

Procurement

Cover Page

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Total Number of Pages including this page: 232

Attached is Request for Quotation No.: 3200038803 and all related documentation. Please notify the United Nations immediately if any part of this Request for Quotation is missing and/or illegible at the above facsimile number. Please be advised that this facsimile number may be used only to send queries.

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REQUEST FOR QUOTATION

3200038803

SUBJECT: Improvement and Rehabilitation of Water Supply Schemes in Bata Tal Settlement, Peshawar, Pakistan

1. The United Nations (UN) hereby requests your price quotation for the item(s) specified in this Request for Quotation (RFQ), which consists of this document and the following annexes:

Annex A: Scope of Work

Annex B: Tech Evaluation Criteria

Annex C: Price Quotation

Annex D: Technical Specifications

2. Quotations are required to be submitted to the UN in English language and in **ONE COPY**, no later than **26-Aug-2026 at 03:00 PM (Islamabad Time)** (the ClosingTime), by E-mail: Habitat.Pakistan@un.org, or by hand to 5-11 Diplomatic Enclave, UN-Habitat Office, UNMOGIP. Quotations received after the Closing Time may be considered or evaluated only in exceptional circumstances.
3. Please note that submissions by e-tendering will be rejected.

Validity of Quotations

4. Your Quotation shall be irrevocable and remain valid for acceptance for at least **60 days** calendar days, commencing on the Closing Time.
5. If deemed necessary by the UN, Bidders may be requested to extend the validity of their Quotations for an additional period(s), in order to finalize the solicitation process. If the extension of the validity period is accepted by a Bidder, the Bidder will not be permitted to otherwise modify or consequently withdraw its Quotation.

Evaluation Criteria and Contract Award

6. All Quotations will be evaluated, and the Quotation which is technically compliant and offers the lowest price may be selected.
7. The UN reserves the right, at its sole discretion, to:
- 7.1. Award separate or multiple Contracts for same or different elements covered by this RFQ in any combination it may deem appropriate, or only a portion of the requirements. If a Quotation is submitted on an "all or none" basis, it should be clearly stated as such;
 - 7.2. Reject any or all Quotations received in response to this RFQ and negotiate with any of the Bidders in any manner deemed to be in the best interest of the UN;
 - 7.3. Add new considerations, information or requirements at any stage of the process.
8. In exceptional situations, the UN may cancel this RFQ through written notification to all Bidders.

Notice of Award

9. The selected Bidder(s) will be notified in writing that the UN considers an award of the Contract. No legal obligation exists until the issuance of a Contract or Purchase Order (PO) by the UN.
10. Unsuccessful Bidders will be notified in writing. The UN has the right to retain unsuccessful Quotations. Unsuccessful Bidders having questions about the name of the selected Bidder(s), the Contract/Purchase Order value(s), or the reasons for non-selection of their Quotation, may contact the Procurement Officer at the email/fax number provided for submission of Quotations.

11. Any Contract or Purchase Order entered into with the successful Bidder will be subject to the UN General Conditions of Contract (UNGCC). You will find the link to the UNGCC at https://www.un.org/Depts/ptd/pdf/general_condition_goods_services.pdf. A Draft Form of Contract may also be included in this RFQ. By submitting a Quotation, the Bidder confirms that it has accessed, read, understood, agreed and accepted the UNGCC and the Draft Form of Contract, if applicable and if provided herein.

Commercial Instructions

Bidders shall provide all the required information as detailed herein, in accordance to the following terms:

12. **Payment Terms.** The standard UN terms of payment are net **30 days** calendar days following satisfactory delivery of goods, performance of services and the submission of an invoice, whichever is later. Payment for any goods or services by the UN shall not be deemed an acceptance of the goods or services. The provisions of Incoterms 2010 shall apply to any delivery terms specified in this RFQ.
13. The UN policy is to preclude advance payments or payment by Letters of Credit. Such provisions in a Quotation will be prejudicial to its evaluation by the UN.
14. **Currency.** Prices may be quoted in a currency other than the PKR. However, for the purposes of comparison of all Quotations, the UN will convert the currency quoted in the Quotation to US Dollar in accordance with the prevailing UN Operational Rate of Exchange at the Closing Time.
15. The Contract/Purchase Order, Bidder's invoices and the UN payments will be made in the currency as originally quoted by the Bidder in their Quotation.
16. **Price.** The offered price should be all inclusive. If the price excludes certain fees and/or charges, the Bidder must provide a detailed list of excluded fees, with a complete explanation of the nature of those fees. Unless otherwise provided in this RFQ, the Contract or the Purchase Order shall be concluded on a Firm Fixed Price basis, and shall not be subject to any adjustment, including the actual cost incurred by the Bidder in performing the Contract or any market price changes.
17. **GSA Clause (for USA vendors only).** The UN is officially eligible, under the United States Foreign Assistance Act of 1961, to receive full benefits under General Services Administration (GSA) Contracts. Accordingly, Quotation must specify whether or not items quoted by the Bidder are currently subject to GSA Federal Supply pricing and indicate the GSA Contract Number and Expiration Date, wherever applicable.

Liquidated Damages

18. If the Bidder fails to supply specified goods/services within the leadtime to be stipulated in the Contract or in the Purchase Order, for any reason other than the UN act or omission, the UN shall deduct as liquidated damages, a sum equivalent to **5%%** of the total Contract/Purchase Order value, or portion thereof that is delayed, for each calendar day of delay until actual delivery, up to a maximum deduction of **%** of the total Contract/Purchase Order value, or portion thereof that is delayed; all without prejudice to any other remedies available to the UN. A maximum grace period of calendar days may be permitted. However, if the delivery is not completed within the grace period, liquidated damages will apply from the day immediately following the original delivery date. Said amount is agreed to be a reasonable estimation of the damages which the UN will sustain, without the UN having to prove any actual damage, and not as a penalty against the Contractor. In case of a different provision stated in the Draft Form of Contract (if applicable and if provided herein), the Draft Form of Contract shall prevail.

Miscellaneous

19. This RFQ does not commit the UN to award a Contract or to issue a Purchase Order. Any Quotation submitted will be regarded as a proposal by the Bidder and not as an acceptance by the Bidder of any proposal by the UN.

20. Bidders shall bear any and all costs and expenses related to the preparation and/or submission of a Quotation, regardless of whether the Bidder's Quotation is selected or not.
21. Bidders may find the UN Procurement Manual and the UN Financial Rules and Regulations, which are applied to this RFQ, at <https://www.un.org/Depts/ptd/pdf/pm.pdf>.
22. Vendor registration and update of information: Only vendors registered with the UN Secretariat in the United Nations Global Marketplace (UNGM) can participate in this solicitation. Vendors must be registered at the appropriate level in UNGM in order to be considered for award. In the event that a vendor fails to achieve the required registration level by the time the UN is ready to make an award, the UN reserves the right to award an alternative vendor. Vendors are responsible to ascertain their registration level at <http://www.ungm.org> and, if in doubt, contact the UN Secretariat at register@un.org. For UNGM account-related issues, please contact: registry@ungm.org. Vendors are responsible for keeping their information up-to-date in UNGM. More information can be found at <https://www.un.org/Depts/ptd/vendor-registration>.
23. Code of Conduct: By submitting a Quotation, the Bidder confirms that he/she has accessed, read, understood and agrees to comply with the UN Supplier Code of Conduct, which, amongst others, prohibits collusive bidding, anti-competitive conduct, improper assistance and corrupt practices. Bidders should refer to the UN Supplier Code of Conduct at: https://www.un.org/Depts/ptd/pdf/conduct_english.pdf
24. The procurement of goods and/or services by the United Nations shall be in compliance with Security Council resolutions, and the rules, regulations and policies promulgated by the United Nations' principal organs.
25. If so requested, the Contractor shall furnish to the UN, within 5 business days of the UN's request, an electronic copy of the applicable price list(s) including item identification references, which shall serve as a catalogue of goods and/or services that can be ordered by the UN.

Independent Price Determination

26. Consistent with the UN Supplier Code of Conduct, by submitting a Quotation, the Bidder certifies that:
 - 1) the prices offered in the Quotation have been arrived at independently, without any consultation, communication, or agreement in any manner that would result in restriction of competition with any other Bidder or competitor relating to (a) those prices, (b) the intention to submit a Quotation, and/or (c) the methods or factors used to calculate the prices offered;
 - 2) the prices in the Quotation have not been and will not be knowingly disclosed by the Bidder, directly or indirectly, to any other Bidder or competitor before the UN issues an award under this solicitation; and
 - 3) no attempt has been made or will be made by the Bidder to induce any other entity to submit or not to submit a Quotation for the purpose of restricting competition.Failure to comply with the above Independent Price Determination provisions shall result in the rejection of the Quotation(s). In addition, the UN reserves the right to exercise any other rights and remedies available to it.

We look forward to your Quotation and thank you in advance for your interest in UN procurement opportunities.



Annex-A

Scope of Works

Improvement and Rehabilitation of Water Supply Schemes in Bata Tal Settlement, Peshawar, Pakistan

Background:

UN-Habitat is implementing a slum upgradation project in 5 cities of Pakistan. The targeted settlements face significant challenges in accessing safe and reliable water supply services. Existing water supply infrastructure is inadequate, deteriorated, and unable to meet the growing needs of the community, resulting in limited access to potable water and adversely affecting public health, hygiene, and overall quality of life. In addition, due to the power cuts, the pumping is affected and the casing of the existing bore holes needs to be replaced.

To address these challenges, the United Nations Human Settlements Programme (UN-Habitat) is implementing water supply improvement interventions as part of its infrastructure and basic service enhancement programme. These interventions were identified and prioritized by the target communities through a participatory settlement planning process, during which communities developed Strategic Settlement Plans (SSPs) to comprehensively address their development needs and challenges.

Successful implementation will depend on timely access to the work sites, consistency and completeness of the approved technical documents, identification and protection of existing utilities, coordination of required permits/NOCs, community engagement, traffic and service-continuity arrangements, and availability of work fronts. The Contractor shall address these factors in its work programme and method statements, promptly document constraints and assumptions, and submit mitigation or recovery measures for UN-Habitat review. The Contractor shall not implement any unauthorized deviation affecting scope, quality, time or cost.

1. Objective of the Works:

The objective is to complete, test, commission, and hand over all contracted works for the improvement and rehabilitation of the Drinking Water Supply Scheme, including replacement of existing casing, powered pumping system consisting of solar PV modules, mounting structures, a 30-kW inverter, a 30 HP submersible pump, and all associated electrical and protection components. Renovation of pump house and laying of HDPE distribution network in accordance with the approved drawings, technical specifications, BoQ, safeguards requirements, and approved work programme, thereby improving access to safe and reliable drinking water for the beneficiary community.

2. Scope of Works:

The scope of work comprises the construction, rehabilitation, testing, commissioning, and handover of a complete solarized borehole-based drinking water supply system. The works include hydrogeological



investigations; drilling and development of a production borehole; installation of PVC casing, strainers, gravel pack, column pipes, valves, a chlorination system, and construction of a pump chamber.

The works also include the supply, installation, testing, and commissioning of a solar-powered pumping system comprising solar PV modules, mounting structures, a 30 kW inverter, a 30 HP submersible pump, and all associated electrical, control, and protection components.

The project further includes the installation of an HDPE water distribution network (25 mm to 110 mm dia., PN-20), including trenching, pipe laying, fittings, valves, thrust blocks, household connections, testing, disinfection, and commissioning.

The Contractor shall also renovate the existing pump house comprising two rooms and a veranda, including all necessary civil and electrical works such as painting, floor and roof repairs, PCC works, complete internal electrification, lighting fixtures, fans, switches, and associated fittings.

The scope further includes all associated civil, mechanical, electrical, and environmental, social, health and safety (ESHS) works, site preparation, mobilization, quality control, restoration of affected areas, and all ancillary activities necessary to deliver a complete and functional drinking water supply system. The existing submersible water pump is available on site and is therefore excluded from the Contractor's scope of supply.

Detailed quantities and technical requirements are provided in the Bill of Quantities (BoQ), approved drawings, and technical specifications. This narrative summarizes the works and does not supersede those contract documents. Any material change to the scope, quantities, specifications, contract price, or completion period shall require prior written authorization in accordance with the Contract.

3. Roles and Responsibilities:

Contractor: The Contractor's roles and responsibilities shall include, but shall not be limited to, the obligations below. The Contractor shall be responsible for all activities necessary for complete, safe, functional, tested, commissioned and timely delivery of the specified and priced works, including activities reasonably incidental to proper completion. This catch-all obligation shall not authorize a material addition to or change in the contracted scope, quantities, price or completion period without the required prior written approval under the Contract.

- The Contractor shall execute and complete all works in full compliance with the approved designs, BoQ, technical specifications, applicable standards and regulations, environmental and social safeguards requirements, and authorized written instructions. Verification by local authorities or a technical committee may inform the process; contractual acceptance of the works shall remain with UN-Habitat.
- Fulfil all technical, administrative, and contractual requirements prior to commencement of works.
- Implement all occupational health, safety, environmental, and traffic management measures required under the contract and applicable laws.
- Prepare and maintain accurate measurement books and as-built/shop drawings, where applicable, documenting completed works and quantities executed.
- Submit measurement records, testing results, and completion documentation for verification by UN-Habitat prior to certification of works and release of payments.

- Submit final payment and completion documentation for review and approval following completion of works and prior to site demobilization and handover.
- The Contractor shall identify, protect, and manage all existing utilities encountered during construction. Any damage to utilities resulting from the Contractor's negligence or failure to take adequate precautions shall be repaired or restored at the Contractor's own cost.
- Responsibility for providing, operating, and maintaining all temporary diversions and arrangements necessary for roads, sewerage lines, drainage systems, and other affected services during the execution of the works shall rest with the contractor.
- The Contractor shall ensure proper collection, transportation, and disposal of all construction debris and waste materials at approved disposal locations. Household service connections affected during pipeline installation shall be reconnected by the Contractor. Any additional works within private properties, including replacement of internal plumbing or excavation beyond the agreed reconnection point, shall remain the responsibility of the beneficiary households.
- Review the site conditions and all issued drawings, BoQs, specifications and other technical documents before commencing the relevant activity; promptly notify UN-Habitat in writing of discrepancies, omissions, constructability concerns or conflicts and obtain clarification before proceeding.
- Submit, within the periods stated in the Contract or approved mobilization schedule, a baseline work programme, resource and equipment deployment plan, method statements, shop drawings, material submittals, Quality Control Plan and Inspection and Test Plan, site-specific environmental/social and health-and-safety plans, traffic and service-continuity plans, and other pre-commencement submissions required for the awarded lot.
- Obtain and maintain activity-specific permits, licenses, worksite permissions, traffic approvals and clearances for which the Contractor is responsible, while coordinating with UN-Habitat regarding project-level facilitation and stakeholder engagement.
- Deploy qualified personnel, supervision, labour, plant and equipment in sufficient numbers and capacity to implement the approved programme. Where the Contractor is awarded two lots, it shall maintain the separate site resources and essential equipment required for concurrent implementation without adversely affecting quality or completion time.
- Maintain daily site records, measurement books, inspection requests, test records, material certificates, photographic records, updated programmes, non-conformity and corrective-action records, and progress reports sufficient to verify quantities, quality, safeguards compliance and achievement of milestones.
- Remain fully responsible for the acts, omissions, performance and compliance of all subcontractors, suppliers and personnel engaged in the works.

UN-Habitat: UN-Habitat shall provide project-level coordination, technical oversight and contract administration in accordance with the Contract. UN-Habitat's support or review shall not relieve the Contractor of responsibility for execution, safety, quality, permits, temporary works, methods, measurements or compliance.

- Provide project funding and process payments to the Contractor in accordance with the Contract.
- Coordinate with relevant government authorities, utilities, Community Development Committees and stakeholders to facilitate implementation, site access and project-level clearances, as applicable, without assuming the Contractor's responsibility for activity-specific permits and worksite permissions.

- Provide the Contractor with the approved drawings, BoQs, technical specifications and other project information available to UN-Habitat and relevant to execution. The Contractor shall review the documents and promptly seek clarification of any identified discrepancy or missing information.
- Review and respond to the Contractor's correspondence, submissions, and requests in a timely manner.
- Facilitate project-level coordination, including support for obtaining required NOCs and confirmation of site layouts, without relieving the Contractor of its responsibility to secure activity-specific permits, clearances, traffic management approvals, and worksite permissions.
- Monitor project progress, quality of works, and compliance with technical, environmental, occupational health, and safety requirements, either directly or through designated third-party monitoring arrangements.
- Issue or confirm technical instructions and corrective actions through the designated contract-administration channels where necessary to address delay, non-compliance or quality concerns. Any instruction affecting scope, contract price or completion period shall be handled through the authorized contractual process.
- Coordinate with local authorities, where necessary, to facilitate identification of authorized waste-disposal locations. The Contractor shall remain responsible for lawful handling, transport, disposal and documentary evidence of disposal.

4. Environmental, Social, Health and Safety Requirements:

The applicable Environmental and Social Safeguards and Sustainability (ESSS), Environmental and Social Management Plan (ESMP), occupational health and safety requirements, site-specific mitigation measures and relevant legal requirements shall be strictly implemented. Before commencing work, the Contractor shall submit the required site-specific plans and method statements for review and shall maintain implementation records throughout the Contract. The Contractor shall:

- Properly manage and dispose of construction waste.
- Implement the "Do No Harm" principle throughout project implementation.
- Install warning signs, barricades, and traffic control measures where required.
- Ensure compliance with ESMP and all site-specific mitigation measures.
- Ensure occupational health and safety (OHS) of workers through the provision of appropriate personal protective equipment (PPE).
- Minimize dust, noise, vibration, waste generation, wastewater discharge, and other environmental impacts, and restore disturbed areas upon completion of the works.
- Protect nearby communities by implementing traffic management, public safety measures, and maintaining safe access to residences, businesses, schools, and public facilities.
- Prevent child labour, forced labour, discrimination, sexual exploitation and abuse, sexual harassment (SEA/SH), and all forms of gender-based violence in accordance with UN standards.
- Immediately report environmental, social, health and safety incidents through the prescribed reporting channels, provide the required written information within the applicable timeframe, investigate causes and implement corrective and preventive actions as directed by UN-Habitat and/or the Engineer.
- Ensure that all subcontractors comply with the same ESSS requirements throughout the duration of the contract.



- Provide and maintain temporary diversions for roads and sewerage lines during construction to minimize disruption to traffic and public services.

5. Deliverables, Records and Acceptance Requirements:

The Contractor shall submit complete and verifiable documentation proportionate to the awarded lot. As a minimum, the following shall be provided:

- Pre-commencement submissions: mobilization plan; baseline work programme and milestone schedule; organization chart and personnel/equipment deployment; method statements; shop drawings; material-source and product submittals; Quality Control Plan and Inspection and Test Plan; site-specific ESSS/ESMP and health-and-safety plans; traffic, pedestrian-access and service-continuity plans; utility verification records; and applicable permits/NOCs/approvals.
- Implementation records: periodic progress reports comparing planned and actual progress; updated programmes and recovery plans where required; measurement books and quantity records; inspection requests; approved material certificates; laboratory and field-test results; photographs; non-conformity and corrective-action records; environmental/social and safety monitoring records; incident reports; and community/complaints records.
- Handover submissions: completion report; final measurements; as-built drawings in editable source format and PDF; operation and maintenance manuals where applicable; commissioning and trial-run records; test certificates; warranties and guarantees; asset/equipment schedules; training records where required; statutory or authority clearances; signed handover documentation; and evidence that all punch-list items, defects and site-restoration obligations have been completed.
- A submission or completed activity shall not be considered accepted merely because it has been received, inspected or certified by a local authority or technical committee. Acceptance requires completeness, compliance with the Contract, correction of identified deficiencies and written acceptance by UN-Habitat through the authorized contract-administration process. Certification or payment shall not waive latent defects or the Contractor's Defects Liability Period obligations.

6. Duration of Work:

The works shall be completed within six (6) months from the effective commencement date or Notice to Proceed stated in the Contract. The Contractor shall complete mobilization within the specified mobilization period and shall implement multiple awarded lots concurrently where required. Any extension or adjustment affecting contractual time shall be valid only when approved in writing through the applicable Contract procedure.

7. Standard of Performance:

The Contractor shall execute the works and perform its obligations with due diligence, efficiency, economy and professional skill, in accordance with recognized engineering and construction practices, the approved technical documents and applicable standards. The Contractor shall use safe, suitable and effective materials, technologies, equipment, machinery and methods, and shall maintain effective site management, supervision, quality control and safeguards compliance.

The Contractor shall operate and maintain all plant and equipment used for the works in accordance with applicable laws, manufacturer requirements and safe operating procedures. Contractor-owned or hired



equipment shall be fit for purpose, properly maintained, inspected and available in sufficient capacity to meet the approved programme.

8. Defects Liability Period:

The Defects Liability Period shall be six (6) months from the date of the Completion/Take-Over Certificate for the relevant lot, subject to confirmation in the Contract. During this period, the Contractor shall, at its own cost and within the period instructed by UN-Habitat, correct defects, failures, omissions or non-conforming work attributable to the Contractor, including consequential reinstatement and retesting.

If the Contractor fails to remedy a notified defect within the required period, UN-Habitat may apply the remedies available under the Contract, including arranging corrective work at the Contractor's risk and cost. Performance security, retention and their release shall be governed by the Contract/Special Conditions and shall be aligned with the confirmed Defects Liability Period; they shall not be treated as interchangeable mechanisms.

9. Site Safety:

The Contractor shall implement and maintain all necessary health and safety measures throughout the works, including appropriate PPE, warning signs, barriers, illumination and protection of excavations and work areas. Open trenches and hazardous areas shall not be left unprotected or unattended. Adequate first-aid facilities, trained first-aiders and emergency-response/medical-transport arrangements shall be maintained. The Contractor shall conduct and document daily safety inspections and immediately correct unsafe conditions. UN-Habitat may direct suspension of unsafe activities in accordance with the Contract, without relieving the Contractor of its obligations.

10. Contractor's Resources:

The Contractor shall provide all personnel, supervision, labour, materials, plant, tools, machinery, temporary works, utilities and other resources necessary to execute the works safely, properly and within the approved programme. The Contractor is encouraged, to the extent permitted by applicable law and without compromising required qualifications or fair employment standards, to engage suitably qualified skilled and unskilled labour from the project areas.

11. Existing Structures and Utilities:

Prior to commencing the works, the Contractor shall coordinate with UN-Habitat and notify all relevant authorities, utility providers, and concerned entities of its intention to begin construction activities.

The Contractor shall be responsible for identifying and verifying the exact locations of all existing utilities, infrastructure networks, structures, and equipment through site investigations and exploratory measures before commencing work. Appropriate precautions shall be taken to prevent damage and service interruptions. Any utility or infrastructure damaged due to the Contractor's activities shall be repaired or restored at the Contractor's own expense.

Upon completion of the works, the Contractor shall remove all surplus materials, debris, waste, tools, equipment, and machinery from the site, restore affected areas, and leave the worksite clean, safe, and ready for inspection, handover, and acceptance.

12. Project Governance and Contract Administration:

UN-Habitat shall designate an Engineer/Project Manager and focal points for day-to-day technical administration. Their functions may include review of the work programme, drawings, method statements and material submittals; inspection and measurement of works; review of tests and progress records; recommendation of payment certification; identification of non-conformities; and coordination of completion and handover. No person shall have authority to amend the scope, price, completion period or other contractual obligations unless such authority is expressly provided or the instruction is confirmed in writing by an authorized UN-Habitat official in accordance with the Contract. All formal correspondence and submissions shall follow the designated contract-administration channels.

Where a Contractor is awarded two lots, one suitably qualified Project Manager may oversee both contracts only if this arrangement is accepted through the technical evaluation and the Contractor demonstrates adequate capacity. Separate site supervision, labour, work fronts and essential equipment shall be deployed as required to implement both lots concurrently without adverse impact on safety, quality or completion time.

13. Completion, Inspection and Handover:

The Contractor shall give UN-Habitat reasonable advance written notice of the anticipated completion of a lot or defined work section and request inspection. UN-Habitat and relevant technical stakeholders may conduct a joint inspection and issue a punch list. The Contractor shall correct all identified deficiencies and submit complete handover documentation, including final measurements, test and commissioning records, completion certificates, as-built drawings, O&M manuals and warranties, as applicable. Local-authority or technical-committee confirmation may be included as supporting evidence, but formal contractual acceptance and authorization of final payment shall remain with UN-Habitat.

14. Mobilization and Demobilization:

The Contractor shall complete mobilization within fifteen (15) calendar days from the contractual commencement date, including deployment of personnel and equipment, site establishment, verification of utilities and work fronts, and submission of required pre-commencement documents. Demobilization shall be completed within fifteen (15) calendar days after completion and written authorization to demobilize, and shall include removal of temporary facilities, surplus materials, equipment and waste; reinstatement of disturbed areas; and leaving the site clean, safe and ready for final acceptance.

15. Contract Approach:

The Contract shall be a BoQ-based measurable works contract. Interim payments shall be based on quantities actually executed, measured, verified and accepted in accordance with the Contract and the agreed payment schedule. The Contractor shall not execute a variation, substitute a material or design, or alter a quantity, alignment or specification without the required prior written authorization. Instructions, site discussions or technical reviews that are not issued or confirmed through the authorized contractual process shall not constitute an approved change.

16. Quality Control and Testing:

The Contractor shall establish and implement a project-specific Quality Control Plan and Inspection and Test Plan covering material-source approval, product and sample submittals, inspection hold/witness points, workmanship controls, field and laboratory testing, calibration, records, non-conformity management and corrective action. Tests shall be performed by competent personnel and, where required, accredited or otherwise approved laboratories. UN-Habitat may inspect, test, reject or require replacement/rework of non-conforming materials, equipment or workmanship. Review, inspection or witnessing by UN-Habitat shall not relieve the Contractor of responsibility for quality and compliance.

17. Key Performance Indicators:

The following KPIs supplement, and do not replace, the approved drawings, BoQs, specifications, safeguards requirements, inspection/testing obligations and acceptance criteria. KPI performance shall be supported by objective records. Non-compliant work shall not be certified as acceptable, and corrective action or other contractual remedies shall be applied only in accordance with the Contract.

