tank constructed of 4mm thick steel sheet, with channel side saddle supports, 1" NPT drains, 4" NPT inspection/emergency vent ports,

visual fuel level gauge and vent cap as shown on the drawing. Tank exterior shall be finished with oil-resistant textured enamel paint.

Tank connections shall include fuel inlet, fuel supply, vent opening, manual fill, and overflow as shown on the drawing. The tank shall also be provided with a man-hole on the top side for cleaning purpose of adequate size.

Day tanks in buildings and on roofs should be provided with gravity overflow pipes to the bulk tank for failsafe overfill protection. Return flow pumps may be allowed by some codes, however for this application a failsafe method of protection is justified.

The tank shall be installed at the roof of the HVAC plant room on a 4-inch-high concrete pad of base size according to the tank's supports size.

Tank shall be provided with factory fitted ultra-sonic level control sensors along-with the necessary cables to connect with the diesel oil pump set.

The day tank shall be complete in all respect and shall comply all relevant and latest codes and standards Particularly the followings and others. No-Waiver shall be given to contractor/supplier. In-case of any conflict among these, the stringent requirement shall govern.

1. NFPA 30 *Flammable and Combustible Liquids Code*
2. NFPA 30 Flammable and Combustible Liquids Code
3. UL 80 UL Standard for Safety Steel Tanks for Oil-Burner Fuels and Other Combustible Liquids
4. UL-142 UL 142 Aboveground Flammable Liquid Tanks
5. International Fire Code, 2000 Edition
6. Uniform Fire Code, 2000 Edition

2-08.6

DUPLEX PUMP SET FOR DIESEL OIL TRANSPORTATION

Provide and install a factory assembled "Packaged" Duplex Fuel Oil Pump Set. The set shall have all components mounted on a steel base support fabricated of 3/16" steel plate with 3" steel side rails sealed to form a containment basin with 1/2" NPT plugged drain connection. Containment basin shall encompass the entire perimeter of the duplex pump set and no components or factory piping shall overhang. Pipe shall be schedule 40, ASTM Grade A-53 Black pipe with 150#. (Option: Provide a float operated leak sensor with protective shroud in the pump set containment basin to shut off the pumps and energize an audible and visual alarm should a leak be detected.)

Provide bucket oil strainer, sized to produce less than 1/2 PSI pressure drop, through a clean strainer basket with the maximum anticipated flow. Strainer shall be of one-piece cast iron and come complete with level wrench handle.

Provide two (2) Pedrollo peripheral impeller fuel oil pumps, each with a capacity of not less than 50 Lit/Min @ 40 PSIG discharge pressure when operating with No. 2 oil (HSD). Each pump shall be close coupled

to a 1.1 HP 2,900 RPM totally enclosed fan-cooled motor, capable of operating on 220/400 volt, single or 3 phase, 50 HZ electrical service.

Provide two (2) in-line, check valves with metal-to-metal lapped seat and 316 stainless steel springs. Check valve is to have a minimum of 1/2 PSI cracking pressure and to be located on the discharge side of each pump.

Carbon steel ball valves, class 150 shall be provided on both the suction and discharge of each pump to provide pump isolation for service.

One (1) 2 1/2" compound gauge shall be provided on the suction side of system. Gauge shall be liquid filled to dampen pulsation, with bright finish stainless steel case, brass movement, and bronze bourbon tube. Gauge shall read 30" vacuum - 60 PSIG and shall be mounted with isolation ball valve.

Two (2) 2 1/2" dial pressure gauges to be placed on discharge side of each pump. The gauges shall be liquid filled to dampen pulsation, have bright finished stainless steel case, brass movement and bronze bourbon tube. Gauge range shall be based on the fuel oil system operating pressure and shall be mounted with isolation ball valves.

Provide pump set mounted system control cabinet to monitor and control the fuel oil delivery system in response to day tank demand. Cabinet shall be completely pre-wired, tested and shipped as an integrated system to insure jobsite reliability. Control strategy shall be microprocessor-based and utilize a PLC (Programmable Logic Controller). Relay logic is not acceptable. Cabinet enclosure shall be constructed of a minimum of 18-gauge steel, continuously welded and constructed to NEMA 3R standards. Cabinet interior and exterior shall be primed and finished in durable chemical-resistant enamel suitable for industrial environments. PLC shall have sufficient I/O to accomplish all necessary control functions. The control strategy shall be burned into an EPROM at the factory, and shall be safeguarded against re-configuration by unauthorized or unqualified personnel. All cabinet front devices shall be identified by black labels with engraved white lettering. Cabinet shall consist of but not be limited to the following:

- Microprocessor based PLC with pump alternation
- Magnetic motor starters with overload protection
- Motor circuit breakers
- Manual-Off-Auto illuminated mode selector switch for each pump
- Press to test button for all alarms and indicating lights
- Alarm silence / System reset push-button
- Alarm buzzer
- Discrete output for common alarm to interface with the BMS
- System indicating alarms as follows:
 - Power on
 - Pump set leak detected
 - Day tank high level alarm
 - Day tank low level alarm
 - Day tank rupture basin leak detected alarm

The duplex packaged pump set shall be from Pedrollo West Europe or Simplex USA or equal.

2-09 not-used

2-10 PUMPS

2-10.1 CENTRIFUGAL WATER PUMPS.

Base-Mounted, Flexible Coupled, End suction Pump

Pumps shall be of type as specified in Equipment Schedule with casings designed for working pressure at least one and a half times the total pressure on the casing. Flange connections shall correspond to casing working pressure.

Certified test curves of pump performance shall be furnished for approval showing horsepower, total dynamic head, efficiency versus water flow.

Each pump shall be driven by a Variable speed VFD compatible motor through a flexible coupling. Motor horsepower shall be selected in a way that the motor shall not be overloaded at any point on the characteristic curve when operating at design speed. Electric Motors must meet NEMA MG 1 and be the wattage horsepower, speed, and voltage indicated. Motor enclosure must be open drip proof [totally enclosed fan cooled]. Motor must have heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Open drip proof motor efficiencies must comply with ASHRAE 189.1. [Totally enclosed fan cooled motor efficiencies must comply with NEMA MG 1.]. Motor shall be VFD compatible, Motor shall be suitable for variable and low speed operation. Motor shall have shaft grounded ring to mitigate the VFD harmonics.

Each pump shall be guaranteed to circulate not less than the quantity of water against the required circulating head when operating continuously, without overheating the motor or bearings, etc. When more than one pumps are required to operate in parallel, the pumps performance curves when operating in parallel shall be provided to show that required flow at the specified head will be obtained. Pumps shall not transmit vibration to the building and shall operate without producing noise, audible anywhere in the building, outside the space in which the pumps are installed.

Chilled/ hot water and condenser water pumps shall have stainless steel shaft and mechanical seals. Pump impellor shall be Hydraulically and dynamically balance to HI 9.6.4 balance grade G6.3, closed, overhung, single suction, fabricate from cast bronze, key to shaft and secured by a locking cap screw.

Pumps and motor shall be mounted on common base frame and shall have been manufacturer's factory aligned. Baseplate must be of steel construction fully enclosed at sides and ends with welded cross members and fully open grouting area for field grouting. Minimum base plate stiffness must conform to HI 1.3 for horizontal baseplate design standards.

Equip with an integrally flushed mechanical seal assembly or a positive pressure external seal flushing line. Provide a mechanical seal with ceramic seal seat and carbon seal ring. Seal assembly must be rated up to 107 degrees C 225 degrees F.

Provide pumps with capacities as indicated; base mounted, separately-coupled, end suction designed with volute housing mounted to the frame to allow for pump service without relocating the motor or disturbing piping connections. Bearings and seals must be serviceable without disturbing piping. Pump must be factory

hydrostatically tested in accordance with Hydraulic Institute standards and thoroughly cleaned. Incorporate maintenance free, permanently lubricated and sealed bearings in the pump bearing frame. [Regreasable ball bearing type with provision for purging or flushing through the bearing surface and greased while running after start-up.]

Provide a flexible-type coupler between the pump and motor, capable of absorbing torsional vibration and variable speed operation between the pump and motor. The coupler must allow replacement with no need to move the hubs. Coupler must have natural rubber or neoprene type element materials with a maximum misalignment capability of 4 degrees angular and 3 mm 0.125 inches parallel. Couplers shall be rated for required maximum rpm, amperage horsepower and torque. The coupler shall be shielded by a coupler guard securely fastened to the base.

1. The Contractor shall submit all technical data sheets to provide and install end suction centrifugal pumps as scheduled and shown on plans as specified below meeting scheduled capacities and characteristics upon approval of his submission by consultant.
2. Pumps shall be end-suction centrifugal type with casings designed for working pressure at least one & a half times the total pressure on the casing. Flange connections shall correspond to casing working pressure.
3. Each pump shall be driven by a constant speed TEFC squirrel cage motor (Sized 10% higher than the rated pump load) through a flexible coupling. Motor horsepower shall be selected in a way that the motor shall not be overloaded at any point on the characteristic curve when operating at design speed.
4. Each pump shall be guaranteed to circulate not less than the quantity of water against the required circulating head when operating continuously, without overheating the motor or bearings, etc. When more than one pump is required to operate in parallel, the pumps performance curves when operating in parallel shall be provided to show that required flow at the specified head will be obtained.
5. Pumps shall not transmit vibration to the building & shall operate without producing noise, audible anywhere in the building, outside the space in which the pumps are installed. Flexible connections shall be provided at pump suction & discharge.
6. Chilled water, hot water & condenser water pumps shall have bronze impeller, stainless steel shaft, factory painted, safety mesh, & guard with mechanical seals.
7. Pump & motor shall be mounted on machine finished common base frame & shall have been factory aligned & tested for vibration, sound & any abnormal operational signs.
8. All pumps greater than 11 KW (15hp) shall be of horizontal, single stage, double suction (preferably), volume type.
9. Outdoor installed pumps shall be provided with rain protected canopy to avoid the entry of rain water & to avoid the weather effects.
10. Pump efficiency when operating at the specified duty, shall be within 5% of the maximum available efficiency for the particular pump.
11. All pumps, drives & accessories shall be of the highest commercial standard & shall be designed, constructed, rated & tested in accordance with BS 559, Hydraulic institute standards of the USA, latest edition.
12. Pump motor shall be supported by a separate steel base plate & the drive shaft shall be completely protected by a mesh safety screen.
13. The Contractor shall be required to commission the pump as per manufacturer's recommendations. The pump test runs shall be carried out by the contractor & comparison with operational curves submitted to the consultants.

14. The chilled/hot condenser water pump with motor shall be of make & origin as specified.
15. The nominal speed of the pump shall be 1500 RPM, insulation class F and minimum efficiency class IE-4.
16. The contractor shall supply the following information for each pump dully Screw / Revit on pump identification plate of brass / aluminium construction.
 1. Make & model No. _____
 2. Flow rate, US G.P.M. _____
 3. Discharge head FT _____
 4. Size / RPM _____
 5. Impeller Size _____
 6. Manufacturing Date & Place _____
 7. B.H.P. _____
 8. Type of motor & pump _____
 9. Manufacturer performance guarantees certificate & compliance certificate

2-11

Pressurization System

The pressurization system shall be provided as a complete automatic packaged assembly forming an integral part of the closed-loop chilled water and hot water hydronic network. The system shall maintain stable operating pressure throughout all modes of operation, compensate for thermal expansion and contraction of system fluid, absorb minor water losses, and ensure reliable circulation under varying temperature and load conditions.

The pressurization system is intended to protect the hydronic network from low-pressure conditions, air ingress, vapor formation, cavitation, and hydraulic instability while maintaining the minimum static pressure required at the highest point of the piping system. The system shall automatically regulate pressure through the coordinated operation of expansion tanks, pressurization pumps, pressure sensors, and automatic make-up assemblies.

The pressurization system shall form a fully integrated part of the closed-loop chilled water and hot water hydronic network, designed to maintain stable operating pressure, absorb thermal expansion, eliminate entrained air, and ensure continuous, safe, and energy-efficient system performance under all operating conditions. The system shall maintain the minimum static pressure at the highest point of the network while preventing cavitation, vacuum formation, oxygen ingress, flashing, and hydraulic instability throughout seasonal operation.

The complete system shall include duplex pressurization pumps with automatic lead-lag alternation, ASME-rated diaphragm expansion tanks, pressure reducing valves, backflow preventers, make-up water assembly, pressure transmitters, safety relief valves, air separators, automatic air vents, suction diffusers, strainers, thermometers, gauges, drain valves, and chemical dosing or glycol charging connections. The control panel shall include automatic pressure monitoring, low/high-pressure alarms, pump protection, phase failure protection, auto/manual operation, BACnet/BMS interface, and abnormal make-up consumption alarm to indicate potential leakage conditions.

Automatic make-up water or glycol solution shall compensate only for minor operational losses. The system shall include abnormal make-up

alarm monitoring to identify leakage or pressure decay conditions. Expansion tanks shall be sized to accommodate the total thermal expansion volume of the system fluid, considering operating temperature range, glycol concentration, and design pressure conditions.

Expansion tanks shall be sized based on total system volume, fluid temperature range, glycol concentration, and maximum operating pressure. Pressurization equipment shall be installed at the point of no pressure change near the circulation pump suction to ensure hydraulic stability and proper air elimination.

Installation shall include vibration isolation, housekeeping pads, insulated piping, service clearance, flushing connections, drain routing, and complete commissioning. Final commissioning shall include pressure testing, system flushing, venting, balancing, expansion tank pre-charge verification, control calibration, safety valve testing, glycol concentration verification, and operational demonstration prior to handover.

2-11.1 System Components

1. Pressurization pumps (duplex, lead/lag auto alternation).
2. ASME bladder-type expansion tank.
3. Make-up water assembly with:
 - a) Pressure reducing valve,
 - b) Double check/backflow preventer,
 - c) Water meter,
 - d) Isolation valves,
 - e) Solenoid make-up valve.
4. Air and Dirt separator with automatic air vent.
5. Safety relief valve piped to drain.
6. Suction diffuser/Y-strainer.
7. Pressure gauges, thermometers, and pressure transmitters.
8. Low-pressure, high-pressure, and low-water alarms.
9. Electrical control panel with VFD (if applicable), HOA selector, phase protection, and BAS integration.
10. Chemical pot feeder/glycol charging connection for water treatment.

2-11.2 Expansion Tanks

- The Contractor shall provide and install single Package Expansion Tank as shown on plans and specified below meeting scheduled capacities and characteristics.
- Tank shall be procured & provided upon approval of manufacturer data sheets approval by consultant and shall be installed as per manufacturer recommendation in connection with the details shown on drawings.
- Tank should be pre-charged vertical / horizontal steel expansion tank with replaceable heavy-duty bladder.
- Tank shall be fitted or dully Screw / Revit minimum information of Tank Actual Volume, Operational Pressure Ratings, Manufacturer Model, Year of Manufacturing, Origin.
- The tank shall be of Welded Steel design and shall be built, tested and stamped in accordance with the ASME BPV Code Section VIII, Division 1 and rated for working pressure upto 160 psi and working temperatures of 03°C-80°C.
- The shell of the tank shall be constructed with carbon steel finished with grey primer finish.

- The tank shall have top mounted carbon steel connection with flexible internal flow tube.
- The bladder shall be nontoxic replaceable type manufactured with high quality butyl rubber; acceptable volume of bladder shall not accede to 90% of tank capacity.
- Tank shall be externally finished with superior quality long-lasting epoxy paint finish to ensure greater protection against atmospheric corrosion.
- The tank shall also have Air Troll fitting with tank drainer.
- The tank shall also have top mounted auto air vent with air charging valve of dia 1/4" protected with guard.

2-11.3 Air & Dirt Separators

- Furnish & install centrifugal Air Separator as required.
- Contractor shall be responsible to select and submit technical literature with calculation procedure to consultant for its review and approval before ordering and supply of air separator.
- The unit shall have screwed connection upto dia 2 1/2" pipe size & flanged for larger inlet & outlet.
- Connections shall be tangential to the vessel shell.
- Vessel shell diameter to be at-least three times of the nominal inlet/outlet pipe diameter.
- The unit shall have an internal air collector tube with 5/32" (3.9mm) diameter perforation & 60% open area designed to direct accumulated air to the compression tank via screwed connection at the top of the unit.
- The unit shall have removable stainless steel or brass strainer with 3/16" diameter preformation & a free area of not less than five times the cross-sectional area of the connecting pipe.
- A drain connection with drain valve shall be provided.
- The air separator shall be suitable for 125psi (8.5 bars) SVP & 180°C (350°F) in accordance with the Section VIII, Division-I of ASME boiler & pressure vessel code.
- The air separator shall be provided with two coats of anti-rust primer & two coats of stove enamelled paint.

2-11.4 Functional Requirements

- Maintain minimum pressure at highest point of system.
- Prevent pump suction pressure from falling below cavitation limit.
- Accommodate full thermal expansion volume.
- Automatic make-up shall compensate minor system losses only.
- Provide alarm for abnormal make-up frequency indicating leakage.