KPI Category	Indicator	Acceptable Standard / Target	Tolerance	Frequency of Measurement	Required Corrective Action / Contractual Response
Work Progress	Completion of planned works against approved work schedule	Achievement of approved interim milestones and 100% completion by the contractual completion date	No more than 10 percentage points behind the approved cumulative programme; slippage requires an approved recovery plan	Biweekly	Recovery plan and corrective action; contractual remedies as applicable
Borehole GI Column pipe installation		Fully Vertical and depth as per survey report	Depth as per survey report or site Engineer instructions	After installation	Payment as per actual work done
Casing Pipe	12"-inch Class D PVC Blind Pipe in bore.	Material grade and wall thickness as per BSS 3505 standards.	Zero Tolerance in material class.	Quality check by engineer	Removal and replacement at Contractor's cost; material rejected
Casing Pipe	3-inch diameter GI column pipe	Pipe manufactured from mild steel	Zero tolerance for	Quality check by engineer	Removal and replacement at

(Blind & Screen) Mild Steel		conforming to BS 1387, BS EN 10255, ASTM A53, or equivalent approved standard; minimum wall thickness 4 mm	thickness/material deviation		Contractor's cost; material rejected
Discharge Testing	Actual discharge rate	Verification of sustainable yield and draw-down levels.	Recharge rate must be equal or more than discharge rate	After successful bore for 36 hours	As per Engineer's instructions
Health & Safety	Compliance with approved HSE Plan, PPE usage, barricading and warning signage	Zero fatalities; no uncorrected major safety violation; implementation of approved HSE controls	Zero tolerance for major violations	Daily	As per Contract and HSE provisions
Environmental Compliance	Proper disposal of excavated material, wastewater and construction debris	No major environmental incident and no substantiated community complaint left unresolved beyond the agreed corrective-action period	Minor deviations corrected within 24 hours	Weekly	Corrective action and non-certification of non-compliant work; other remedies as applicable under the Contract

18. Payment and Contractual Provisions:

Detailed payment milestones, retention, performance security, payment-processing provisions, variation/change-order procedures and security-release conditions shall be set out in the solicitation and Contract/Special Conditions. Payments shall be based on quantities actually executed, measured, verified and accepted by UN-Habitat. No payment shall constitute acceptance of defective, incomplete or non-conforming work. Any retention release or final payment linked to the Defects Liability Period shall be aligned with the confirmed Defects Liability Period.

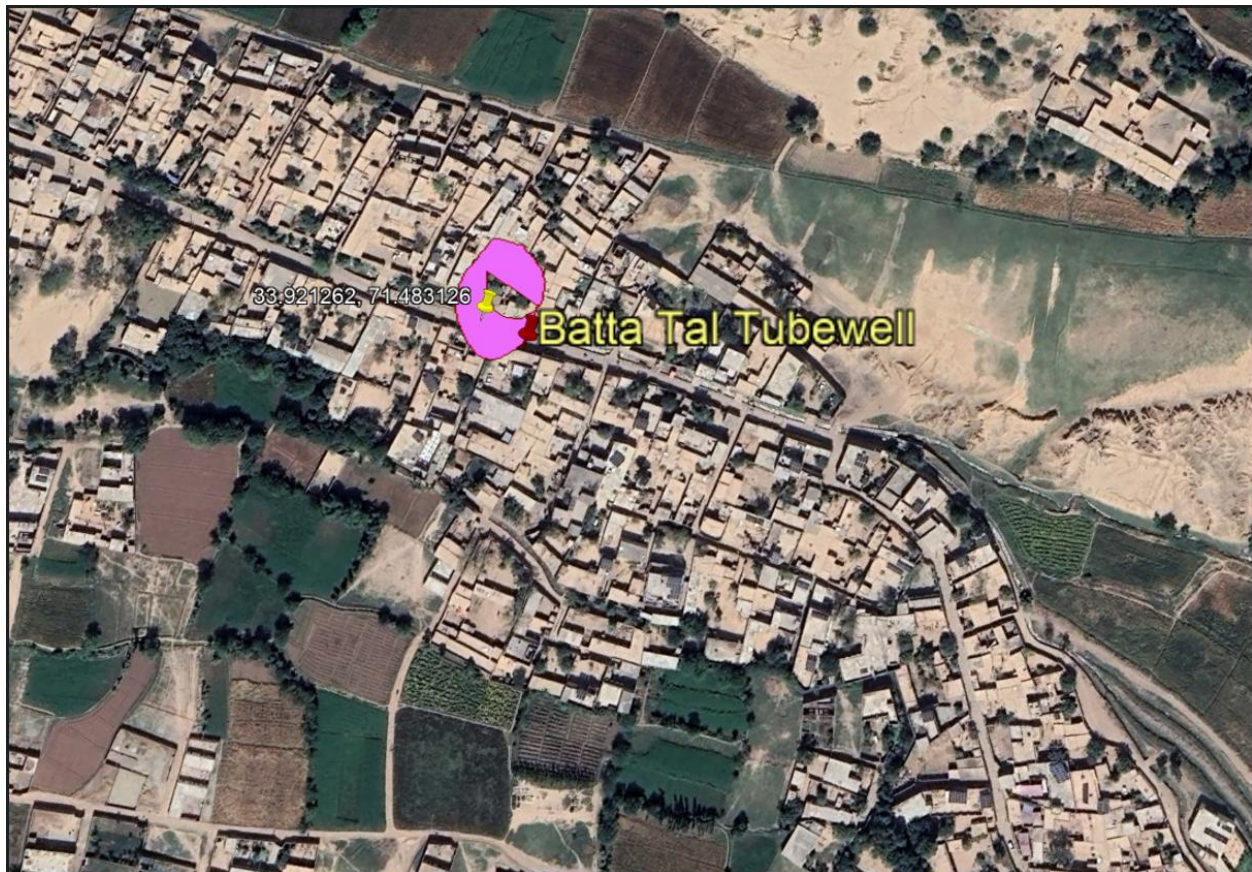
19. Annexes and Technical Document Register:

Before solicitation, the Requisitioning Office shall attach and record the title, revision number and date of each applicable technical document. At a minimum, the final package should include:

- BoQ, with measurement units, item descriptions, quantities and pricing structure fully reconciled with the drawings and specifications.

- Approved design drawings, layouts, details, schedules and site/location maps for every scheme.
- Technical specifications and applicable standards, including material, workmanship, testing and commissioning requirements.
- Required formats/templates for work programme, progress reporting, measurement, inspection requests, material approval, test records, as-built drawings, completion and handover.

Location Map of Taube well:



Isometric View of Chamber 10X10X10:



Annex-C - Evaluation Criteria

No.	Evaluation Criteria	Description of Criteria	Documents required from Bidders	PASS/FAIL
1	Company Registration	The bidder shall submit proof of company registration by the relevant authority and a valid PEC Registration in Category C-6 or above with specialization code CE-09 (Sewerage & Water Supply).	i. Company Registration Certificate or ii. Certificate of Incorporation iii. Valid PEC License	Pass/Fail
2.	Experience in Water Supply	At least two (2) completed similar contracts, of which at least one is substantially comparable in principal work components and implementation complexity to the proposed work.	i. List of Projects with brief description of each project, including scope, duration, contract value, and project start and completion dates. ii. Client details – name of the client organizations, name of the focal person in the client organization, official email, and contact number.	Pass/Fail
3.	Company Financial Capability	Financial statements or audited accounts for at least two (2) years (e.g., 2023, 2024 or 2025 or the most recent available financial years) or any evidence demonstrating sufficient financial stability and liquidity to complete the work;	i. Signed and Stamp Bank statement; or ii. Audited financial statements for at least two (2) consecutive years among 2023, 2024 or 2025; iii. Any evidence provides the financial stability to undertake the assignment	Pass/Fail
4.	List of Machinery and Equipment	- Hydraulic Drilling Rig Machine (1,020 ft capacity) – 01 No. - Generator Set – 01 No. - Concrete Mixer Machine (for pump house rehabilitation works) – 01 No. - Well Development and Pump Testing Equipment – 01 Set. - Hand Tools and Safety Equipment – 01 Set.	List of machinery and equipment intended for the project, indicating type, quantity, and ownership/rental details.	Pass/Fail
6.	Mobilization Commitment	The Bidder shall provide a written statement confirming readiness and commitment to mobilize within fifteen (15)	Written statement on letterhead confirming compliance with the mobilization time-frame.	Pass/Fail

		calendar days from contract approval.		
7	Minimum Key Personnel Requirements			
i	Project Manager / Lead Civil Engineer	Degree in Civil Engineering, Construction Management or closely related discipline; at least 5 years' overall experience,		Pass/Fail
ii	Site Engineer	Degree or diploma in Civil Engineering or closely related discipline; at least 5 years' overall experience, including at least 3 years in relevant works and participation in at least two similar projects. Separate Site Engineer required for each concurrently implemented lot.		Pass/Fail
iii	Site Supervisor	Relevant technical/trade qualification and at least 5 years' relevant site-supervision experience, including at least one similar project. Separate Site Supervisor required for each concurrently implemented lot.		Pass/Fail
iv	QA/QC or Materials Engineer/Officer	Relevant degree/diploma and at least 3 years' relevant experience in inspection plans, material approvals, testing, quality records and non-conformity control.		Pass/Fail
v	Quantity Surveyor / Measurement Engineer	Relevant degree/diploma and at least 3 years' experience in BoQ measurement, measurement books, valuation, progress certification support and completion accounts.		Pass/Fail

Evaluation Conclusion

Bidder:			
Mandatory criteria result:	PASS / FAIL		
Brief justification / material deficiencies:			
TEC Evaluators' names and signatures:		Date:	



Annex-C – Financial Quotation

Attached is the detail excel file of BOQ. Please fill in the file without changing the formula and format. Please submit the dully filled file soft copy and sign / stamp copy.

All quotations should be clear, concise, comprehensive, and itemized according to the specifications and quantities indicated in Annex C-1. Quotations shall be subject to arithmetic review of prices. Where total prices are incorrect, unit prices should govern.



GENERAL CONDITIONS OF CONTRACT

CONTRACTS FOR THE PROVISION OF GOODS AND SERVICES

1. ☐ **LEGAL STATUS OF THE PARTIES:** The United Nations and the Contractor shall also each be referred to as a “Party” hereunder, and:

1.1 ☐ Pursuant, *inter alia*, to the Charter of the United Nations and the Convention on the Privileges and Immunities of the United Nations, the United Nations, including its subsidiary organs, has full juridical personality and enjoys such privileges and immunities as are necessary for the independent fulfillment of its purposes.

1.2 ☐ The Contractor shall have the legal status of an independent contractor *vis-à-vis* the United Nations, and nothing contained in or relating to the Contract shall be construed as establishing or creating between the Parties the relationship of employer and employee or of principal and agent. The officials, representatives, employees, or subcontractors of each of the Parties shall not be considered in any respect as being the employees or agents of the other Party, and each Party shall be solely responsible for all claims arising out of or relating to its engagement of such persons or entities.

2. ☐ **RESPONSIBILITY FOR EMPLOYEES:** To the extent that the Contract involves the provision of any services to the United Nations by the Contractor’s officials, employees, agents, servants, subcontractors and other representatives (collectively, the Contractor’s “personnel”), the following provisions shall apply:

2.1 ☐ The Contractor shall be responsible for the professional and technical competence of the personnel it assigns to perform work under the Contract and will select reliable and competent individuals who will be able to effectively perform the obligations under the Contract and who, while doing so, will respect the local laws and customs and conform to a high standard of moral and ethical conduct.

2.2 ☐ Such Contractor personnel shall be professionally qualified and, if required to work with officials or staff of the United Nations, shall be able to do so effectively. The qualifications of any personnel whom the Contractor may assign or may propose to assign to perform any obligations under the Contract shall be substantially the same, or better, as the qualifications of any personnel originally proposed by the Contractor.

2.3 ☐ At the option of and in the sole discretion of the United Nations:

2.3.1 ☐ the qualifications of personnel proposed by the Contractor (*e.g.*, a curriculum vitae) may be reviewed by the United Nations prior to such personnel’s performing any obligations under the Contract;

2.3.2 ☐ any personnel proposed by the Contractor to perform obligations under the Contract may be interviewed by qualified staff or officials of the United Nations prior to such personnel’s performing any obligations under the Contract; and,

2.3.3 ☐ in cases in which, pursuant to Article 2.3.1 or 2.3.2, above, the United Nations has reviewed the qualifications of such Contractor’s personnel, the United Nations may reasonably refuse to accept any such personnel.

2.4 ☐ Requirements specified in the Contract regarding the number or qualifications of the Contractor’s personnel may change during the course of performance of the Contract. Any such change shall be made only following written notice of such proposed change and upon written agreement between the Parties regarding such change, subject to the following:

2.4.1 ☐ The United Nations may, at any time, request, in writing, the withdrawal or replacement of any of the Contractor’s personnel, and such request shall not be unreasonably refused by the Contractor.

2.4.2 ☐ Any of the Contractor’s personnel assigned to perform obligations under the Contract shall not be withdrawn or replaced without the prior written consent of the United Nations, which shall not be unreasonably withheld.



- 2.4.3□ The withdrawal or replacement of the Contractor's personnel shall be carried out as quickly as possible and in a manner that will not adversely affect the performance of obligations under the Contract.
- 2.4.4□ All expenses related to the withdrawal or replacement of the Contractor's personnel shall, in all cases, be borne exclusively by the Contractor.
- 2.4.5□ Any request by the United Nations for the withdrawal or replacement of the Contractor's personnel shall not be considered to be a termination, in whole or in part, of the Contract, and the United Nations shall not bear any liability in respect of such withdrawn or replaced personnel.
- 2.4.6□ If a request for the withdrawal or replacement of the Contractor's personnel is *not* based upon a default by or failure on the part of the Contractor to perform its obligations in accordance with the Contract, the misconduct of the personnel, or the inability of such personnel to reasonably work together with United Nations officials and staff, then the Contractor shall not be liable by reason of any such request for the withdrawal or replacement of the Contractor's personnel for any delay in the performance by the Contractor of its obligations under the Contract that is substantially the result of such personnel's being withdrawn or replaced.
- 2.5□ Nothing in Articles 2.2, 2.3 and 2.4, above, shall be construed to create any obligations on the part of the United Nations with respect to the Contractor's personnel assigned to perform work under the Contract, and such personnel shall remain the sole responsibility of the Contractor.
- 2.6□ The Contractor shall be responsible for requiring that all personnel assigned by it to perform any obligations under the Contract and who may have access to any premises or other property of the United Nations shall:
- 2.6.1□ undergo or comply with security screening requirements made known to the Contractor by the United Nations, including but not limited to, a review of any criminal history;
- 2.6.2□ when within United Nations premises or on United Nations property, display such identification as may be approved and furnished by the United Nations security officials, and that upon the withdrawal or replacement of any such personnel or upon termination or completion of the Contract, such personnel shall immediately return any such identification to the United Nations for cancellation.
- 2.7□ Within one working day after learning that any of Contractor's personnel who have access to any United Nations premises have been charged by law enforcement authorities with an offense other than a minor traffic offense, the Contractor shall provide written notice to inform the United Nations about the particulars of the charges then known and shall continue to inform the United Nations concerning all substantial developments regarding the disposition of such charges.
- 2.8□ All operations of the Contractor, including without limitation, storage of equipment, materials, supplies and parts, within United Nations premises or on United Nations property shall be confined to areas authorized or approved by the United Nations. The Contractor's personnel shall not enter or pass through and shall not store or dispose of any of its equipment or materials in any areas within United Nations premises or on United Nations property without appropriate authorization from the United Nations.

3.□ ASSIGNMENT:

- 3.1□ Except as provided in Article 3.2, below, the Contractor may not assign, transfer, pledge or make any other disposition of the Contract, of any part of the Contract, or of any of the rights, claims or obligations under the Contract except with the prior written authorization of the UN. Any such unauthorized assignment, transfer, pledge or other disposition, or any attempt to do so, shall not be binding on the United Nations. Except as permitted with respect to any approved subcontractors, the Contractor shall not delegate any of its obligations under this Contract, except with the prior written consent of the UN. Any such unauthorized delegation, or attempt to do so, shall not be binding on the United Nations.
- 3.2□ The Contractor may assign or otherwise transfer the Contract to the surviving entity resulting from a reorganization of the Contractor's operations, *provided that*:
- 3.2.1□ such reorganization is not the result of any bankruptcy, receivership or other similar proceedings;
and,



3.2.2 such reorganization arises from a sale, merger, or acquisition of all or substantially all of the Contractor's assets or ownership interests; *and*,

3.2.3 the Contractor promptly notifies the United Nations about such assignment or transfer at the earliest opportunity; *and*,

3.2.4 the assignee or transferee agrees in writing to be bound by all of the terms and conditions of the Contract, and such writing is promptly provided to the United Nations following the assignment or transfer.

4. **SUBCONTRACTING:** In the event that the Contractor requires the services of subcontractors to perform any obligations under the Contract, the Contractor shall obtain the prior written approval of the United Nations. The United Nations shall be entitled, in its sole discretion, to review the qualifications of any subcontractors and to reject any proposed subcontractor that the United Nations reasonably considers is not qualified to perform obligations under the Contract. The United Nations shall have the right to require any subcontractor's removal from United Nations premises without having to give any justification therefor. Any such rejection or request for removal shall not, in and of itself, entitle the Contractor to claim any delays in the performance, or to assert any excuses for the non-performance, of any of its obligations under the Contract, and the Contractor shall be solely responsible for all services and obligations performed by its subcontractors. The terms of any subcontract shall be subject to, and shall be construed in a manner that is fully in accordance with, all of the terms and conditions of the Contract.

5. **PURCHASE OF GOODS:** To the extent that the Contract involves any purchase of goods, whether in whole or in part, and unless specifically stated otherwise in the Contract, the following conditions shall apply to any purchases of goods under the Contract:

5.1 **DELIVERY OF GOODS:** The Contractor shall hand over or make available the goods, and the United Nations shall receive the goods, at the place for the delivery of the goods and within the time for delivery of the goods specified in the Contract. The Contractor shall provide to the United Nations such shipment documentation (including, without limitation, bills of lading, airway bills, and commercial invoices) as are specified in the Contract or, otherwise, as are customarily utilized in the trade. All manuals, instructions, displays and any other information relevant to the goods shall be in the English language unless otherwise specified in the Contract. Unless otherwise stated in the Contract (including, but not limited to, in any "INCOTERM" or similar trade term), the entire risk of loss, damage to, or destruction of the goods shall be borne exclusively by the Contractor until physical delivery of the goods to the United Nations in accordance with the terms of the Contract. Delivery of the goods shall not be deemed in itself as constituting acceptance of the goods by the United Nations.

5.2 **INSPECTION OF THE GOODS:** If the Contract provides that the goods may be inspected prior to delivery, the Contractor shall notify the United Nations when the goods are ready for pre-delivery inspection. Notwithstanding any pre-delivery inspection, the United Nations or its designated inspection agents may also inspect the goods upon delivery in order to confirm that the goods conform to applicable specifications or other requirements of the Contract. All reasonable facilities and assistance, including, but not limited to, access to drawings and production data, shall be furnished to the United Nations or its designated inspection agents at no charge therefor. Neither the carrying out of any inspections of the goods nor any failure to undertake any such inspections shall relieve the Contractor of any of its warranties or the performance of any obligations under the Contract.

5.3 **PACKAGING OF THE GOODS:** The Contractor shall package the goods for delivery in accordance with the highest standards of export packaging for the type and quantities and modes of transport of the goods. The goods shall be packed and marked in a proper manner in accordance with the instructions stipulated in the Contract or, otherwise, as customarily done in the trade, and in accordance with any requirements imposed by applicable law or by the transporters and manufacturers of the goods. The packing, in particular, shall mark the Contract or Purchase Order number and any other identification information provided by the United Nations as well as such other information as is necessary for the correct handling and safe delivery of the goods. Unless otherwise specified in the Contract, the Contractor shall have no right to any return of the packing materials.

5.4 **TRANSPORTATION & FREIGHT:** Unless otherwise specified in the Contract (including, but not limited to, in any "INCOTERM" or similar trade term), the Contractor shall be solely liable for making all transport arrangements and for payment of freight and insurance costs for the shipment and delivery of the goods in accordance with the requirements of the Contract. The Contractor shall ensure that the United Nations receives



all necessary transport documents in a timely manner so as to enable the United Nations to take delivery of the goods in accordance with the requirements of the Contract.

5.5 **WARRANTIES:** Unless otherwise specified in the Contract, in addition to and without limiting any other warranties, remedies or rights of the United Nations stated in or arising under the Contract, the Contractor warrants and represents that:

5.5.1 The goods, including all packaging and packing thereof, conform to the specifications of the Contract, are fit for the purposes for which such goods are ordinarily used and for any purposes expressly made known in writing in the Contract, and shall be of even quality, free from faults and defects in design, material, manufacturer and workmanship;

5.5.2 If the Contractor is not the original manufacturer of the goods, the Contractor shall provide the United Nations with the benefit of all manufacturers' warranties in addition to any other warranties required to be provided under the Contract;

5.5.3 The goods are of the quality, quantity and description required by the Contract, including when subjected to conditions prevailing in the place of final destination;

5.5.4 The goods are free from any right of claim by any third-party, including claims of infringement of any intellectual property rights, including, but not limited to, patents, copyright and trade secrets;

5.5.5 The goods are new and unused;

5.5.6 All warranties will remain fully valid following any delivery of the goods and for a period of not less than one (1) year following acceptance of the goods by the United Nations in accordance with the Contract;

5.5.7 During any period in which the Contractor's warranties are effective, upon notice by the United Nations that the goods do not conform to the requirements of the Contract, the Contractor shall promptly and at its own expense correct such non-conformities or, in case of its inability to do so, replace the defective goods with goods of the same or better quality or, at its own cost, remove the defective goods and fully reimburse the United Nations for the purchase price paid for the defective goods; and,

5.5.8 The Contractor shall remain responsive to the needs of the United Nations for any services that may be required in connection with any of the Contractor's warranties under the Contract.

5.6 **ACCEPTANCE OF GOODS:** Under no circumstances shall the United Nations be required to accept any goods that do not conform to the specifications or requirements of the Contract. The United Nations may condition its acceptance of the goods upon the successful completion of acceptance tests as may be specified in the Contract or otherwise agreed in writing by the Parties. In no case shall the United Nations be obligated to accept any goods unless and until the United Nations has had a reasonable opportunity to inspect the goods following delivery. If the Contract specifies that the United Nations shall provide a written acceptance of the goods, the goods shall not be deemed accepted unless and until the United Nations in fact provides such written acceptance. In no case shall payment by the United Nations in and of itself constitute acceptance of the goods.

5.7 **REJECTION OF GOODS:** Notwithstanding any other rights of, or remedies available to the United Nations under the Contract, in case any of the goods are defective or otherwise do not conform to the specifications or other requirements of the Contract, the United Nations, at its sole option, may reject or refuse to accept the goods, and within thirty (30) days following receipt of notice from the United Nations of such rejection or refusal to accept the goods, the Contractor shall, in sole option of the United Nations:

5.7.1 provide a full refund upon return of the goods, or a partial refund upon a return of a portion of the goods, by the United Nations; or,

5.7.2 repair the goods in a manner that would enable the goods to conform to the specifications or other requirements of the Contract; or,

5.7.3 replace the goods with goods of equal or better quality; and,

5.7.4 pay all costs relating to the repair or return of the defective goods as well as the costs relating to the storage of any such defective goods and for the delivery of any replacement goods to the United Nations.



5.8□ In the event that the United Nations elects to return any of the goods for the reasons specified in Article 5.7, above, the United Nations may procure the goods from another source. In addition to any other rights or remedies available to the United Nations under the Contract, including, but not limited to, the right to terminate the Contract, the Contractor shall be liable for any additional cost beyond the balance of the Contract price resulting from any such procurement, including, *inter alia*, the costs of engaging in such procurement, and the United Nations shall be entitled to compensation from the Contractor for any reasonable expenses incurred for preserving and storing the goods for the Contractor's account.

5.9□ **TITLE:** The Contractor warrants and represents that the goods delivered under the Contract are unencumbered by any third party's title or other property rights, including, but not limited to, any liens or security interests. Unless otherwise expressly provided in the Contract, title in and to the goods shall pass from the Contractor to the United Nations upon delivery of the goods and their acceptance by the United Nations in accordance with the requirements of the Contract.

5.10□ **EXPORT LICENSING:** The Contractor shall be responsible for obtaining any export license required with respect to the goods, products, or technologies, including software, sold, delivered, licensed or otherwise provided to the United Nations under the Contract. The Contractor shall procure any such export license in an expeditious manner. Subject to and without any waiver of the privileges and immunities of the United Nations, the United Nations shall lend the Contractor all reasonable assistance required for obtaining any such export license. Should any Governmental entity refuse, delay or hinder the Contractor's ability to obtain any such export license, the Contractor shall promptly consult with the United Nations to enable the United Nations to take appropriate measures to resolve the matter.

6.□ **INDEMNIFICATION:**

6.1□ The Contractor shall indemnify, defend, and hold and save harmless, the United Nations, and its officials, agents and employees, from and against all suits, proceedings, claims, demands, losses and liability of any kind or nature brought by any third party against the United Nations, including, but not limited to, all litigation costs and expenses, attorney's fees, settlement payments and damages, based on, arising from, or relating to:

6.1.1□ allegations or claims that the possession of or use by the United Nations of any patented device, any copyrighted material, or any other goods, property or services provided or licensed to the United Nations under the terms of the Contract, in whole or in part, separately or in a combination contemplated by the Contractor's published specifications therefor, or otherwise specifically approved by the Contractor, constitutes an infringement of any patent, copyright, trademark, or other intellectual property right of any third party; or,

6.1.2□ any acts or omissions of the Contractor, or of any subcontractor or anyone directly or indirectly employed by them in the performance of the Contract, which give rise to legal liability to anyone not a party to the Contract, including, without limitation, claims and liability in the nature of a claim for workers' compensation.

6.2□ The indemnity set forth in Article 6.1.1, above, shall not apply to:

6.2.1□ A claim of infringement resulting from the Contractor's compliance with specific written instructions by the United Nations directing a change in the specifications for the goods, property, materials, equipment or supplies to be or used, or directing a manner of performance of the Contract or requiring the use of specifications not normally used by the Contractor; or

6.2.2□ A claim of infringement resulting from additions to or changes in any goods, property, materials equipment, supplies or any components thereof furnished under the Contract if the United Nations or another party acting under the direction of the United Nations made such changes.

6.3□ In addition to the indemnity obligations set forth in this Article 6, the Contractor shall be obligated, at its sole expense, to defend the United Nations and its officials, agents and employees, pursuant to this Article 6, regardless of whether the suits, proceedings, claims and demands in question actually give rise to or otherwise result in any loss or liability.