2-11.5 Installation & Commissioning

- Install at point of no pressure change near pump suction.
- Flush, vent, pressure test, and chemically treat system before operation.
- Verify tank pre-charge, pressure settings, sensor calibration, and relief valve operation.
- Installation shall comply with ASHRAE hydronic design practices.
- The air separator shall be installed in strict accordance with manufacturer recommendations.
- The contractor shall be responsible for the commissioning & testing of the air separator to the satisfaction of the consultants.

2-12 Water Treatment System

2-12.1 Chemical Dosing Units

2-12.2 COOLING WATER DOSING SYSTEM

- The Contractor shall provide continuous drip injection pump type chemical feeder for condenser water system.
- The chemical feeder make shall be subject to Employer's/Consultant's approval.
- Sufficient chemicals for Preliminary Tests, Pre-start & Commissioning Tests & for one year of plant operation after commissioning shall be provided.

2-12.3 CHILLED WATER DOSING SYSTEM

- The contractor shall provide technical data and bases of proposed chemicals and its feeders along with dosing system for consultant review and acceptance prior procuring and solution.
- The contractor shall provide gravity bypass type chemical feeder for chilled water system. Feeders shall be installed as shown on Drawings.
- Gravity Bypass Feeder shall be of 5 US gallon capacity cast iron construction (or MS construction with inside epoxy lining), complete with bottom drain tapping & couplings.
- The make of Feeder shall be subject to Employer's/Consultant's approval.
- Sufficient chemicals for Preliminary Tests, Pre-start & Commissioning Tests & for one year of plant operation after commissioning shall be provided.

2-13 GLYCOL feed system (MAKE-UP AND PRESSURIZATION)

2-13.1 GENERAL

Provide complete factory-fabricated and factory-assembled glycol make-up and pressurization system for closed-loop heating water systems serving air handling units, fan coil units, radiators, heat exchangers, terminal heating devices, and associated hydronic piping systems. The system shall be designed to maintain system pressure, accommodate thermal expansion, compensate for minor fluid losses, provide glycol charging capability, and ensure reliable and stable hydronic operation under all operating conditions.

The Contractor shall furnish all labour, materials, equipment, controls, accessories, supports, interconnecting piping, electrical components, and appurtenances necessary for a complete and fully operational installation.

2-13.2 PRODUCTS

The glycol make-up and pressurization system shall include, but shall not be limited to, the following components:

- Glycol storage and mixing tank complete with calibrated level indication and sealed access cover.
- Duplex glycol feed pumps arranged as one duty and one standby unit with automatic alternation.
- Pressure reducing, regulating, and automatic make-up assembly.
- Expansion tank connection assembly.
- Air separator with automatic air elimination devices.
- Safety relief valve, drain valves, balancing valves, check valves, isolation valves, and Y-strainers.
- Flexible pipe connectors and vibration isolation devices.
- Pressure gauges, thermometers, and pressure sensing devices.

- Low-level switch, overflow alarm, and dry-run pump protection.
- Factory-wired electrical control panel complete with HOA selector switches, alarm indication, automatic sequencing, and BAS interface capability.
- First-fill charging connection with quick-connect hose assembly.
- Chemical pot feeder and glycol sampling/test station.

2-13.3 GLYCOL SOLUTION

Provide inhibited propylene glycol specifically formulated for HVAC hydronic systems. Glycol concentration shall be selected based on project freeze protection requirements and anticipated operating temperatures. The glycol solution shall contain corrosion inhibitors, scale inhibitors, and biological growth inhibitors compatible with system piping, valves, pumps, seals, and heat transfer equipment.

2-13.4 INSTALLATION AND WORKMANSHIP

Install equipment on reinforced concrete housekeeping pads with adequate service and maintenance clearances. Provide complete pipe insulation, supports, anchors, identification labels, flushing connections, drain piping, and venting arrangements. Installation shall be executed in a neat and professional manner consistent with recognized HVAC industry standards and manufacturer recommendations.

Upon completion, the entire system shall be flushed, cleaned, pressure tested, vented, balanced, commissioned, and verified for proper glycol concentration and control operation prior to final acceptance and handover.

2-14 ELECTRIC HEAT TRACE SYSTEM FOR PIPING

2-14.1 GENERAL

Provide complete self-regulating electric heat tracing system for freeze protection of exposed hydronic heating piping, valves, strainers, expansion tanks, pumps, and associated accessories installed in outdoor or unconditioned areas subject to ambient temperatures down to -18°C and high-altitude operation. System shall maintain minimum pipe temperature of +5°C under worst-case ambient conditions. Heat tracing system shall include:

- Self-regulating heating cable
- Power connection kits
- End seals and splice kits
- Thermostats and control panels
- High temperature alarms
- Junction boxes
- Weatherproof insulation cladding
- Identification labels

Heat tracing system shall comply with applicable electrical and energy code requirements.

2-14.2 Heating Cable

Heating cable shall be self-regulating parallel resistance type capable of automatically varying heat output based on pipe temperature. Cable shall be:

- UV resistant
- Moisture resistant
- Suitable for outdoor installation
- Rated for minimum 250V operation
- Suitable for continuous energized operation

Minimum heat output shall be:

- 15–25 W/m for insulated steel piping
- Increased as required by pipe size and insulation thickness

Cable outer jacket shall be fluoropolymer or thermoplastic suitable for wet and corrosive environments.

2-14.3 Controls

Provide electronic temperature controllers with ambient sensing thermostat. System shall energize automatically at +4°C and de-energize at +10°C adjustable setpoint. Provide:

- Local disconnect switch
- Pilot lights
- Ground fault protection
- Alarm contacts for BMS integration

2-14.4 Insulation

All heat-traced piping shall be insulated with closed-cell elastomeric or mineral wool insulation with aluminium weatherproof cladding. Minimum insulation thickness:

- 50 mm for piping up to 50 mm dia
- 75 mm for larger piping
- All insulation joints shall be vapor sealed.

2-14.5 INSTALLATION

Install heat tracing in accordance with manufacturer recommendations. Heating cable shall be installed continuously along bottom quadrant of piping and additionally spiral wrapped where required. Provide separate tracing for valves, strainers, pumps, and flanges. Do not install tracing over expansion joints unless approved connection kits are provided.

2-14.6 TESTING & COMMISSIONING

Contractor shall perform:

- Insulation resistance testing
- Continuity testing
- Functional thermostat testing

- Ground fault testing
- Submit commissioning reports and as-built routing drawings.

2-14.7 Not-used

2-15 Not used

2-16 Not used

2-17 TREATED FRESH AIR HANDLING UNITS

2.17.1 Scope

The scope of this section comprises of the supply of double-skin "Treated Fresh Air Units conforming to the following specifications. The manufacturer or their principals shall have at least 10 years of designing and manufacturing experience directly in the product i.e. energy recovery devices, with a two tier, two air stream unit design. The heat recovery wheel and box should be from the same manufacturer.

2.17.2 Type

The Treated Fresh Air units shall conform to Eurovent or AHRI standards and shall be suitable for outdoor installation, each TFAU unit shall be two stream units in double skin construction, comprising of supply air section, return air section and Heat Recovery Section. The supply air section shall include the following sections if defined in the Schedule: Cooling/Heating Section, Microvee filter section, Mixing Box Section, UVG Section, Sound Attenuator Section, Damper Section, Humidifier Section, and Inspection Section. Option shall be available for Digital Air Flow Measurement, Pressure Transmitter And Filter Cleaning Alarm if required in the Schedule.

2.17.3 Capacity

The Treated Fresh Air units shall be of such capacities and static pressures as mentioned in the equipment schedules.

2.17.4 Casing

Casing shall be double skin type from hot dip galvanized and shall have a raised insulation consisting of a factory applied polyurethane layer injected between the panels having a minimum density of 2.5 lbs./ft³ (40 Kg/m³) be made of sheet steel minimum thickness 0.6 mm and finished with electro-statically coated powder baked paint. The unit frame-work shall consist of powder coated or hot-dip galvanized multi-angle sectional elements, assembled with reinforced corners. Re-location of fan section in relation with coil section shall be possible to achieve up-blast, down-blast, top horizontal and bottom horizontal discharge, and vertical or horizontal arrangement of AHU. Factory assembly shall be as scheduled. If scheduled, Treated Fresh AHU shall include factory assembled mixing box with RA and OA inlet connection, and RA/OA dampers.

If TFU are to be installed outdoors (if scheduled), then the outdoor units shall be equipped with a canopy made of galvanized steel sheet. Access

doors shall be equipped with robust quick release locks and hinged doors with handles for easier opening.

2.17.5 Supply Air Section

The supply air section shall comprise of the following:

Fan Section

The fan shall be centrifugal forward curved or backward curved, double inlet double width type. The impeller and the fan casing shall be made of hot galvanized sheet steel. The impeller shall be mounted on a solid shaft supported to housing with angle iron frame and pillow block heavy duty ball bearing. The impeller shall be statically and dynamically balanced. Fan housing and motor shall be mounted on a common galvanized steel or aluminium block base which can be drawn out from side for ease of maintenance. Quarter pins lock arrangement between the slide and guide pin lock arrangement between Fan and TFA outlet should be provided. All fresh air induction inlets shall be equipped with bird mesh, decorative louvers and rain protection hood.

Motor And Drive

Motors shall be 3-phase totally enclosed, minimum protection IP-55, IE4, insulation class F, fan cooled with dynamically balanced rotors and per-lubricated ball bearings. They shall be mounted on an adjustable base for belt tensioning. Drive shall be provided through belt – drive arrangement. Belts will be of oil-resistant type.

Filter Section

The filter section shall be normally designed for deep folded disposable synthetic pre-filters for Class G-3. The filter elements shall be mounted on rails and shall be easily pulled out for replacement. Pressure drop at 500 fpm shall not exceed 0.05" wg. The rails shall be factory built of 16-gauge galvanized steel with seal or efficient gaskets to minimize the risk of leakage. If mentioned in the Bill of Quantities the section shall be designed to include filters up to class F-8 in accordance with latest ASHRAE standards for filter efficiency.

2.17.6 Return Air Section

The return air section shall comprise of above sections. The specification for this section shall remain same as defined above. All exhaust air outlet discharge shall be equipped with bird mesh, decorative louvers and rain protection hood. Suitable distance shall be provided between inlet and discharge inlets and outlets.

2.17.6.1 UV Light Section

- UV lights shall be installed at locations shown in TFU sectional arrangement, Lamps and fixture shall be configured in sufficient quantity and in such a manner so as to provide an equal distribution of UVC energy. Each lamp shall contain no more than 5.5 milligrams of mercury consistent with current

environmental practices while procuring the specified output at 500 fpm in temperatures of 60-135°F.

- Fixtures shall be constructed of aluminium with UVC proof metal bases & UL approved fixtures for mechanical and electrical connections that facilitate proper installation and coupling to A/C power from one end.
- Each fixture shall be equipped with an electrical interlock, which shall not allow the fixture to energize unless it's properly installed to its factory supplied and manufacturer recommended track.
- All access panels and doors to the UVC assembly and/or within view of the fixture shall include mechanical interlock switched to de-energize the UVC assembly when any of this access is opened.
- Lamp life shall be 9000 hours with no more than 20% output loss at the end of one year of continuous use.
- Door safety switches shall be provided on all doors in unit to de-energize the UV lights when an access door is opened. In addition, safety labels shall be located on all doors that have a door safety switch. If the segment does not have door, a label will be added to segment panel.
- A NEMA-3R UV control panel turn off the UV lights shall be factory tested and installed; the control panel shall disconnect the UV lighting circuit before opening of an access door. Should an access door be opened before disconnecting the UV circuit, the door safety switches shall turn off UV lights automatically.

2.17.6.2 Heat Recovery Section

The Heat Recovery section shall include 'ECOFRESH' make enthalpy wheels and shall have minimum recovery of 75 % of total heat, i.e. both sensible and latent (each being 75 %). The recovery of sensible and latent shall be equal. Necessary computerized selection of the wheel should be provided along with the bid to justify the same. The wheel shall be made of pure aluminium foil coated with molecular sieve desiccant "Ecosorb 300" with pore diameter of 30A. The cross contamination between the two air streams shall be nil and leakage less than 0.04%. The vertical and radial run of the wheel shall be less than 1 mm per meter of diameter. The wheels shall have non-contact labyrinth seals for effective sealing between the two air streams.

Detailed specification for the wheel shall be as per 8.0 i.e. "HEAT RECOVERY WHEEL"

2.17.8 Heat Recovery Wheel specifications

Rotor/wheel matrix shall be of "Ecofresh" make —

The substrate: The substrate or wheel matrix should be only of pure aluminium foil so as to allow.

- a) Quick and efficient uptake of thermal energy.
- b) Sufficient mass for optimum heat transfer
- c) Maximum sensible heat recovery at a relatively low rotational speed of 20 to 25 rpm.

Non-metallic substrates made from paper, plastic, synthetic or glass fibre media, will therefore, not be acceptable.

The substrate shall not be made from any material which is combustible or supports combustion like synthetic fibrous media.

The wheel has to be certified as per DIN EN ISO 846 with 0% fungal and bacterial growth at 95% Relative humidity and above.

Fire Rating

NFPA - 90A certification with 0% for Flame spread classification should be confirmed by manufacturer.

Pressure Drop

The pressure drop across the rotary heat exchanger shall not exceed 0.1 inch for every 100 FPM face velocity, or part thereof, for the minimum stated / required Latent recoveries / efficiencies

necessary software selection of the wheel has to be enclosed to justify the pressure drop and efficiency calculations.

The Desiccant

The desiccant should be water molecule selective and non-migratory.

The desiccant should be molecular sieve 3Å (Ecosorb 300), so as to keep the cross contamination to absolute minimum and also ensure the exclusion of contaminants from the air streams, while transferring the water vapor molecules.

The desiccant, of sufficient mass which should not be less than 5 kg per 1000 Cfm of air, should be coated with non-masking porous binder adhesive on the aluminium substrate so as to allow quick and easy uptake and release of water vapours. A confirmation has to be provided by manufacturer of wheel to this effect. A matrix with desiccants impregnated in non-metallic substrates, such as synthetic fibre, glass fibre, etc. will not be accepted.

The rotor/wheel matrix shall have equal sensible and latent recovery.

The weight of desiccant coating and the mass of aluminium foil shall be in a ratio so as to ensure equal recovery of both sensible and latent heat over the operating range.

Accordingly, a rotor matrix which has an etched or oxidized surface to make a desiccant on a metal foil and results in insufficient latent recovery and hence unequal recovery, or a rotor matrix made from desiccant integrated in a synthetic fiber matrix which results in insufficient sensible recovery, high rotation speed, and unequal recovery, will not be accepted.

Rotor

1. With optimum heat and mass through matrix formed by desiccant, of sufficient mass, coated on an aluminium foil, the rotor should rotate at lower than 20 to 25 RPM, thereby also ensuring long life of belts and reduced wear and tear of seals.
- 2.
3. The rotor shall be made of alternate flat and corrugated aluminium foil of uniform width. The rotor honeycomb matrix foil should be so wound and adhered as to make a structurally very strong and rigid

media which shall not get cracked, deformed etc. due to change of temperature or humidity.

- 4.
5. The rotor having a diameter up to 2800 mm shall have spokes to reinforce the matrix. From 2000 mm diameter upwards, the option of a special wing structure, to prevent the rotors from wobbling or deforming due to the successive pressure differentials, will be available.
6. Sectioned wheels, with pie segments, capable of being assembled in the field, shall be available as an option, above 2000 mm in diameter.
7. The surface of the wheel/rotor should be highly polished to ensure that the vertical run out does not exceed + 1 mm for every 1-meter diameter, thereby ensuring, negligible leakage, if labyrinth non-contact seals are provided, and minimal drag, if contact wiper seals are provided.
8. The radial run out also shall not exceed + 1 mm for every 1-meter diameter, thereby minimizing the leakage/drag on the radial seals, and minimizes the fluctuation in the tension of the drive belt.
9. The number of wraps (of alternative corrugated and flat foil) for every inch of rotor radii shall be very consistent so as to ensure uniform air flow and performance over the entire face in the air stream. Flute height and pitch will be consistent to a very tight tolerance to ensure uniform pressure drop and uniform airflows across the rotor face.
10. The rotor shall be a non-clogging aluminium media, having a multitude of narrow aluminium foil channels, thus ensuring a laminar flow, and will allow particles up to 800 microns to pass through it.
11. The media shall be cleanable with compressed air, or low-pressure steam or light detergent, without degrading the latent recovery.

The Cassette / Casing.

The recovery wheel cassette/casing shall be manufactured from tubular / sheet metal structure to provide a self-supporting rigid structure, complete with access panels, purge sector, rotor, bearings, seals, drive mechanism complete with belt.

The rotor/wheel should have a field adjustable purge mechanism to provide definite separation of airflow minimizing the carryover of bacteria, dust and other pollutants, from the exhaust air to the supply air. It shall be possible, with proper adjustment, to limit cross contamination to less than 0.04% of that of the exhaust air concentration.

The face and radial seals shall be four (4) pass non-contact labyrinth seals / brush seals for effective sealing between the two air streams, and also for a minimum wear and tear ensuring long life of the seals.