6.4□ The United Nations shall advise the Contractor about any such suits, proceedings, claims, demands, losses or liability within a reasonable period of time after having received actual notice thereof. The Contractor shall have sole control of the defense of any such suit, proceeding, claim or demand and of all negotiations in connection with the settlement or compromise thereof, except with respect to the assertion or defense of the



privileges and immunities of the United Nations or any matter relating thereto, for which only the United Nations itself is authorized to assert and maintain. The United Nations shall have the right, at its own expense, to be represented in any such suit, proceeding, claim or demand by independent counsel of its own choosing.

6.5 ☐ In the event the use by the United Nations of any goods, property or services provided or licensed to the United Nations by the Contractor, in whole or in part, in any suit or proceeding, is for any reason enjoined, temporarily or permanently, or is found to infringe any patent, copyright, trademark or other intellectual property right, or in the event of a settlement, is enjoined, limited or otherwise interfered with, then the Contractor, at its sole cost and expense, shall, promptly, either:

6.5.1 ☐ procure for the United Nations the unrestricted right to continue using such goods or services provided to the United Nations;

6.5.2 ☐ replace or modify the goods or services provided to the United Nations, or part thereof, with the equivalent or better goods or services, or part thereof, that is non-infringing; *or*,

6.5.3 ☐ refund to the United Nations the full price paid by the United Nations for the right to have or use such goods, property or services, or part thereof.

7. ☐ **INSURANCE AND LIABILITY:**

7.1 ☐ The Contractor shall pay the United Nations promptly for all loss, destruction, or damage to the property of the United Nations caused by the Contractor's personnel or by any of its subcontractors or anyone else directly or indirectly employed by the Contractor or any of its subcontractors in the performance of the Contract.

7.2 ☐ Unless otherwise provided in the Contract, prior to commencement of performance of any other obligations under the Contract, and subject to any limits set forth in the Contract, the Contractor shall take out and shall maintain for the entire term of the Contract, for any extension thereof, and for a period following any termination of the Contract reasonably adequate to deal with losses:

7.2.1 ☐ insurance against all risks in respect of its property and any equipment used for the performance of the Contract;

7.2.2 ☐ workers' compensation insurance, or its equivalent, or employer's liability insurance, or its equivalent, with respect to the Contractor's personnel sufficient to cover all claims for injury, death and disability, or any other benefits required to be paid by law, in connection with the performance of the Contract;

7.2.3 ☐ liability insurance in an adequate amount to cover all claims, including, but not limited to, claims for death and bodily injury, products and completed operations liability, loss of or damage to property, and personal and advertising injury, arising from or in connection with the Contractor's performance under the Contract, including, but not limited to, liability arising out of or in connection with the acts or omissions of the Contractor, its personnel, agents, or invitees, or the use, during the performance of the Contract, of any vehicles, boats, airplanes or other transportation vehicles and equipment, whether or not owned by the Contractor; *and*,

7.2.4 ☐ such other insurance as may be agreed upon in writing between the United Nations and the Contractor.

7.3 ☐ The Contractor's liability policies shall also cover subcontractors and all defense costs and shall contain a standard "cross liability" clause.

7.4 ☐ The Contractor acknowledges and agrees that the United Nations accepts no responsibility for providing life, health, accident, travel or any other insurance coverage which may be necessary or desirable in respect of any personnel performing services for the Contractor in connection with the Contract.

7.5 ☐ Except for the workers' compensation insurance or any self-insurance program maintained by the Contractor and approved by the United Nations, in its sole discretion, for purposes of fulfilling the Contractor's requirements for providing insurance under the Contract, the insurance policies required under the Contract shall:

7.5.1 ☐ name the United Nations as an additional insured under the liability policies, including, if required, as a separate endorsement under the policy;



7.5.2□include a waiver of subrogation of the Contractor's insurance carrier's rights against the United Nations;

7.5.3□provide that the United Nations shall receive written notice from the Contractor's insurance carrier not less than thirty (30) days prior to any cancellation or material change of coverage; *and*,

7.5.4□include a provision for response on a primary and non-contributing basis with respect to any other insurance that may be available to the United Nations.

7.6□The Contractor shall be responsible to fund all amounts within any policy deductible or retention.

7.7□Except for any self-insurance program maintained by the Contractor and approved by the United Nations for purposes of fulfilling the Contractor's requirements for maintaining insurance under the Contract, the Contractor shall maintain the insurance taken out under the Contract with reputable insurers that are in good financial standing and that are acceptable to the United Nations. Prior to the commencement of any obligations under the Contract, the Contractor shall provide the United Nations with evidence, in the form of certificate of insurance or such other form as the United Nations may reasonably require, that demonstrates that the Contractor has taken out insurance in accordance with the requirements of the Contract. The United Nations reserves the right, upon written notice to the Contractor, to obtain copies of any insurance policies or insurance program descriptions required to be maintained by the Contractor under the Contract. Notwithstanding the provisions of Article 7.5.3, above, the Contractor shall promptly notify the United Nations concerning any cancellation or material change of insurance coverage required under the Contract.

7.8□The Contractor acknowledges and agrees that neither the requirement for taking out and maintaining insurance as set forth in the Contract nor the amount of any such insurance, including, but not limited to, any deductible or retention relating thereto, shall in any way be construed as limiting the Contractor's liability arising under or relating to the Contract.

8.□ **ENCUMBRANCES AND LIENS:** The Contractor shall not cause or permit any lien, attachment or other encumbrance by any person to be placed on file or to remain on file in any public office or on file with the United Nations against any monies due to the Contractor or that may become due for any work done or against any goods supplied or materials furnished under the Contract, or by reason of any other claim or demand against the Contractor or the United Nations.

9.□ **EQUIPMENT FURNISHED BY THE UNITED NATIONS TO THE CONTRACTOR:** Title to any equipment and supplies that may be furnished by the United Nations to the Contractor for the performance of any obligations under the Contract shall rest with the United Nations, and any such equipment shall be returned to the United Nations at the conclusion of the Contract or when no longer needed by the Contractor. Such equipment, when returned to the United Nations, shall be in the same condition as when delivered to the Contractor, subject to normal wear and tear, and the Contractor shall be liable to compensate the United Nations for the actual costs of any loss of, damage to, or degradation of the equipment that is beyond normal wear and tear.

10.□ **COPYRIGHT, PATENTS AND OTHER PROPRIETARY RIGHTS:**

10.1□Except as is otherwise expressly provided in writing in the Contract, the United Nations shall be entitled to all intellectual property and other proprietary rights including, but not limited to, patents, copyrights, and trademarks, with regard to products, processes, inventions, ideas, know-how, or documents and other materials which the Contractor has developed for the United Nations under the Contract and which bear a direct relation to or are produced or prepared or collected in consequence of, or during the course of, the performance of the Contract. The Contractor acknowledges and agrees that such products, documents and other materials constitute works made for hire for the United Nations.

10.2□To the extent that any such intellectual property or other proprietary rights consist of any intellectual property or other proprietary rights of the Contractor: (i) that pre-existed the performance by the Contractor of its obligations under the Contract, or (ii) that the Contractor may develop or acquire, or may have developed or acquired, independently of the performance of its obligations under the Contract, the United Nations does not and shall not claim any ownership interest thereto, and the Contractor grants to the United Nations a perpetual license to use such intellectual property or other proprietary right solely for the purposes of and in accordance with the requirements of the Contract.

10.3□At the request of the United Nations, the Contractor shall take all necessary steps, execute all necessary documents and generally assist in securing such proprietary rights and transferring or licensing them to the United Nations in compliance with the requirements of the applicable law and of the Contract.



10.4□ Subject to the foregoing provisions, all maps, drawings, photographs, mosaics, plans, reports, estimates, recommendations, documents, and all other data compiled by or received by the Contractor under the Contract shall be the property of the United Nations, shall be made available for use or inspection by the United Nations at reasonable times and in reasonable places, shall be treated as confidential, and shall be delivered only to United Nations authorized officials on completion of work under the Contract.

11.□ **PUBLICITY, AND USE OF THE NAME, EMBLEM OR OFFICIAL SEAL OF THE UNITED NATIONS:** The Contractor shall not advertise or otherwise make public for purposes of commercial advantage or goodwill that it has a contractual relationship with the United Nations, nor shall the Contractor, in any manner whatsoever use the name, emblem or official seal of the United Nations, or any abbreviation of the name of the United Nations in connection with its business or otherwise without the written permission the United Nations.

12.□ **CONFIDENTIAL NATURE OF DOCUMENTS AND INFORMATION:** Information and data that is considered proprietary by either Party or that is delivered or disclosed by one Party ("Discloser") to the other Party ("Recipient") during the course of performance of the Contract, and that is designated as confidential ("Information"), shall be held in confidence by that Party and shall be handled as follows:

12.1□ The Recipient shall:

12.1.1□ use the same care and discretion to avoid disclosure, publication or dissemination of the Discloser's Information as it uses with its own similar Information that it does not wish to disclose, publish or disseminate; *and*,

12.1.2□ use the Discloser's Information solely for the purpose for which it was disclosed.

12.2□ Provided that the Recipient has a written agreement with the following persons or entities requiring them to treat the Information confidential in accordance with the Contract and this Article 12, the Recipient may disclose Information to:

12.2.1□ any other party with the Discloser's prior written consent; *and*,

12.2.2□ the Recipient's employees, officials, representatives and agents who have a need to know such Information for purposes of performing obligations under the Contract, and employees officials, representatives and agents of any legal entity that it controls, controls it, or with which it is under common control, who have a need to know such Information for purposes of performing obligations under the Contract, *provided that*, for these purposes a controlled legal entity means:

12.2.2.1□ a corporate entity in which the Party owns or otherwise controls, whether directly or indirectly, over fifty percent (50%) of voting shares thereof; *or*,

12.2.2.2□ any entity over which the Party exercises effective managerial control; *or*,

12.2.2.3□ for the United Nations, a principal or subsidiary organ of the United Nations established in accordance with the Charter of the United Nations.

12.3□ The Contractor may disclose Information to the extent required by law, *provided that*, subject to and without any waiver of the privileges and immunities of the United Nations, the Contractor will give the United Nations sufficient prior notice of a request for the disclosure of Information in order to allow the United Nations to have a reasonable opportunity to take protective measures or such other action as may be appropriate before any such disclosure is made.

12.4□ The United Nations may disclose Information to the extent as required pursuant to the Charter of the United Nations, or pursuant to resolutions or regulations of the General Assembly or rules promulgated thereunder.

12.5□ The Recipient shall not be precluded from disclosing Information that is obtained by the Recipient from a third party without restriction, is disclosed by the Discloser to a third party without any obligation of confidentiality, is previously known by the Recipient, or at any time is developed by the Recipient completely independently of any disclosures hereunder.

12.6□ These obligations and restrictions of confidentiality shall be effective during the term of the Contract, including any extension thereof, and, unless otherwise provided in the Contract, shall remain effective following any termination of the Contract.

**13. FORCE MAJEURE; OTHER CHANGES IN CONDITIONS:**

- 13.1 In the event of and as soon as possible after the occurrence of any cause constituting *force majeure*, the affected Party shall give notice and full particulars in writing to the other Party, of such occurrence or cause if the affected Party is thereby rendered unable, wholly or in part, to perform its obligations and meet its responsibilities under the Contract. The affected Party shall also notify the other Party of any other changes in condition or the occurrence of any event which interferes or threatens to interfere with its performance of the Contract. Not more than fifteen (15) days following the provision of such notice of *force majeure* or other changes in condition or occurrence, the affected Party shall also submit a statement to the other Party of estimated expenditures that will likely be incurred for the duration of the change in condition or the event of *force majeure*. On receipt of the notice or notices required hereunder, the Party not affected by the occurrence of a cause constituting *force majeure* shall take such action as it reasonably considers to be appropriate or necessary in the circumstances, including the granting to the affected Party of a reasonable extension of time in which to perform any obligations under the Contract.
- 13.2 If the Contractor is rendered unable, wholly or in part, by reason of *force majeure* to perform its obligations and meet its responsibilities under the Contract, the United Nations shall have the right to suspend or terminate the Contract on the same terms and conditions as are provided for in Article 14, "Termination," except that the period of notice shall be seven (7) days instead of thirty (30) days. In any case, the United Nations shall be entitled to consider the Contractor permanently unable to perform its obligations under the Contract in case the Contractor is unable to perform its obligations, wholly or in part, by reason of *force majeure* for any period in excess of ninety (90) days.
- 13.3 *Force majeure* as used herein means any unforeseeable and irresistible act of nature, any act of war (whether declared or not), invasion, revolution, insurrection, terrorism, or any other acts of a similar nature or force, provided that such acts arise from causes beyond the control and without the fault or negligence of the Contractor. The Contractor acknowledges and agrees that, with respect to any obligations under the Contract that the Contractor must perform in areas in which the United Nations is engaged in, preparing to engage in, or disengaging from any peacekeeping, humanitarian or similar operations, any delays or failure to perform such obligations arising from or relating to harsh conditions within such areas, or to any incidents of civil unrest occurring in such areas, shall not, in and of itself, constitute *force majeure* under the Contract.

14. TERMINATION:

- 14.1 Either Party may terminate the Contract for cause, in whole or in part, upon thirty (30) day's notice, in writing, to the other Party. The initiation of conciliation or arbitral proceedings in accordance with Article 17 "Settlement of Disputes," below, shall not be deemed to be a "cause" for or otherwise to be in itself a termination of the Contract.
- 14.2 The United Nations may terminate the Contract at any time by providing written notice to the Contractor in any case in which the mandate of the United Nations applicable to the performance of the Contract or the funding of the United Nations applicable to the Contract is curtailed or terminated, whether in whole or in part. In addition, unless otherwise provided by the Contract, upon sixty (60) day's advance written notice to the Contractor, the United Nations may terminate the Contract without having to provide any justification therefor.
- 14.3 In the event of any termination of the Contract, upon receipt of notice of termination that has been issued by the United Nations, the Contractor shall, except as may be directed by the United Nations in the notice of termination or otherwise in writing:
- 14.3.1 take immediate steps to bring the performance of any obligations under the Contract to a close in a prompt and orderly manner, and in doing so, reduce expenses to a minimum;
 - 14.3.2 refrain from undertaking any further or additional commitments under the Contract as of and following the date of receipt of such notice;
 - 14.3.3 place no further subcontracts or orders for materials, services, or facilities, except as the United Nations and the Contractor agree in writing are necessary to complete any portion of the Contract that is not terminated;
 - 14.3.4 terminate all subcontracts or orders to the extent they relate to the portion of the Contract terminated;



- 14.3.5□ transfer title and deliver to the United Nations the fabricated or unfabricated parts, work in process, completed work, supplies, and other material produced or acquired for the portion of the Contract terminated;
- 14.3.6□ deliver all completed or partially completed plans, drawings, information, and other property that, if the Contract had been completed, would be required to be furnished to the United Nations thereunder;
- 14.3.7□ complete performance of the work not terminated; *and*,
- 14.3.8□ take any other action that may be necessary, or that the United Nations may direct in writing, for the minimization of losses and for the protection and preservation of any property, whether tangible or intangible, related to the Contract that is in the possession of the Contractor and in which the United Nations has or may be reasonably expected to acquire an interest.

14.4□ In the event of any termination of the Contract, the United Nations shall be entitled to obtain reasonable written accountings from the Contractor concerning all obligations performed or pending in accordance with the Contract. In addition, the United Nations shall not be liable to pay the Contractor except for those goods delivered and services provided to the United Nations in accordance with the requirements of the Contract, but only if such goods or services were ordered, requested or otherwise provided prior to the Contractor's receipt of notice of termination from the United Nations or prior to the Contractor's tendering of notice of termination to the United Nations.

14.5□ The United Nations may, without prejudice to any other right or remedy available to it, terminate the Contract forthwith in the event that:

- 14.5.1□ the Contractor is adjudged bankrupt, or is liquidated, or becomes insolvent, or applies for a moratorium or stay on any payment or repayment obligations, or applies to be declared insolvent;
- 14.5.2□ the Contractor is granted a moratorium or a stay, or is declared insolvent;
- 14.5.3□ the Contractor makes an assignment for the benefit of one or more of its creditors;
- 14.5.4□ a Receiver is appointed on account of the insolvency of the Contractor;
- 14.5.5□ the Contractor offers a settlement in lieu of bankruptcy or receivership; *or*,
- 14.5.6□ the United Nations reasonably determines that the Contractor has become subject to a materially adverse change in its financial condition that threatens to substantially affect the ability of the Contractor to perform any of its obligations under the Contract.

14.6□ Except as prohibited by law, the Contractor shall be bound to compensate the United Nations for all damages and costs, including, but not limited to, all costs incurred by the United Nations in any legal or non-legal proceedings, as a result of any of the events specified in Article 14.5, above, and resulting from or relating to a termination of the Contract, even if the Contractor is adjudged bankrupt, or is granted a moratorium or stay or is declared insolvent. The Contractor shall immediately inform the United Nations of the occurrence of any of the events specified in Article 14.5, above, and shall provide the United Nations with any information pertinent thereto.

14.7□ The provisions of this Article 14 are without prejudice to any other rights or remedies of the United Nations under the Contract or otherwise.

15.□ **NON-WAIVER OF RIGHTS:** The failure by either Party to exercise any rights available to it, whether under the Contract or otherwise, shall not be deemed for any purposes to constitute a waiver by the other Party of any such right or any remedy associated therewith, and shall not relieve the Parties of any of their obligations under the Contract.

16.□ **NON-EXCLUSIVITY:** Unless otherwise specified in the Contract, the United Nations shall have no obligation to purchase any minimum quantities of goods or services from the Contractor, and the United Nations shall have no limitation on its right to obtain goods or services of the same kind, quality and quantity described in the Contract, from any other source at any time.

17.□ **SETTLEMENT OF DISPUTES:**

17.1□ **AMICABLE SETTLEMENT:** The Parties shall use their best efforts to amicably settle any dispute, controversy, or claim arising out of the Contract or the breach, termination, or invalidity thereof. Where the



Parties wish to seek such an amicable settlement through conciliation, the conciliation shall take place in accordance with the Conciliation Rules then obtaining of the United Nations Commission on International Trade Law (“UNCITRAL”), or according to such other procedure as may be agreed between the Parties in writing.

17.2 **ARBITRATION:** Any dispute, controversy, or claim between the Parties arising out of the Contract or the breach, termination, or invalidity thereof, unless settled amicably under Article 17.1, above, within sixty (60) days after receipt by one Party of the other Party’s written request for such amicable settlement, shall be referred by either Party to arbitration in accordance with the UNCITRAL Arbitration Rules then obtaining. The decisions of the arbitral tribunal shall be based on general principles of international commercial law. The arbitral tribunal shall be empowered to order the return or destruction of goods or any property, whether tangible or intangible, or of any confidential information provided under the Contract, order the termination of the Contract, or order that any other protective measures be taken with respect to the goods, services or any other property, whether tangible or intangible, or of any confidential information provided under the Contract, as appropriate, all in accordance with the authority of the arbitral tribunal pursuant to Article 26 (“Interim measures”) and Article 34 (“Form and effect of the award”) of the UNCITRAL Arbitration Rules. The arbitral tribunal shall have no authority to award punitive damages. In addition, unless otherwise expressly provided in the Contract, the arbitral tribunal shall have no authority to award interest in excess of the London Inter-Bank Offered Rate (“LIBOR”) then prevailing, and any such interest shall be simple interest only. The Parties shall be bound by any arbitration award rendered as a result of such arbitration as the final adjudication of any such dispute, controversy, or claim.

18. **PRIVILEGES AND IMMUNITIES:** Nothing in or relating to the Contract shall be deemed a waiver, express or implied, of any of the privileges and immunities of the United Nations, including its subsidiary organs.

19. **TAX EXEMPTION:**

19.1 **Article II, Section 7, of the Convention on the Privileges and Immunities of the United Nations provides, *inter alia*, that the United Nations, including its subsidiary organs, is exempt from all direct taxes, except charges for public utility services, and is exempt from customs restrictions, duties, and charges of a similar nature in respect of articles imported or exported for its official use. In the event any governmental authority refuses to recognize the exemptions of the United Nations from such taxes, restrictions, duties, or charges, the Contractor shall immediately consult with the United Nations to determine a mutually acceptable procedure.**

19.2 **The Contractor authorizes the United Nations to deduct from the Contractor’s invoices any amount representing such taxes, duties or charges, unless the Contractor has consulted with the United Nations before the payment thereof and the United Nations has, in each instance, specifically authorized the Contractor to pay such taxes, duties, or charges under written protest. In that event, the Contractor shall provide the United Nations with written evidence that payment of such taxes, duties or charges has been made and appropriately authorized, and the United Nations shall reimburse the Contractor for any such taxes, duties, or charges so authorized by the United Nations and paid by the Contractor under written protest.**

20. **MODIFICATIONS:**

20.1 **Pursuant to the Financial Regulations and Rules of the United Nations, only the Chief of the United Nations Procurement Division, or such other Contracting authority as the United Nations has made known to the Contractor in writing, possesses the authority to agree on behalf of the United Nations to any modification of or change in the Contract, to a waiver of any of its provisions or to any additional contractual relationship of any kind with the Contractor. Accordingly, no modification or change in the Contract shall be valid and enforceable against the United Nations unless provided by a valid written amendment to the Contract signed by the Contractor and the Chief of the United Nations Procurement Division or such other contracting authority.**

20.2 **If the Contract shall be extended for additional periods in accordance with the terms and conditions of the Contract, the terms and conditions applicable to any such extended term of the Contract shall be the same terms and conditions as set forth in the Contract, unless the Parties shall have agreed otherwise pursuant to a valid amendment concluded in accordance with Article 20.1, above.**



20.3□The terms or conditions of any supplemental undertakings, licenses, or other forms of agreement concerning any goods or services provided under the Contract shall not be valid and enforceable against the United Nations nor in any way shall constitute an agreement by the United Nations thereto unless any such undertakings, licenses or other forms are the subject of a valid amendment concluded in accordance with Article 20.1, above.

21.□AUDITS AND INVESTIGATIONS:

21.1□Each invoice paid by the United Nations shall be subject to a post-payment audit by auditors, whether internal or external, of the United Nations or by other authorized and qualified agents of the United Nations at any time during the term of the Contract and for a period of three (3) years following the expiration or prior termination of the Contract. The United Nations shall be entitled to a refund from the Contractor for any amounts shown by such audits to have been paid by the United Nations other than in accordance with the terms and conditions of the Contract.

21.2□The United Nations may conduct investigations relating to any aspect of the Contract or the award thereof, the obligations performed under the Contract, and the operations of the Contractor generally relating to performance of the Contract at any time during the term of the Contract and for a period of three (3) years following the expiration or prior termination of the Contract.

21.3□The Contractor shall provide its full and timely cooperation with any such inspections, post-payment audits or investigations. Such cooperation shall include, but shall not be limited to, the Contractor's obligation to make available its personnel and any relevant documentation for such purposes at reasonable times and on reasonable conditions and to grant to the United Nations access to the Contractor's premises at reasonable times and on reasonable conditions in connection with such access to the Contractor's personnel and relevant documentation. The Contractor shall require its agents, including, but not limited to, the Contractor's attorneys, accountants or other advisers, to reasonably cooperate with any inspections, post-payment audits or investigations carried out by the United Nations hereunder.

22.□LIMITATION ON ACTIONS:

22.1□Except with respect to any indemnification obligations in Article 6, above, or as are otherwise set forth in the Contract, any arbitral proceedings in accordance with Article 17.2, above, arising out of the Contract must be commenced within three years after the cause of action has accrued.

22.2□The Parties further acknowledge and agree that, for these purposes, a cause of action shall accrue when the breach actually occurs, or, in the case of latent defects, when the injured Party knew or should have known all of the essential elements of the cause of action, or in the case of a breach of warranty, when tender of delivery is made, except that, if a warranty extends to future performance of the goods or any process or system and the discovery of the breach consequently must await the time when such goods or other process or system is ready to perform in accordance with the requirements of the Contract, the cause of action accrues when such time of future performance actually begins.

23. **ESSENTIAL TERMS:** The Contractor acknowledges and agrees that each of the provisions in Articles 24 to 29 hereof constitutes an essential term of the Contract and that any breach of any of these provisions shall entitle the United Nations to terminate the Contract or any other contract with the United Nations immediately upon notice to the Contractor, without any liability for termination charges or any other liability of any kind.

24. **SOURCE OF INSTRUCTIONS:** The Contractor shall neither seek nor accept instructions from any authority external to the United Nations in connection with the performance of its obligations under the Contract. Should any authority external to the United Nations seek to impose any instructions concerning or restrictions on the Contractor's performance under the Contract, the Contractor shall promptly notify the United Nations and provide all reasonable assistance required by the United Nations. The Contractor shall not take any action in respect of the performance of its obligations under the Contract that may adversely affect the interests of the United Nations, and the Contractor shall perform its obligations under the Contract with the fullest regard to the interests of the United Nations.

25. **OFFICIALS NOT TO BENEFIT:** The Contractor warrants that it has not and shall not offer to any representative, official, employee, or other agent of the United Nations any direct or indirect benefit arising from or related to the performance of the Contract or of any other contract with the United Nations or the award thereof or for any other purpose intended to gain an advantage for the Contractor.



26. **OBSERVANCE OF THE LAW:** The Contractor shall comply with all laws, ordinances, rules, and regulations bearing upon the performance of its obligations under the Contract. In addition, the Contractor shall maintain compliance with all obligations relating to its registration as a qualified vendor of goods or services to the United Nations, as such obligations are set forth in the United Nations vendor registration procedures.
27. **CHILD LABOR:** The Contractor represents and warrants that neither it, its parent entities (if any), nor any of the Contractor's subsidiary or affiliated entities (if any) is engaged in any practice inconsistent with the rights set forth in the Convention on the Rights of the Child, including Article 32 thereof, which, *inter alia*, requires that a child shall be protected from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development.
28. **MINES:** The Contractor represents and warrants that neither it, its parent entities (if any), nor any of the Contractor's subsidiaries or affiliated entities (if any) is engaged in the sale or manufacture of anti-personnel mines or components utilized in the manufacture of anti-personnel mines.
29. **SEXUAL EXPLOITATION:**
- 29.1 The Contractor shall take all appropriate measures to prevent sexual exploitation or abuse of anyone by its employees or any other persons engaged and controlled by the Contractor to perform any services under the Contract. For these purposes, sexual activity with any person less than eighteen years of age, regardless of any laws relating to consent, shall constitute the sexual exploitation and abuse of such person. In addition, the Contractor shall refrain from, and shall take all reasonable and appropriate measures to prohibit its employees or other persons engaged and controlled by it from exchanging any money, goods, services, or other things of value, for sexual favors or activities, or from engaging any sexual activities that are exploitive or degrading to any person.
- 29.2 The United Nations shall not apply the foregoing standard relating to age in any case in which the Contractor's personnel or any other person who may be engaged by the Contractor to perform any services under the Contract is married to the person less than the age of eighteen years with whom sexual activity has occurred and in which such marriage is recognized as valid under the laws of the country of citizenship of such Contractor's personnel or such other person who may be engaged by the Contractor to perform any services under the Contract.

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Annex-C

The United Nations Human Settlements Programme

**“Harmonizing Afghan Refugees and Host Communities in Urban Slums in Pakistan
for Peaceful Coexistence and Social Cohesion”**

Technical Specification (Drinking Water Supply Schemes)

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SECTION-1-PART "A" -GENERAL

1.1. SITE INFORMATION

The Contractor shall visit the site prior to making his bid and shall ascertain the nature of strata, the earth, its quality/quantity, locations, and suitability to meet the specified requirements, existing situation of working area and he shall base his bid estimates solely on his own studies and tests.

Any subsurface information including bore logs is provided for reference only and shall not relieve the Contractor of his responsibility to verify actual site conditions. No claim arising from misinterpretation of such information shall be entertained.

1.2. LAYOUT

The layout of works for the purposes of execution of roads, water supply, sewerage, drainage and facilities under the scope of work shall be carried out by the Contractor subject to confirmation / check by the Engineer which must be accurately as per the Drawings and instructions of the Engineer. Before commencement of construction work, the layout shall be checked and certified by the Engineer's Representative or Engineer. The measurement for payment shall not be taken for this item of the work, price shall be deemed to be included in other items of Works.

1.3. SURVEY EQUIPMENT

The Contractor with the approval of the Engineer shall provide survey equipment for the Engineer's Representative and his staff which shall be of the number, type and quality (or equivalent) as listed in **Table 1.1.**

Table 1.1, List of Survey Equipment

Sr. No.	Equipment	Quantity
1	Total Station complete with standard accessories, minimum angular accuracy ± 5 seconds, distance accuracy $\pm(2\text{mm} + 2\text{ppm})$, conforming to ISO 17123 or equivalent approved standard. Any model e-g SOKKIA SET ,Laika ,topcop, Hitech	1-No.
2	Single Tilting Range Pole Prism Complete Set Model SOKKIA KPS 11 PT or Equivalent	1-Set
3	Single Tilting Prism W / Coaxial Target Complete Model SOKKIA KPS 12 or Equivalent	1-Set
4	Automatic Levels, with Standard Aluminium Tripod Model B20	2-Nos.
5	Steel Measuring Tapes 50m and 20m long	2-Each
6	Steel Measuring Tapes 3m long	6-Nos.
7	Levelling Staff (4m)	2-Nos.
8	Ranging Rods	as required
9	All Miscellaneous Tools, Equipment and Materials required in Surveying	as required

The cost of said survey equipment shall be deemed included in other items of works; as such no separate payment shall be made. All surveying equipment shall be new and maintained in perfect working condition throughout the contract period and replaced by the Contractor in case of damage or loss under the terms and condition of the agreement.

1.4. PLANT, EQUIPMENT AND TOOLS

The Contractor shall provide at his cost modern plant, equipment and tools, adequate and befitting to the nature, magnitude and size of this Contract, in strict compliance with the requirements of the Contract.

1.5. STORAGE & HANDLING FACILITIES

The Employer will provide the necessary space if available with him, for constructional activities including batching plant, laboratory, workshop, storage of plant, equipment and materials and for Contractor's temporary office/camp, during the currency of the Contract. If the space is ' not available with the Employer then the contractor shall arrange these facilities without additional cost to the Employer.

1.6. TEST LABORATORY TESTING AND TESTING REPORT

Testing, except as otherwise specified herein, shall be performed by a testing agency

approved by the Engineer and at no extra cost to the Employer. The Contractor shall bear the Cost of such Testing. The Engineer may require all or part testing to be carried out under his supervision only.

The quality control testing shall be performed by the Contractor's competent personnel in accordance with a site testing and quality control program to be established by the Contractor and approved by the Engineer. The Contractor shall keep a complete record of all quality tests performed on site.

All quality control and tests shall be carried out in accordance with applicable latest editions of applicable ASTM, ACI, AASHTO, BS or ISO standards as specified in respective sections.

1.7. PROTECTION OF THE WORKS

The Contractor shall whenever necessary cover up and protect the works from weather and damage by his own or other workmen performing subsequent operation at no extra cost to the Employer including all necessary dust sheets, barriers and guard rails and clear away the same on completion.

1.8. RESTORATION AND CLEANING

Upon completion of the works the Contractor shall restore all items covered by the Contract to the satisfaction of the Engineer.

The Contractor shall do regular cleaning and clean away all rubbish and excess materials that may accumulate from time to time on completion and before handing over. Upon completion of the Works, he shall obliterate all signs of temporary construction facilities such as work areas, structures, foundations of temporary structures, stock piles of excess or waste materials, as directed by the Engineer. Trash shall be removed daily to the satisfaction of the Engineer.

1.9. COORDINATION WITH OTHER WORKS

The Contractor shall coordinate with other Contractors executing other works in the project area or in the vicinity. The Contractor shall plan and schedule these activities in close liaison with other Contractors. The cost of this coordination will be deemed to be included in other items of work as such no separate payment is admissible for the coordination.

1.10 DEFINITIONS

Capitalized terms used in these specifications shall have the meanings specified in Volume-I, Condition of Contract, unless the context expressly or by necessary implication otherwise requires.

1.11. ABBREVIATIONS

Whenever, in these specifications, the following abbreviations are used, the intent and meaning shall be interpreted as follows:

°C	Degree Centigrade
°F	Degree Fahrenheit
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
ACI	American Concrete Institute
ASIC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
BS	British Standards
BSI	British Standard Institute
CBR	California Bearing Ratio
cm	Centimetre
DIN	Deutsches Institut für Normung
EN	European Norm
HDPE	High Density Polyethylene Pipe
HP	Horse Power
ISO	International Standards Organization
JMF	Job Mix Formula
kg	Kilogram
km	Kilometre
lb	Pound
m	Metre
mm	Millimetre
PN	Pressure Nominal
WBM	Water Bound Macadam

SECTION-2 -"EARTH WORK FOR WATER LINES

2.1. SCOPE OF WORK

2.1.1 .EARTH WORK FOR WATER LINES

The work covered by this section of the specifications consists of furnishing all plant, labour, equipment, appliances, and materials and performing all operations in connection with excavation, trenching and back filling (with compaction) for water lines and appurtenances in strict accordance with this section of the specifications and the applicable Drawings, and subject to the terms and conditions of the Contract.

2.2. CLEARING AND GRUBBING

The sites of all excavations shall be cleared of all shrubs, plants, bushes, large roots, rubbish and other surface materials. All such materials shall be removed and disposed of in a manner satisfactory to the Engineer. All trees and shrubbery that are designated by the Engineer to remain shall be adequately protected and preserved in an approved manner.

2.3. EXCAVATION

2.3.1. General

All excavation of whatever substance encountered shall be performed to the depths indicated or as otherwise specified. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving. All excavated material unsuitable or not require such a manner that street passage is not blocked by excavated material. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulated therein shall be removed by pumping or by other approved methods. Unless otherwise indicated or approved by the Engineer, excavation shall be open cut.

2.3.2 Trench Excavation

Unless otherwise directed or permitted by the Engineer not more than 500 feet of any trench in advance of the end of the pipeline already laid shall be opened at any time, unless otherwise directed permitted by the Engineer not more than 1000 feet of any one trench shall be worked on at a time. The banks of the pipe trench shall be as nearly vertical as practicable. Bell holes and depressions for joints shall be dug after the trench bottom has been prepared. The pipe, except for joints, shall rest on the prepared bottom for its length. Bell holes and depressions shall be only of such length, depth, and width as required for properly making the particular type of joints. Stones shall be removed to avoid point bearing. Whenever wet or otherwise unstable

material that is incapable of properly supporting the pipe as determined by the Engineer is encountered in the bottom of the trench, such material shall be removed to the depth required and the trench backfilled to the proper grade with coarse sand, or other suitable approved granular material. Such replacement of unsuitable material will be paid for at the contract unit price for that item of work. Trenches shall be of a depth to provide a maximum cover, over the top of the pipe, of 30 in. from the existing ground surface or finished grade whichever is closer except that trenches for pipe laid in lanes and alleys of narrow travelled way (average width of 8 feet or less between structures) shall be of a depth to provide a minimum cover, over the top of the pipe, of 18 in from the existing ground surface or finished grade whichever is closer.

2.3.3 Excavation for Appurtenances

Excavation for appurtenances shall be sufficient to leave at least 12-inch but not more than 24 in., between the outer surface and the embankment or timber that may be used to hold and protect the banks. Any over depth excavation below such appurtenances that has not been directed by the Engineer, will be considered unauthorized and shall be refilled with compacted sand, gravel or concrete, as directed by the Engineer and at no additional cost to the Employer.

2.3.4 Maintenance of Excavation

All excavation shall be properly maintained while they are open and exposed. Sufficient suitable barricades, warning lights, flood lights, signs, and similar items shall be provided by the Contractor. The Contractor shall be responsible for any damage due to his negligence.

2.3.5 Removal of Water

The Contractor shall build all drains and do ditching, pumping, well pointing, bailing, and all other work necessary to keep the excavation clear of ground water, sewage and storm water during the progress of the work and until the finished work is safe from injury. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer and necessary precautions against flooding shall be taken.

2.3.6 Sheet piling and Bracing

If ordinary open cut excavation is not possible or advisable, sheet piling and bracing shall be furnished to the work and to provide working conditions which are safe. The Contractor shall furnish and place all sheet piling, shoring, wall braces, timbers and similar items, necessary for the safety of the work, the general public and adjacent property. Sheet piling shoring and bracing shall be removed as the work progresses and in such a manner as to prevent damage to finished work and adjacent structures and property. As soon as withdrawn, all voids left by the sheet piling and bracing shall be carefully filled

with sand and compacted. The Contractor shall be fully responsible for the safety of work in progress, for the finished work, the workmen, and the public and adjacent property.

2.3.7 Protection of Facilities

Existing subsurface facilities likely to be encountered during the execution of work require special precaution for the protection, such as sewers, drain pipes, water main, conduits and electric cables and the foundations of adjacent structures. The Contractor shall be responsible for the damage of any such facility and shall repair the same at his expense whether or not this facility has been shown on the Drawings.

2.3.8 Surplus Materials

All surplus materials shall be disposed of at locations approved by the Engineer. The disposal of surplus material shall not interfere with other works and shall not damage or spoil other material. When it is necessary to haul earth or rock material over street or pavement, the Contractor shall prevent such material from falling on the street or pavement.

2.3.9 Cutting Pavement

In cutting or breaking street surfacing, the Contractor shall not use equipment which will damage the adjacent pavement. Existing paved surfaces shall be cut back beyond the edges of the trenches to form neat square cuts. The road ballast, brick pavement, and other materials shall be placed on one side and shall be preserved for reinstatement when the trench is filled. Wherever necessary or required for the convenience of the public or individual residents, at street crossings and at private driveways, the Contractor shall provide suitable temporary bridges over unfilled excavations. All such bridges shall be maintained in service until backfilling has been completed. The Contractor shall keep the road crossings manned 24 hours per day. During night time, enough red lights shall be provided to warn traffic. If a detour is necessary, the Contractor shall make a proper detour for the traffic and shall install signs 1 metre by 1.2 metre in size indicating the detour.

2.3.10 BACKFILLING

a. The trenches shall not be completely backfilled until all required pressure tests are performed and until the water lines as installed conform to the requirements of specifications. Where in the opinion of the Engineer, damage is likely to result from withdrawing sheeting, shoring; the same shall be left in place and cut off at a level 12-inch below ground surface. Sheeting left in place at the direction of the Engineer will be paid for at the contract unit price/approved rate for that item of work. Trenches shall be backfilled to the ground surface

with selected excavated material or other material that is suitable for proper compaction. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density. The surface shall be restored to its original or better condition. Pavement and base course disturbed by trenching operations shall be replaced.

b. Lower Portion of Trench: Backfill material shall be deposited in 6-inch maximum thickness layers and compacted with suitable hand tampers to ninety percent of maximum density until there is a cover of not less than 12-inch over the water lines. The backfill material in this portion of trench shall consist of sandy clay or other approved materials free from stones and humps.

c. Remainder of Trench: The remainder of the trench shall be backfilled with material that is free from stones larger than 6-inch in any dimension. Backfill material shall be compacted to ninety percent of maximum density.

2.4. BORROW

Where suitable material for backfill is not available in sufficient quantity from required excavations, suitable material shall be obtained from approved sources at the contractor's responsibility. The necessary clearing and grubbing or borrow areas, disposal and burning of debris there from, the development of sources including any access roads for hauling and the necessary right-of-way, and the satisfactory drainage of the borrow shall be considered as incidental items to borrow excavation.

2.5. GRADING

After the completion of all backfilling operations, the contractor shall grade the work areas to the lines, grades and elevation shown on the Drawings. Finished grading shall not be done until the installation of all water lines has been completed and tested. The top surface after completion shall be "in level" to the adjacent existing surface. Prior to final acceptance, all damage due to settlement shall be repaired by and at the expense of the Contractor.

2.6. TESTING DENSITY OF SOIL IN PLACE

The Engineer will make tests using the calibrated sand cone method/core cutter method to determine the density of soil in place. If soil in place fails to meet the specified degree of compaction the areas represented by the failing tests shall be removed, replaced and compacted to the specified density in the manner directed by the Engineer and at no additional cost to the Employer.

2.7. MEASUREMENT AND PAYMENT

2.7.1 Measurement

The measurement shall be made for the actual quantity of the work done in cubic foot or cubic metre (whichever is included in Bill of Quantities). The maximum width of the trenches along with height allowed for payment for various pipe sizes are included in the Drawings.

2.7.2. Payment

The unit rate included in the Bill of Quantities for excavation of trenches for water supply lines shall be considered as full compensation for the work specified in this section and shall include all excavation, backfilling, compacting, constructing and removing all temporary arrangements, pumping and dewatering, disposal of surplus materials, removal of soft soil from bottom of trenches, removing the surface material and all incidentals to complete this work in all respects.

SECTION-3- HDPE PIPES & FITTINGS

3.1. SCOPE OF WORK

This work shall consist of providing, laying, testing and disinfection of High- Density Polyethylene (HDPE) pipes conforming to ISO 4427(International standard for polyethylene pipes used in water supply), DIN 8074 (covers dimensions and requirements for PE pipes) /8075(provides testing methods for these pipes) & PS 3580(Pakistan Standard for polyethylene pipes, harmonized with ISO/DIN but adapted for local regulatory requirements.) with PN-8, 10 , 12.5, 16, & 20 (PE 100) and in trenches to correct alignment and grade, as indicated in the drawing and specifications including all other accessories and equipment.

3.2. DEFINITIONS

The following terms shall have the meanings hereby assigned to them except where the Contract clearly renders these meanings inapplicable.

"Pipe" means pipe or pipes, bends, fittings and other specials and includes joints, jointing parts and materials.

"Valves" means gate valves, butterfly valves, air valves and the like and includes jointing materials, operating gear and associated fittings.

"Installation" means removing from storage, loading, hauling, handling, placing, fixing, joining in position and testing whether in trench or elsewhere in the Works.

"Pipeline" means those parts of the works comprising pipe, fittings, valves, valve chambers, other chambers, anchors, thrust blocks and all other appurtenances required for proper functioning, operation and maintenance of the pipeline.

3.2.1. Abbreviated terms

DN/OD	Nominal size, outside-diameter-related
MFR	Melt mass-flow rate
MRS	Minimum required strength
OIT	Oxidation induction time
PE	Polyethylene
PFA	Allowable operating pressure
PN	Nominal pressure
S	Pipe series
SDR	Standard dimension ratio

3.3. APPLICABLE STANDARDS AND CODES

The following codes and standards, to the extent specified herein, form a part of this specification. The latest edition of these codes and standards shall govern the work.

ISO 4427	Polyethylene (PE) pipes for water supply specifications
ISO161-1	Thermoplastic pipes for conveyance of fluids - nominal outside diameter and nominal pressure- part 1: Metric series
ISO 1167-1 to 4	Thermoplastic pipes, fittings and assemblies for the conveyance of fluids
ISO 3126	Plastic pipe - Measurement of dimensions
ISO 4065	Thermoplastic pipes - Universal wall thickness table
ISO 6964	Polyolefin pipes and fittings - Determination of carbon black content by calcination and pyrolysis - Test method and basic specification.
ISO 9080	Thermoplastic pipes for the transport of fluids - Method of extrapolation of hydrostatic stress rupture data to determine the long-term hydrostatic strength of thermoplastic pipe materials.
ISO 11922-1	Thermoplastic pipes for the conveyance of fluids - Dimensions and tolerances Part: 1: Metric series.
ISO12162	Thermoplastic materials for pipes and fittings for pressure applications - Classification and designation - overall service (design) coefficient.
ISO 13761	Plastic pipes and fittings - pressure reduction factors for polyethylene pipeline systems for use at temperatures above 200 C.
ISO 7005- 3	Metallic flanges - Part 3, Copper alloy and composite flanges
BS EN 12201	Plastic piping systems for water supply · polyethylene
ISO 974	Determination of the brittleness temperature by impact
ISO 2505	Thermoplastics pipes · Longitudinal reversion
ISO 6259	Determination of tensile properties
ISO 1133	Determination of the melt mass-flow rate (MFR) and the melt volume-flow
ISO 877	Methods of exposure to direct weathering

3.4. TECHNICAL REQUIREMENTS

3.4.1 Material

All pipes and fittings shall be manufactured from High-Density Polyethylene (HDPE) compound conforming to ISO 4427 (latest edition) applicable to polyethylene pressure piping systems for water supply.

The compound shall be clearly identified by the manufacturer, including the material designation (e.g., PE 100, PE 80) and the Minimum Required Strength (MRS).

The Contractor shall submit manufacturer's certificates, Test Reports and technical data sheets confirming that the material complies with the required pressure rating, design temperature, and long term hydrostatic strength .

The pipes and fittings shall be produced from clean, reprocessable material generated from the manufacturers own production of products to ISO 4427 may be used. Reprocessable material from external sources and all recyclable materials are strictly prohibited.

The polyethylene compound shall contain only those additives (e.g., antioxidants, UV stabilizers, pigments) necessary for manufacture and end-use. All additives must be uniformly dispersed.

The material shall be suitable for outdoor storage and installation, with adequate resistance to ultraviolet degradation and aging for a minimum of two (2) years from the date of manufacture, when stored in accordance with manufacturer's recommendations.

All pipes and fittings shall be compatible and suitable for jointing by butt fusion and/or electrofusion methods in accordance with the manufacturer's installation guidelines and relevant international standards. The Contractor shall ensure that fittings supplied are of the same pressure class and material grade as the corresponding pipes to maintain uniform system performance and design life. The manufacturer shall demonstrate that the compound is fusible by testing the tensile strength of a butt-fusion joint in accordance with ISO 13953.

Materials in contact with drinking water shall not constitute a toxic hazard, support microbial growth, or impart unpleasant taste, odor, or discoloration. The material must comply with WHO Guidelines or EC Council Directive 98/83/EC, whichever is more stringent

Any proposed change in compound type, grade, manufacturing process, or manufacturing location shall require prior written approval of the Engineer.

The Contractor shall submit manufacturer certifications, compliance test reports, and installation guidelines to facilitate timely approval, procurement, and proper installation of the pipe system.

Technical Reference Table 3.1

Property	Requirement (ISO 4427-1)
Material Designation	PE 100 (Standard for high pressure)
MRS / Design Stress	10.0 MPa / 8.0 MPa
Density	≥930 kg/m ³
OIT (Thermal Stability)	≥20 minutes at 200 °C
Carbon Black Content	2.0% to 2.5%
MFR (190 °C/5 kg)	0.2 to 1.4 g/10 min

3.4.2 Physical Properties

Pipes and fittings shall be manufactured from High-Density Polyethylene (HDPE) conforming to ISO 4427 (latest edition) and classified as PE100.

The polyethylene compound used for manufacturing shall comply with the material requirements specified in Clause 4.4 (Table 1 and Table 2) of ISO 4427-1.

The Compounds shall be classified by their MRS. For PE 100, the MRS is 10.0 MPa, allowing for a design stress (σ_s) of 8.0 MPa based on a standard design coefficient (C) of 1.25.

For continuous operation at temperatures between 20 °C and 40 °C, the pressure reduction coefficients in ISO 4427-1, Annex A must be applied (e.g., 0.87 at 30 °C; 0.74 at 40 °C). and, The pipes and fittings shall be designed for a minimum service life of fifty (50) years at 20 °C under normal operating conditions as defined in ISO 4427.

3.4.3 Pipe Dimensions

The Pipe dimensions for Water supply shall conform to the "S" (Pipe Series) and "SDR" (Standard Dimension Ratio) designations defined in ISO 4427-2 .

All dimensional measurements for pipes and fittings shall be carried out in accordance with ISO 3126.

For pipes with a nominal diameter less than 160 mm, coils shall not exceed 100 m in length. In accordance with **ISO 4427**, the coil diameter shall be at least 18 times the nominal outside diameter (DN/OD) to prevent localized deformation.

3.4.4 Pipe Appearance

When viewed without magnification, internal and external surfaces shall be smooth, clean, and free from scoring, cavities, and other surface defects

All polyethylene pipes to be used for the transmission and distribution of potable water shall be black and have blue stripes.

For black compounds, the carbon black content shall be 2.0% to 2.5% by mass (measured per ISO 6964).

The dispersion of carbon black when determined in accordance with ISO 11420 shall be equal to or less than grade 3 (Grade 1= Best , Grade 5=Worst).

3.4.5 Fittings

Fittings shall be produced from the same compound as the pipe or a compatible compound as defined in ISO 4427-3

The wall thickness of the fitting body (E) at any point shall be equal to or greater than the minimum wall thickness (e_{min}) of the corresponding pipe.

3.4.6 Fittings Appearance

When viewed without magnification the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects. The fitting shall be blue or black.

3.4.7 Pipe Installation

a. Trench excavation shall be carried out in accordance with Section Excavation of the specifications.

b. Install pipe, fittings, and accessories in accordance with manufacturer's instructions:

- Provide qualification details of the manufacturer's technical expert to be assigned to the Contract. The technical expert shall have expertise, experience and skills necessary for advising and monitoring all aspects of transport, storage, handling, installation and testing of pipes as appropriate.

- The technical expert shall provide comprehensive technical assistance to the Contractor throughout the Contract and regularly monitor the Contractor's activities and report on shortcomings.

c. The pipeline shall be installed within 25 mm (1 inch) of the specified horizontal alignment. The invert level shall be within 6 mm of the specified design value. For gravity pipelines, the installation must ensure there is no back-fall at any point.

d. Bedding, pipe surround, and backfill materials shall be selected and installed in accordance with the manufacturer's requirements and the structural design of the pipeline to prevent localized stress or deformation.

e. Install appurtenant facilities on the pipeline such as manholes, valve chambers as specified of the specification and location in the drawings or as per the Engineer Instruction.

f. Unless otherwise directed by the Engineer, pipes shall be laid from the

downstream end toward the upstream end. Appurtenant facilities, such as manholes and valve chambers, shall be installed at the locations specified in the Contract Drawings.

g. While HDPE allows for gradual changes in direction, the pipe shall not be bent to a radius less than 25 times the outside diameter (25 X dn) at an ambient temperature of 20 °C. If the installation temperature is lower, the minimum bending radius must be increased according to the manufacturer's derating charts to prevent stress cracking.

h. When cutting is required, it must be performed using a dedicated pipe-cutting machine or tool to ensure a smooth, clean cut at a 90 degree right angle to the pipe axis. All cut ends intended for butt fusion must be chamfered or prepared as per the jointing specification.

i. All pipes and fittings shall be inspected and confirmed to be sound and free of internal debris before laying. To prevent contamination or the entry of animals/water, pipe ends must be fitted with watertight plugs or caps at all times when work is not in progress. Caps shall only be removed immediately before making a connection or performing a pressure test and must be replaced promptly upon completion.

3.4.10 Backfilling

The selected fill material, as specified in the Drawings/BOQs, shall be placed and hand compacted in layers not exceeding 150 mm to complete the pipeline surround.

In cases where sand is used for the pipe surround, it must be placed at an optimum moisture content and mechanically compacted (e.g., using vibrating plate compactors for the layers above the initial 300 mm protective zone) to ensure a stable, high modulus soil envelope.

To prevent lateral displacement or "floating" of the flexible HDPE pipe, compaction shall be carried out equally and simultaneously on both sides of the pipeline.

Any temporary supports (e.g., trench sheeting or stays) shall be gradually withdrawn as bedding and backfill materials are placed to ensure no voids remain between the material and the trench wall.

The remaining portion of the trench shall be compacted in layers with excavated suitable material not exceeding 200 mm using approved mechanical rammers, ensuring that no direct impact or heavy vibration is transmitted to the pipe.

Where geotextile filter fabric is used to enclose granular surrounds, it shall be placed on the prepared formation and lapped by a distance equal to the trench width once the surround is complete. The Contractor must ensure the membrane remains unpunctured during backfilling to prevent the migration of fines.

For pipes specified with concrete bedding, no backfill (beyond the first 150 mm of cover) shall be placed until the concrete has achieved a compressive strength of at least 15 MPa as specified in SECTION "PLAIN & REINFORCED CONCRETE". This ensures the rigid support is fully set before the pipe is subjected to the weight of the full trench backfill.

3.4.11 Cutting Pipes

The Contractor shall be responsible for all field measurements required to determine accurate closing lengths. The piping system must allow for field adjustments to suit actual site conditions and variations in stationing. Cutting of HDPE pressure pipes shall be performed exclusively using an approved mechanical pipe-cutting machine or tool specifically designed for plastic piping.

All cuts must be neat, clean, and made at a 90-degree right angle to the axis of the pipe. This is critical to ensure uniform contact during the fusion process required by ISO 4427.

and, Cut ends of pipes shall be deburred and chamfered as required by the jointing method. For butt-fusion, the ends must be faced using the fusion machine's planing tool to ensure the surfaces are smooth and free of visible ridges or valleys.

The Contractor shall ensure that both measurements and cuts are performed to the required tolerances. Any errors or damage to the pipe during the cutting process shall be remedied by the Contractor at their own expense, as directed by the Engineer.