2.17.9 Commissioning & Testing.

12. The pre-commissioning check list to be provided by the commissioning engineer prior commissioning to the installer for proper installation & pre-check the installation prior to start commissioning without any extra charge.
13. The Contractor shall provide a factory authorized & trained commissioning Engineer, employed by the manufacturer, to perform &/or supervise pressure test (when required), Top-up chiller with refrigerant, place unit into operation, & calibrate all controls in

- accordance with the manufacture's written start-up, operating, & maintenance instructions.
14. The Commissioning Engineer shall furnish a start-up log indicating that proper operation conditions, operating sequences & operating & safety control functions are obtained.
 15. The Commissioning Engineer of chiller may recommend specified tests & these test reports shall be submitted to the Consultants by the Contractor in suitable test forms.
 16. Once the chillers) shall be successfully commissioned & the report prepared by the factory authorized commissioning engineer, the final report handed over to the client shall be countersigned by the factory' engineer (placed in the manufacturing plant) for its performance authenticity as per the design performance requirements.
 17. Contractor will ensure that, after unit start-up has been performed & witnessed by client, the Authorized Commissioning Engineer shall be available on site for a period of instruction not to exceed accumulative 36 working hours to instruct the owner's personnel in the proper start-up, operating, & maintenance procedures & hands on training.
 18. All chilled water supply/return connections, power line connections, valves installation, valves & pipeline tagging, electric power & control wiring/cabling to be provided by the installation contractor.
 19. Installation contractor shall also be responsible to ensure all control interfaces complete in all respect to connect AHU, Chillers, Pumps; VFD's or with any related equipment etc.

2-18 Chilled/ Hot water Fan coil units (FCU)

2-18.1

Each unit shall be selected as the requirement of the cooling load and interior layout in the respective space to be air-conditioned. The unit shall be equipped with an electronic expansion valve, which can communicate with the VRF controller motorized control valve in the condensing unit.

The fan shall of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation.

Each indoor unit shall be equipped with cordless local control unit for setting the operating parameters. The address of the indoor unit shall be set automatically in case of individual and group control. Option of centralized control should also be achievable. Controls shall be provided to maintain the set room temperature within close tolerance limits.

2-18.2 REMOTE CONTROL UNIT:

A Remote-Control Unit shall be provided for the system, suitable to be mounted near the entrance door of the premises. It should be possible to operate the entire air conditioning system and set working parameters of all indoor units and the VRF outdoor unit from this control unit. The unit shall be equipped with self-diagnosis for easy and quick maintenance and service. The remote controller shall memorize the latest malfunction code for easy maintenance. The Controller shall be equipped with a battery back-up and a real time clock.

It should be possible to control several number of indoor units and change fan speed and angle of swing flap individually and in group.

2-18.3 DRAIN PIPING

The drain piping shall be made out of rigid PVC pipes of 10 Kg/cm² class. The piping shall be supported by clamping on MS angle 25mm x 3mm running continuously below the pipe. The piping shall be insulated with 6mm thick closed cell nitrile rubber sleeves.

The drain pans of IDUs shall be connected to rigid PVC pipe by braided PVC flexible pipe with appropriate adapters. U trap shall be providing in the drain connection of each IDU. All pipes support/clamps shall be painted with red oxide primer followed by two coats of synthetic enamel finish paint.

2-19 Variable Refrigerant Flow Systems (VRF)

2-19.1 GENERAL

The system shall be air-cooled, direct expansion type central air conditioning system consisting of one or more Variable Refrigerant Flow Condensing unit (Outdoor Unit) and connected to it one or more Evaporator (indoor) units.

VRF systems must comply with ASHRAE Standard 15 (packaged with Standard 34): Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants. This addresses refrigerant capacities and possible leakage, especially if the system serves small rooms, which could cause oxygen depletion. According to Standard 15, a VRF system is classified as a direct system/high-probability system where a refrigerant leak can potentially enter into the occupied space.

ASHRAE Standard 15 requirements should be applied to each VRF system design in the following steps:

- Determine the occupancy classification for the rooms
- Calculate room volume
- Determine the amount of refrigerant in the system including the outdoor unit, indoor units, and associated piping
- Verify that the room is not too small using the following formula:

2-19.2 CONDENSING UNIT (OUTDOOR UNIT):

The condensing unit shall be capable of assessing the requirement of liquid refrigerant volumetric flow of each evaporating unit at all times by means of a sophisticated microprocessor controller and generating the required total volume of refrigerant liquid for supply to the evaporator units.

The condensing unit shall be a factory-assembled unit housed in a sturdy weatherproof casing constructed from rust proof galvanized powder coated steel panels. The noise level of the unit shall not be more than 70dB (A) measured horizontally 1 m away and 1.5 m above base level.

The compressors shall be hermetically sealed Inverter driven variable speed type scroll type, capable of changing the capacity in accordance to the cooling load requirement.

The condenser coils shall be constructed out of copper tubes mechanically bonded to aluminium fins.

The surface of the condenser coil shall be coated with suitable chemical coating to prevent deterioration due to coastal climate.

All necessary safety devices shall be provided to ensure safe operation of the system.

Unit should be equipped with a highly efficient oil separation system to ensure stable operation with long refrigerant piping.

The VRF condensing unit shall be located in open on a terrace with adequate clearance from nearby objects to ensure unobstructed air flow and easy approach for maintenance.

The VRF condensing unit for AHUs shall be complete in all respects including AHU Control Kit, Automatic Controls, Communication and integration etc.

2-19.3 INDOOR UNITS (EVAPORATING UNITS):

Each unit shall be selected as the requirement of the cooling load and interior layout in the respective space to be air-conditioned. The unit shall be equipped with an electronic expansion valve, which can communicate with the VRF controller in the condensing unit.

The fan shall of the dual suction multi blade type and statically and dynamically balanced to ensure low noise and vibration free operation.

Each indoor unit shall be equipped with cordless local control unit for setting the operating parameters.

The address of the indoor unit shall be set automatically in case of individual and group control.

Option of centralized control should also be achievable.

Controls shall be provided to maintain the set room temperature within close tolerance limits.

Each indoor unit shall be equipped with Electrical Safety fuse and Isolation switch.

2-19.4 REMOTE CONTROL UNIT:

A Remote-Control Unit shall be provided for the system, suitable to be mounted near the entrance door of the premises. It should be possible to operate the entire air conditioning system and set working parameters of all indoor units and the VRF outdoor unit from this control unit. The unit shall be equipped with self-diagnosis for easy and quick maintenance and service. The remote controller shall memorize the latest malfunction code for easy maintenance. The Controller shall be equipped with a battery back-up and a real time clock.

It should be possible to control several numbers of indoor units and change fan speed and angle of swing flap individually and in group.

2-19.5 REFRIGERANT PIPING:

The refrigerant piping interconnecting to indoor & outdoor units shall be made out of hard copper tubes, in brazed construction. The refrigerant line sizing should be designed to achieve minimum pressure drop and avoid oil return problem. The pipe sizes and connections shall be designed such that the

evaporator units do not face back pressure due to the functioning of the evaporator next to it.

All suction piping shall be insulated with closed cell elastomeric class 'O' nitrile rubber foam tubes of suitable diameter and thickness.

All piping shall be neatly laid and supported on galvanized perforated sheet metal trays and clamped firmly. Piping should be shrouded, where necessary, to protect it from accidental damage/leaks during work by any agencies.

All the wiring interconnecting the indoor and outdoor units shall be PVC insulated copper conductor flexible wires of appropriate rating, and shall be laid through PVC conduits.

The refrigerant piping for the VRF system shall be of minimum wall thickness as per copper pipe-ASTM B88, L-Type standard HARD drawn copper pipes. The copper pipe shall be internally chemically cleaned, free of dirt, dust, oxidation and any other deposits. All joints shall be made by brazing. Inert gas purging shall be used during the brazing process to prevent oxidation.

Suction line shall be insulated with 19mm thick sleeve made out of closed cell elastomeric nitrile rubber foam insulation of fire retardant 'O' class. Wiring interconnecting the indoor and outdoor unit shall be done with PVC insulated copper conductor flexible wires of appropriate rating.

U-bends shall be provided for efficient oil return in suction line, at appropriate locations.

All piping shall be supported on GI perforated cable trays, and covered by GI sheet channels from the top, to prevent accidental damage during work of other agencies. The GI covers and trays shall be fixed to MS angle supports by bolting, to facilitate removal of the trays for verification of pipe leaks.

All pipe supports/clamps shall be painted with red oxide primer followed by 2 coats of synthetic enamel finish paint.

The piping and wiring shall be laid such that it does not spoil the aesthetics of the premises, and is safe, secure and approachable for leak detection/repair/replacement.

2-19.5 DRAIN PIPING

The drain piping shall be made out of rigid PVC pipes of 10 Kg/cm² class. The piping shall be supported by clamping on MS angle 25mm x 3mm running continuously below the pipe. The piping shall be insulated with 6mm thick closed cell nitrile rubber sleeves.

The drain pans of IDUs shall be connected to rigid PVC pipe by braided PVC flexible pipe with appropriate adapters. U trap shall be providing in the drain connection of each IDU. All pipes support/clamps shall be painted with red oxide primer followed by two coats of synthetic enamel finish paint.

2-20 Split Units

2-20.1 GENERAL

Provide complete factory-assembled inverter-driven ducted split air-conditioning and heat pump system suitable for continuous cooling and heating operation under extreme ambient conditions, including low ambient winter operation down to -18°C outdoor temperature. System shall be suitable

for commercial, institutional, residential, or mission-critical applications requiring concealed ducted indoor installation.

2-20.2 SYSTEM DESCRIPTION

The system shall consist of:

1. Outdoor air-cooled inverter condensing unit.
2. Concealed ducted indoor fan coil unit.
3. Variable-speed inverter compressor.
4. Electronic expansion valve (EEV).
5. R410A or R32 refrigerant.
6. Wired programmable controller with heating/cooling auto changeover.
7. Refrigerant piping, controls, drain piping, and accessories.

2-20.3 DESIGN CONDITIONS

1. Indoor Cooling Condition: 24°C ±1°C.
2. Indoor Heating Condition: 22°C ±1°C.
3. Unit shall maintain stable heating capacity at low ambient using inverter compressor technology and intelligent defrost control.

2-20.4 PERFORMANCE REQUIREMENTS

- Minimum Energy Efficiency: IEER/COP as per applicable ASHRAE and local energy codes.
- Inverter compressor shall modulate capacity from 20% to 100%.
- Heating operation shall remain functional at -18°C ambient without compressor damage.
- System shall include low ambient protection, crankcase heater, compressor insulation jacket, and intelligent defrost cycle.

2-20.5 OUTDOOR UNIT

- Heavy-duty galvanized steel casing with epoxy coating.
- DC inverter rotary or scroll compressor.
- Low-noise condenser fan with ECM motor.
- Factory-installed crankcase heater.
- Anti-corrosion coated condenser coil.
- Refrigerant leak protection and high/low pressure safety controls.

2-20.6 INDOOR DUCTED UNIT

- Concealed ceiling mounted type.
- Double-skin insulated drain pans.
- ESP suitable for ducted distribution system.
- Washable synthetic air filters.
- Low-noise centrifugal fan with multi-speed ECM motor.

2-20.7 CONTROLS

- Microprocessor-based control system.
- Weekly programmable thermostat.
- Automatic restart after power failure.
- Heating/cooling mode lockout capability.

- BACnet/Modbus gateway compatibility.

2-20.8 INSTALLATION REQUIREMENTS

- Refrigerant piping insulation shall be UV-resistant closed-cell elastomeric type.
- Condensate drain piping shall be insulated and trapped.
- Outdoor unit supports shall include vibration isolation mounts.
- Heat trace shall be provided for condensate drains exposed to freezing conditions.

2-20.9 TESTING & COMMISSIONING

Contractor shall perform:

- Refrigerant leak testing.
- Vacuum dehydration.
- Functional testing in cooling and heating modes.
- Verification of operation at low ambient conditions.
- Airflow balancing and controls calibration.

2-20.10 WARRANTY

Provide minimum:

- 5 years compressor warranty.
- 1-year parts and labour warranty.

Recommended efficient thermostat settings for operation shall comply with recognized HVAC practices

2-21 Not used

2-22 Not used

2-23 Not used

2-24 Not used

2-25 Not used

2-26 Not used

2-27 Not used

2-28 Not used

2-29 Not used

2-30 FANS (ventilation Equipment)

General

These specifications are for all fans other than fitted inside Roof Top and/or FCUs. All fans shall be of make and origin as mentioned in Equipment Schedules unless otherwise approved by the Engineer.

All fans shall have been rated per AMCA standard 210- 74 or ASHRAE standard 51-75 or equivalent. Wheels shall be heavily rigidly constructed and accurately balanced both statically and dynamically, and be free from objectionable vibration or noises. Actual brake horsepower of fan and drive shall not exceed nameplate rating of motor driving fan. Motor shall be included.

h the factory balanced and tested fan wheels and casing (Complete).

2-30.1 Centrifugal Fans

These shall be centrifugal type, of characteristics and capacities as Scheduled. Fans shall be belt driven as Scheduled. Fan motors above 1/2 HP shall be 3-phase induction type and 1/2 HP or smaller shall be single phase split capacitor. Centrifugal impeller shall be attached to the motor shaft end. Motors for belt driven fans shall be mounted on fan casing. Motor base shall be adjustable type with pivot at one end for easy and accurate belt adjustment. The fan inlet shall have an aerodynamic design to ensure turbulence free air flow at discharge. Centrifugal impeller blades shall be backward inclined or aero foil type. Fan impeller shall be made of heavy gauge steel. Impeller shall be dynamically balanced and shall have cast iron hub. The fan bearings shall be self-aligning ball bearing type. Fans shall be complete with cabinet casing, mounting frames, brackets for ceiling suspension, bolts and accessories, including belt guard and spring vibration isolators as required. Access doors will be provided with double hinges. Weather proof junction box for electric connection will be provided with each unit.

All supply fans shall be supplied with the factory installed washable filters will be provided by manufacturer. Contractor shall supply/exhaust centrifugal fans.

2-30.2 Staircase Pressurization System

The contractor shall supply, install, commission, test and set to work stair case pressurization systems in accordance with the requirements relevant codes and standards.

The contractor shall be responsible to verify the Stair case fan sizing and ESP required to maintain the pressure in stair case, considering the changes during construction of Building.

In brief the system shall comprise but not be restricted to the following:

- Inverter controlled fans as required complete with all duct work and ancillaries to ensure effective operation.
- Inverter controlled soffit mounted low profile induction fans finished to suit the Staircase/Stairwell pressurization application.
- Master control panel incorporating automatic changeover switch (power supplies by others)
- Manual override control Interfaces between all panels and with the BMS for fault reporting
- An addressable multi-criteria smoke detection system

- Fault detection link to a central control panel as installed by the contractor.
- Anti-vibration mounts and all supporting materials (all isolation must achieve 99% efficiency)
- Identification of all plant and equipment
- Installation of fans, ducts, detectors, controls, electrical wiring, cable tray, all associated support steelwork and fixings. (complete in all respects)
- Full commissioning of fan systems, controls and detection systems to include witnessing by

2-30.2.1 MOTOR:

1. Motors power supply is are 400 V, 50 Hz.
2. Motors should suitable for DOL (direct on line) start.
3. Motor protection is IP 55 and the insulation is class F or H, depending on model.
4. Energy efficiency class IE-4 motor.

2-30.2.2 INSTALLATION:

1. Each jet fan should supply with fixing brackets, for ceiling (or wall) installation.
2. Jet fans need to be installed at least 0.5 m from beams on the inlet side and at least 2.0 m from beams on the outlet side (beam height: 400 mm).

2-30.3 Vehicle Exhaust Ventilation System (LEV)

The following codes, regulations and guidelines are to be considered part of these specifications and are a minimum standard of evaluation for this Hazardous Material Exhaust System.

- NIOSH
- Underwriters Laboratory (UL)
- National Fire Protection Agency (NFPA)
- National Electric Code (NEC)
- NFPA 1500 – 2002 Edition
- Air Movement and Control Association International Inc.(AMCA)
- International Mechanical Code (IMC)
- Uniform Mechanical Code (UMC)
- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)

2-30.3.1 The system shall meet the following minimum performance criteria:

1. The exhaust removal system must provide virtually 100% complete evacuation of all vehicle emissions (particulate, gasses and fumes) at the source from start up to exit of the apparatus from the fire station. Independent certification documents shall be provided and attached to the bid proposal.

2. The exhaust system shall not block doorways, exits, and aisles in the apparatus bay, which could endanger the welfare of fire personnel or visitors.

2-30.3.2 Standard Products:

Equipment and materials provided for the system installation(s) shall be manufactured and provided by the supplier of primary exhaust removal system (Equipment Manufacturer) and be a standard product of manufacturer currently engaged in the manufacture of Vehicle Exhaust Extraction Systems. Where the requirement calls for a packaged exhaust system to be provided, all items shall be the standard product of the manufacturer. The Vehicle Exhaust Extraction System Manufacturer has provided Vehicle Exhaust Systems for a minimum period of ten (10) years.