3.4.12 METHOD OF JOINTING

3.4.12.1 Butt Fusion Jointing

Butt fusion shall only be performed between pipes of the same material designation (e.g., PE 100 to PE 100) and compatible Melt Mass-Flow Rates (MFR) as defined in ISO 4427-1. Components must have the same nominal wall thickness and outside diameter.

The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- The fusion machine must be operated within a shelter. Pipe ends must be plugged
 - to prevent "chimney effect" drafts that can cause uneven cooling of the melt.
- Components shall be secured in a purpose-built clamping jig. Protruding pipe lengths must be supported by roller cradles to ensure perfect axial alignment and reduce drag.
- Pipe ends shall be faced with a mechanical planer until a continuous shaving strip is produced, ensuring surfaces are smooth and free of oxidized material. The maximum radial mismatch (offset) between ends shall not exceed 10% of the wall thickness.
- A calibrated pyrometer must be used to verify the heater plate's surface temperature. Temperature-indicating crayons may be used for the plate's edge but must never touch the fusion zone.

- After heating at the prescribed interfacial pressure and time, the heater tool shall be removed quickly (within the "dwell time") and the ends joined. A uniform double bead must form, indicating a proper weld geometry.

3.4.12.2 Saddle /Sidewall Fusion Jointing

Saddle fusion shall be executed using a mechanical saddle fusion machine to ensure consistent alignment and pressure control.

The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- The pipe main and the saddle fitting must be cleaned. The fusion area on the pipe must be mechanically scraped to remove the oxidized layer and expose fresh material. Residue must be removed using an approved dry wipe or brush.
- Surface temperatures must be verified periodically. Following the heating cycle, the fitting shall be joined to the pipe with the prescribed fusion force.
- The joint must remain undisturbed in the machine until the cooling period is complete. No external stresses or pressure testing shall be applied until the joint reaches ambient temperature.

3.4.12.3 Electrofusion Jointing

Electro fusion jointing involves heating the electro fusion joint internally, either by a wire coil at the interface of the joint or by a conductive polymer. Heat is created by an electric current passed to the conductive material in the fitting.

- Fittings must be dimensionally checked for compatibility. The pipe ends must be cut square and the insertion depth marked clearly on the pipe surface.
- The entire fusion area of the pipe must be mechanically scraped to remove surface degradation. Hand sanding is prohibited as it does not effectively remove the oxidized layer.
- A specialized alignment clamp must be used to prevent any movement or "misalignment" during the fusion and cooling stages.
- An automatic electrofusion control box must be used to apply the specific voltage and time parameters required by the fitting manufacturer.
- The joint must remain clamped for the full duration specified on the fitting's barcode or data sheet. Premature removal can lead to joint failure under internal pressure.
- Allow the joint to cool for the recommended time and remove the clamping fixtures. Do not remove prematurely from the clamps as any strain on a joint that has not fully cooled can be detrimental to joint performance.

3.4.13 Mechanical Joints and Fittings

Many types of mechanical connection styles and methods exist. The Contractor shall submit suitable mechanical joints. All such joints shall be recommended and acceptance tested by the manufacturer of the pipe.

All mechanical fittings must be tested for "fitness for purpose" according to ISO 4427-5.

Fittings must be of the "restrained" or end-load resistant type to counteract the thermal expansion and contraction characteristic of PE materials.

When tightening polyethylene flanges care shall be taken to produce an equal torque load to the limits given by the manufacturer. A calibrated torque wrench shall be used for flange bolting in a star pattern. Due to the viscoelastic creep of polyethylene, all bolts must be re-tightened after 24 hours and again prior to final commissioning to maintain a watertight seal.

All joint elastomers and gaskets shall be suitable for use in the prevailing climate, soil, ground water, and compliant with ISO 4427-1 Clause 5 for potable water contact.

3.5. TOOLS

The Contractor shall provide a complete set of professional tools required for the installation of HDPE systems, including but not limited to:

- Mechanical pipe cutters (ensuring 90-degree square cuts).
- Rotary scrapers (for uniform removal of the oxidized layer).
- Calibrated pyrometers and Digital Manometers.
- Hydraulic butt fusion machines with data-logging capabilities.
- De-beading tools (to inspect the internal and external quality of butt fusion joints).

3.6. CONTROL OF WATER (Dewatering and Site Management)

The Contractor shall be responsible for the control of all surface and groundwater during the installation of the HDPE pipeline. The trench must be kept dry and stable throughout the laying and jointing process to prevent contamination of fusion surfaces and to ensure proper bedding compaction.

The Contractor shall provide and maintain all necessary pumps, sumps, and drainage channels to keep the trench floor free from water. No pipe laying or jointing (butt fusion or electrofusion) shall be permitted in standing water or during heavy rain unless a specialized, dry environmental shelter is provided.

3.7. INSPECTION AND TESTING

3.7.1 Certification and Quality Audit

The Contractor shall supply the Engineer with copies of certificate and test documents. Such documentation shall be subject to the Engineers' approval prior to shipping.

3.7.2 Test Results and Frequencies

The Manufacturer shall establish, maintain, and provide a comprehensive record of test results in accordance with ISO 4427-1 (General), ISO 4427-2 (Pipes), and ISO 4427-3 (Fittings) or as required by the Engineer.

For the Compound Verification the Manufacturer shall perform all "Batch Release Tests" (BRT) and "Process Verification Tests" (PVT) as defined in the standard to verify the material's physical characteristics, including density, Melt Mass-Flow Rate (MFR), and Oxidation Induction Time (OIT).

For Dimensional Conformance Continuous ultrasonic scanning or equivalent calibrated measuring devices shall be used to ensure that mean outside diameters, wall thicknesses, and ovality meet the tolerances specified in ISO 3126.

All test documentation, including raw material certificates (CoAs) and production batch records, shall be documented with the frequencies specified in the Quality Plan. To ensure long-term accountability for the 50-year design life of the system, all quality records shall be retained for a minimum of 2 years.

Testing Frequencies as per ISO 4427-2 (Pipes) and ISO 4427-3 (Fittings). Table 3.1			
No.	Parameter	Test Method	Frequency
1	Dimensions (OD, Wall Thickness)	ISO 3126	Every Batch / 1m interval
2	Ovality (Out-of-Roundness)	ISO 3126	Every Batch
3	Melt Mass Flow Rate (MFR)	ISO 1133	Per Batch
4	Density	ISO 1183	Per Batch
5	Oxidation Induction Time (OIT)	ISO 11357-6	Per Batch (≥20 min)
6	Hydrostatic Strength (80°C)	ISO 1167	Per Type Test
7	Carbon Black Content/Dispersion	ISO 6964 / 18553	Per Batch (2.0–2.5%)

3.7.3 Acceptance Criteria

The acceptance of any supply order shall be contingent upon meeting the following technical and documentation criteria

- a. The Contractor must provide a "Certificate of Analysis" (CoA) from the raw material

manufacturer for every batch of PE 100 resin used. This documentation must confirm that the compound meets the physical characteristics defined in ISO 4427-1 Table 1, including density ($\geq 930 \text{ kg / M}^3$), Melt Mass-Flow Rate (0.2 to 1.4 g/10 min), and Oxidation Induction Time ($\geq 20 \text{ min}$)

- b.** Pipe wall thickness and eccentricity shall be monitored during the extrusion process using continuous ultrasonic scanning or other non-destructive qualified electronic devices. These devices must be calibrated at least once every six months by an ISO/IEC 17025 certified laboratory to ensure compliance with ISO 3126.
- c.** Notwithstanding factory certifications, the Engineer shall collect random samples from the pipes delivered to the site or storage yard for independent verification. These samples shall be tested by a reputable national laboratory (such as PCSIR or PCRWR) for the parameters summarized in Table 3.1, including Hydrostatic Strength at 80 °C and Carbon Black Dispersion
- d.** 100% of the pipes shall be visually inspected for internal and external surface defects. Any pipe showing gouges, scratches, or inclusions deeper than 10% of the nominal wall thickness (en) shall be rejected. Dimensions must be verified to be within the tolerances specified in ISO 4427-2.
- e.** Every pipe length or coil must be indelibly marked as per ISO 4427-2, showing the manufacturer's name, material designation (PE 100), SDR, PN rating, and production date to ensure full traceability to the test records and summarised in Table 3.1

3.7.4 Quality Assurance/Quality Control

The Manufacturer shall submit a detailed, project-specific QA/QC plan to the Engineer for review and concurrence. This plan must explicitly outline the testing frequencies for Batch Release Tests (BRT) and Process Verification Tests (PVT) as required by ISO 4427-1 and ISO 4427-2.

The Manufacturer's facility shall be certified to ISO 9001 (Quality Management Systems). However, the existence of ISO 9001 certification shall not be used as a sole basis for waiving the Engineer's right to conduct independent quality audits or to witness Factory Acceptance Testing (FAT).

The QA/QC plan shall include a procedure for the identification, segregation, and reporting of non-conforming products to ensure they are not accidentally dispatched to the project site.

3.8. PIPELINE TESTING

3.8.1 General Requirements

The Contractor shall submit a detailed "Pipeline Testing Method Statement" for the Engineer's approval. This must include a testing schedule, equipment list (pumps, calibrated gauges), and the source of potable water for testing.

All hydrostatic tests must be witnessed and signed off by the Engineer or their authorized representative.

To ensure trench stability in local soil conditions, no section of the pipeline shall remain untested with joints exposed for more than 7 days after laying. Failure to adhere to this timeline shall not be grounds for a time extension or additional costs.

Pipelines must be fully completed and properly supported. All concrete thrust blocks at bends and tees must have reached their 7-day design strength before any pressure is applied to the line.

The Contractor shall ensure all "open ends" are secured with temporary plugs, caps, or blank flanges that are sufficiently restrained to withstand the maximum test pressure. Thrusts at bends and branch outlets must be transmitted to solid ground.

Only clean, potable water shall be used for testing and cleaning to prevent biological contamination of the PE 100 system.

The Contractor shall provide the Engineer with a minimum of 24 hours' written notice before commencing any formal pressure test. Successful completion of interim tests on individual sections does not relieve the Contractor of the requirement to perform a final acceptance test on the entire completed system.

Satisfactory test results do not absolve the Contractor of their responsibility for any defects or leaks that may appear during the warranty (Defects Liability) period.

3.8.2 Interim Pipeline Testing

The interim test shall be conducted on individual sections after laying and jointing. To ensure pipe stability and prevent "snaking" during the test, the trench must be backfilled to at least 300 mm (12 inches) above the pipe crown. However, all fusion joints and mechanical connections must remain fully exposed for visual inspection

The pipeline shall be divided into manageable test sections, typically not exceeding 500 meters (1,500 feet), and The section shall be filled slowly from the lowest point to prevent water hammer. High point air release valves or temporary manual cocks must be open during filling to ensure 100% air removal, as trapped air will invalidate the test results.

The HDPE expands under pressure, a "Conditioning Phase" is mandatory:

- Raise the pressure to the Nominal Pressure (PN) of the pipe (e.g., 10 Bar for PN10).
- Maintain this pressure for a minimum of 12 hours. During this time, the Contractor may need to pump small amounts of water to compensate for the diametric expansion of the pipe.
- The test period only begins once the pipe has stabilized and expansion has ceased.

In the Main Pressure Test (The 1.5x Rule) :

- After conditioning, the pressure shall be raised steadily to the Test Pressure ($1.5 \times \text{PN}$) (e.g., 15 Bar for PN10 pipe).
- The pump shall be disconnected, and the pressure monitored for 3 hours.

Acceptance Criteria:

- No visible leaks, sweating, or weeping at any joint or fitting.
- The pressure drop should not exceed 0.2 to 0.5 Bar over the test duration (this accounts for minor temperature fluctuations and residual expansion).
- In the context of water loss, If a "make-up" water test is used, the volume added must not exceed the calculated limit for PE pipes (standard leakage formulas for iron pipes must not be used).

If the test fails, the Contractor must locate and repair the leak (usually by cutting out the defective fusion joint and re-welding) at their own expense. The entire testing cycle, including the 12-hour conditioning, must be repeated.

All test data, including start/end times, temperatures, and gauge readings, must be recorded in a "Pressure Test Certificate" signed by the Engineer.

PipeLine Technical Summary for PE 100 Pressure Testing		
Requirement	Value / Standard	Reason
Reference Temp	20°C	Base temperature for MRS classification.+1
Test Pressure	$1.5 \times \text{PN}$	Standard safety factor for hydrostatic field tests.
Conditioning	Up to 12 Hours	Allows for the natural diametric expansion of PE material.
Material Class	PE 100	Specified for high-pressure water supply in Pakistan.

3.8.3 Final Acceptance Testing

The final acceptance test shall be conducted on the complete pipeline system after all individual sections have been successfully joined, all valves and fittings installed, and the entire trench backfilled and compacted to final grade (excluding any areas required for visual inspection during the test). This test is mandatory to verify the integrity of the total network and the performance of "tie-in" joints.

Moreover, The final acceptance procedure shall follow the same strict protocol as the interim testing, including the mandatory **12-hour stabilization/conditioning phase** at the rated pressure (PN) to account for the cumulative viscoelastic expansion of the PE 100 material across the entire line.

Acceptance Criteria The pipeline system shall be deemed to have passed the final acceptance test if:

- There is no visible leakage at any exposed connection, valve, or manhole.
- The total pressure drop remains within the allowable limits (typically ≤ 0.2 Bar) after accounting for temperature fluctuations.
- Any water loss measured through the make-up pump does not exceed the calculated allowable limit for the total length of the system.

3.8.4 Valves and Appurtenances

All valves, air release valves (ARVs), and pipeline appurtenances shall be hydraulically tested in-situ along with the pipeline section. The test pressure shall be 1.5 times the rated pressure (PN) of the system. During the test, valves shall be in the fully "Open" position to ensure the entire internal surface is subjected to the test pressure.

Following the hydrostatic test, each valve shall be tested for functional operation under full working pressure. The Contractor shall demonstrate that all valves operate smoothly, achieve a drip-tight seat, and are adjusted to the manufacturer's specific torque tolerances.

Before commencing any pressure test, the Contractor shall perform a final internal inspection to ensure all pipes and valve seats are free of debris, silt, or construction waste. The presence of foreign matter can damage valve seals and invalidate the "potable water" status of the line.

All "open ends" of the test section shall be secured using blank flanges or mechanical end-caps. Given the high axial thrust generated in PE 100 systems, these ends must be additionally secured by temporary struts, wedges, or proprietary restrained joints.

No pressure shall be applied until all permanent anchor blocks, thrust blocks, and pipe straps have reached their design strength (typically 7 days for concrete). All mechanical couplings must be re-torqued as per the manufacturer's instructions to account for the potential "creep" of the HDPE material.

For flanged connections to valves, the Contractor must ensure perfect axial alignment. Excessive "pulling" of the HDPE pipe to meet a valve flange can introduce localized bending stresses that lead to long-term fatigue failure.

3.9. PIPELINE DISINFECTION

3.9.1 General

All potable water pipelines, including fittings and valves, shall be thoroughly cleaned and disinfected following successful hydrostatic testing and prior to final commissioning. The process ensures that the PE 100 system, which is naturally resistant to biological growth, is free from any external contaminants introduced during construction.

3.9.2 Disinfection of Pipelines

3.9.2.1 Responsibility: The Contractor shall provide all labor, potable water, chemicals (Sodium Hypochlorite), and specialized dosing equipment.

3.9.2.2 Preliminary Flushing: Before chlorination, the main shall be flushed with potable water at a minimum velocity of 0.9 m/s until the discharge is clear and free of debris.

3.9.2.3 Chlorine Dosing: A stock solution of Sodium Hypochlorite (minimum 15% available chlorine) shall be injected at a constant rate into the pipeline as it is filled. The target concentration shall be 50 mg/l to 70 mg/l of free chlorine.

3.9.2.4 Retention Period: The chlorinated water shall remain in the pipeline for a minimum of **24 hours**.

3.9.2.5 Testing and Verification: After 24 hours, the free chlorine residual shall be measured. If the residual is less than **2 mg/l**, the disinfection process must be repeated.

- Once the 24-hour residual is confirmed, the line shall be flushed with potable water until the residual chlorine matches the level of the source water (typically < 0.5 mg/l).
- Following final flushing, the Contractor shall collect water samples in sterilized bottles in the presence of the Engineer. These samples must be submitted to an approved independent laboratory (e.g., PCRWR or PCSIR).
- The system is only considered disinfected if the laboratory report confirms the absence of Coliform organisms and E. coli.

3.9.3 Cleaning of Pipe work

Mechanical Cleaning: If the Engineer determines that flushing alone has not removed internal dirt/silt, the Contractor shall use "swabbing" or "pigging" with approved foam swabs to clean the interior of the HDPE pipes.

Foreign Material Prevention: The Contractor must keep pipe ends capped during all work breaks to prevent the entry of animals, soil, or runoff, which significantly reduces the time and water required for disinfection.

3.9.4 Disposal of Water Used for Testing, Disinfection and Cleaning

Highly chlorinated water used for disinfection must be neutralized (dechlorinated) before disposal if it is being discharged into sensitive environments or open water bodies. The Contractor shall ensure disposal does not damage local agriculture, structures, or property and must obtain approval from local environmental authorities for the discharge location.

3.10 PACKING, MARKING AND VENDOR DOCUMENTATION

3.10.1 Pipe Identification and Packing

The marking information and sequence shall comply with ISO 4427. All pipes and fittings, including test samples shall be clearly and permanently marked using indent printing in a colour that contrasts with the pipe.

All pipes shall be indelibly marked at maximum intervals of 1m indicating at least the following information:

- The manufacturer's name and/or trademark;
- The dimensions (nominal outside diameter x nominal wall thickness);
- Material and designation;
- The nominal pressure (PN) in bar;
- The pipe series (S or SDR) (optional);
- The production period (date or code); and
- The number of this International Standard.

The word "water" shall also be included if the pipe is intended for potable water. The maximum quantity of pipe to have the same coil/length number is one silo (coiled pipe) or one bundle (straight lengths). The maximum combined length of pipe in the silo or bundle with the same coil/length number shall not exceed the maximum allowable coil length as specified,

When pipe material is boxed, the coil number shall be clearly marked on the outside edge of the box or silo. Invoices and packing lists shall include the date of manufacture and coil/length numbers for all material in the shipment.

The fittings shall be packaged in bulk or individually protected where necessary in order to prevent deterioration and contamination. The package shall have at least one label with manufacturer name, type and dimension of the fittings and number of units.

3.10.2 Packaging and Transportation

The Contractor/Manufacturer shall provide packing and transportation procedures for approval by the Engineer and shall comply with the following requirements.

a. Delivery and Shelf Life

To ensure the pipe retains its full design life, all pipes and fittings delivered to the site shall be no older than six (6) months from the stamped date of manufacture.

The Manufacturer shall provide a certificate confirming the pipe compound contains a minimum of 2.0% to 2.5% Carbon Black, ensuring UV protection as per ISO 4427-1. While pipes are theoretically stable for longer, any pipe stored in the open in Pakistan for more than 12 months must be inspected for surface oxidation (chalking) before use.

b. Securing and Tie downs

HDPE pipes must be secured using 100 mm wide synthetic webbing to prevent surface damage and point loading. A minimum of six straps is required for every 12-meter length, ensuring the pipe remains stable without being over-compressed. All tie-downs must be clean, and pipes must be supported by timber bolsters every 2 meters to maintain straightness during transit.

c. Transport Vehicle Requirements (Trucking)

To ensure compliance with ISO 4427 and prevent structural degradation during transit, all transport vehicles must be equipped with a clean, flat bed entirely free of sharp edges, protruding bolts, or nails that could gouge the pipe wall. The pipe must be continuously supported over its entire length to prevent permanent longitudinal bowing; consequently, no overhang beyond the trailer bed is permitted. Furthermore, given the high ambient temperatures in Pakistan which increase the material's sensitivity to chemical absorption, the Contractor must ensure pipes are shielded from direct contact with diesel exhaust fumes, battery acid, and other volatile hydrocarbons.

3.11. STORAGE OF PIPES AND APPURTENANCES

All pipes and materials shall be stored in accordance with the manufacturer's recommendations and the following:

- All specialized jointing materials (electrofusion fittings), operational gear, valves, and gaskets shall be stored in a climate-controlled, dry, and covered warehouse. While HDPE pipes are UV stabilized with carbon black, in Pakistan's high UV environment, pipes stored for more than six months shall be covered with breathable, opaque tarpaulins to prevent surface oxidation (chalking).
- Pipes shall be stacked on a level, graded surface free of sharp stones or rubble. They must be supported on uniform timber bearers (minimum 100mm wide) spaced at maximum 2-meter intervals. To prevent the bottom course from becoming permanently ovalized (deformed) under weight
- Straight Pipes Shall not be stacked more than 1.5 meters high or three tiers, whichever is less.
- Parallel Alignment of All pipes must be stacked parallel to one another; "cross-stacking" is strictly prohibited as it creates localized point-loading.
- The outermost pipes in every tier must be secured with wooden wedges or sandbags to prevent accidental rolling.
- The storage yard shall be organized with clearly marked access tracks for cranes and transport vehicles to prevent accidental impact with the stacks. Pipes shall only be distributed to the installation site in quantities that can be laid within one work week to minimize exposure to roadside dust and potential mechanical damage
- The term "corrosion" does not apply to HDPE; however, any pipes showing signs of UV degradation (color fading/brittleness), surface gouges exceeding 10% of the wall thickness, or permanent "flat spots" (ovalization) due to improper stacking shall be rejected and immediately removed from the site. No "treatment" of oxidized HDPE is permitted; defective sections must be cut out or the entire length replaced at the Contractor's expense

- Valves, meters, and electrofusion fittings must remain in their original factory packaging (often sealed in UV-protective polyethylene bags) until the moment of installation to ensure fusion surfaces remain free of dust and moisture

3.12. MEASUREMENT AND PAYMENT

3.12.1 Measurement

Measurement for HDPE pipes for water supply shall be made for the actual quantity of the work done in linear metre or linear feet (whichever is included in Bill of Quantities) on the axis of the piping including all fittings, bends, crosses, tees etc. No deduction will be made for the laying lengths of valves, fire hydrants, specials, etc. installed in the lines

3.12.2 Payment

The unit rate quoted in the Bill of Quantities for supplying and laying HDPE pipe for water supply shall be the full compensation for all cost of completing the item of work as per provision of this section and shall include cost of pipe, its carriage to the site, laying, cutting, joining, testing and disinfecting, etc. and all incidentals to complete the item except valves assembly and backing blocks, which shall be paid separately.

SECTION-4-PIPELINE APPURTENANCES

4.1. SCOPE OF WORK

The work under this section includes the supply, handling, trenching, laying, jointing, cleaning, disinfection, hydrostatic testing, and commissioning of pipelines and all associated appurtenances for water supply. The Contractor shall provide all labor, materials, and specialized equipment required, including the transport of materials from storage to the site, excavation, backfilling, compaction, disposal of surplus excavated material, and the removal of excess pipes and fittings.

The Contractor shall bear sole responsibility for the safety, integrity, and soundness of all materials until final handover. It is mandatory for the Contractor to conduct preliminary "interim" tests at their own expense to ensure the soundness of valves and joints before requesting a formal witnessed test by the Engineer.

4.2. GATE VALVE

Gate valves shall be of cast iron body conforming to BS 5150 with bolted bonnet, solid wedge, inside screw, non-rising stem, flange connection and fitted with cast iron hand wheel.

Specific clauses of BS 5150 are amplified as follows:

Sr. No.	Parameter	Details
1	Clause 3: Types of Valves	Solid wedge with non-rising stem
2	Clause 4: Nominal Sizes	All valves shall be of flanged end with sizes as specified on the Drawings
3	Clause 5: Nominal Pressure	PN 16 unless otherwise specified on the Drawings
4	Clause 9: Body Tapping	As specified to BS 21 (1S0 /R7) fitted with bronze or gunmetal plug
5	Clause14: Operation	Gate valves shall be provided with cast iron hand wheels or square heads for tee key operation as required. The direction of operation shall be clockwise to close the valve. Hand wheels shall require a force not greater than 20 kg on the outer rim to operate with a balanced pressure across the valve. Tee keys shall require a force not greater than 12 kg applied at the opposite ends of a standard key from the closed position.

6	Clause 19: Test Certificates	The Contractor shall provide a test certificate confirming that the valves have been tested in accordance with BS 5150 and stating the actual pressure and medium used in the test. In addition, the Contractor shall ensure that the Engineer has access to the manufacturer's works at all reasonable times for the purposes of inspecting the assembled valves and witnessing testing.
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The material of construction of gate valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet	Grey cast iron
3	Wedge	Grey cast iron
4	Gland	Grey cast iron
5	Stem	Stainless steel 304
6	Seat Ring, Wedge Ring	Stainless steel 304
7	Back Seat Bush	Stainless steel 304
8	Nuts & Bolts	Stainless steel 304
9	Painting	Wet blue epoxy paint, corrosion resistant

4.3. CHECK VALVE

Check valves shall comply with the requirements of BSS 5153. The valve shall be of swing type with quick acting single door and pressure rating of PN 16 unless otherwise specified on the Drawings. The valve design shall ensure closure in the shortest possible time following deceleration of the water column, ideally reaching its seat without slamming at the instant forward motion of the column cases.

The material of construction of check valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet (Top Plate)	Grey cast iron
3	Disc	Grey cast iron
4	Seat Rings	Stainless steel 304
5	Hinge Pin	Stainless steel 304
6	Disc Hanger	Grey cast iron
7	Gasket	Flexible graphite
8	Nuts & Bolts	Stainless steel 304
9	Painting	Wet blue epoxy paint, corrosion resistant

Swing Check Closure is affected by gravity (Weight of disc) and reverse flow. The pivot point of the swing check is outside the periphery of the disc and the greater the head, the greater the possibility that the fluid will flow back through the valve before the disc can be

shut off. To completely shut off, the disc of a swing check valve must travel through a 700 to 900 arc to the valve seat. Without resistance to slow the disc's downward thrust and reverse flow, the shut off can result in slamming and damaging water hammer.

4.4. AIR-RELEASE VALVE

Automatic air relief valve shall be designed to meet the following conditions:

- a.** Discharge air during charging of the pipeline.
- b.** Admit air during emptying of the pipeline or when the pipe in pressure falls below atmospheric pressure during a surge event.
- c.** Discharge air accumulated at local peaks along operating conditions the pipeline under normal

Conditions 'a' and 'b' shall be met by the employment of a large orifice capable of handling large volumes of air at a high flow rate and condition 'c' by a small orifice capable of discharging small quantities of air as it accumulates. Valves with air intakes or exhaust facilities shall have approved screening arrangements to prevent the ingress of air borne sand.