2-30.3.3 Quality Assurance:

The manufacturer must be ISO 9001:2000, certificate must state for the Design, Assembly, Marketing and Sales of Extraction and Filtration Systems and Equipment. UL and CUL Certified and certified by the Air Movement and Control Association (AMCA) to ensure quality, consistency and reliability of products. Certification documents shall be provided and attached to the bid proposal. All Workmanship, manufacturing procedures, airflow design and materials shall be performance guaranteed. If any performance as outlined in the performance/technical specifications, the bidder shall remove and replace at his expense the materials in question.

2-30.3.4 Manufacturers Qualifications:

Bids shall only be accepted from bidder's supplying equipment from manufacturers that have an established reputation in the business of manufacturing Vehicle Exhaust Extraction Systems for a minimum of no less than ten (10) years. System bid shall have a life of service of no less than ten (10) years to establish proof of quality, longevity and service. Equipment life of service shall meet the department's expectations for similar types of equipment.

2-30.3.5 Requirement of Exhaust Extraction System:

Upon emergency vehicle(s) starting, the exhaust ventilation fan shall be automatically energized by the output pressure generated by any internal combustion engine and evacuate the toxic exhaust fume.

The nozzle must release and disconnect near the threshold of the exit door regardless of the speed the vehicle may exit the door.

Systems which limit the exiting speed are not acceptable as they can limit emergency response time.

Due to harmful effects of diesel exhaust, the system must be designed and capable of virtually capturing 100% of the exhaust gases and particulate even in the event of a complete power failure. Stand-alone system with no additional wiring to make it operate.

The system will not detach itself from the apparatus for any reason during a power failure other than normal exiting of the apparatus bay.

Systems that require additional or alternate power source to eliminate detaching during power failure are not acceptable due to additional maintenance requirements.

To protect the apparatus electrical system from any possible damage, the system bid shall not incorporate any type of electromagnetic device that requires the apparatus to be utilized as an electrical ground for the system's operation.

The system will not incorporate any electromagnetic or magnetic devices that require either fastening or drilling into the side body panels or tailpipes of the fire apparatus, which could affect vehicle warranty. A pneumatic system is preferred.

The nozzle release mechanism must be external on the system to insure safe disconnect of nozzle from tailpipe.

The upper hose assembly must be rated for 600°F continuous, 700°F intermittent temperature to ensure the exhaust fume does not deteriorate the hose and leak. The lower hose assembly must be rated for 900°F continuous, 1221°F intermittent.

A safety disconnect handle shall completely separate the lower nozzle section from the upper hose assembly.

All electronic and electrical components shall be UL listed and shall provide documentation of such. Control panel must meet NFPA 74 for arc flash protection and panel shall be manufactured in a 508A panel shop.

The upper and lower hose sections must be capable to swivel 360 degrees, (if swivel is incorporated in design) allowing free flowing system operation, thus allowing no tension on the hose attachment and the hose release features.

Systems that utilize adaptors which mate with Magnetic type nozzle connection in order to secure the nozzle to exhaust pipe in a fastening mode must be metal to metal connection.

Systems which require disconnection of nozzle from vehicle when working on vehicle's fuel system, recharging batteries or whenever there is a risk of inflammable dust or explosive gases, are not acceptable.

Manufacturer must be an ISO 9001:2000 Certified Company with Certification issued to United States Facility. Certification must be accompanied with bid.

Attachment shall be made in any direction of the nozzle, no attachment point mandated. It may be a Clip and Go.

Due to safety of fire personnel, systems which require tailpipes or their adaptors to protrude beyond the outside edge of the chassis are not acceptable due to NFPA 1901, 2009 requirements.

The transition from the Magnetic nozzle to the flexible hose (if used) shall be one piece welded construction to prevent leaks of exhaust fumes. The transition shall be made of stainless steel for durability.

All components used along the track and in system shall be of non-rusting material. Components shall be set at heights to not impede movement of apparatus.

Nozzle construction at point of contact to exhaust pipe must be metal to metal connection.

System must allow in station pump test for 15 minutes / 1500 RPMs, this feature must be printed on Control Center for System Operation procedures.

Tailpipe Adapters (if used) must be bolted onto the exhaust system, welded on adapters will not be acceptable.

Control panel must have system indicator lights and AUTO START-STOP-MANUAL RUN controls.

Controls that require electrical or pneumatic devices installed to exhaust blower must not cause interference with any equipment.

System shall have an automatic timer set to properly operate for the duration of the 100% exhaust capture. After the time has expired, the exhaust blower will shut off.

Blower must provide design flow for use. Specifications will be supplied by bidder for use design.

Duct work shall be designed to meet extraction system.

All non-welded ductwork, fittings and joints must be securely fastened and sealed with a mechanical Teflon duct collar with locking bolt mechanism as required by the International Mechanical Code and the Uniform Mechanical Code.

Back-draft damper exhaust rain cap must provide protection from rain and other inclement weather.

Silencer/Muffler must be connected to exhaust discharge to reduce discharge air noise for all fans to reduce noise decibels to 64dba.

System must be covered for warranty of not less than 5 years of full parts and labour complete. Submitting company must include service center location within IL and provide such address and contact information. Training to be provided by Bidder at the time of installation to the Fire Staff for the use and operation of the Vehicle Exhaust Extraction System to all three shifts.

Bidder must make an on-site survey of the facility and provide a layout drawing showing location of vehicles and equipment to be supplied. This is a mandatory requirement to ensure the proposed system meets the intent of the specifications and fits within the building space. Drawing must be included with the bid.

2-30.4 Parking Ventilation and Smoke extraction System

The contractor shall design, supply, install, commission, test and set to work vehicle smoke extraction systems in accordance with the requirements of Parts B and F of the building regulations which are summarised as follows:

Fire condition:

The system shall be capable of providing a minimum of 10 air changes per hour (or 12 air changes per hour in order to incorporate the use of 2 speed fans if this presents a cost saving). The smoke outputs and ventilation requirements shall be assessed in accordance with BS7346 Part 7.

The contractor shall carry out CFD modelling to demonstrate to building control as required that both car park and common area ventilation methodologies achieve the requirements of Parts F and B of the building regulations as appropriate. Use CFD (Computational Fluid Dynamic) software is to analyse complex systems and make a precise model of the airflow (direction and speed), of the pressure and of the temperature in each point of the system. Submit the same for approval.

Care should be taken to ensure that there are no stagnant areas in either daily ventilation or smoke ventilation operational mode. Provision should be made for the supply of replacement air to the car park. All fans intended to move or exhaust hot gases used within a car park ventilation system should be tested in accordance with EN 12101-3. Each item shall be CE marked in compliance with EN 12101-2 and shall be in line with BS 9991 and BS 9999.

The contractor shall liaise electrical contractor to coordinate services generally, locations of power supplies, containment and outlets as required.

The car park ventilation will be provided to achieve two purposes, day to day ventilation of the car park and protection of the building and fire fighters in the event of a fire and is described below.

There shall be at least two fans capable of extracting 50% of the required rates and able to operate independently or simultaneously. Each fan shall be rated to run at 300°C for a minimum of 2 hours as shall all connecting ductwork and any other ancillaries and support mechanisms. Final openings to the external atmosphere are shown on drawings these will be assessed by the smoke ventilation specialist to ensure cohesion with the ventilation design.

The resistance to airflow and turbulence caused by down stand beams and any other obstruction should be taken into account when placing the jet fans.

Care should be taken to ensure that the number of jet fans activated will not induce the movement of a volume of air greater than that which the main extract fans are capable of extracting.

Where a sprinkler system is to be installed, the location of the sprinkler heads and jet fans should be co-ordinated to ensure that the effect of the jet fans on the spray pattern of the sprinklers is minimized.

In brief the system shall comprise but not be restricted to the following:

- Inverter controlled car park extract fans and attenuation as required complete with all duct work and ancillaries to ensure effective operation
- Car park extract fans to be completed with acoustic fan jacket to ensure noise criteria.
- Inverter controlled soffit mounted low profile induction fans finished to suit the car park environment

- Master control panel incorporating automatic changeover switch (power supplies by others)
- Manual override control
- Interfaces between all panels and with the BMS for fault reporting
- CO detectors with a minimum life of 6 years with link to control panel indicating expiry
- An addressable multi-criteria smoke detection system
- Fault detection link to a central control panel.
- Anti-vibration mounts and all supporting materials (all isolation must achieve 99% efficiency)
- Identification of all plant and equipment
- All plant and distribution support systems and containment

The services associated with the installation shall comprise but not be restricted to the following:

- a. Installation of fans, ducts, detectors and controls
- b. Installation of electrical wiring and cable tray
- c. Installation of all associated support steelwork and fixings
- d. Full commissioning of fan systems, controls and detection systems to include witnessing by the appropriate authorities – allow for separate visits for commissioning and handover.
- e. The design requirements associated with the installation shall comprise but not be restricted to the following:
 - Full CFD analysis – to prove system design is suitable to meet the requirements of AD B3 and to prove general effectiveness of ventilation with regards to AD F1
 - Compliance with BS 7671 (17th Ed)
 - Controls system software design
 - All wiring diagrams
 - Control schematics

Components

An integral fireman's key switch will be provided on the fire alarm indicator panel. This key switch will be a 3-position switch with the following designations:

- Auto
- Off
- Fans on

The fireman's key switch will be hard wired to the smoke vent control panel which will directly control all smoke system's operation via override relays without software intervention. On each jet fan, terminal box should supply as standard.

MOTOR:

1. Motors power supply is are 400 V, 50 Hz.
2. Motors should suitable for DOL (direct on line) start.
3. Motor protection is IP 55 and the insulation is class F or H, depending on model.
4. Motor efficiency class IE-4.

INSTALLATION:

1. Each jet fan should supply with fixing brackets, for ceiling (or wall) installation.
2. Jet fans need to be installed at least 0.5 m from beams on the inlet side and at least 2.0 m from beams on the outlet side (beam height: 400 mm).

2-30.5 Axial Fans

Axial Long Case Non-Decorative Fans For Parking.

The contractor shall furnish & install, Axial flow aerofoil long case axial fans unit with manufacturer specified construction meeting specified schedule and specifications, All fans shall be of long case either single or multi stage to suit the performance & duty specified meeting EN-12101-3-2002 and suitable for 2h operation under 400°C.

The fans shall be installed in casing that shall extend over the motor & fan assembly, two stage fans shall have contra-rotating impellers & each impeller shall be driven by a separate motor. Axial flow fans shall be of the non-overloading direct driven type, with impeller secured to the motor shaft by means of a key & lockout.

The fan blade shall be aerofoil & shall be of the adjustable pitch type, the pitch angle of the blades shall be readily & accurately adjustable in the factory. Axial flow aerofoil fan shall be selected with minimum efficiency of 70% at the design air flow rate as determined by the contractor. The impeller & hub shall be statically & dynamically balanced, made of die cast aluminium alloy to BS 1490-1970 & examined by X-Ray to ensure flawless casting.

Fan casings shall be fitted with wire guards where shown on drawings & as necessary to provide full protection where fan inlet are accessible. Fan casing shall be fitted with coned inlets where shown on drawings & where necessary for the achievement of the rated fan performance. The fan housing or casing shall be of heavy galvanized steel sheet construction of the 'L' type hot dip galvanized after manufacture & shall be rigidly constructed & correctly proportioned to allow optimum performance, The housing shall be made with drilled flanges at each joint & joints shall be made alright with natural rubber or neoprene gaskets. The fan casing shall be fitted with an electrical terminal box complying BS 4999 for dust, fire & waterproof conditions. Access panel shall be provided in fan casing for all fans having impellers 500mm diameter & above. Access panel shall be fitted in a readily accessible position, shall be large enough to permit ease for maintenance & shall be securely bolted to the casing with studs & wing nuts.

Axial Fan drive shaft & IP 44 squirrel cage motor shall be selected & designed such that to suit continuous operation and shaft speed at 130% & motor power at 120% respectively with an operational temperature range 0°C-400°C with 2hrs fire rating.

2-30.6 Inline Fans

Duct In-line Centrifugal Fans

The contractor shall furnish & install duct mounted inline supply/exhaust air fans where shown on the drawings of capacity & characteristics as schedule. The in-line fans shall be direct driven centrifugal type light weight compact units.

The fan housing shall be galvanized steel skin securely attached to a galvanized steel frame work. Easy access to motor, impeller & bearing for inspection & repair through the door at the side of the fan shall be provided. Inlet venturi to be precision spun for exact matching of the inlet to the wheel inlet.

The aluminium wheel is to have backward inclined blades designed for maximum efficiency & is to be dynamically balanced with permanently affixed balance weights. Motors shall be open drip-proof type of the voltage & phase as schedule. Units shall be AMCA certified for air & sound performance.

2-30.7 Not used

2-30.8 Not used

2-30.9 Not used

2-30.10 Jet Fans / Tunnel Ventilation Fans

2-30.10.1 Uni Directional Jet Fans

Jet fans shall be either single or multi stage to suit the performance & duty specified. The fans shall be installed in casing that shall extend over the motor & fan assembly, Fan shall be of the non-overloading direct driven type, with impeller secured to the motor shaft by means of a key & lockout.

The fan impeller shall be aerofoil & shall be of the adjustable pitch type, the pitch angle of the blades shall be readily & accurately adjustable in the factory. Fan casing shall be fitted with flat inlets where shown on drawings & where necessary for the achievement of the rated fan performance. The fan housing or casing shall be of heavy galvanized steel sheet construction of continuous weld of the 'L' type hot dip galvanized after manufacture & shall be rigidly constructed & correctly proportioned to allow optimum performance.

The fan casing shall be fitted with an electrical terminal box complying BS 4999 for dust & waterproof conditions. Fan drive shaft & IP 55 squirrel cage two speed motor shall be 3 phase fully enclosed selected & designed such that to suit shaft speed at 130% & motor power at 120% respectively.

All bearings are lubricated for life. The bearing life time is min. 20000 hours. The halogen free and flame resistant power cables are connected to the external terminal box. Under normal duties the jet fan has to be designed to run at temperatures between 0 and +50°C. In the event of a fire, the jet fan has to withstand a temperature of up to 250°C for 90 minutes. In order to prove this, for the relevant parts like the impeller, motor, terminal box and terminals a heat test according to EN 12101-3 of a complete unit has to be conducted. The test must be certified by an independent laboratory. Testing of single parts e.g. impeller blades is not valid or sufficient. If the manufacturer cannot provide a suitable certificate, then the costs for a heat test must be included in the quoted price.

2-30.10.2 Accessories

The jet fans should be equipped with the following minimum accessories.

2-30.10.3 Mounting structure

The jet fans would be mounted in parallel to the tunnel axis at the ceiling. The mounting structure is made of stainless steel 1.4571 in a welded construction. Between the mounting structure and jet fan, suitable vibration attenuators have to be provided.

2-30.10.4 Safety wires

In case the mounting structures collapse, the fan is secured from falling down by safety wires, made from stainless steel 1.4401. A slack of about 10 mm must be kept.

2-30.10.5 Tear of guard

The mounting structure is guarded against tear of by an inductive proximity switch in IP65.

2-31 Not used

2-32 Energy Recovery Units (HRU/ERV)

The Contractor shall provide Energy Recovery type ventilators for providing fresh air in the conditioned area where shown on the drawings.

2-32.1 High Efficiency Plate Heat Exchanger

The equipment shall be equipped with cross flow heat exchanger having a high efficiency central core which recover energy from the indoor air and transfer it to the fresh incoming air without mixing stale air with the fresh air. The heat exchanger shall be total enthalpy type to recover both sensible & latent heat from the outgoing exhaust air.

2-32.2 Construction

The heat exchanger shall be constructed with a group of plates located diagonally in the unit casing which is formed of high moisture permeability ER paper sheets jointed together to have good air tightness, excellent tear resistance and aging resistance. To achieve air tightness silicon seal shall be applied generously. The clearance between the fibres shall be so small so only the moisture molecules of small diameter can pass through. The lower part of the casing shall form a watertight pan to recover possible condensate.

2-32.3 Efficiency

ERV shall be 75% efficient at 115 F ambient temperature, ERV fan shall be 75% efficient. Access doors shall be provided with double hinges. Fans for ERV shall be statically and dynamically balanced and factory tested.

SECTION 3 - FOUNDATIONS AND SUPPORTS

3-01

GENERAL

All equipment, piping and ductwork where used shall be mounted on or suspended from foundations and supports, all as specified, as shown and as required. All concrete foundations where required, including thickened structural slab, housekeeping pads and concrete for inertia pads will be provided by the Employer or other Contractor engaged by the Employer or HVAC Contractor as described in Special Provisions Clauses SP-02 & SP-03.

Shop drawings, other information and templates for all concrete foundations where used, shall be provided by Contractor as per recommendations of the manufacturer of the equipment. Necessary integral steel framings, concrete reinforcing rods welded to frame, required anchor bolts, spring mountings, and neoprene pads, shall be provided by the Contractor. The Contractor shall cooperate with those doing the flooring work to ensure proper installation of all these elements.

Foundations and vibration isolation mountings for various equipment, piping, and ductwork where used shall be as per requirements specified. Vibration isolators where used shall be of approved make.

All reinforced concrete inertia pads shall have a minimum 4" thickness. On all corners of inertia concrete pads and integral rigid structural steel bases supporting mechanical equipment, install angles with snubbers. These shall be built up from 3 thicknesses of neoprene waffle pad bonded with suitable adhesive and fixed to angles.

All ceiling hung equipment having fans and motor as integral part of equipment shall have adequate vibration isolators.

Flexible duct connections, as specified elsewhere, shall be fitted wherever ducts cross building expansion joints, at suction and discharge end of each ducted air handling unit and ducted fan, and/or wherever shown on the drawings. Supply outlet of concealed ceiling-mounted fan coil unit shall also be connected to Fan-coil with flexible connection.

Details of all vibration isolators, flexible connections and bases shall be submitted to the Engineer for approval.

3-02

MOUNTING OF EQUIPMENT

3-02.1

Floor or roof mounted equipment

All floor or roof mounted equipment shall be placed on 4" concrete housekeeping pads, unless otherwise indicated. Special attention shall be given to the equipment at roof and intermediate floors and manufacturer's recommendations for prevention of vibration and noise travel to the structure shall be adopted. The foundation details shall be subject to the approval of the Engineer.

3-02.2

Walls Mounted Equipment

All equipment installed through wall shall have 20-gauge galvanized sheet metal which shall remain in place permanently. Sleeves shall be packed

with non-combustible glass fibre insulation minimum of 1.5 lb/cu.ft density and sealed with sealant. Equipment installed through walls shall have supporting wall brackets.

3-02.3 Air inlets/outlets

All air devices including EA/OA louvers shall be fixed to wooden/ metallic frames provided by HVAC Contractor and not to the ceiling material/wall masonry.

3-02.4 Ceiling-hung equipment

All ceiling-hung equipment shall be hung from ceiling (concrete slab) and shall not rest on false ceiling.

3-02.5 Floor mounted equipment

All floor-mounted equipment shall be resting directly on the raised floor pad (or supported from wall when approved by the Engineer).

3-03 VIBRATION ISOLATION

Vibration isolation bases shall be provided and installed under all pumps (where used), to prevent the transmission of vibration to the building structure, as shown on Drawings.

Where fans and motors are integral parts of factory assembled air handling units and the fans and motors are not spring isolated from the air handling unit, the entire unit shall be mounted on vibration isolators.

Inertia pads where indicated shall be reinforced cement concrete pad, at least 4" thick with 4" steel channel all around to protect concrete edges. Reinforcing rods shall be welded to channel frame.

Floor mounted Fans with belt drives shall be mounted on continuous rails with sliding base for motor adjustment and fan-rails shall be mounted on vibration isolators as specified above. When shown on Drawings, continuous rails shall be mounted on Inertia pads and pads shall be mounted on vibration isolators.

Flexible pipe connectors shall be installed in piping to prevent vibration and noise travel. Location and construction of these connectors are specified in Section on "Piping, Fittings, Valves and Specialties."

SECTION 4 - DUCTING AND SHEET METAL WORK

4-01 GENERAL

4-01.1 Ducting Material

All duct work shall be of galvanized steel sheet unless otherwise indicated on Drawings. Galvanized steel shall be of lock forming quality (LFQ) and shall have a galvanized coating of 8 oz total for both sides of one square meter of a sheet.

Galvanized steel sheet shall be Cut Lengths Coated by the Hot-Dip Method and manufactured per ISO Standard 3575-76 zinc coating designation Z-275, and base metal quality 02.

4-01.2 Structural Steel

Structural Steel shall be M.S. members rolled from Pakistan Steel billets or equivalent conforming to ASTM designation A-36 standard specifications for structural steel.

4-01.3 Canvas Cloth

Canvas Cloth shall have specified weight with flame retardant quality.

4-01.4 Painting

All steel work in connection with supports for ductwork etc. exposed to the elements is to be painted with two coats of an approved rust preventive paint.

All exposed metal surface of hangers, brackets, etc. must be painted with two under-coats and two finishing coats of enamel paint of approved colour. G.I. sheet is not to be painted. However, all uninsulated pipe work and valves are to be painted as stated above.

Identification bands shall be painted on uninsulated ducting, or on insulation at frequent intervals. Lettering shall be agreed with the Engineer.

All duct hangers in concealed locations shall be given one coat of black asphalt paint before being concealed.

4-02 DUCT FABRICATION

All sheet metal duct work shall be of a standard construction and erected in a first-class workmanlike manner. The site storage for Duct shall be a clean and dry environment where the ductwork is protected from dust, must be provided for the storage of ductwork prior to installation; all sealed ends shall be visually examined and if damaged resealed with an appropriate material.

The duct work shall be constructed as per SMACNA Low Velocity Duct Construction Standards.

During Construction the contractor shall cover the openings of duct work to prevent the entry of dust and debris into the duct. All self-adhesive labels for part identification are to be applied to external surfaces only; to maintain

cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.

Where specified, duct work shall be provided with interior insulation. Ducts shall be straight and smooth on the side, with joints neatly finished. Where ducts are lined with interior insulation, the dimensions required shall be for the net free area after insulation is applied. Ducts shall be anchored securely to the structure in an approved manner and shall be installed so as to be completely free from vibration under all conditions of operation.

Sheet metal ducts shall be properly braced and reinforced with steel angles, or other structural members approved by the Engineer Unless otherwise required, the internal ends of all slip joints shall be installed in the direction of flow.

Finished work shall show no flaking or peeling within 1/4" of a cut edge. The construction and gauge of material, size and spacing of stiffeners for duct work shall be as follows:

Larger Dim. of Duct (in.)	Gauge (US)	Traverse Joint Type /Size (in.)	Interm Bracing, Angle Size (in.)	Max. Spacing Between Trav. Joint and/or Interm Reinforcement (ft.)
Thru 10	26	Drive slip/-	-	-
10 thru 18	24	-do-	-	-
19 thru 30	24	Pocket Lock/1	1x1x1/8	5
31 thru 42	22	Pocket Lock/1	1x1x1/8	5
43 thru 54	22	Pocket Lock/1-1/2	1-1/2 x 1-1/2 x1/8	5
55 thru 60	20	Pocket Lock/1-1/2	1-1/2 x 1-1/2 x1/8	5
61 thru 84	20	Angled Reinforced Standing Seam	1-1/2 x 1-1/2 x1/8	5
85 thru 96	18	-do-	1-1/2 x 1-1/2 x1/4	2.5
over 96	18	-do-	1-1/2 x 1-1/2 x1/4	2.5

Other types of Traverse joints allowed as per ASHRAE/ SMACNA Standards shall be acceptable, subject to Approval of Engineer, in places where pocket lock is not possible due to tight space.

All angles for bracing shall be painted with one coat of approved rust-inhibitive paint before fixing to duct.

All duct work in the finished areas shall be run parallel to the beams wherever possible. All outlet opening and open ends shall be kept closed with sheet metal caps during construction. Rectangular duct shall be constructed by breaking the corners and grooving the longitudinal seams. Elbows and transformation sections may be formed with Pittsburgh corner seams but complicated fittings shall be constructed with double seams. Angle bracing shall be of steel and shall be carried out on all four sides of the ducts. All bracing is to be in accordance with the current addition of the ASHRAE Hand Book/ SMACNA Standards.

Ducts shall be built with curves and bends, where required, to affect an easy flow of air. Curved elbows shall have a centre line radius at least equal to 150% of the width of the duct unless otherwise indicated. All duct curves having an inside radius smaller than the width of the curve shall be equipped with approved single thickness vanes.

Vertical ducts shall have full size bends where horizontal branches are taken off unless otherwise indicated, and/or approved.

Where square elbows are used in changing directions, approved and aerodynamically correct vanes as per latest SMACNA Duct Construction Standards shall be used.

These turning vanes must be free from vibration when the system is in operation.

4-04

HANGERS

Hangers and supports shall be fastened to the structure in a manner approved by the Engineer. All fastening shall be such as to ensure permanent stability and to be capable of supporting at least three times the applied load.

Galvanized sheet metal ducts less than 20" in width (larger dimension) may be suspended by means of galvanized iron straps extended along the bottom of the duct to form a trapeze, only if hanger length above the duct is not more than 12".

All other ducts shall be suspended by means of iron bars securely fastened to the angle iron bracing or angle iron placed under the duct. Bars shall be fastened to bracing only on un-insulated ducts.

Bars shall be welded to angles at ceiling, attached therein by anchor screws and heavy iron washers. Where horizontal ducting is fixed to walls, columns, supported from floor slabs, etc. angle iron frames are to be fabricated and fitted to support rectangular ductwork and associated equipment.

Vertical ducts are to be supported by steel angles bolted to at least two sides of the duct and on the complete circumference of the ducts where the larger duct dimension is greater than 24".

Angle iron extensions shall be either grouted or bolted to the structure.

Hangers spacing and sizes shall be as follows.

Larger duct dim. (in)	Strap Size (in)	Bar Dia (in)	Bottom Angle Size (in)	Maximum Spacing (ft)
Thru 20	1x1/8	3/8	1-1/2 x 1-1/2x1/8	10
21 thru 60	-	3/8	2 x 2 x 1/8	10
61 thru 84	-	3/8	2 x 2 x 2/8	10
85 thru 96	-	3/8	2 x 2 x 2/8	10
over 96	-	3/8	2 x 2 x 2/8	7

Hanger rods shall be cross-braced whenever the length of rod above duct work is more than 3 ft. to prevent swing of ducts.

All structural steel including hanger rods and angle iron shall be painted with one coat of approved rust- inhibitive paint before installing.

4-05 QUADRANTS FOR VOLUME DAMPERS

All dampers other than dampers behind registers and diffusers shall be fitted with substantial locking quadrants, mounted outside the duct in an accessible position. On insulated ducts the quadrants shall be fastened to bearing plates flush with the outside finish of the insulation.

4-06 DAMPERS

4-06.1 Volume Dampers (V.D)

A substantially constructed manual volume damper of the butterfly or multiple blade type as per latest SMACNA Duct Construction Standards shall be fitted where shown on the Drawings and at all branch entries or exits with main ducts for balancing purposes. Dampers shall have galvanized or painted steel interlocking blades of 8" maximum blade width. Blades shall be fabricated from 16-gauge steel with seamed edges and a maximum length of 4 ft. It should be noted that these dampers, shall be separate and independent from the dampers, hereinafter specified. Volume Dampers are not required where splitter Dampers, as specified hereinafter, are installed.

4-06.2 Splitter Dampers (S.D)

At each point of division in a supply trunk duct where a branch is taken off a trunk duct, an adjustable splitter or deflecting damper, one gauge heavier than the duct with operating rod and locking quadrant as above, shall be installed. These deflecting dampers shall be permanently set and locked in position after completion of the installation and adjustment with fans running.

Operating rods are to be full blade length extending through the duct to externally mounted bearing plates. Construction shall be as per latest SMACNA Duct Construction Standards.

4-06.3 Fire Dampers (F.D)

Fire dampers are to installed at SA /RA duct penetration of building envelope membrane.

Frame shall be 2"x1/2"x1/8" galvanized steel channel with 16 gauge thick blades. Blades shall have an overlap of 1" and shall be fixed on self-lubricating bronze type bearings.

Dampers shall be complete with linkage rod and fusible link rated at 160 deg F. Damper construction shall meet NFPA 90-A requirements, and shall have the "hour" fire-rating not less than the fire rating of the plane where installed. Fire dampers shall be air tight when in close position.

4-07 FLEXIBLE DUCT CONNECTIONS

Flame proof flexible connections shall be furnished and installed on all suction and discharge connections of fans and air-conditioning units for prevention of transmission of vibration through the ducts to occupied spaces.

Flexible connections also be provided wherever ducts cross building expansion joints.

Flexible connections shall be factory fabricated of imported origin, made from chemically impregnated canvas or other material approved by the Engineer. Connections shall fit closely and are to be secured in an airtight fashion at connections to ductwork, fans and apparatus. The unclamped section of the flexible connection between apparatus and ductwork shall not be less than 6" in length. Flexible connections shall not be painted or insulated. Samples of the material shall be presented to the Engineer for approval before installation.

4-08 ACCESS DOORS AND PANELS

Wherever necessary, suitable access openings, doors and frames to permit inspection, operation and maintenance of all filters, controls, dampers, bearings or other apparatus shall be provided in ducting. Doors shall be of double construction, of not lighter than 20-gauge metal sheet and shall have neoprene gaskets around their entire perimeter. On insulated duct work the space between the inner and outer door sheets shall be insulated as specified for the ductwork. All access doors in sheet metal shall have air tight seal, shall be hung on heavy flat hinges and shall be secured in the closed position by means of wing type nuts and screws or coin operated catches.

4-09 SLEEVES

Where ducts pass through walls, partitions, or floors, wooden sleeves shall be provided by the Contractor and these sleeves shall remain in place permanently. Sleeves shall be packed with non-combustible glass- fibre insulation, minimum of 1.5 lbs/cu.ft. density and sealed with sealant.

4-10 TEST WELLS

The Contractor shall provide test wells for measurement of air velocity and static pressure for balancing purpose. These wells made up of a brass nipple with screwed caps are to be fixed into the duct or casing on the downstream sides of each fan, filter, PU, FCU and branch volume damper in each branch supply duct, and on upstream side of branch volume damper in each branch return. The design of test well shall be subject to Engineer's approval.

SECTION 5 - PIPING, FITTINGS

5-01 PIPING, FITTINGS & ACCESSORIES

5-01.1 Refrigerant Piping:

The refrigerant piping interconnecting to indoor & outdoor units shall be made out of hard copper tubes, in brazed construction. The refrigerant line sizing should be designed to achieve minimum pressure drop and avoid oil return problem. The pipe sizes and connections shall be designed such that the evaporator units do not face back pressure due to the functioning of the evaporator next to it.

All piping shall be neatly laid and supported on galvanized perforated sheet metal trays and clamped firmly. Piping should be shrouded, where necessary, to protect it from accidental damage/leaks during work by any agencies.

The refrigerant piping for the VRF system shall be of minimum wall thickness as per copper pipe-ASTM B88, L-Type standard HARD drawn copper pipes. The copper pipe shall be internally chemically cleaned, free of dirt, dust, oxidation and any other deposits. All joints shall be made by brazing. Inert gas purging shall be used during the brazing process to prevent oxidation.

U-bends shall be provided for efficient oil return in suction line, at appropriate locations.

All pipe supports/clamps shall Hot-Dip Galvanized, Pipe support system shall be as per approved manufacturer.

The piping and wiring shall be laid such that it does not spoil the aesthetics of the premises, and is safe, secure and approachable for leak detection/repair/replacement.

5-01.2 Refrigerant Piping Brazing and Handling

All joints are brazed in the field. Multi V Water Mini refrigeration system components contain very small capillary tubes, small orifices, electronic expansion valves, oil separators, and heat exchangers that can easily become blocked. Proper system operation depends on the installer using best practices and utmost care while assembling the piping system. Store pipe stock in a dry place; keep stored pipe capped and clean. Blow clean all pipe sections with dry nitrogen prior to assembly.

- Proper system operation depends on the installer using best practices and the utmost care while assembling the piping system.
- Use adapters to assemble different sizes of pipe.

Always use a non-oxidizing material for brazing. Do not use flux, soft solder, or anti-oxidant agents. If the proper material is not used, oxidized film may accumulate and clog or damage the compressors. Flux can harm the copper piping or refrigerant oil.

- Use a tubing cutter, do not use a saw to cut pipe. De-bur and clean all cuts before assembly

- Use a dry nitrogen purge operating at a minimum pressure of three (3) psig and maintain a steady flow.

- Use a 15% silver phosphorous copper brazing alloy to avoid overheating and produce good flow.
- Protect isolation valves, electronic expansion valves, and other heat-sensitive control components from excessive heat with a wet rag or heat barrier spray.

5-01.3 Drain Piping

The drain piping shall be made out of rigid PVC pipes of 10 Kg/cm² class. The piping shall be supported by clamping on MS angle 25mm x 3mm running continuously below the pipe. The piping shall be insulated with 6mm thick closed cell nitrile rubber sleeves.

The drain pans of IDUs shall be connected to rigid PVC pipe by braided PVC flexible pipe with appropriate adapters. U trap shall be providing in the drain connection of each IDU. All pipes support/clamps shall be painted with red oxide primer followed by two coats of synthetic enamel finish paint.

5-01.3.1 Pipe Schedule

S. No	Service	Size	Specifications
b)	Galvanized Steel	All sizes	Galvanized steel, Light Quality BSS 1387
(i)	Cooling Coil condensate Drain		

5-01.3.2 Fittings Schedule

S. No.	Service	Size	Specifications
b)	Galvanized Steel Piping		
(i)	Cooling Coil condensate Drain	All sizes	150 lb malleable iron galvanized screwed fittings to ANSI B16.3

SECTION 6 - INSULATION

6-01 GENERAL

- 6-01.1 The Contractor shall provide insulation for the services and equipment specified hereafter. Insulation shall be as per following Insulation Schedule.
- 6-01.2 Insulation material shall be complete with vapour barrier protection covering and jacketing (where specified), adhesives, insulation tape, duct sealer and/or sealing tape, fastening material, and jacketing for outdoor ducting and piping.
- 6-01.3 Identification bands shall be painted on insulation at frequent intervals. Lettering shall be agreed with the Engineer.