The valve shall conform to AWWA C512 pressure rating of PN 16 unless otherwise specified on the Drawings. Valve Body ends shall be flanged with raised faces and drilled to EN 1092-1.

The material of construction of air release valves shall be as under:

Sr. No.	Part	Material
1	Body	Grey cast iron
2	Bonnet (Top Plate)	Grey cast iron
3	Float Ball	Stainless steel 304
4	Gasket	EPDM - Asbestos Free
5	Nuts & Bolts	Stainless steel 304
6	Painting	Wet blue epoxy paint, corrosion resistant

Each valve shall be provided with isolating valves as detailed in the Drawings.

4.5. VALVE CHAMBERS

Chambers for gate valves, air valves, washouts, etc. shall be constructed in accordance with the details shown on the Drawings, or as directed by the Engineer.

Brick masonry, Portland cement concrete, and other materials shall meet the specified requirements of the relevant sections of these specifications.

4.6. VALVE BOX

Valve boxes shall be provided for all valves which are installed below ground level in conformance with the details shown in the Drawings. Valve boxes shall be of the heavy-duty type capable of withstanding a ten-ton load when located within carriageways.

Ordinary valve boxes shall be used in other locations. All valve boxes shall be of the lockable type. They shall be installed on concrete bases as shown in the Drawings.

4.7. THRUST BLOCKS

4.7.1 . General Requirements

The Contractor shall construct thrust blocks at all changes in direction (bends), changes in diameter (reducers), and at dead ends (tees/caps). While HDPE jointing (butt-fusion) is inherently "restrained," thrust blocks are mandatory to protect the surrounding soil and manage the axial forces generated by internal pressure and temperature-induced stress.

4.7.2. Design and Ground Conditions

- **Dimensions:** Blocks shall adhere to the Drawings based on the specified soil bearing capacity.
- **Site Adaptation:** If actual ground conditions differ from the design parameters (e.g., encountering rock or saturated silt), the Contractor must submit revised calculations based on the **Safe Bearing Capacity (SBC)** of the soil to the Engineer for approval 48 hours prior to casting.
- **Bearing Face:** Concrete must be cast directly against **undisturbed ground**. If the trench wall is over-excavated, the gap must be filled with lean concrete or the soil pre-compacted to **95% Modified Proctor Density** before casting the block.

4.7.3 . Concrete Class and Curing

- **Material:** Thrust blocks shall be constructed using **Class C (minimum 20 MPa / 3,000 psi cylinder strength)** concrete.
- **Curing Time:** No internal pressure (hydrostatic testing) shall be applied until the concrete has cured for a minimum of **7 days** and reached at least 70% of its design strength.

4.7.4. Accessibility and Protection

- **Joint Clearance:** Concrete shall be kept clear of all butt-fusion joints, flanges, and mechanical couplings. Joints must remain accessible for inspection during pressure testing.
- **Protective Barrier:** A protective layer of **polyethylene sheeting (minimum 500 microns)** or felt must be placed between the HDPE pipe and the concrete block to prevent the concrete from bonding to the pipe and causing stress concentrations due to thermal movement.

4.7.5 . Steep Gradient Anchorage For pipelines laid on steep inclines, mechanical anchorage is required to prevent "creep" or sliding:

- **Gradient 1:20 to 1:15:** Every third pipe length must be anchored.

- **Gradient 1:15 to 1:10:** Every second pipe length must be anchored.
- **Gradient 1:5 or steeper:** Every individual pipe length must be anchored using a reinforced concrete anchor block.

4.8. APPROVAL OF MATERIALS AND EQUIPMENT

As soon as practicable but within thirty-days after the receipt of notice to proceed and before any material or equipment is purchased, the Contractor shall submit for approval by the Engineer a complete schedule of materials and equipment to be incorporated in the work, together with the names and addresses of the manufacturers and their catalogue, item numbers and trade names. The schedule shall include catalogue cuts, diagrams, drawings, and such other descriptive data and as may be required by the Engineer. Samples of materials shall be provided as required. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under this provision shall not be construed as authorization of any deviations from the specifications unless the attention of the Engineer has been directed to the specific deviations. Laboratory results and certifications, specified or otherwise required, shall be submitted prior to delivery of the material or equipment to the site.

4.9. TESTS AND ACCEPTANCE

All valves and accessories must arrive on-site with batch-specific test reports certifying compliance with ISO 4427 or BS EN 1074; failure to provide these or to facilitate witnessed Factory Acceptance Testing (FAT) constitutes grounds for immediate rejection. Should a batch be rejected, it may only be reconsidered if the Contractor performs a full suite of re-tests under the Engineer's supervision at their own expense.

Furthermore, the Engineer reserves the right to conduct independent verification tests on any consignment, with the Contractor providing all necessary labor and equipment to facilitate these inspections..

4.10. MEASUREMENT AND PAYMENT

4.10.1 Measurement

Measurement for fire hydrants, valves, air release valves, washout valves etc. shall be made in number and shall include the chamber and all other materials to complete the work as per Drawings including connection with pipeline. Backing blocks for bends, tees etc. shall be measured in cubic foot or cubic metre (whichever is included in Bill of Quantities).

4.10.2 Payment

The unit rates quoted in the Bill of Quantities for the supply and installation of fire hydrants, air release valves, sluice/gate valves, washout valves including chambers and other specials and shall be full compensation for supply, installation, testing, commissioning, disinfecting and all incidentals to complete the items of the work as per Drawings. The thrust blocks provided will be measured separately for payment.

SECTION-5- PIPE BEDDING

5.1. SCOPE OF WORK

The Contractor shall furnish, place, and compact a sand envelope around all HDPE pipelines and associated structures. This "Pipe Surround" includes the foundation bedding, haunching (support under the pipe curves), and initial backfill up to 300 mm above the pipe crown. The sand surround is a mandatory structural requirement to protect the pipe from point loading and to ensure long-term hydraulic stability.

5.2. PURITY AND STACKING

Sand bedding shall be from a source and of specifications approved by the Engineer.

The sand stone shall be free from clay, salt, alkali, organic matter, shale, loam, soft flaky particles and other deleterious substances. It shall be stacked at the place designated by the Engineer and kept free from the admixture of deleterious materials mentioned herein. The sand shall not contain clay/silt more than 5%. Laboratory testing prior to its use under bedding will be arranged.

5.3. PLACING OF BEDDING MATERIAL

A uniform layer of sand shall be placed and compacted to a minimum thickness of 100 mm to provide a level surface for the pipe.

After the pipe is laid, sand shall be carefully "tucked" and compacted under the lower quadrants of the pipe (the haunches). This is the most critical area to prevent pipe deflection.

Sand shall be placed simultaneously on both sides of the pipe in layers not exceeding 150 mm, continuing until the sand reaches 300 mm above the pipe crown.

Each layer shall be compacted using approved rammers to a minimum of 95% Modified Dry Density (AASHTO T-180). Manual tamping is required near the pipe to prevent mechanical damage from heavy vibratory equipment.

5.4. MEASUREMENT AND PAYMENT

5.4.1 Measurement

The measurement shall be made by volume for the actual quantity of the work done and the unit of measurement shall be cubic foot or cubic metre (whichever is included in Bill of Quantities).

5.4.2 Payment

Payment for this item of work shall be made for the actual quantity of work done as

specified in this section, at the unit rate quoted in the Bill of Quantities.

SECTION -6-WATER SUPPLY SERVICE CONNECTIONS

6.1. SCOPE OF WORK

The work under this section includes the provision of all materials, specialized tools, and labor required to execute consumer service connections. This involves tapping the main pipeline, installing clamp saddles, laying service pipes, and providing all necessary fittings and end-caps as per the Drawings and Manufacturer's standards. The Contractor is responsible for the integrity of the connection point to the main line

6.2. MATERIAL REQUIREMENTS

Service Pipe: Shall be PE 100 High-Density Polyethylene (HDPE), PN 16 rated, conforming to ISO 4427-2. of diameter as shown on the Drawings.

Whereas, Clamp Saddles shall be manufactured from high-grade Polypropylene (PP-B) or Ductile Iron with a reinforced stainless steel bolt-down system. The saddle must feature a captured EPDM/NBR O-ring or rubber gasket (Potable Water Grade) to ensure a high-pressure seal against the main pipe wall.

Fittings and Specials of all compression fittings or electrofusion tapping tees shall comply with ISO 17885.

Whereas, The terminal end of the service pipe shall be sealed with a specialized HDPE mechanical end-cap or a heat-sealed plug to prevent the ingress of debris or contaminants until the final meter installation

6.3. CONSTRUCTION REQUIREMENTS

Service connection shall be executed as per Drawings or as indicated by the Engineer.

Service connections shall be executed using a "dry-tapping" or "under-pressure tapping" method as directed. The main pipe surface must be thoroughly cleaned and free of scratches before the saddle is mounted.

The service pipe shall be connected to the main line (whether located on the same side or across the road) with sufficient "slack" or an "S-bend" to accommodate potential soil settlement or thermal expansion/contraction without straining the saddle joint.

Trenching for Service Lines cross roads, they must be laid at a minimum depth of 600 mm and protected by a G.I. or PVC sleeve pipe if specified to prevent damage from vehicular loading.

Joining of All connections between the saddle and the service pipe shall be made using high-quality mechanical compression fittings or electrofusion tapping tees to ensure a pull-out resistant joint.

All service connections shall be hydrostatically tested along with the main pipeline. Any leakage at the saddle interface or service fittings shall be rectified by the Contractor. The

connection is only considered complete once the service end is securely plugged and the location is marked for future utility reference.

6.4. MEASUREMENT AND PAYMENT

6.4.1 Measurement

Measurement for service connection shall be the number of service connections installed, tested and commissioned including all fittings, saddle arrangement, etc. but excluding cost of pipe as per specifications and accepted by the Engineer for payment.

Measurement for HDPE pipe of specified diameter is in linear metre or linear feet (whichever is included in Bill of Quantities) on the axis of the pipe.

6.4.2 Payment

Measurement as carried above shall be paid for at the unit rate quoted in the Bill of Quantities and shall be full compensation for furnishing all materials, tools, plants, labour and incidentals to complete the work.

PART "C" -TUBE WELL

SECTION-7- GENERAL

7.1. DESCRIPTION

The work consists of drilling a tube well of the specified capacity using Direct or Reverse Rotary methods. The borehole depth shall be determined by the actual hydrogeological conditions encountered.

7.1.1 Lithological Logging

The Contractor shall maintain a precise, depth-referenced drilling log and preserve representative formation samples (taken at every 3m or change of strata) in a labeled sample box for the Engineer's inspection.

7.1.2. Casing & Screen

Upon completion of the pilot hole and electrical logging (if required), the Contractor shall install the assembly consisting of blind casings and slotted screens (Stainless Steel Grade 304 or high-grade UPVC as specified). The Pump Housing (Ductile Iron or Epoxy-Coated Steel) shall be connected via a tapered reducer.

7.1.3. Shrouding & Development

The annular space shall be packed with Gravel Shrouding (clean, water-worn, silica-based gravel) of specified gradation. The well shall be developed using air-compressor surging and over-pumping until it produces sand-free water at a discharge rate 50% higher than the design capacity.

7.1.4. Completion

Following successful testing, the Contractor shall install a Submersible pump, chlorination unit (Where recommended), and electrical controls, ensuring a fully functional water production facility.

7.2. CONTRACT DRAWINGS

Tender drawings indicate the estimated scope. Actual construction details (casing schedule, screen position, and pump setting) shall be finalized by the Engineer based on the Drilling Log of the encountered strata. The Contractor shall prepare "As-Built" drawings upon completion

7.3. SIZE OF TUBEWELL

The final pump head and motor horsepower shall be adjusted based on the actual Static Water Level (SWL) and Drawdown observed during the 24-hour pumping test. The depths

shown on drawings are indicative; the Contractor shall not be entitled to claims based on strata variation within reasonable limits.

7.4. BILL OF QUANTITIES

The bill of quantities set forth is the approximate quantities of the works. The amount of bid for each item of bill of quantities shall be full payment for completion and maintenance of the works specified herein and elsewhere in the document and Drawings.

7.5. STANDARDS

Except as otherwise provided by this specification or the Drawings and in case no specification and standards are indicated in the document, all materials, equipment fabrication and testing thereof shall conform to the latest applicable standards and specifications in accordance with the specification epilogue.

All materials and processes shall conform to the latest editions of:

- **AWWA A100:** Water Wells.
- **ASTM D5092:** Design and Installation of Ground Water Monitoring Wells.
- **BS EN 1074:** Valves for water supply. Any deviation must be submitted in writing with technical justification for the Engineer's approval.

7.6. CONSTRUCTION EQUIPMENT AND MATERIAL

Unless otherwise specifically stated in the document, the Contractor shall furnish all necessary construction equipment and material for the construction and installation of the tube well and appurtenances. The construction equipment shall include but not be limited to drilling equipment of the Rotary or percussion type, together with all supporting and additional equipment and accessories necessary for taking samples for installing the tube well casing and pumping-housing casings, for placing gravel shrouding and cement grouting, for developing and testing the tube well, for determining the straightness and verticality for pump housing casing; for constructing the cement concrete pump pedestal and floor slab for installing the pump motor, motor controls and necessary electrical equipment, chlorinator, valves and discharge pipes, for constructing the pump house and for the performance of development tests.

All construction equipment shall be in good, serviceable condition and shall be capable of doing the work.

The Contractor shall also furnish all testing instruments, equipment and materials required by the Contractor for his use in ascertaining that construction materials, permanently installed equipment and the finished work conforms to the requirements of specifications and for carrying out all

tests required by the specifications to be performed by the Contractor.

Materials to be furnished by the Contractor shall include all materials necessary for the operation and maintenance of the Contractor's equipment and all the materials for installation in the tube well including casing, gravel shrouding, Portland cement, brick, reinforcement, aggregates, electrical conductance, wiring and fittings and all other equipment and materials necessary to perform the work in complete and satisfactory manner.

7.7. CLEAN UP

Upon commissioning, the Contractor shall remove all temporary structures, drilling fluids (slush pits must be backfilled and compacted), and debris. The site shall be restored to a clean, safe condition, and any damage to surrounding property caused by drilling runoff shall be rectified at the Contractor's expense.

SECTION-8- DRILLING OF BOREHOLE

8.1. SCOPE OF WORK

The work covered under the specifications is furnishing all plant, labour, equipment, appliances, and materials, and in performing all operations in connection with the drilling of borehole(s) in strict accordance with this section of specifications in reasonably close conformity with the lines and dimensions shown on the Drawings or established by the Engineer.

8.2. DRILLING OPERATION

Drilling of tube well shall include, but not be limited to moving in, setting up, preparing the site, drilling the borehole, collecting data and removing temporary casing, dismantling, moving out and cleaning up. Measurement for tube well drilling will be made of the actual depth of each borehole drilled, measuring from the original ground surface. No measurement will be made over-drilling required because of the sloughing, caving ground or for the Contractor's use in setting casing; for tube well abandoned due to jammed tools, caving ground, or negligence on the part of the Contractor; or for tube well not constructed in accordance with all the requirements of these specifications.

8.3. DRILLING

The Contractor shall drill each borehole of the diameter indicated on the Drawings and at the locations shown on the Drawings. The Contractor shall prepare the site for the construction of the tube well and shall provide for the disposal of water, cuttings, and refuse from his operation away from the site and to the satisfaction of the Engineer.

The borehole shall be drilled by the reverse circulation rotary method. Each borehole shall be drilled to the depth specified by the Engineer. It is anticipated that the depth of tube well (s) will vary; however, no minimum depth of any individual tube well or average depth for all tube wells is guaranteed. The borehole shall be drilled sufficiently straight and plumb so that the pump and the tube well casing may be installed concentric with the hole and within the tolerance specified for the plumbness of the casing. Waste materials from the drilling operation shall be disposed of in a manner approved by the Engineer.

The Contractor shall be responsible for protecting the tube well from contamination by foreign materials until the completed tube well and appurtenant facilities are accepted by the Engineer. The Contractor shall bear any expense that may result from damage to any tube well, tools or equipment that may be caused by caving, washing or other disturbance within the tube well.

If unstable material is encountered in drilling, the Contractor shall stabilize the material in a manner approved by the Engineer. The use of drilling fluid additives or other suitable materials may be employed for stabilizing the borehole when such use is specifically approved by the Engineer. If necessary, temporary casing shall be furnished and installed by the Contractor to hold walls of the hole during drilling operations and until the gravel shrouding has been placed. All temporary casing shall be removed by the Contractor in stages as gravel shrouding is placed. The temporary casing may be new or used and will remain the property of the Contractor.

If, in the opinion of the Engineer, it is necessary to discontinue work on any borehole because it is out of line more than the amount specified or on account of jammed tools, caving ground or because of negligence on the part of the Contractor, he will not be entitled to payment for any work done or materials furnished for borehole abandoned as a result of his operations or negligence.

8.4. DATA AND RECORDS

The Contractor shall keep accurate drilling logs of borehole drilled including description of all materials encountered and their location in the borehole. The fact that the Engineer or his representative may be present and keep a separate record, shall not release the Contractor from this responsibility. In the case of defective or incomplete records, the Contractor shall complete the records at his own expense. All records and data shall be kept by the Contractor on forms approved by the Engineer. The Contractor shall deliver to the Engineer, the original of all records and all such records shall become the property of the Owner.

Representative ditch samples or cuttings of the materials penetrated shall be taken of each lithology encountered and from each ten feet of the depth for non-water bearing depth and each four feet for water bearing depth of the borehole. Special care shall be exercised to determine the thickness and location of each change in material encountered and to obtain satisfactory samples. Immediately upon taking samples, the samples shall be placed in a cloth bag, partitioned wooden box, or other approved container, properly marked for identification, and plainly labelled with the depth of the top and bottom of the section of the borehole represented. The containers shall be furnished by the Contractor, the method of obtaining, processing and storing the samples shall be subject to approval by the Engineer. The Contractor shall deliver all samples to the Engineer at the site of the tube well or to the field headquarters of the Engineer as directed.

8.5. MEASUREMENT AND PAYMENT

8.5.1 Measurement

The quantity of drilling to be paid for shall be measured by linear metre or linear foot, whichever is included in Bill of Quantities, and drilled as mentioned above.

8.5.2 Payment

The accepted quantity measured as provided above shall be paid for at the contract unit price per linear metre or linear foot of drilling (whichever is included in Bill of Quantities) of specified diameter of borehole for the pay items included in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, various drilling operations, labour, equipment, tools and incidentals necessary to complete the item.

Backfilling of the borehole, if a particular borehole is not developed, shall be done as per instructions of the Engineer, payment for which shall be made separately.

SECTION-9- TUBEWELL CONSTRUCTION

9.1. SCOPE OF WORK

The Contractor shall furnish all specialized plant, labor, equipment, and materials required to execute the drilling of boreholes in strict accordance with these specifications and the designated lines and dimensions shown on the Drawings. The scope includes site preparation, mobilization, drilling, logging, and site restoration upon completion.

9.2.CASINGS

Casing shall consist of all work required in connection with furnishing and installing casing pipe, comprising of steel conductor pipe and steel pump housing pipe and fibre glass / brass or any other specified material, tube well casing (both plain and slotted), required for the tube well and shall include, but not be limited, providing storing, fabricating and installing including concentric reducers and equalizers.

9.2.1 Fibre Glass Strainer & Blind Pipe

Glass Fibre shall conform to the following specifications:

- ASTM-2996 for Filament-Wound Fibreglass
- ASTM 2997 for Centrifugally Cast Fibreglass

The fibre glass strainer will be from the approved source. The Contractor to this effect will submit for approval of the Engineer, a sample with complete specifications. Prior approval of the material is obligatory and without this approval, the procurement and installation of material will not be accepted for measurement and payment.

9.2.2 Fabrication

The depth of conductor pipe and pump house casing will be established by the Engineer for the tube well depending upon local sanitary conditions of shallow ground waters. Lengths of specified diameter of steel casing shall be provided to extend the pump housing casing from the elevation of the top of the pump housing casing to the depth established by the Engineer.

Adjoining sections of conductor pipe and pump housing casing shall be assembled by field welding. Butt welding straps shall be provided. All field welding shall be performed by the electric arc method, using heavily coated welding rods suitable for all position welding. After being deposited welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather edges without overlap, and freedom from porosity and clinkers. The pump housing casing shall be connected to tube well casing with a concentric tapered reducer.

The length and sizes of tube well casing to be installed will be specified for the tube well by the Engineer, and will be sufficient to extend from the bottom of the pump housing casing to the bottom of the tube well. The bottom of the tube well casing shall be fitted with a bail plug. The tube well casing shall consist of slotted sections for installation in the water yielding formation and plain pipe sections in the lowest one metre of the tube well and opposite non-water yielding formations as directed by the Engineer.

9.2.3 Installation

The Contractor shall install the entire pump housing and tube well casing assembly straight, plumb, and concentric in the drilled hole to permit the installation of the pump in such a manner that it will operate satisfactorily and without damage. The methods employed by the Contractor in the installation of the casing and in obtaining or correcting the verticality and straightness of the pump housing casing shall be subject to the approval of the Engineer.

Centralizer shall be attached to the pump housing casing so that it will be centred in the drilled hole throughout its entire length and held in such position while gravel shrouding is being placed. Centralizers will be placed at 25-foot intervals throughout the length of the tube well or as directed by the Engineer.

The Contractor shall install the pump housing casing, so that the deviation of its axis from the vertical shall not exceed 35 mm at the bottom of the pump housing casing. Measurements for determination of verticality and straightness of the pump housing casing shall be made by the Contractor in the presence of the Engineer, upon completion of gravel shrouding. Plumbs, pipes and dummies used in these tests shall be approved by the Engineer.

Measurements for determining the deviation of the pump housing casing from the vertical shall be made by the use of a circular plumb having a minimum outside diameter of 15 mm less than the inside diameter of the pump housing casing. The plumb shall hang vertically and shall be suspended in the centre of the casing. When the plumb is lowered to the bottom of the pump housing casing, the line from which the plumb is suspended shall not deviate from the centre of the pump housing casing at the top by more than that corresponding to a deviation of the plumb of 35 mm at the bottom of the pump housing casing. All deviations shall refer to a vertical line passing through the centre of the pump housing casing at the top.

Straightness shall be determined by lowering a section of pipe 40 feet long or a dummy of the same length to the bottom of the pump housing casing. The minimum outer diameter of the pipe or dummy shall be 15 mm less than the inside diameter of the pump housing casing. If a dummy is used, it shall consist of a rigid spindle with three cylindrical rings, each ring having a height of at least 300 mm. The rings shall be true cylinders and shall be located at each end

and in the centre of the dummy. The central shaft of the dummy shall be rigid so that it will maintain the alignment of the axis of the cylindrical rings. The pump housing casing shall be sufficiently straight so that the pipe or dummy can be passed freely throughout the entire length of the pump housing casing.

The tube well failing to meet the specified requirements for straightness, verticality and concentricity shall be abandoned, and the Contractor shall construct a new well at his own expense at an alternative site designated by the Engineer.

9.3. GROUTING

The annular space outside of the conductor pipe shall be sealed with cement grout. The grout shall consist of one part of cement and one part of sand by volume and not more than 5 gallons of water per cubic foot of cement. Grout materials shall be ordinary Portland cement conforming to BS 12, clean sand and clean portable water. The annular space shall be flushed with water prior to grouting to ensure that the space is open and to remove foreign material. The grout shall be applied from the bottom up and in one continuous operation. The grout shall be placed through a minimum 1-inch diameter grout pipe extending to the bottom of the annular space initially and shall remain submerged in the grout during the entire time the grout is being placed to ensure complete filling of the annular space. The grout shall be pumped into the pipe or applied continuously by gravity.

The pipe may be left in place or it shall be gradually removed. In the event of interruption in the grouting operations, the bottom of the pipe shall be raised until all air and water have been displaced from the grout pipe. The grout shall be allowed to set a minimum of 7 days after placement prior to resuming work on the well.

9.3.1 GRAVEL SHROUDING

Gravel shrouding shall consist of all work required in connection with furnishing and installing gravel shrouding in the annular space between the conductor pipe and the pump housing pipe, the walls of the borehole and the outside of the casing assembly and in any uncased length of borehole including but not limited to, developing the gravel source, excavating, stockpiling, grading, washing, storing, shipping, and installing gravel shrouding in the tube well.

9.3.2 Material

All gravel used for shrouding shall be clean, hard, well-rounded, washed, carbonate free and water-worn, without thin, flat particles and with the gradation as included in Table 9.1.

Table 9.1, Gradation Requirements for Shrouding Material

Sr. No.	Sieve	Percentage Passing
1	3/8 inch	100
2	No.4	60-80
3	No.7	20-40
4	No.14	0.50

9.3.3 Installation

The specified spaces shall be gravel shrouded by the Contractor from the bottom to the top of the tube well in such a manner that there will be no voids other than the annular space between the gravel particles. The method of placing the gravel, and the equipment used, shall be subject to approval by the Engineer. Water shall be circulated in the tube well, as the gravel is being laced, by lowering the drill pipe inside the casing and operating the circulation pump. The gravel shall be placed to the top of the tube well and shall be finally settled by bailing after all gravel has been placed. The top of the gravel shrouding shall be maintained at the ground level at all times during development, testing and pumping. Gravel and gravel placement not meeting these requirements will be subject to rejection by the Engineer, and all gravel so rejected shall be replaced by the Contractor at his own expense. Temporary casing, if used, shall be carefully withdrawn in 1-3 meters stages during placement of gravel shrouding and gravel shall be introduced so that each stage of the hole above the bottom of the casing is completely filled before the casing is withdrawn to the next stage. The process of withdrawing the temporary casing is at least 3 meters above the top of the tube well casing. Above this point, the temporary casing may be removed or left in place, at the option of the Contractor; however, no payment will be made to the Contractor for temporary casing left in place.

9.4. DEVELOPMENT AND TESTING

Development and testing shall consist of all work required in connection with the development of the tube-well to produce the design capacity of water. It is carried out by breaking the layer of bentonite or sealing clay or compounds in the borehole, and taking out mud, chemical used and fine particles of sand from the shrouding and the aquifer near to shrouding throughout the depth of the tube-well strainer. The development of the well shall be so effective that after its completion the turbidity of water and sand content shall be reduced to minimum permissible limit as recommended by WHO standards. After completion of development of tube-well, the water shall be tested to determine the chemical and bacteriological quality of water, draw down at designed discharge and the specific capacity of tube- well. Any tube-well not developed properly and not meeting above standards shall be rejected and re-drilled. The recovery of tube-well during

the test shall also be observed.