6-02 INSULATION SCHEDULE NBR or similar material,

Service	Thickness (inch)	Insulation type	Vpour barrier	Protection
1	2	3	4	5

- a) Indoor Supply
Return/OA Duct: duct
passing
through con-
ditioned space

i)	Concealed to vision	1	Glass fibre blanket	Reinforced- Aluminium foil	4-Oz Canvas.
ii)	Exposed to vision	1	Glass fibre blanket	Reinforced- Aluminium foil.	8-Oz Canvas.
b)	Outdoor SA / RA Ducts	2	Glass fibre blanket	Reinforced- Aluminium foil.	8-Oz Canvas. With 26 Ga GI Sheet Jacketing
c)	Cooling Coil Condensate Drain Piping	1/8	(Self-adhesive Vinyl Alum. Tape)	Reinforced Aluminium foil.	-

6-03 INSULATION MATERIALS

6-03.1 Duct Insulation

Insulation material for ducts and sheet metal air plenums shall be flexible glass fibre, 0.75 lbs/cu.ft. density and maximum conductivity of 0.27 Btu/hr.sq.ft./inch at 75 deg F

- 6-03.2 Vapour Barrier for Duct Insulation
- Vapour barrier when specified shall be factory applied flame retardant reinforced aluminium foil, 0.02 mils thick.
- 6-03.3 Acoustic Liner Material
- Acoustic liner shall be 1.5 lbs/cu.ft. density fibre-glass with neoprene scrim on inside surface and thermal conductivity value shall not exceeding 0.27 Btu/hr.sft Deg F/inch at 75 Deg F. Material shall conform to TIMA Standard AHC- 101-1975 with latest revisions.
- 6-03.4 Cooling Coil Condensate Pipe Insulation
- Shall be 1/8" thick pipe insulation vinyl aluminium 'foram' with aluminium foil self-adhesive tape 3" wide.
- 6-03.5 Insulation Protection Material and Accessories
- a. Canvas
 - 4 Oz or 8 Oz per sq.ft. as specified in Insulation Schedule.
 - b. Jacket
 - 24 gauge (US) galvanized steel sheet or aluminium sheet.
 - c. Water Proof Paint
 - As approved by the Engineer
 - d. Wire Netting
 - 1" hexagonal mesh, 20 gauge (US), galvanized.
 - e. Metal Lath
 - Expanded metal lath with 1/2 inch diamond mesh.
 - f. Banding
 - 1/2" x 1/48" galvanized steel or aluminium bands.
 - g. Insulation Tape
 - Insulation tape for joints shall be of aluminium foil type, 2 inch wide, equivalent to Scotch No.473.
 - h) Adhesive
 - Adhesive for thermal insulation and acoustic liner shall be Zahbia make suitable for hospital application and approved by Engineer.
 - i) Duct Sealer

Sealer for duct joints shall be butyl rubber caulking, weather proof and water resistant.

j) Duct Sealing Tape

Duct sealing tape shall be 3-inch-wide self-adhesive vinyl cloth tape.

6-04 INSULATION APPLICATION

6-04.1 General

All Thermal and acoustic insulating materials shall be installed as specified hereinafter.

Insulation shall be installed in a smooth, clean, workmanlike manner and joints shall be tight and finished smooth.

All surfaces to be insulated shall be dry and free from loose scale, dirt, oil or water when insulation is applied. Insulation shall be applied in such a manner that there will be no air circulation within the insulation or between the insulation and the surface to which it is applied.

Surface imperfections in the insulation such as clipped edges, small joints or cracks and small voids, or holes not over 1 inch square shall be filled with like insulating material.

Where a vapour barrier is fixed on site it shall be fixed in such a manner as to obviate the possibility of moisture penetration. It shall be fixed where required by means of an approved type bituminous compound or approved equal for tightness.

Insulation for all services shall only be applied until after testing and approval for tightness obtained from the Engineer, unless otherwise instructed in writing by the Engineer.

Insulation for all services shall be continued through sleeves. The insulation on exposed risers shall extend through the floor. Where insulated pipes are indicated on drawings as embedded in the thickness of walls, the insulation thickness may be reduced to 1 inch only.

Insulation is to be applied where indicated on the drawings or called for in these specifications.

6-04.2 Duct Insulation

Before applying insulation, either sealing tape or duct sealer shall be applied on all corners of traverse joints for air tightness.

The insulation shall be fixed on ducts with a suitable adhesive as specified. Adhesive shall be applied on at least 75% surface area. In addition to the fixing by adhesives, insulation on the underside of ducts exceeding 18 inch width must have mechanical fasteners of an approved pattern to prevent insulation sagging, or alternatively bands as specified above shall be used at intervals not exceeding 4 feet.

All joints on the insulation shall be sealed with 2 inch aluminium foil tape. The tape shall only be fixed to the vapour seal and not to the bare insulation

and, therefore, joints in the insulation shall not occur longitudinally at corners of ducts. If it is unavoidable to have joints at longitudinal corners then the insulation must be cut back and the vapour seal folded over the bare edge of the insulation so that the tape adheres only to the vapour seal.

6-04.3 Duct Insulation Protection

Indoor Exposed Duct: Insulation shall be covered over the vapour seal with a single layer of canvas with generous overlaps. The canvas shall be fixed with an approved adhesive.

6-04.4 Condensate Drain Piping

Self-adhesive pipe insulation tape, as specified above, shall be spiral-wrapped around pipe, with 50% overlap.

SECTION 7 - ELECTRICAL EQUIPMENT AND CONTROLS

7-01 SCOPE

The Contractor shall supply all panel boards, starting equipment, circuit breakers, busses, isolators, for each electrically operated HVAC equipment. He shall also provide power cables & earthing conductors between HVAC equipment and termination points of electrical contractor as specified in clause 7-02

7-02 DISTRIBUTION & CONTROL SCHEME

The Employer, through other contractor, will provide incoming power cables and earthing conductors from dual source LT panel to HVAC Motor Control Centre (MCC) at roof (or other location identified by the Employer) From MCC onward to each electrically operated HVAC equipment at location identified by Engineer and/or as shown on drawings shall be furnished and installed by HVAC Contractor, sized to handle respective HVAC equipment load The HVAC Contractor will make connections to respective equipment with necessary circuit breakers and other devices housed in Motor Control Centre.

HVAC contractor shall be responsible to provide and install the complete power network with suitable isolation provisions for all indoor units including but not limited to FCUs, DX/VRF Split Indoor Units, all types of Fans, AHUs at suitable stage during construction in coordination with other trades.,

7-03 GENERAL

All electrically operated equipment shall comply in all respects with the relevant B.S.Standards including dimensional standards where these exist, except in so far as this Specification is at variance therewith.

All electrically operated equipment shall be so designed that it will continue to function without damage to itself or otherwise, if the voltage and/or frequency vary within the following tolerances.

Voltage plus or minus TEN per cent.

Frequency plus or minus SIX percent.

The entire installation shall be in accordance with the requirements and to the entire approval of the Electricity Department of the Government and the approval of the Engineer.

All electrically operated equipment shall be suitable for continuous and prolonged operation in an ambient temperature 115deg F. This temperature makes no allowance for local rises in air temperatures due to the operation of the equipment itself or of heat produced in or by adjacent equipment such as compressors, condensers or heaters. The maximum operating temperature in standards specified shall be observed. Allowance for local high ambient temperature shall be made by reducing the permitted rises of temperature above ambient.

7-04 WIRING

All power wiring and operating control wiring shall run in conduits. All wiring conduits shall be PVC in concealed to vision spaces and G.I. pipe if exposed to vision. Make of cables shall be Pakistan Cables or approved equal. Material and application specifications for wiring accessories shall be subject to Engineer's approval.

7-05 LABELS

Each piece of equipment on the panel and each component in the panel shall be identified by a nameplate. Nameplates may be laminated plastic or metal with 1/4 inch high etched letters and attached to the panel or integral with it. Lettering shall be cut into the plate to a depth of not less than 1/64 inch and shall show a contrasting colour produced by filling with enamel or lacquer or by use of a laminated material. Painting of lettering directly on the surface of the plate or panel will not be permitted.

7-06 EARTHING

7-06.1 General

For scope of work refer to clauses 7-01 and 7-02.

All HVAC equipment with electricity connection and all Motor Control Centres (MCCs), Apparatus Control Panels (ACPs) and Local Isolation Switches (LISs) panels shall have their frames, carcasses and all metal parts not normally carrying current, effectively and continually connected to the general mass of the earth. Each equipment and panel shall be separately connected to a main earth continuity conductor.

7-06.2 Earth Continuity Conductor

Earth continuity conductor shall be round, hard drawn, bare electrolytic copper wire of appropriate sizes as approved by the Engineer. All fixing accessories, earthing clips, sweating sockets, lugs, thimbles, etc., shall be provided for earthing installation.

7-07 CONDUITS AND CONDUIT ACCESSORIES

7-07.1 Material Description

The conduit for wiring shall be of polyvinyl-chloride material for use in concealed to vision locations and G.I. pipe in exposed locations including vertical shafts. All other accessories shall be subject to Engineer's Approval.

7-07.2 Application of PVC Conduit

Manufactured smooth bends shall be used where conduit changes direction. Bending of conduit by heating or otherwise shall be allowed at special situation only, for which approval of Engineer shall be necessarily required. The use of sharp 90-degree bend and tees shall not be allowed. The bends shall have enlarged end to receive conduit without any reduction in the internal diameter at joint. Round Junction Boxes shall be provided with one piece PVC Cover plate which shall be installed on the box by means of galvanized screws. Pull box shall be installed in conduit runs, wherever required to limit the pulling length of cables. Pull Boxes should be installed in conduit runs to limit the pulling lengths as required. The

rectangular inspection or pull boxes shall be 16 S.W.G. thick sheet steel having nipples to receive PVC conduit with force fit. The sheet steel box shall be painted inside and outside with black enamel paint over a base coat of red oxide antirust paint, as approved by Engineer. The minimum length of inspection box shall not be less than four times the cables manufacturer's recommended bending radius of the cable. Bushes shall be used at pipe terminations and PVC solution for jointing of pipes.

7-07.3 Application of G.I. Conduit

Application of G.I. conduit shall be similar to PVC conduit as specified above, except that pipes shall have threaded socket connections. Pipes and fittings shall be as specified in Piping Section, finished with 2 coats of aluminium paint.

7-08 **MOTOR CONTROL CENTRE**

The Contractor shall supply and install the Motor Control Center (MCC) for all equipment installed in Control Room or as directed by Engineer. The panel shall be of sufficient size and dimensions to house the various starting and control equipment for the installation. The panel shall be provided with lock and double set of keys. The Motor Control Centre shall be suitable for operating at the voltage, frequency and the starting method specified. It shall be of the unit construction single fronted or double fronted type with a common set of busbars. It shall be made up of any number of steel plate cubicles with turned edges mounted side by side sub-divided into compartments to suit the control gear items, all bolted together to form a self-contained switchboard. It shall be constructed such that all doors are interlocked, preventing access to the starter until the corresponding isolating switch is in the "off" position. All equipment shall be inspected or maintained from the front of the switchboard, the main cables to the motor control centre and all outgoing cables from it may enter from top, bottom, or rear, depending on the location and convenience with provisions of steel removable panels covering the cable compartment.

Components shall be mounted in a logical order based on the sequence of operation, all components requiring frequent inspection shall be mounted between 2 ft. and 6 ft. above floor level.

This panel will contain the following equipment (but not limited to):

- VFD with accessories inside ventilated enclosure of required rating
- Circuit Breaker on incoming line
- Copper busbars with suitable porcelain isolators.
- Circuit breakers, one on each outgoing line.
- Push button stations, one for each starter. (including starters in remote ACPs if used)
- Pilot lights, one for each incoming main lead, red, yellow and blue to indicate live phases.
- Pilot lights, one for each starter, red for equipment operating. (including starters in remote ACPs if used)
- Ammeters, one for each main incoming lead and one for each starter.
- Starters with thermal overload protection.
- Voltmeter with commutator.
- Toggle switches, labels.

All internal wiring and accessories for the interlocking of the various components, clipped individually to the panel, and arranged parallel or at right angles.

All indications shall be visible from front of the panel. Prior to installation, the Contractor shall submit for approval to the Engineer the electrical diagram of the whole installation and the suggested panel layout showing the arrangement of electric components with samples of instruments and components.

SECTION 8 – TEMPERATURE & HUMIDITY CONTROLS

8.01 GENERAL

8.01.1 OVERVIEW

Furnish all labor, materials, equipment, and service necessary for a complete and operating temperature, relative humidity & pressure control system, utilizing Direct Digital Controls, electronic interfaces and actuation devices, as shown on the drawings and/or as described herein. Drawings (when provided) are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, those are required to meet the functional intent, shall be provided without additional cost to the Employer.

These specifications are general in nature & Items of Hardware described in these specifications shall be furnished when project specific requirement necessitates supply of such item of hardware. All necessary BMS hardware components shall be provided either specifically shown on drawings or not in order to make the system operate properly.

8.01.2 CONTROL SPECIALIST FIRM AS SUB-CONTRACTOR

Sub-Clause SP-02.1(d) of Special Provisions apply

8.01.3 SPECIFICATION NOMENCLATURE

BMS	Building Management System
BMSS	Building Management System Supplier
SDC	Standalone Digital Controller
GDC	Gateway Digital Controller
GP	Graphical Programmer
HMI	Human Machine Interface
PAC	Personnel Access Controller
GUI	Graphical User Interface

8.01.4 INSTALLATION

All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the BMS system manufacturer or its exclusive factory authorized installing contracting field office/representative (referred hereinafter as BMSS, i.e. Building Management System Supplier). The BMSS shall have a minimum of five years of installation experience with the manufacturer and shall provide documentation in submittal package verifying longevity of the BMSS relationship with the manufacturer. Supervision, calibration and checkout of the system shall be by the employees of the local BMSS's office.

The controls specialist firms having experience on SKMH projects may be given preference by the engineer while approving the sub-contractor for BMS work.

8.01.5 CONTROL WIRING

- a) All electrical control wiring and power wiring to the BMS control panels & components of the BMS system shall be the responsibility of the BMSS.
- b) The Contractor (HVAC) shall furnish all power wiring to electrical starters, VFDs, Electric duct heaters, Humidifiers, condensing unit and motors for their operation.
- c) All wiring shall be in accordance with the Project Electrical Specifications.

8.01.6 UNACCEPTABLE BUILDING MANAGEMENT SYSTEM SUPPLIER

Wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems shall not be acceptable as BMSS. Technical Submittals that are not complete in their response to these documents or take exception to any of the capabilities defined within these documents will be rejected.

8.01.7 SUBMITTALS

- a) Technical Submittals of the entire control system shall be submitted and shall consist of system Architecture schematic, a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the drawings. A complete written Sequence of Operation as well as a hard copy graphical depiction of the application control programs shall also be included with the submittal package.
- b) Upon completion of the work, provide a complete set of drawings and application software on magnetic floppy disk media. Drawings shall be provided as AutoCAD files.

8.01.8 MATERIALS

All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use.

8.01.9 WARRANTY

- a) The BMSS shall provide a one-year warranty that will commence from the commissioning of Control System

8.01.10 SOFTWARE LICENSE AGREEMENT

The BMSS shall provide standard software under the manufacturer's standard software and firmware licensing agreement. Such license shall grant use of all programs and application software to Employer

The software shall have Lifetime availability and min 10 years free unlimited upgrades.

Availability of hardware shall be guaranteed for minimum 10 years by the OEMs.

8.01.11 SPECIFICATION COMPLIANCE REVIEW

The BMSS shall supply, at the time of providing Technical Submittal, a paragraph by paragraph specification compliance report. The report shall indicate for each numbered paragraph, how the BMSS meets the criteria of the paragraph. The following format must be utilized in completing the compliance report:

- a) Comply - without exception.
- b) Qualify - meet the functional intent. For each paragraph, the BMSS shall identify all differences in specific functions stated in the given paragraph and provide a description of what is excluded or how the qualifying system will meet the function specified.
- c) Does not comply – cannot meet specified function.