9.4.1 Method

The tube-well shall be developed with a vertical turbine pumping unit preferably closely coupled with a diesel engine through universal cross shaft which facilitates in pump speed adjustment to draw required discharge from the tube-well. Electric prime mover may also be used but with such arrangement which give variable speeds to the pumping units. The pumping unit shall allow the measurement of water level at any time during operation of the pump; and should be able to reverse its direction of rotation.

9.4.2 Equipment Required

The Contractor shall furnish all the equipment required for the development and testing of the tube-well as indicated below:

- a.** Vertical turbine pump with variable speed and reversal in direction of rotation. Capable of discharge twice the rated capacity for the design discharge of the tube-we/I.
- b.** Prime Mover (Electric or diesel) closely coupled with V.T.P. and capable of giving a variable/ adjustable speed to the pumping unit.
- c.** Discharge Measuring Device, Electronic flow metre, sluice valve for regulation of discharge.
- d.** Electronic measuring device to measure water level in tube-well during operation of the pumping unit.
- e.** Imhoff Cone (Sand Cone)

9.4.3 Back Wash

Back washing is done by reversing the direction of the pumping unit for a small time depending upon the condition of the water pumped. The water is pushed back into the aquifer thus stirring the locked sand particles and loosening them for pumping out. Back washing of tube-well shall be done during development at suitable intervals, to pump all fines from the tube-well shrouding. It shall be single backwash if the well is not pumping a greater quantity of sand and shall be doubled if it is sandy. The development and backwashing shall be continued till the sand contents are reduced to permissible limit, which shall be checked continuously by Imhoff Cone graduated in PPM (parts per million).

9.4.4 Duration

Static water level or sub soil water level shall be measured before the start of development.

a. Development (1st Stage)

Initial development shall be done step wise as included in Table 10.2.

Table 9.2, Duration of Development for Tube Well

Sr. No.	Discharge	Period of Development
1	0.75 times the designed discharge of tube well	1 hour
2	1.00 times the designed discharge of tube well	1 hour
3	1.25 times the designed discharge of tube well	1 hour
4	1.50 times the designed discharge of tube well	3 hours
5	2.00 times the designed discharge of tube well	3 hours
	Total	9 hours

Backwash shall be done every 5-minutes depending upon the sand contents pumped.

b. Recovery (1st Stage)

Pump shall be stopped after 1st stage of development and well shall be allowed to recover its water table. Reading/measurement of the water table shall be taken as provided in the under-mentioned intervals.

Table 9.3, Frequency of Measurement during Recovery Period for Tube Well

Sr. No.	Period (from pump closure)	Measurement Frequency
1	1 st 5 minutes	Every minute
2	Up to 15 minutes	Every 2-minutes
3	Up to 30 minutes	Every 5-minutes
4	Up to 1 hour	Every 10-minutes
5	Up to 3 hours	Every 20-minutes
	Total	3-hours

c. Testing for Development (2nd Stage)

The well shall be pumped in steps as included in Table 10.2.

Sand contents shall be measured every 5-minutes during each pumping, however during 1st five minutes sand content shall be taken every minute. The water level shall be measured in the same way as explained in Recovery period, for each pumping stage and draw down (the difference between the static water level and that during pumping) shall be worked out for each measurement

d. Recovery (2nd Stage)

The well shall again be allowed to recover and the measurements of the water table shall be carried out in the same way as in the first stage of recovery; Table 9.3.

The difference shall be noted between 1st stage and 2nd stage of recovery.

e. Testing for Re-Development (3rd Stage)

The tube-well shall be re-developed for another 9 hours in steps as included in Table 9.2.

Sand contents shall be measured every 5-minutes during each pumping, however during 1st five minutes sand content shall be taken every minute. The water level shall be measured in the same way as explained in the Recovery period, for each pumping stage and draw down (the difference between the static water level and that during pumping) shall be worked out for each measurement.

f. Recovery (3rd Stage)

Well shall again be allowed to recover for 3 hours and measurements of the water table shall be done as in 1st and 2nd stage; Table 9.3. There shall be no difference at the recovery of water table between 2nd stage and 3rd stage. If it is observed that there is an appreciable difference of recovery, the well shall be redeveloped for 6 hours with back wash and recovery should again be allowed for 3 hours to match it with 3rd stage recovery. The process shall be repeated till the preceding recovery is matched.

g. Stop Pumping

The pump shall be stopped for next 4 hours before the start of the final pumping test for approval of the well.

h. Final Pump Test

The tube-well shall be pumped finally for 4 hours at the rated discharge and final draw down shall be noted to find out the specific capacity of the tube- well.

Hence the summary of development and testing of tube-well is included in Table 9.4.

Table 9.4, Summary of Tube Well Development Procedure

Sr. No.	Development Step	Time Period
1	Development	
	Development, 1 st Stage	9 hours
	Recovery, 1 st Stage	3 hours
2	Testing	
	Development, 2 nd Stage	9 hours
	Recovery, 2 nd Stage	3 hours
	Development, 3 rd Stage	9 hours
	Recovery, 3 rd Stage	3 hours
	Step Pumping	4 hours
	Final Pump Test	4 hours

The duration of development and testing given above is minimum, and may be increased to a total duration of 72 hours as per the direction of the Engineer.

9.4.5 Performa for Records

Proper Performa shall be developed for development, recovery and testing of the tube-well giving discharge pumped, water level in tube-well, sand contents and timings of the measurements and shall be filled in accurately and precisely. If it seems that there is a mistake in measurement, the process shall be repeated. Proper records shall be kept for each tube-well for subsequent and future references

9.4.6 Operation of Pump & Motor

Power needs to be continuously available to pump during the tests. If power is interrupted, it shall be necessary to terminate the test, allow the well to recover up to initial water level and run a new test. Required pumping rate is to be maintained during the development of the tube-well has been satisfactorily completed and approved by the Engineer. The contractor shall disinfect the tube-well by chlorine solution throughout the entire depth of the well to obtain a minimum chlorine content of 50 parts per million. The procedure and equipment used to introduce and disperse the chlorine in the tube-well shall be approved by the Engineer

9.4.7 Disinfection

After development and testing of the tube well has been satisfactorily completed, and when approved by the Engineer, the Contractor shall disinfect the tube well by dispersing chlorine solution throughout the entire depth of the well to obtain a minimum chlorine content of 50 mg/l. The procedure and equipment used to introduce and disperse the chlorine in the tube

well shall be subject to approval of the Engineer.

9.5. SEALING

Upon completion of disinfections of the tube-well, the contractor shall seal the tube-well by welding the 6mm (1/4") steel plate cap to the pump housing casing around its circumference. Compliance with these requirements will not relieve contractor of his responsibility for safeguarding any complete part of the tube-well until the certificate of acceptance is issued for the entire tube-well installation

9.6. MEASUREMENT AND PAYMENT

9.6.1 Measurement

The quantity of MS housing pipe, blind pipe and screen of specified material and diameter shall be measured in linear metre or linear foot (whichever is included in Bill of Quantities) of actually installed at site on the basis of tentative quantities included in the Drawings.

The bail plugs, well caps and concentric reducers of specified diameter shall be measured in numbers, actually installed as per Drawings.

Grouting of space between inside of well drilled and outside of housing pipe shall be measured in linear metre or linear foot (whichever is included in Bill of Quantities) of actual executed quantity as per site.

The quantity of gravel shrouding shall be measured in cubic foot or cubic metre (whichever is included in Bill of Quantities) of actual executed quantity as per site.

The measurement for development and testing of tube well shall be measured in hours of testing and development to the satisfaction of the Engineer.

9.6.2 Payment

The accepted quantity MS housing pipe, blind pipe and screen of specified material and diameter, as above, shall be paid for at the contract unit rate which price and payment shall constitute full compensation for furnishing all materials, labour, equipment, tools and incidentals to complete these items including cost of centralizers (not payable separately).

The bail plug, well cap, concentric reducer of specified diameter/size, gravel shrouding and cement sand grouting, etc shall be paid at the contract unit rate and this price shall constitute full compensation for furnishing all materials, labour, equipment, etc. to complete this item to the satisfaction of the Engineer.

The payment for development and testing of tube well will be made at the contract unit rate which price and payment will be full compensation for all materials, labour, equipment, development, testing, disinfection, etc. as per the specifications and to the satisfaction of the Engineer.

SECTION-10- WATER TESTING

10.1. SCOPE OF WORK

The work covered under these specifications shall consist of collection, transportation, storage, and laboratory examination of water samples for the tube well that has been developed and tested. The water shall be tested for complete chemical and bacteriological examination in accordance with WHO (World Health Organisation) Guidelines 1985 or latest edition with the procedures established in the latest version of "Standard Methods for Examination of Water and Wastewater" published by American Public Health Association. The examination of water samples shall be carried out in a laboratory approved by the Engineer.

10.2. COLLECTION OF WATER SAMPLES

The water samples shall be collected in separate sterilized containers for bacteriological (i.e., Total Coliform, and Faecal Coliform) and Physio- chemical examination. The samples shall be collected from a tap fitted on the discharge pipe of the pump. The tube well shall be operated at its design capacity for a minimum period of 15 minutes, before collecting the first sample.

10.2.1 Collection for Bacteriological examination

The volume of each sample intended for bacteriological examination shall not be less than 100 ml. Sterilized glass bottles provided with ground-glass stoppers shall be used for collecting samples. The sample bottle shall not be kept unopened until the moment it is required for filling. During sampling, the stopper and neck of the bottle shall be handled to protect from hand contamination. The bottle shall be filled without rinsing and the stopper shall be replaced immediately after the bottle is filled.

10.2.2 Collection for Physio-Chemical Examination

The volume of each sample shall be at least 2 litres. The samples shall be collected in a chemically clean bottle, made of practically colourless glass and fitted with a ground-glass stopper. The bottle shall be rinsed at least three times with the water that is to be sampled before the bottle is filled. While sampling, the bottle shall be held near its base.

10.3. TRANSPORTATION AND STORAGE OF SAMPLES

With the water samples intended for bacteriological examination, the laboratory procedures shall be started as soon as possible, preferably within one hour of collection. However, the time elapsing between collection and examination of samples shall in no case exceed 24 hours. During the elapsing between collection and examination, the temperature of samples shall be maintained as close as the time of sampling.

Water samples intended for physio-chemical examination, the samples shall be kept cool during transport and storage. The time elapsing between collection and examination shall in no case exceed 48 hours.

10.4. LABORATORY EXAMINATION

Following methods shall be used for determination of turbidity, colour, total dissolved solids, chlorides, total coliform and faecal coliform, in the water samples:

10.4.1 Turbidity

The turbidity shall be determined by the Nephelometric method as described in the "Standard Methods". The turbidity of samples shall be measured and reported in the Nephelometric Turbidity Unit (NTU).

10.4.2 Colour

The true colour of sample shall be determined by comparing it with Nessler colour comparison tubes. The colour shall be determined and reported in colour units based on Platinum-Cobalt scale.

10.4.3 Total Dissolved Solids

The total dissolved solids shall be determined by Filtration-Evaporation method and expressed in mg/l.

10.4.4 Chlorides

Chlorides shall be determined by employing Mohr method, which uses silver nitrate as titrant and Potassium Chromate as the indicator. Chlorides shall be expressed and reported in units of mg/l.

10.4.5 Total Coliform and Faecal Coliform

Total coliform and faecal coliform concentrations shall be determined by employing Standard Methods. Dilution-Tube Technique shall be used. The results shall be reported in units of MPN/100 ml.

10.5. RECORD & DATA

A record shall be made of each sample by the Contractor and each bottle shall be identified including the information sufficient to identify the sample at some later date i.e. name of sample collector; date, hour, and location of sampling and water temperature. All records and data shall be kept by the Contractor on forms approved by the Engineer.

10.6. MEASUREMENT AND PAYMENT

10.6.1 Measurement

The measurement shall be made for each sample, tested in accordance with the provisions of this section of the document and accepted by the Engineer.

10.6.2 Payment

Payment shall be made for each set of samples tested and measured as above, at the unit rate appearing in the Bill of Quantities. This price and payment will be full compensation for all steps required to complete the work.

SECTION-11- CONSTRUCTION OF PUMP HOUSE

11.1. SCOPE OF WORK

The work shall consist of construction of pump house complete as per Drawings and in accordance with these specifications and in close conformity with the lines, grades and dimensions shown on the Drawings or as established by the Engineer.

11.2. MATERIALS AND CONSTRUCTION REQUIREMENTS

Materials and construction requirements shall conform to the respective items included in the document.

11.3. MEASUREMENT AND PAYMENT

11.3.1 Measurement

Lump sum or item rate, whichever is included in Bill of Quantities, will be the basis for measurement for the item of various works involved for the completion of this item.

11.3.2 Payment

When the bill of quantities calls for a lump sum price, construction of pump house will be paid for at the contract unit rate which price and payment will be full compensation for all miscellaneous operations for all civil, electrification, lights, fans, complete as shown on the Drawings or established by the Engineer.

SECTION-12-ELECTRICAL & MISC. WORKS

12.1. SCOPE OF WORK

The work shall consist of furnishing all plant, labour, equipment, appliances, and materials and of performing all operations in connection with the electrical work and other works in strict accordance with this section of the specifications and the applicable Drawings, and subject to the terms and conditions of the contract.

12.2. ELECTRICAL WORKS

12.2.1 Regulation

All electrical installation work shall conform to the Electricity Act, 1910 and the Electricity Rules 1937, as adopted and modified by the Government of Pakistan from time to time and WAPDA Specifications; and the requirements specified herein. Except where otherwise shown or specified all electrical equipment shall be suitable for operation 230 volts, 50 cycles, alternating current power supply. All electrical materials shall be new. Defective equipment or equipment damaged during installing or testing shall be replaced or repaired by the Contractor at his own expense.

12.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit and wiring. The Contractor shall study building plans and details so that the outlets and equipment will be properly located and readily accessible. Lighting fixture equipment and outlets shall be located to avoid interference with mechanical or structural features; otherwise, lighting fixtures shall be symmetrically located according to building arrangement. If any conflict occurs necessitating departure from the Drawings, details of departure and reasons therefore shall be submitted as soon as practicable for written approval of the Engineer.

12.2.3 Standard Products

Material and equipment used for this work shall be standard products from manufacturers regularly engaged in producing such equipment and shall be the manufacturer's latest standard design complying with specification requirements.

12.2.4 Material and Equipment Schedules

As soon as practicable and before starting installation of any material or equipment, the Contractor shall submit 6 copies of a complete list of materials and equipment proposed for installation to the Engineer for his approval. The list shall include manufacturer's names and materials or equipment identification such as styles, types, or catalogue numbers, to permit ready and complete identification.

12.2.5 Workmanship

All materials and equipment shall be installed in accordance with recommendations of the manufacturer subject to approval by the Engineer and in such a manner as to conform to the contract documents.

12.2.6 Grounding

All electrical equipment, including motors, meters, lighting and distribution panels, switchgear and similar items shall be grounded. All exposed non-current carrying metallic parts of electrical equipment, raceway systems and neutral conductor of the wiring system shall be grounded. Earth plates for the grounding system shall consist of copper plates of the minimum size of 609.6mm square and 3.175mm thick. The top earth plate shall be 2.44m below the ground level with critical watering arrangement or at the natural water level whichever is easy to install. A minimum 152.4mm layer of charcoal and rock salt shall be provided underneath each earth plate and a minimum

A 457.2mm layer of charcoal and rock salt shall be provided above each earth plate. The ground connection from the earth plate shall be securely bolted by a copper nut and bolt and additionally soldered to the plate. The ground connection including earth plate shall be kept clear of the structure foundation. The earth plate shall be located not nearer than 1.83m from the outer face of the building wall. Ground connections indicated as 3.18x25.4mm copper tape may be made with number 4/0 AWG or SWG cable. Ground connections indicated as 3.18mm by 12.7mm copper tape may be made with number 2/0 AWG or SWG cable. All ground connections shall run vertically and horizontally exposed on the surface of the wall and shall run concealed in the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. Ground connection from the building to the earth plate shall be run at a depth not less two feet below ground level.

12.2.7 Conduit

Unless otherwise indicated, electrical wiring shall be run in galvanized steel (G.I.) conduit or PVC Pipe according to the specification PVC pipe shall not be used as conduit for buried or embedded run. Minimum size of raceways for branch circuit wiring shall be 19.1mm. Conduit pipes shall be exposed on walls and ceilings but shall run concealed in floors. Conduit shall be continuous when passing through wall or floor. Conduits installed on the surface of walls shall be supported and secured at intervals of not more than 0.91m and shall be installed parallel or perpendicular to walls, structural members or inter sections of vertical planes and ceilings. Field made bends and offsets shall in general be avoided, but if so required these shall be made with an approved method or by conduit bending machine. Changes in direction of runs shall be made with symmetrical bends or cast-iron fittings. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be

taken to prevent the lodgement of plaster, dirt or trash in raceways boxes, fittings, and equipment during the course of construction. Clogged raceways shall be entirely free of obstructions or shall be replaced. Raceways crossing expansion joints in concrete slabs shall be provided with suitable expansion fittings or other suitable means to compensate for expansion contraction. Raceways installed underground or under slabs shall be coated with an approved type of protective coating.

a. Galvanized Iron (GI) Conduits

The galvanized iron (GI) conduits shall have minimum wall thickness of 1.65mm (i.e., 16 SWG) and shall have the diameter indicated on the Drawings. Damaged portions of galvanizing at joints shall be cleaned and painted with a silver-coloured rust inhibitive paint. Conduit shall be cut and threaded in such a manner that there are no sharp edges. Conduit bends shall be uniform and shall have a minimum radius of 5 times the diameter of the conduit or shall be made through pull or junction boxes.

b. PVC Pipe

PVC pipe and specials shall conform to British Standard Specification BS 3505:1962 "Unplasticized PVC pipe (Type 1420) for Cold Water Supply" and shall be class B. The entire conduit system shall be completed by cutting the PVC pipes and jointing and sealing to respective specials with P.V.C. solution as recommended by the PVC pipe manufacturers.

c. Additional Requirements for Exterior Conduit

All joints between sections of conduit, conduit and specials, and conduit and switches or lights shall be made water proof in an approved manner. Except where otherwise indicated, conduit shall be supported at least every 0.914m. Drainage fittings or seep holes shall be provided at unavoidable low points where moisture can collect. A maximum of two 90-degree bends will be allowed between boxes. Conduits shall be buried underground at minimum of 457.2mm below finish grade. The bearing of conduit shall be uniform throughout its length in the bottom of the trench. Backfilling shall be in 101.6x152.4mm layers, compacted to 95 percent of maximum density.

12.2.8 Conductors

a. General

Conductors shall be new and shall be of polyvinyl chloride (PVC) insulated copper unless otherwise specified. Wire connectors of insulating material or solderless pressure connectors properly taped shall be utilized for all splices where possible soldered mechanical joints insulated with tape shall be kept to a minimum. Vinyl plastic tape of suitable quality is acceptable in lieu of rubber and friction tapes. The entire conduit system shall be completed and

anchored prior to installing the wiring.

b. Conductor Sizes

Conductor sizes for tube-well motor main cables shall be as indicated in the Drawings. Control circuit conductors shall not be smaller than number 12 AWG except that for circuits of more than 30.48m from panel to load centre number 10 AWG shall be used.

c. Conductor Insulation

In normally dry locations, conductor number 8 AWG or larger shall have rubber or thermoplastic insulation of a heat resistant grade RH, RW, RHH or THW. Conductors smaller than number 8 AWG shall have a heat resistant rubber insulation type RH or RH RW or thermoplastic insulation, type T or TW.

12.2.9 Boxes and Supports

Boxes shall be provided wherever required for pulling of wires, making connections, and mounting devices or fixtures. Boxes for metallic raceways shall be of the cast iron hub type when located in normally wet locations. Boxes in other locations shall be sheet steel except that non-metallic boxes may be used with non-metallic conduit systems. Steel boxes shall be fabricated of structural quality flat rolled minimum 18-gauge sheet of steel free from irregularities, mill scale and surface corrosion shall be neatly and accurately formed with corners squared and sides jointed by welding. Each box shall have the volume required for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall be not less than 4 inches. Cast iron boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Boxes for use with raceway systems shall not be less than 38.1mm deep. Exterior pull boxes, junction boxes, boxes for exterior electrical supply points, switch boxes and all other boxes required for exterior electrical work shall be weather proof, heavy duty, galvanized steel.

12.2.10 Lamp Fixture and Accessories

All incandescent lighting fixtures shall be suitable for bayonet base lamps. All accessories such as straps, mounting plates, nipples or brackets shall be provided as required for proper installation. The exterior light points shall be provided with all fittings, accessories, metal clad switches, weatherproof light fixtures, holders, bulbs and covers.

12.2.11 Electrical Supply Points (Outlet Connections)

Electrical supply points shall be provided where indicated on the Drawings. Electrical supply points shall have the types of receptacles suitable for the plugs of the equipment to be connected to these points. Where receptacles are not available to match the plugs of equipment, standard receptacles

shall be used and plugs on equipment supply leads shall be replaced by the contractor with plugs to match standard receptacles. Each electrical supply point shall be complete with a switch. Exterior electrical supply points shall be provided where indicated. Exterior electrical supply points shall be weather proof, complete with switch and of the type suitable for the plugs of the equipment to be connected to these points.

12.2.12 Flexible Connections

Flexible connections of short lengths shall be provided for all motors and equipment. The flexible connections shall be water tight.

12.2.13 Fuse Circuits and Fuse Boxes

The Contractor shall provide proper fuse boxes for each circuit. The fuse boxes and the switches shall be metal clad and suitable for the load for which the circuit is designed. All fuse boxes shall be complete with proper size fuse strips fitted to fuse bridges.

12.2.14 Power Switchgear Assemblies

Power switchgear assemblies shall be metal enclosed and air circuit breaker type. The type and make of the circuit breaker shall be subject to approval of the Engineer.

12.2.15 Exterior Switches

Except where otherwise indicated exterior switches shall be of the push button weatherproof type.

12.2.16 Testing

Before any electrical system is put into service, the entire system installation shall satisfactorily pass the tests prescribed by the Electricity Department and the following tests. The Contractor shall furnish all instruments and personnel required for the tests, and the Employer will furnish the necessary electric power.

a. Insulation Resistance

The insulation resistance shall be measured by applying voltage between earth and the entire system of conductor or any section thereof, with all fuses in place and all switches on. A direct current voltage of not less than twice the working voltage shall be applied. The insulation resistance of the installation measured as above shall not be less than 25 megaohms divided by the number of points in the circuit. The metal conduit shall be tested for electrical resistance. The electrical resistance of such conduits measured between the main switch and each point shall not exceed 2 ohms.

b. Operating Test

After the wiring system has successfully passed the insulation resistance test, and at such time as the Engineer may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Engineer.

c. Earth Plate Resistance

Resistance to each earth plate shall be tested by a standard earth tester, not sooner than 72 hours after a rain and without prewetting ground. The resistance of each earth plate shall not be more than 10 ohms. The test shall be performed by the contractor in the presence of the Engineer. Earth plates having a resistance of more than 10 ohms shall be replaced and retested. The Contractor shall submit in writing to the Engineer upon completion of the project, the measured ground resistance of each earth plate, indicating the location of the earth plate and the resistance and the soil conditions at the time, the measurements were made.

12.2.17 Repair

The work shall be carefully laid out in advance. Cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces as necessary for the proper installation, support or anchorage of the conduit, raceways or other electrical work shall be carefully done. Damage to building surfaces, piping and equipment (including pointing work) shall be repaired to its original condition by skilled mechanics of the trades involved at no additional cost to the Employer.

12.3. POWER TRANSFORMER

12.3.1 General

The power transformer shall be indoor type, oil immersed, self-cooled, designed and built to give efficient and reliable service at their full rated capacity on the climatic conditions given in the general information of these specifications. Transformers built to the following standard will be acceptable.

- BS 171-1970 or any other relevant latest British Standard
- VDE 0532

12.3.2 Construction

The transformer tank shall be constructed of welded sheet steel plates and provided with external radiating tubes.

The transformer shall be fully tropicalized for temperature rise, humidity, altitude etc. The local conditions shall be taken into account while following the above standards. The transformer shall be complete with oil filling, all

accessories and attachments detailed in these specifications or otherwise required and the contractor shall provide all details, drawings, data and complete test results for final approval before installation. The tank and radiating tubes shall be designed to withstand, without developing any deformation, pressure at least 25% greater than the maximum operating pressure. The steel plate cover shall be bolted to the tank, using a gasket for perfect oil seal. Two earth terminals shall be provided at the base of the tank.

The oil preservation system shall utilize on expansion the conservative tank fitted with silica gel breather and oil level indicator.

The transformer core shall be built of high-grade electrical steel laminations, each lamination insulated to reduce eddy current losses. The core laminations shall be clamped and bolted effectively to reduce 'humming'.

The winding core shall be of high-grade electrolytic copper conductor, flat or round paper insulated, thoroughly dried and impregnated as desired.

The high voltage leads shall be brought out and terminated to glazed porcelain insulator bushings for external connection.

The low voltage three lines and neutral leads shall be brought out and terminated to glazed porcelain insulator bushings for connection to L.V. side by copper bus bars or cables. The transformer neutral shall be earthed.

Off-load operated tap changer shall be provided on the tank cover. The tapping shall be - 7.5%, $\pm 5\%$, $\pm 2.5\%$. A clear marking illustrated by diagram shall be provided to indicate the tap positions.

The transformer shall be provided with the following accessories.

- Oil filling valve for vacuum filling of oil;
- Oil drain plug;
- Bi-directional rollers fixed to the base steel channel, for rolling in the directions of both centre lines of the transformer;
- Lifting lugs, for handling and un-tanking the transformer; and
- Dial type thermometer for indicating oil temperature and having two hands, one showing existing oil temperature and other showing maximum oil temperature reached since the hand was last reset.

12.3.3 Drawings and Data

The manufacturer shall supply complete structural drawings showing plan and elevations with complete dimensions and all relevant details of technical data of the offered transformer.

12.3.4 Transformer Technical Data

The technical data for Power Transformer shall be as included in Table 12.1.