8.02 Integrated Building Automation System

8.02.1 Standard Terms

A) Standard

- ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers
- AHU: Air Handling Unit
- BACnet: Building Automation Controls Network
- BMS: Building Management System
- DDC: Direct Digital Control
- EIA: Electronic Industries Alliance
- GUI: Graphical User Interface
- HVAC: Heating, Ventilation, and Air Conditioning
- IEEE: Institute Electrical Electronic Engineers
- MER: Mechanical Equipment Room
- PID: Proportional, Integral, Derivative
- VAV: Variable Air Volume Box

B) Communications and protocols

- ARP: Address Resolution Protocol
- CORBA: Common Object Request Broker Architecture
- CSMA/CD: Carrier Sense Multiple Access/Collision Detect
- DDE: Dynamic Data Exchange
- FTT: Free Topology Transceivers
- HTTP: Hyper Text Transfer Protocol

- IIOP: Internet Inter-ORB Protocol
- LAN: Local Area Network
- LON: Echelon Communication – Local Operating Network
- MS/TP: Master Slave Token Passing
- ODBC: Open Database Connectivity
- ORB: Object Request Broker
- SNVT: Standard Network Variables Types
- SQL: Structured Query Language
- UDP: User Datagram Protocol
- XML: eXtensible Markup Language

C) Controllers

- ASD: Application Specific Device
- AAC: Advanced Application Controller
- ASC: Application Specific Controller.
- CAC: Custom Application Controller.
- DCU: Distributed Control Unit
- LCM: Local Control Module
- MC: MicroControllers
- MCI: MicroInterface
- MZ-II: Microzone II direct digital controller
- MN-FLO: Micronet 2000 Pressure Independent VAV Controller
- NSC: Network Server Controller
- PEM: Package Equipment Module
- PPC: Programmable Process Controller
- SDCU: Standalone Digital Control Units
- SLC: Supervisory Logic Controller
- UEC: Unitary Equipment Controller
- VAVDDC: Variable Air Volume Direct Digital Controller

D) Tools and Software

- AMBCx: Automated Monitoring Based Commissioning

- APEO: Automated Predictive Energy Optimization
- DR: Demand Response
- CCDT: Configuration, Commissioning and Diagnostic Tool
- BPES: BACnet Portable Engineering Station
- LPES: LON Portable Engineering Station
- POT: Portable Operator's Terminal

8.02.2 PRODUCTS

A. Pre-approved Manufacturers/Installers

- i. Honeywell USA
- ii. Schneider electric, USA
- iii. Johnson control, USA

B. Scope of Work

i. The Contractor shall furnish and install a complete building automation system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as approved by the engineer. All components of the system – application controllers, unitary controllers, etc. shall communicate using the BACnet/IP protocol. No gateways shall be used for communication to controllers furnished under this section. At a minimum, provide controls for the following:

Air handling units

Exhaust and supply fans

Zone temperature, relative humidity & differential pressure, Electric duct heaters Smoke extraction sequence of AHUs.

The AHUs, Treated FAHUs and FCUs (if applicable) shall be interlocked with the fire alarm and detection system. In case of any fire alarm/ the HVAC equipment serving that zone shall be stopped. The restoration of the particular zone equipment operation shall be made after physical inspection and physical reset of the alarm/ switch.

Maximum Operations, Controls, System Settings and status monitoring (On, Off, Trip, Interlock and Fault etc) of complete HVAC system and equipment should be provided.

8.02.3 DDC Sensors and Point Hardware

i. Temperature Sensors

A. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F. Space temperature sensors shall be accurate to +/- 0.5 degrees F over a range of 40 to 100 degrees F.

B. Duct Probe Sensor: Sensing element shall be fully encapsulated in potting material within a stainless-steel probe. Useable in air handling applications where the coil or duct area is less than 14 square feet.

C. Duct Averaging Sensor: Averaging sensors shall be employed in ducts which are larger than 14 square feet.

The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of rigid or flexible copper tubing.

- D. Pipe Immersion Sensor: Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications. Provide sensor probe length suitable for application. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F.
- E. Not Used
- F. A pneumatic signal shall not be allowed for sensing temperature.

ii. Humidity Wall Transmitter

- A. Transmitters shall be accurate to +/- [1] % at full scale.
- B. Transmitter shall have replaceable sensing element.
- C. Sensor type shall be thin-film capacitive.
- D. Sensor element shall contain multipoint calibration on-board in non-volatile memory
- E. Operating range shall be 0 - 100% RH noncondensing, 50 to 95 F
- F. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC.
- G. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
- H. Transmitter shall be available in an enclosure made of high impact ABS plastic for mounting on a standard electrical box.
- I. Transmitter shall have LCD display
- J. Transmitter shall be available with a certification of NIST calibration
- K. Transmitter shall have integrated temperature sensor

iii. Humidity Duct Transmitter

- A. Transmitters shall be accurate to +/- [1] % at full scale.
- B. Transmitter shall be fully encapsulated in potting material within a stainless-steel probe.
- C. Transmitter shall have replaceable sensing element.
- D. Sensor type shall be thin-film capacitive.
- E. Sensor element shall contain multipoint calibration on-board in non-volatile memory
- F. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
- G. Output shall be 4-20 mA or 0-5/0-10 VDC.
- H. Transmitter shall accept 12-30 VDC or 24 VAC supply power.

- I. Transmitter shall be available with a certification of NIST calibration
- J. Transmitter shall have integrated temperature sensor

iv. Humidity Outdoor Transmitter

- A. Transmitters shall be accurate to $\pm 2\%$ at full scale.
- B. Transmitter shall be fully encapsulated in potting material within a stainless-steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
- C. Transmitter shall have replaceable sensing element.
- D. Sensor type shall be thin-film capacitive.
- E. Sensor element shall contain multipoint calibration on-board in non-volatile memory
- F. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
- G. Output shall be 4-20 mA or 0-5/0-10 VDC.
- H. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
- I. Transmitter shall be available with a certification of NIST calibration
- J. Transmitter shall have integrated temperature sensor

v. Not used

vi. Not used

vii. Air Pressure Transmitters.

- A. Sensor shall be microprocessor profiled ceramic capacitive sensing element
- B. Transmitter shall have 14 selectable ranges from 0.1 – 10" WC
- C. Transmitter shall be $\pm 1\%$ accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
- D. Transmitter shall be field configurable to mount on wall or duct with static probe
- E. Transmitter shall be field selectable for Unidirectional or Bidirectional
- F. Maximum operating pressure shall be 200% of design pressure.
- G. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
- H. Transmitter shall accept 12-30 VDC or 24 VAC supply power
- I. Response time shall be field selectable T95 in 20 sec or T95 in 2 sec
- J. Transmitter shall have an LCD display
- K. Units shall be field selectable for WC or PA

- L. Transmitter shall have provision for zeroing by pushbutton or digital input.
 - M. Transmitter shall be available with a certification of NIST calibration
- viii. Not used
- ix. Not Used
- x. Current Sensors
 - A. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in split core models, and offer either a digital or an analogue signal to the automation system.
- xi. Not Used
- xii. Not Used
- xiii. Not Used
- xiv. Not Used
- xv. Not Used
- xvi. Not Used
- xvii. Not Used
- xviii. Not Used
- xix. Not Used
- xx. Smoke Detectors
 - A. Air duct smoke detectors shall be by Air Products & Controls or approved equivalent. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
 - B. The smoke detector shall utilize a photoelectric detector head.
 - C. The housing shall permit mechanical installation without removal of the detector cover.
 - D. The detectors shall be listed by Underwriters Laboratories and meet the requirements of UL 268A.
- xxi. Not Used
- xxii. Variable air volume Box
- xxiii. Not used**

xxiv. Room differential Pressure Sensor

The Room differential pressure sensor shall be provided with display. It shall be capable of sensing at 0.5 %, (± 0.25 %) full scale accuracy and with a display resolution up to 0.1 pascal
It should meet the requirement of pressure critical healthcare space, biocontainment clean rooms and any application where very low room pressure sensing required.

xxv. Not Used

8.02.4 Not Used

8.02.5 Software Installation

i. General.

- A. The Contractor shall provide all labour necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

8.02.6 Database Configuration.

- i. The Contractor will provide all labour to configure those portions of the database that are required by the points list and sequence of operation.

8.02.7 Color Graphic Displays.

- i. Unless otherwise directed by the owner, the Contractor will provide color graphic displays for all systems in the HVAC drawings for each system and floor plan. For each AHU, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.

8.02.8 Reports.

- i. The Contractor will configure a minimum of 4 reports for the owner. These reports shall, at a minimum, be able to provide:
 - C. Trend comparison data
 - D. Alarm status and prevalence information
 - E. Energy Consumption data
 - F. System user data

8.02.9 Documentation

- i. As built software documentation will include the following:
 - A. Descriptive point lists
 - B. Application program listing
 - C. Application programs with comments.
 - D. Printouts of all reports.
 - E. Alarm list.
 - F. Printouts of all graphics
 - G. Commissioning and System Startup

8.02.10 Point to Point Checkout.

- i. Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

8.02.11 Controller Checkout.

- i. A field checkout of all BMS system shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

8.02.12 System Acceptance Testing

- i. All application software will be verified and compared against the sequences of operation approved by the engineer.

- ii. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
- iii. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (HMI display, workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Arrangement for audible alarm in case of detection of smoke shall be provided also be provided. Submit a Test Results Sheet to the owner.
- iv. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.
- v. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

8.02.13 SEQUENCE OF OPERATION

The controls specialist firm to propose the sequence of operation and is subject to engineer's approval.

8.02.14 Indication

Following equipment shall have the indication at the controller / display.

EQUIPMENT	TYPE	INDICATION	
• Fan status			
• Condensing units			
• Smoke detector;	DI	SMOKE/NO SMOKE	
• Room Differential Pressure	AI	Digital pascal +/-	
• Room/Zone Rel. Humidity		AI	
		DIGITAL %RH	
• Room/zone Air Temp.		AI	
	DIGITAL DEG	C	
• Supply Air dischargeTemp.		AI	
	DIGITAL DEG	C	
• Air Filter P.D.	DI	DIRTY/CLEAN	
• Supply Air Fan	DO	ON/OFF	
• Supply Air Fan P.D.	DI	NO-PRESS/NRML	
• Mixed Air temp.(on-coil)		AI	Digital
		Deg C	
• Return Air Temp.	AI	Digital Deg C	
• Supply Air Temp. (off-coil)		AI	Digital
		Deg C	
• Humidifiers	DO	ON/OFF	
• Re-Heat / heating Coil		DO	
	ON/OFF		

Data to be available at HMI Touchscreen display (Min. 12", colored display) shall include, but not limited to parameters listed for local controller & additional data as follows

On/off status of each operating equipment /component of equipment, zone temperatures, zone Rh, differential pressures of zones. Also refer to controls schematic diagram for details.

SECTION 9 – AIR INLETS AND OUTLETS

9-01

GENERAL

Before placing orders for these items, the Contractor shall check that all items to be supplied by the manufacturer complies for spread, throw, drop and noise, with capacities and characteristics as indicated on the drawings and schedules. All outlets shall be specifically selected for their particular application and designed for quite operation. All items are to be approved by the Engineer.

All air inlets/outlets shall be of material as indicated on the Drawings and Schedules, and/or as specified.

Colours and finish shall be subject to Engineer's approval. Ceiling diffuser face and margin sizes and styles shall be coordinated with false ceiling/boxing type. All devices shall have substantial approved gaskets to completely prevent streaking on walls or ceilings due to leakage.

Where ceiling panels and ceiling diffusers are of different size, ceiling diffuser shall be centered in ceiling panel. Routing of ducts concealed above false ceiling may slightly be adjusted, if necessary, for this purpose or duct drops for diffuser necks may be offset upto a max. of 30 degrees. or diffuser locations having requirement of greater than 30 degrees offset, flexible round insulated duct connection shall be used.

All wooden frames for wall inlets/outlets (where not mounted directly on the duct) shall be 3/4" thick set permanently in the walls. These frames shall be provided by the Contractor. The Contractor shall be responsible for all cuttings of walls, fixing of wooden frames in walls and repair of masonry/plaster required for fixing side-wall inlets/outlets. The Contractor shall furnish wooden frames for wall inlets/outlets to those responsible for civil construction for installation at locations indicated on shop drawings prepared by the Contractor for this purpose.

Ceiling inlets/outlets shall not be supplied on false-ceiling. Cutting of false ceiling (tiles), where applicable, shall be the responsibility of the HVAC Contractor.

Manufacturer's certified free area for each type and size of grille, register, linear/square diffuser and louver shall also be provided for the purpose of air balancing.

9-02

GRILLES / REGISTERS

All side wall outlets and inlets shall be of sizes and characteristics as scheduled and shown on the Drawings.

Double deflection type grilles shall have vertical front bars and horizontal back bars.

All supply outlets shall have opposed blade dampers, finished in black paint, fixed to the outlet and shall be operatable with a removable key inserted from front of the grille.

All return and/or exhaust inlets shall have similar dampers if scheduled.

9-03**CEILING DIFFUSERS**

Ceiling diffusers shall be of the sizes and characteristics as scheduled and shown on the Drawings.

Ceiling diffusers shall be furnished with volume dampers furnished by the diffuser manufacturer, finished in black paint.

Volume control for these diffusers shall be accessible through the diffuser from below the ceiling and shall maintain their setting when adjusted. Each diffuser shall be provided with sponge rubber or felt gasket. Return diffusers shall be similar to supply diffusers unless otherwise indicated. Inner core shall be removable and shall be mounted on outer frame. (Throw pattern for supply diffusers shall be as shown on Drawings by arrows or as shown in schedule, or as directed by the Engineer.)

Ceiling diffusers intended for use with flexible round insulated duct shall have suitable inlet box with butterfly damper at side / top inlet (as required), finished in black paint.

9-04**EA/OA LOUVERS**

All louvers shall be of approved construction as per AMCA standard 500-74. All louvers shall be fitted with aluminium mesh bird and anti vermin screens. The design of the OA inlet louver blades shall be suitable to arrest rain water, sand and dust from incoming outdoor air, and shall include channels for filter insertion. Sizes are to be as given on the Drawings. Louvers shall be complete in all respects with mounting accessories. Louvers shall be of Scheduled material and finish. Design of OA and EA louvers shall be similar. All EA louvers shall have backdraft dampers upstream of louvers.

SECTION 10 - INSTRUMENTS AND GAUGES

10-01 GENERAL

All necessary indicating and measuring instruments as required, specified and shown shall be furnished and installed by the Contractor. All thermometers shall have labels indicating their function.

These instruments shall be installed as specified / shown on drawings. Portable testing and maintenance instruments shall be supplied in carrying cases.

Duct thermometers shall be installed at PU inlets and outlets

10-03 THERMOMETERS

Calibrations shall be in degrees Fahrenheit with suitable increments. Range shall place operating temperature at or near the middle of scale. Range shall not be less than one and half times the maximum operating temperature.

Thermometers for ducts shall be dial type
Valid calibration certificates should be provided and the instrument should be tagged with calibration tags.

10-04 not used

SECTION 11 - PAINTING & EQUIPMENT IDENTIFICATION

11-01 GENERAL

All material and labour for painting and identification of services shall be provided by the Contractor, as specified hereunder:

11-02 PAINTING

All steel work in connection with supports for ductwork etc. exposed to the elements is to be painted with two coats of an approved rust preventive paint.

All exposed metal surface of hangers, brackets, etc. must be painted with two under-coats and two finishing coats of enamel paint of approved colour. G.I. sheet is not to be painted.

All machinery and equipment which have been painted in factory to the satisfaction of the Engineer shall have a finishing coat of paint before Final Acceptance if the factory paint is damaged during transportation, storage or installation.

Identification bands shall be painted on uninsulated ducting, or on insulation at frequent intervals. Lettering shall be agreed with the Engineer

Internal surfaces of grilles, diffusers and register boxes and connections visible to occupants of rooms, shall be painted by Air Distribution Contractor with two coats of dull black paint or other colour as directed by the Engineer.

All duct hangers in concealed locations shall be given one coat of black asphalt paint before being concealed.

All cradles, vibration isolation rails that will be covered, partially covered, set in cement or fill, or not accessible when the installation is completed, shall be given two coats of black asphalt paint.

11-03 MANUFACTURER'S NAMEPLATES

Each unit or equipment shall be identified by a permanently attached nameplate made of brass or other corrosion resistant material. Plates shall not be less in size than 1.5" x 3" Plates shall bear information pertaining to unit as follows:

- System and unit designation from Schedule of Equipment.
- Manufacturer's name and address (only distributor's or agent's name and address will not be accepted).
- Rated capacity.
- Temperature, pressure or other limitations.
- Electrical Data

Dampers and controls shall be designated by distinguishing numbers in English on the charts or diagrams. The Contractor shall provide stamped

brass tags for all designated items with numbers corresponding to those on the charts.

The tags shall be not less in size than 1.5" in diameter with depressed black numbers of 1/2" height.

The Contractor shall provide separate lists designating the location and function of each damper and control.

The charts, diagrams and lists shall be of sizes, type and character as approved.

SECTION 12- INSPECTION TESTING AND COMMISSIONING

12-01 GENERAL

- 12-01.1 The whole of the works supplied under this Contract shall be subject to inspection and tests by the Employer and/or Engineer should he so require, during manufacturing erection and after completion. The inspection and tests shall include, but not be limited to, the requirements of this Section of the Specifications.
- 12-01.2 For this purpose the Engineer shall, at all reasonable times, be allowed free and ready access to the Contractor's shop and the shops of his suppliers for the purpose of inspecting the specified equipment components, or any other parts, and obtaining information as to the progress of the work. Failure on the part of the Engineer at this or any other time, to discover or reject materials or work which do not meet specified requirements shall not be deemed an acceptance thereof nor a waiver of defects therein.
- 12-01.3 Specific tests required by the various items of the Plant, Parts, materials and equipment shall be treated in accordance with the specifications of the corresponding clauses of the Specifications.
- 12-01.4 The Contractor shall submit to the Engineer, one month prior to the date of commencement of the balancing and performance tests, six (6) copies of the complete test procedure. The procedure, method and points of measurement as well as the method of calculation shall be approved by the Engineer before any test is carried. Six (6) copies of the test results shall be furnished to the Engineer for his approval.
- 12-01.5 The Contractor shall supply all necessary testing and balancing instruments, which shall include, (but not limited to) the instruments listed in Section 10, INSTRUMENTS AND GAUGES, and carryout any test of any kind on a piece of equipment, apparatus part of system or on a complete system if the Engineer requests such a test for determining specified or guaranteed data, as given in the Specifications or in the Schedule of Equipment. Necessary skilled staff shall be provided by Contractor.
- 12-01.6 Any damage resulting from the test shall be repaired and/or damaged material replaced with intimation to the Engineer, all to the satisfaction of the Engineer, and at no extra cost to the Employer. Skilled staff shall again be provided by the Contractor.
- 12-01.7 In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void and shall be recommenced after the adjustment or repairs have been completed.
- 12-01.8 All testing, balancing and final adjustment shall be in accordance with the provision of the applicable ASHRAE Standards, or other approved relevant standards.
- 12-01.9 The Contractor shall test a piece of equipment, apparatus, parts of system or a complete system in accordance to determine Specified or Guaranteed data, given in the Specifications, Schedule of Equipment and Equipment Supplier's Data Sheets.

12-01.10 The contractor shall be responsible for carrying out tests on the material/equipment/installation furnished by him and or Equipment Supplier.

12-02 PRELIMINARY INSPECTION & TESTS

12-02.1 General

All equipment shall be inspected and tested to determine the completeness and general conformance to specified requirements, when operated independent of overall HVAC System, for noise, vibration, and electrical data.

12-02.2 Piping Works

All copper piping shall be tested with nitrogen pressure of 1-1/2 times the operating pressure for sufficient time to detect leaks and defects. All leaks and defects shall be made good in a proper workmanlike approved manner. If necessary, piping shall be taken down and re-erected, and any make-shift or temporary repair of leaks will not be permitted.

The Contractor shall, during construction, properly cap pipes and ducts to prevent the entrance of dirt, etc. Each ducting and piping circuit shall be blown through, after completion, for as long a time as necessary to thoroughly clean that circuit.

12-02.3 Ductwork

Inspection on ductwork shall be carried out by Contractor's supervisor in the presence of Engineer's representative to the satisfaction of the Engineer.

All joints in ducts and at outlets shall be physically inspected for air leakage. All dampers shall be tested for proper operation.

Ducts, plenums and casing shall be inspected and made substantially air tight before covering with insulation or concealing in the masonry. The terms substantially airtight, shall be construed to mean that no air leakage will be noticeable through the senses of feeling or hearing.

After the entire installation has been completed, the Contractor shall commission the equipment, making all necessary adjustments in the equipment, plants, air dampers, air devices, etc., as called for and submit reports of performance tests as specified elsewhere in this specification.

All seams and joints shall be checked and all audible and noticeable leaks repaired in a good workman like manner, by filling with an approved sealant to the inside of the joint, so that the air pressure tends to force the sealant into the joint. A cfm leakage upto 5% of the volume of the duct section under test shall be permissible.

The Contractor shall, during construction, properly cap pipes and ducts to prevent the entrance of dirt, etc. Each ducting and piping circuit shall be blown through, after completion, for as long a time as necessary to thoroughly clean that circuit.

All air ducting sections shall be given a pressure test before fixing insulation and cutting openings for branches and air devices. Any opening made shall be sealed off with airtight metal caps, balloons or any other convenient device for giving the pressure test.

The ducts shall be pressurized with a rotary blower or nitrogen cylinder.

- a. Low pressure ducts upto 2" wg.
- b. Medium pressure ducts upto 6" wg, and
- c. High pressure ducts upto 8" 0 wg.

In case the Consultant directs the Contractor to carry out final measured leakage test for medium or high-pressure ducting, he will follow SMACNA procedure for leak testing.

12-02.4 Equipment

All HVAC equipment shall be inspected for visible damage, operation of moving parts, noise and vibration. Tests shall be carried out with readings of RPM, ampere, voltage, etc. to verify the name plate data.

12-02.5 Electrical Equipment

All electrical panels shall be cleaned and adjusted on site before application of power. The following tests shall be carried out:

Wire and cable continuity tests.

Insulation resistance tests, phase to phase and phase to earth, on all circuits and equipment, using 500 volts megger. The megger reading shall not be less than one meg.ohm.

Earth resistance between metallic conduit systems and earth must not exceed half (1/2) ohm.

Phasing out and phase rotation tests.

Operating tests on all protective relays to prove their correct operation before energizing the main equipment.

Operating tests on all starters, circuit breakers, etc.

12-03 BALANCING AND COMMISSIONING

12-03.1 Air Balancing

All air handling and ventilating equipment, ductwork air inlet and outlets, air volume control dampers, shall be adjusted and balanced to deliver within 10% of the specified quantities indicated on the Drawings. Where the

equipment or systems depend upon controls for proper operation, functioning and performance, the Engineer may ask the Contractor that the later shall be operated simultaneously with the equipment or system during tests.

If the air quantities cannot be delivered without exceeding the speed range of the sheaves or the available horsepower, the Engineer shall be notified before proceeding with the balancing of air distribution system.

Any addition/replacements required to meet the specified flow rates shall be the responsibility of the Equipment Supplier

12-03.2

Commissioning

Upon completion of air balancing and when the whole or part of HVAC System is substantially complete and ready for operation as specified, the Contractor shall carry out Commissioning. Appropriate Seasons are not necessary and the purpose of the commissioning is to start-up the whole or part of HVAC System with manual and/or automatic controls and to put the whole or part of HVAC plant in operation to make it ready to provide cooling and/or heating.

The Commissioning shall be considered completed when complete HVAC plant put into operation and made ready to provide either cooling or heating as directed by the Engineer. The Engineer may direct the Contractor to commission part of central plant along with part of PUs, and distribution network. This will be considered as partial commissioning.

SECTION 13 - MEASUREMENTS AND PAYMENTS

13-01 GENERAL

The Contractor shall furnish all labour, materials, equipment, and service necessary for a complete and operating HVAC system, as shown on the drawings and/or as specified. Tender Drawings are diagrammatic only. Equipment and labour not specifically referred to herein or on the plans, that is required to meet the functional intent, shall be provided without additional cost to the Employer.

Unless expressly excluded, the cost of all materials, equipment and works required by Special Provisions and Technical Provisions of Specifications, acceptably furnished, installed and tested as Specified, shall be considered to be included in the amounts tendered against the item listed in the Bill of Quantities.

13-02 BOQ ITEMS with Unit as 'EACH'

13-02.1 Measurement

Measurement will be made of each item and all associated accessories and work acceptably furnished, installed and tested as individual units.

13-02.2 Payment

Payment of these items will be made at the Contract Unit Rates for these items entered in Bill of Quantities.

13-03 BOQ ITEMS with Unit as 'LOT'

13-03.1 Measurement

No measurement will be made of the items mentioned above.

13-03.2 Payment

Payment will be made at a Contract Lumpsum Price entered for the respective item in Bill of Quantities.

13-04 BOQ ITEMS Ducting & sheet metal work, with unit as 'sft'

13-04.1 Measurement

Measurement will be made for surface area of installed, sheet metal ducting and plenums for different gauges. No measurement will be made for wastage, bracing flanges, hangers and supports, fasteners, anchor bolts air-turning vanes, splitter dampers, and duct protection.

13-04.2 Payment

Payment will be made for the number of units measured as provided above at the Contract Unit Rates as entered in BOQ.

13-05 BOQ ITEMS insulation with unit as 'sft'

13-05.1	Measurement	Measurement will be made of the area of sheet metal to which the acoustic Liner or insulation is applied. No measurement will be made for accessories and adhesive.
13-05.2	Payment	Payment or deduction will be made for the number of units measured as above at the Contract Unit Rates entered in BOQ.
13-06	BOQ ITEMS filters, dampers, air inlets/outlets with unit as 'sft'	
13-06.1	Measurement	Measurement will be made of the core area of the respective item acceptably furnished, installed and tested. No measurement will be made of frames, accessories and attachments.
13-06.2	Payment	Payment will be made for the number of units measured as provided above at the Contract Unit Rates as entered in BOQ.
13-07	BOQ ITEMS, flex duct connection, with unit as 'rft'	
13-07.1	Measurement	Measurement will be made of the length of pipe/flex. round duct/ flex. duct connection with route at centre line of pipe/ duct, for the piping/ ducting, fittings and accessories, acceptably furnished, installed and tested. No measurement will be made for fittings, accessories, attachments, hangers, nuts and bolts.
13-07.2	Payment	Payment will be made for the number of units measured as provided above at the Contract Unit Rates as entered in BOQ.
13-08	BOQ ITEMS insulation with unit as 'rft'	
13-08.1	Measurement	Measurement will be made of the length of piping at centre line, to which the insulation is applied. No measurement will be made for accessories, adhesive, etc.
13-08.2	Payment	Payment will be made for the number of units measured as above at the Contract Unit Rates entered in BOQ.

EQUIPMENT SCHEDULES

SCHEDULE OF WATER-COOLED SCREW WATER CHILLER

S.NO.	DESCRIPTION	
1	CODE	CH-1, CH-2
2	QUANTITY	2
3	TYPE	HIGH EFFICIENCY MICROPROCESSOR BASED VFD CONTROLLED WATER COOLED SCREW TYPE CHILLERS
4	COOLING CAPACITY AT SPECIFIED CONDITIONS (KW)	527
5	MINIMUM ACCEPTABLE IPLV AT SPECIFIED CONDITIONS	4.5 (AT FULL LOAD)
6	CHILLED WATER	
	a) LITER/MIN	567
	b) MAX. PD, IN EVAPORATOR Kpa	65
	c) EWT, deg C	12
	d) LWT, deg C	6
7	CONDENSER WATER	
	a) LITER/MIN	1730
	b) MAX. PD, IN EVAPORATOR Kpa	75
	c) EWT, deg C	38
	d) LWT, deg C	32
8	POWER SUPPLY	415 V/3-PH/50 HZ
9	EQUIPMENT POWER RATING	400 V/3-PH/50 HZ
10	TYPE OF REFRIGERANT	R134a, R407C or R410a
11	FOULING FACTOR (M ² . °C/KW)	
	a) EVAPORATOR	0.088
	b) CONDENSER	0.176
12	ALTITUDE (METER)	2500
13	TYPE OF CONTROLS	MANUFACTURER'S STANDARD
14	ACCESSORIES	AS SPECIFIED
15	REMARKS	--

NOTES:

- 1-** IF CHILLERS OF EXACT CAPACITY ARE NOT AVAILABLE THEN NEXT LARGER UNIT SHALL BE PROVIDED.
- 2-** CHILLERS SHALL BE **EUROVENT, JIS OR AHRI** CERTIFIED.

SCHEDULE OF HOT WATER GENERATOR

S.NO.	DESCRIPTION	
1	CODE	HWG - 1 , HWG -2, HWG-3
2	TYPE	TYPE FIRE TUBE HOT WATER GENERATOR
3	QUANTITY	3 Nos. (as per BoQ)
4	NET OUTPUT KW (MIN. ACCEPTABLE)	450
5	LEAVING WATER TEMP., (deg C)	80
6	WATER TEMP. RISE, (deg C)	20
7	WATER QUANTITY, Lit/Min	550
8	MAX. OPERATING PRESSURE (K.Pa)	600
9	BURNER TYPE	OIL/GAS BURNER (DUAL FUEL)
10	TYPE OF FUEL	LIGHT DIESEL OIL/ LPG
11	CALORIFIC VALUE OF DIESEL OIL (KJ/Kg)	44,800
12	ALTITUDE	2500 METERS
13	POWER SUPPLY	415V/3 Ph/50 Hz
14	STACK HEIGHT (m)	3
15	MAX. PD. (K.Pa)	860
16	TYPE OF CONTROLS	MANUFACTURER STANDARD
17	ACCESSORIES	AS SPECIFIED
18	REMARKS	BURNER PILOT SHALL BE DIESEL FIRED

SCHEDULE OF COOLING TOWERS

1	CODE	CT-1, Qty.1
2	TYPE	INDUCED VERTICAL DISCHARGE CROSS FLOW SQUARE MULTI-CELL TYPE CLOSE-CIRCUIT COOLING TOWER WITH INTERNAL PIPING FOR WATER INLET
3	Cooling Capacity	MINIMUM 650 KW HEAT REJECTION PER CELL CAPACITY
	CASING	GI-CONSTRUCTION
4	WATER FLOW RATE (Lit/Min)	1740
5	ENTERING WATER TEMPT. (deg C)	38
6	LEAVING WATER TEMPT. (deg C)	32
7	AMBIENT AIR TEMPT. (deg C)	28.9
8	FAN DRIVE	BELT DRIVE
9	MIN. NO. OF CELLS (N+1)	2-DUTY+1 STANBY
10	MOTOR	IE-4 efficiency class
(a)	POWER SUPPLY SYSTEM	415V/3-PH/50HZ OR VFD
(b)	EQUIPMENT VOLTAGE RATING	400V
(c)	MAX. RPM	1400
11	DIMENSIONAL LIMITATION (MM x MM)	4300 x 7300
12	ACCESSORIES	VIBRATION ISOLATORS
13	REMARKS	CLOSE-CIRCUIT COOLING TOWER INCLUDING ALL ACCEESORIES AND COMPONENT SUCH AS SPRAY PUMP, NOZZELS, HEAT-EXCHANGE COIL, VFD FAN ETC

NOTE:

- 1- WHEN COOLING TOWER UNIT WITH EXACT APACITY IS NOT AVAILABLE THEN NEXT LARGER MODEL SHALL BE PROVIDED
- 2- IN MULTICELL TOWERS, EACH TOWER CELL SHALL HAVE INDEPENDENT BASIN AND FULL HEIGHT PARTITION.
- 3- WATER BASIN SHALL HAVE ENOUGH CAPACITY TO ACCOMMODATE THE WATER QUANTTTY TRANSFERRED FROM UPPER TRAYS DURING POWER FAILURE AVOIDING WATER SPILL OVER FROM BASIN.

SCHEDULE OF PUMPS

1	CODE	CWP-1, CWP-2 Qty. = 2	CHP-1, CHP-2 Qty. = 2	HWP-1, HWP-2 Qty. = 2
2	TYPE	END SUCTION, CENTRIFUGAL COMMON-Long BASE MOUNTED PUMP-MOTOR SET	END SUCTION, CENTRIFUGAL COMMON-BASE MOUNTED PUMP-MOTOR SET	END SUCTION, CENTRIFUGAL COMMON-BASE MOUNTED PUMP-MOTOR SET
3	MAKE	KSB/B&G / Grundfos OR APPROVED EQUAL	KSB/B&G / Grundfos OR APPROVED EQUAL	KSB/B&G / Grundfos OR APPROVED EQUAL
4	MODEL FOR REFERENCE ONLY	ETA (KSB)	ETA (KSB)	ETA (KSB)
5	MOTOR			
	MAKE	SIEMENS	SIEMENS	SIEMENS
	MOTOR COMPATIBILITY	VFD RATED AND COMPATIBLE. IE-4 EFFICIENCY CLASS	VFD RATED AND COMPATIBLE. IE-4 EFFICIENCY CLASS	VFD RATED AND COMPATIBLE. IE-4 EFFICIENCY CLASS
	c) POWER SUPPLY	415V/3-PH/50 HZ	415V/3-PH/50 HZ	415V/3-PH/50 HZ
	d) VOLTAGE RATING	400 V	400 V	400 V
6	SERVICE	COOLING WATER CIRCUIT	CHILLED/HOT WATER CIRCUIT	CHILLED/HOT WATER CIRCUIT
7	DISCHARGE (L/M)	1740	567	567
8	CIRCULATING HEAD, Kpa	320	400	400
P	PRESSURE RATING, PSIG	125	125	125
13	REMARKS	PARALLEL PUMP OPERATION	PARALLEL PUMP OPERATION	PARALLEL PUMP OPERATION

NOTES:

1. WHEN TWO PUMPS OPERATE IN PARALLEL, PUMP SELECTION SHOULD BE MADE BASED ON PARALLEL PUMP CURVE DRIVEN FROM CATALOGUED SINGLE PUMP CURVE. OPERATING POINT FOR TOTAL SYSTEM GPM AT INDICATED HEAD MUST LIE ON DEVELOPED PARALLEL PUMP CURVE, AND MOTOR HP SHALL BE SELECTED ACCORDINGLY.

2. CONTRACTOR /SUPPLIER SHALL RECALCULATE THE PUMPS HEAD BEFORE SUBMITTAL SUBMISSION AND ALONGWITH THE CALCULATIONS.