Table 12.1, Technical Data for Power Transformer

Sr. No.	Parameter	Data
1	KVA rating	As shown on Drawings
2	No load ratio	11kv/415 V
3	H.V. Winding	
	Line to line volts	11000
	Connections	Delta
4	L.V. Winding	
	Line to line volts	415
	Connections	Star
5	Vector Group	DY 11
6	Tapping on H.V side	-7.5%, $\pm 5\%$, $\pm 2.5\%$
7	H.V Termination	Bushing
8	L.V cable size	7x300 mm ²
9	L.V Termination	Bushing
10	Impedance voltage	4.5% to 6%
11	Losses in watts	
	Iron at no load	to be furnished by Bidder
	Copper at full load	to be furnished by Bidder
12	Cooling	On
13	Temperature rise over 50°C ambient	
	Oil	40°C
	Winding	50°C

12.4. MEASUREMENT AND PAYMENT**12.4.1 Measurement**

The measurement of each item shall be as per provisions of the bill of quantities.

12.4.2 Payment

The items will be paid for at the contract unit price which price and payment shall be full compensation for furnishing, installing and commissioning all machinery and equipment for electrical works, chlorination equipment etc. complete in all respects as shown in the Drawings including all labour, tools, equipment and incidental to complete the work.

SECTION-13 -"EXCAVATION, BACKFILLING & DISPOSAL

13.1. SCOPE OF WORK

The work under this section consists of excavating, in all types of soil, lifting, transportation and disposal of the excavated material, back-fill and fill for building foundations, and under floors including all incidental work necessary for excavation to the required depth and dimensions and in accordance with the Drawings or as directed. The work shall be carried out in complete conformity with the specifications set-forth hereunder.

13.2. AUTHORIZED OUTLINES

Unless otherwise specified or directed in writing, all earthwork, i.e., excavation of trenches, pits, etc. for foundations, filling under floors, etc. shall be executed to the widths, depths, lengths, alignments, grades and levels shown on the Drawings. If they are not indicated on the Drawings then the Contractor shall prepare the drawing showing the existing ground levels and the actual grades and levels of excavation for obtaining necessary approval from the Engineer before excavating the ground.

Similarly, for all backfill and fill works the Contractor shall prepare drawings showing the existing ground levels and the actual finished level to ascertain the volume of fill for obtaining approval before the commencement of work.

13.3. CONSTRUCTION REQUIREMENTS

13.3.1 Excavation

a. General

All excavation, in any kind of soil encountered, shall be performed to the depths and widths indicated or as otherwise specified by the Engineer. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving. Topsoil shall be stockpiled separately, for subsequent re-use as necessary. All excavated material unsuitable or not required for backfilling shall be removed and collected at a location approved by the Engineer.

It is anticipated that all excavation work under this Contract will be earth excavation. The term "earth" as used herein shall include all materials which do not in the opinion of the Engineer, require blasting, barring or wedging of material for removal from its original bed.

Unless otherwise indicated or approved by the Engineer, excavation shall be open cut.

b. Timbering or Sheeting

The Contractor shall provide adequate timbering or sheeting for excavation where necessary, as part of the excavation work, to hold up the sides and ends of all excavations. Should the sides and ends of any excavation give away, the Contractor shall, at no extra cost to the Employer reinstate all disturbed ground.

If ordinary open-cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations generally in accordance with the details shown on Drawings to provide safe working conditions. The Contractor shall furnish and place all sheeting walls, braces, timbers, and similar items, necessary for the safety of the work, the general public and adjacent property. Sheeting and bracing shall be removed, as the work progresses in such a manner as to prevent damage to finished work and adjacent structures and property. As soon as it is withdrawn, all voids left by the sheeting and bracing shall be carefully filled with selected material and compacted. The Contractor shall be fully responsible for the safety of work in progress, for the finished work, the workmen, the public and adjacent property. All sheeting and bracing shall be at the Contractor's expense, as part of the work under the excavation items and at no extra cost to the Employer.

The Engineer may order, in writing, any or all shoring, sheeting and piling to be left in place for safety reasons, whether such sheeting is shown on Drawings or not. If left in place, such sheeting shall be cut off at the elevation approved by the Engineer, and shall be paid separately.

c. Inspection of Foundations

When excavation up to foundation level is reached, as per Drawings, it is inspected by the Engineer and approved before start of any permanent construction. If safe foundation could not be obtained at the depth shown on the Drawings or at maximum depth of Excavation shall continue until suitable bearing strata is encountered as approved by the Engineer. Additional cost, if any approved by the Engineer, shall be paid in accordance with the provisions of the Conditions of Contract.

d. Disposal of Unsuitable/Surplus Materials

The unsuitable /surplus earth shall not be heaped within 5-feet of the top edge of any foundation. All surplus material excavated by the Contractor shall be disposed of at locations approved by the Engineer. The method of disposal shall not interfere with other works and shall not damage or spoil other materials. When it is necessary to haul earth material over streets or pavements, the Contractor shall prevent such material from falling on the

streets or pavements. The surplus material shall be disposed-of within the site without any additional cost.

e. Excavation to be kept Free of Water

All excavations shall be kept free from water from whatever source it may come, at all times, except where otherwise specified or permitted in writing by the Engineer.

As part of the works, under the excavation items, and at no extra cost to the Employer, the Contractor shall build all drains and do ditching, pumping, well pointing, bailing and other work necessary to keep the excavation clear of ground, sewage or storm water during the progress of the work and until the finished work is safe from injury. The Contractor shall provide all necessary pumping equipment for the dewatering works as well as operating personnel, maintenance, power etc. all at no extra cost to the Employer. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the Engineer. Necessary precautions against flooding shall be taken.

f. Safety Measures

All excavations shall be properly maintained while they are open and exposed. Sufficient suitable barricades, warning lights, signs and similar items shall be provided by the Contractor. The Contractor shall be responsible for any personnel injury or property damage due to his negligence.

The Contractor shall take special precautionary and protective measures with existing subsurface facilities likely to be encountered during the execution of works such as sewers, drain pipes, water mains, conduits, electric cables, communication cables, foundations of adjacent structures etc. As part of the works, the Contractor shall shore up all buildings, walls, poles and other structures, the stability of which is liable to be endangered by the execution of the works. The Contractor shall be responsible for damage to any such facility and shall repair the same at his expense whether or not this facility has been shown on the Drawings.

g. Excess Excavation

In the event of any excavation being carried out wider or deeper than shown on the Drawings, it shall be filled in by the Contractor at his own expense to meet the required dimension and levels with concrete or any other material approved for such purpose.

The bottom and side slopes of excavation upon or against which structures or other required constructions are to be placed shall be finished accurately to the required grades and dimensions and, if required, shall be moistened

with water and tamped or rolled with suitable tools or equipment for the purpose of forming a firm foundation. Whenever the natural foundation material is disturbed or loosened or excavated beyond the approved lines and grades the loose material shall be removed and the extra excavation made good at Contractor's expense with selected materials which shall be thoroughly compacted by tamping rolling in layers not exceeding 6-inch.

h. Classification of Material

No classification will be made for payment purposes of any material excavated as to its class, nature, origin or condition, unless an unusual obstruction or embedded matter or substance is encountered. If this occurs, it shall be submitted by the Contractor for evaluation of design and working out of a necessary treatment. New items shall be mutually agreed.

i. Transportation of Materials

All carts, trucks or other vehicles used by the Contractor for transportation of the material shall be suitably constructed or lined out to permit any leakage of soil while the vehicles are on the move. These would be so loaded and arranged as not to spill on the site and public roads. Whenever any vehicle so used is found leaking and unsuitable it shall be immediately withdrawn from the work.

13.3.2 Compacted Backfill

a. Excavated Earth for Backfilling

All fill or refill around structures, i.e., within the slopes and limits of the established lines for excavation for the structures and below the natural surface level, shall be defined as "Back Filling".

Backfilling operations for structure shall be performed as part of Contractor's work under the payment items for earth excavation, and at no extra cost to the Employer. It comprises returning, transportation and filling the selected excavated material around foundations, and at back of walls etc., up to finished levels shown on the Drawings or as required in layers not exceeding 6 inches carefully rammed and consolidated (with addition of water if required) so as to achieve a maximum minimum 95% of Modified Proctor Maximum Dry Density per ASTM D1557.

The backfilling earth shall be free from stones and hard clods, larger than 3 inches in any dimension and also free from trash, lumber and other debris. No backfilling shall be made until the concrete foundations and footings etc have been inspected and approved. Earth to be used for filling must be free of all the organic impurities, debris or any other foreign matter. Earth which contains more than 1% of salts, particularly sulphates, will not be used in filling.

Testing shall be performed using the calibrated sand cone method to determine the density of soil in place. If soil in place fails to meet the specified degree of compaction it shall be removed, replaced with approved material and compacted to the specified density in the manner directed by the Engineer, in the areas represented by the failing tests at no additional cost to the Employer.

b. Borrow Earth for Backfilling

In case of non-sufficiency of excavated material and unsuitability of earth for back-filling, appropriate material conforming to these specifications shall be brought by the Contractor.

Where satisfactory materials for backfill are not available in sufficient quantity from required excavation, "Earth Borrow" shall be obtained from suitable sources at the Contractor's responsibility as a separate payment item. The necessary clearing and grubbing of borrow areas, disposal and burning of debris there from the development of sources including any access roads for hauling and the necessary right-of-way, and the satisfactory drainage of the borrow areas, shall be considered as incidental items to borrow excavation. "Earth Borrow" under this separate payment item shall be furnished and placed by the Contractor only where specifically called for by the Engineer.

Filling shall be approved selected material from excavated or other predominantly granular material, free from slurry and organic or other unsuitable matter and capable of compaction by ordinary means

c. Sand Backfill

Special sand backfill is to be provided when specifically required by the Drawings or when ordered in writing by the Engineer. This work shall consist of removal of the excavated material to waste and provision in lieu of graded clean and fill, free of all foreign matter, such that 100% passes a $\frac{3}{4}$ " screen with not more than 5% passing a No.4 sieve. This shall be compacted to 95% of the maximum density as determined by AASHTO T 180, Method D.

13.3.3 Filling Under Floors

Earth Filling

All fill or refill (from the excavated earth at site) about structures, i.e., above the natural surface level shall be defined as "filling under floors or embankment from excavated earth".

After the masonry has been laid up to the plinth level and the Damp Concrete Proof Course, if required is laid the space between the walls shall be cleared of debris and loose earth shall be laid in layers of 6-inch and each layer watered and compacted until the filling is completed up to the base level of the floor as shown on the Drawings. Only sandy soil free from salt peter either from the materials excavated from the foundations if such materials is suitable and sufficient or suitable material brought from outside shall be used.

13.3.4 Sand Filling

All fill or refill, from the material provided and brought from outside the site (any lead), about structures, i.e., above the natural surface level shall be defined as "filling under floors with earth provided and brought from outside".

Unless otherwise specified the base of all ground floors shall be constructed through sand filling, done in layers not more than 4-inch thick and shall be rammed after saturation to such an extent that 4-inch layer is reduced to about 2.7" after compaction.

The required In situ density shall comply with BS 1377 – latest edition or ASTM D1557.

Sand shall conform in all respect to the specifications for fine aggregate except for its grading, i.e., it shall pass through a sieve No. 16 and not more than 30% shall pass through a sieve No. 100.

13.4. MEASUREMENT AND PAYMENT

13.4.1 Measurement

The measurement shall be made in cubic feet or cubic metre (whichever is included in Bill of Quantities) of earth acceptably excavated and backfilled for trenches and structures within the lines and grades shown on the drawing or as directed by the Engineer duly compacted as required. The measurement of dewatering in trenches or structures shall not be made and cost of this item shall be deemed included in the cost of excavation, backfilling and compaction.

Any excavation carried beyond the limits shown on the Drawings and specified herein as the payment limits, shall be treated as excess excavation and shall not be measured for payment.

13.4.2 Payment

Payment for this item of work shall be made for the actual quantity of work done as specified in this section, at the unit rate quoted in the Bill of Quantities.

Filling under floors from excavated earth or borrowed sand shall be measured and paid separates as per respected items included in the Bill of Quantities

SECTION-14- PLAIN & REINFORCED CONCRETE

14.1. SCOPE OF WORK

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, manufacturers, transporting, placing, consolidating and curing of plain & reinforced concrete and its constituents. Reinforcing steel does not form part of this section and is described in SECTION-“**PLAIN & REINFORCED CONCRETE**”

14.2. APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

14.2.1 Pakistan Standards

- PS 232, Portland cement (ordinary & rapid hardening)
- PS 243, Natural aggregates for concrete
- PS 279, Abrasion of coarse aggregates by the use of Los Angeles machine
- PS 280, Determination of aggregates crushing value
- PS 281, Organic impurities in sand for concrete aggregate
- PS 282, Material finer than No. 200 PS test sieve in aggregates
- PS 283, Soundness test for aggregates by the use of sodium sulphate or magnesium sulphate
- PS 284, Sampling aggregates for concrete
- PS 285, Sieve or screen analysis of fine and coarse
- PS 286, Description and classification of mineral aggregates
- PS 421, Sampling fresh concrete
- PS 422, Slump test for concrete
- PS 560, Making and curing concrete compression test specimen in the field
- PS 612, Sulphate-resistant Portland cement type 'A' and sampling fresh concrete in the laboratory
- PS 716, Mixing
- PS 717, Compacting factor test for concrete
- PS 746, Definitions and terminology of cements
- PS 849, Making and curing concrete compression test cubes

14.2.2 ASTM (American Society for Testing and Materials)

- ASTM C 33, Concrete Aggregates

- ASTM C 39, Test Method for Compressive Strength of Cylindrical Concrete Specimens

- ASTM C 40, Organic impurities in sand for concrete
- ASTM C 87, Effect of organic impurities in fine aggregates on strength of mortar
- ASTM C 88, Soundness of aggregates
- ASTM C 94, Ready mixed Concrete
- ASTM C 109, Compressive strength of hydraulic cement mortars
- ASTM C 117, Material finer than No. 200 (0.075mm) sieve
- ASTM C 123, Light weight pieces in aggregates
- ASTM C125, Concrete and concrete aggregates
- ASTM C 127, Specific gravity and absorption of coarse aggregate
- ASTM C 128, Specific gravity and absorption of fine aggregate
- ASTM C 13, Resistance to abrasion of small size coarse aggregate
- ASTM C 136, Sieve or screen analysis of fine and coarse aggregate
- ASTM C 142, Clay lumps and friable particles in aggregates
- ASTM C 143, Slump of Portland Cement Concrete
- ASTM C 150, Portland cement
- ASTM C 156, Water retention by concrete curing material
- ASTM C 171, Sheet material for curing concrete
- ASTM C 185, Air content or hydraulic cement mortar
- ASTM C 188, Density of hydraulic cement
- ASTM C 191, Time of setting of hydraulic cement by vicat needle
- ASTM C 260, Air entraining admixture for concrete
- ASTM C 289, Potential reactivity of aggregate
- ASTM C 309, Liquid membrane forming compounds for curing concrete
- ASTM C 494, Chemical admixtures for concrete
- ASTM C 535, Resistance to abrasion of large size coarse aggregates
- ASTM C 75, Aggregate sampling
- ASTM C 994, Preformed expansion joint filler for concrete
- ASTM C 1190, Concrete joint sealer (hot poured elastic type)
- ASTM C 1715, Preformed expansion joint filler for concrete paving and structural concrete
- ASTM D 1850, Concrete joint sealer (cold application type)
- ASTM E11, Wire cloth sleeves for testing purposes
- ASTM E 96, Water vapour transmission of materials in sheet form
- ASTM E 154, Materials for use as vapour barrier under concrete slabs
- ASTM E 337, Relative humidity by wet and dry bulk psychrometer

14.2.3 ACI (American Concrete Institute)

- ACI 211, Recommended practice for selecting proportions for normal and heavy weight concrete
- ACI 214, Quality control charts
- ACI 301, Specifications for structural concrete for building
- ACI 304, Recommended practice for measuring, mixing, transporting and placing concrete
- ACI 305, Hot weather concreting
- ACI 308, Recommended practice for curing concrete
- ACI 309, Recommended practice for consolidation of concrete
- ACI 315, Manual of standard practice of detailing reinforcement concrete structure
- ACI 318, Building code requirement of reinforced concrete
- ACI 347, Recommended practice for concrete formwork

14.2.4 British Standards

- BS 12, Portland cement, ordinary and rapid hardening
- BS 410, Test Sieves
- BS 812, Methods for the sampling and testing of mineral aggregates, sand fillers
- BS 822, Concrete aggregates from natural sources
- BS 1881, Methods of testing concrete
- BS 3148, Tests for water for making concrete
- BS 3837, Expanded polystyrene boards
- BS 3869, Rigid expanded polyvinyl chloride for thermal insulation.
- BS 4027, Sulphate – resisting Portland cement
- CP 8110, Structural use of concrete
- OP 114, Structural use of reinforced concrete in buildings

In addition, the latest editions of other Pakistan and British Standards, American Concrete Institute Standards, American Society for Testing and Materials Standards and other Standards as may be specified by the Engineer for special Materials and Construction are also relevant.

14.3. SUBMITTALS

- a.** Suitable templates or instructions or both shall be provided for setting out

of items not placed in the forms. Embedded items and other materials for mechanical and electrical operations shall have been completed, inspected, tested and approved before concrete is placed.

- b.** For special concrete finish and for special methods of construction, formwork shop drawings shall be designed and prepared by the Contractor, at his own cost. Approval of shop drawings as well as that of actual samples of concrete finish shall be obtained before work is commenced.
- c.** The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate 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.
- d.** The grading of the coarse and fine aggregates shall be tested at least once for every 100 tons supplied, to ensure that the grading is uniform and same as that of the samples used in the preliminary tests.
- e.** Where doubt exists as to the suitability of the water, it shall be tested in accordance with BS 3148.
- f.** The Contractor shall provide Mix design by weight for each class of concrete. Manufacture 12 test cylinders for each 3 mix design batches (6 Dia. x 12 high) inches in accordance with the Mix design batching by weight and testing 3 cylinders each at 3, 7, 14 & 28 days intervals in the presence of an Engineers Representative and submitting 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.
- g.** 'Workability' of Concrete shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given ASTM C 143.
- h.** The slump or compaction factor for each class of concrete shall be determined during the preliminary Test mixes and the value obtained shall not be modified without the written consent of the Engineer.
- i.** Manufacturer's recommendations and instructions along with the sample of material shall be submitted to the Engineer for his approval.
- j.** The Contractor shall, at his own cost, make optimum mix design and testing for approval of the composition of non-shrinking grout and non- shrink second stage Concrete Grout, prior to Commencement of the work.
- k.** The Contractor shall be required to submit a sample of pre-cast units for the approval of the Engineer: all pre-cast units shall strictly conform to the approved sample. The proposal for transporting and erecting pre-cast units in position shall also be submitted by the Contractor for the approval of the Engineer.
- l.** All submittals shall be made as per the requirements of the relevant section.

14.4. MATERIAL REQUIREMENTS

14.4.1 Aggregates

- a.** The sources of supply of all fine and coarse aggregates shall be as specified

or approved by the Engineer.

b. 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. They shall be placed on sloped hard strata to ensure well draining at all times.

c. Fine aggregate shall be hard coarse sand, crushed stone or gravel screenings and shall conform to requirements of PS 243 and/or BS 882 and or ASTM C-33. Only fine aggregate of grading zones 1 to 3 (BS 882) shall be used.

d. Coarse aggregate shall be crushed stone of hard, durable material free from laminated structure and conforming to PS 243 and/or BS 882 and/or ASTM C-33, graded as included in Table 14.1, for use in mass concrete as in foundations.

Table 14.1, Gradation Requirements for Coarse Aggregate in Mass Concrete

Sr. No.	BS Sieve	Percent Passing by Weight
1	3-inch (76.20mm)	100
2	1.5-inch (38.10mm)	95-100
3	0.75-inch (19.05mm)	30-70
4	0.37-inch (9.52mm)	10-35
5	0.19-inch (4.76mm)	0-5

e. Coarse aggregate for all cast-in-place concrete other than mass concrete, as for foundations, shall be graded with the limits as included in Table 14.2.

Table 14.2, Gradation Requirements for Coarse Aggregate in other than Mass Concrete

Sr. No.	BS Sieve	Percent Passing by Weight
1	1.5-inch (38.10mm)	100
2	0.75-inch (19.05mm)	95-100
3	0.37-inch (9.52mm)	25-55
4	0.19-inch (4.76mm)	0-10

f. Wherever feasible, the nominal maximum size of aggregate for cast-in place reinforced concrete slabs and other members shall be 3/4- inch. If there are difficulties in placing such a concrete the maximum size may be restricted to 1/2-inch. Provided the requirements for strength are satisfied, as approved by the Engineer.

g. Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4-inch maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day). The grading of

the coarse and fine aggregates shall be tested at least once for every 100 tons supplied, to ensure that the grading is uniform and same as that of the samples used in the preliminary tests.

14.4.2 Cement

- a.** The cement shall be fresh and of approved origin and manufacture. It shall be one of the following as may be specified by the Engineer.
- b.** Ordinary or Rapid Hardening Portland cement complying with the requirements of PS 232 or BS 12 or ASTM C-150.
- c.** Sulphate Resisting Portland/Cement complying with the requirements of P.S.612 or BS 4027 or ASTM C-150.
- d.** Unless otherwise specified. Ordinary Portland cement complying with the requirements of BS 12 shall be used.
- e.** For all fair faced concrete, it will be necessary to use approved cement with a view to obtain a light shade concrete as approved by the Engineer.
- f.** The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate 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.
- g.** 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.
- h.** There shall be sufficient cement at site to ensure that each section of work is completed without interruption. If the cement is supplied by the Employer, the Contractor should inform the Employer of his requirements sufficiently in advance of its use in construction.
- i.** Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- j.** The contractor shall provide and erect (at his cost) a suitable plain, dry, well ventilated, weather proof and water proof shed of sufficient capacity to store the cement.
- k.** The cement shall be used as soon as possible after delivery and cement which the Engineer considers 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.
- l.** The mixing together of different types of cement will not be permitted.

14.4.3 Water

Water shall be tested in accordance with PS 3148 and shall be used only from an approved

source.

The Contractor shall supply sufficient water for all purposes, including mixing the concrete, curing and cleaning plant and tools. Where water can be shown to contain any sugar or an excess of acid, alkali or salt, the Engineer may refuse to permit its use.

14.4.4 Additive

All additives such as foaming and water proofing agents shall be from a manufacturer approved by the Engineer.

Air Entraining Admixtures conforming to ASTM C-260, and other Admixtures conforming to ASTM C-494 shall be used subject to approval of the Engineer.

14.4.5 PVC Water Stop

PVC Water Stop shall follow the requirements as included in SECTION-**"POLYVINYLECHLORIDE WATERSTOP"**.

14.4.6 Non-Shrink Grout

Grout for placement under base and bearing plates of machinery and equipment, for grouting anchor bars and dowels and for similar uses shall be as follows:

- Non-shrink grout of less than 1-inch thickness shall consist of one-part Portland cement and one part of clean sharp sand conforming to the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminium powder containing non-polishing agent.
- Non-shrink grout of 1-inch or more in thickness shall be proportioned as above except that 1-1/2 parts of 3/8-inch to 1/4--inch pea gravel shall be added.
- The above-specified composition may be varied if required by the Engineer.
- Proportioning shall be done by weight.
- Mixing water shall be proportioned so as to provide a flow able mixture without segregation or bleeding. Dry packing will not be permitted.

14.4.7 Non-Shrink Second Stage Concrete Grout

Non-shrink second stage concrete grout shall be provided and placed in position where shown on the Drawings or as directed by the Engineer. Non-shrink concrete mix proportions shall be one-part cement, two parts coarse clean sand and four parts of coarse aggregates meeting the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminium powder containing non-polishing agent. Proportioning shall be done by weight.

The above-specified composition may be varied if required by the Engineer.

14.4.8 Non-Shrink Concrete Grout for Stair Railing Column Post

Grout for placement in pockets for stair columns shall be non-shrink and shall be of strength 10,000 psi.

14.5. NOMINAL CONCRETE MIXES

14.5.1 Proportions of Mix

a. Cement and aggregates

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 so as to provide the concrete of the required crushing strength when tested as set out in Table 7.3.

b. The Contractor shall prepare a mix design of various grades of concrete for the approval of the Engineer prior to starting concrete works. He shall regulate and arrange mixing of the ingredients of the concrete by weight batching. The cost of designing the mix shall be borne by the Contractor.

c. Water Cement Ratio

The quantity of water used shall be just sufficient to produce a dense concrete of adequate strength and workability for its purpose. For all external work and foundations, the water/cement ratio should not exceed 0.55.

d. Workability

The workability shall be controlled by direct measurement of the water content, allowance being made for any water in the fine and coarse aggregates. The concrete shall be sufficiently workable to be placed and compacted, without difficulty, by the available means.

Workability shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given in PS 422 and PS 177 or ASTM C-143. The slump or compaction factor for each class of concrete shall be determined during the preliminary test mixes and the value obtained shall not be modified without the written consent of the Engineer. Unless otherwise permitted or specified, the concrete shall be proportioned and produced to have a slump of 3-inch or less if consolidation is to be by vibration. A tolerance of up to 1-inch above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

14.5.2 Strength requirements for concrete

a. Concrete made with Portland cement shall comply with the strength requirements as included in Table 14.3.

Table 14.3, Strength Requirements for Portland Cement Concrete

Sr. No.	Concrete Class	Nominal Ratio*	Concrete Strength**
1	A	1:1:2	4500

2	B (or A3)	1:1.5:3	4000
3	C (or A1)	1:2:4	3000
4	D	1:3:6	2200
5	E (Lean Concrete)	1:4:8	1400

* Nominal Ratio is indicative only, Contractor to prepare mix design to achieve the cylinder strength for the corresponding class of concrete.

** Cylinder strength at 28-days after mixing and pouring in psi.

b. The strengths given in Table 14.3 are based on the assumption that average temperature is 20 degree C. Where accurate records of temperature are kept, allowance may be made for change of temperature or the cylinders may be tested at the equivalent maturity.

c. All structural concrete shall conform to BS 5328.

d. Unless otherwise stated, the types of concrete shall be classified on the basis of compressive strength requirements. The Contractor shall provide Mix Design by weight for each class of concrete.

Manufacture 12 test cylinders (6-inch diameter x 12-inch height) in accordance with the mix design, batching by weight, and test 3 cubes each at 3, 7, 14 & 28 days intervals in the presence of Engineer's Representative 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.

No payments for producing the mix design, manufacture of test cubes and testing shall be made. The Contractor shall include this cost in the relevant item of concrete.

14.6. DELIVERY, STORAGE AND HANDLING

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4" maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day).

The Contractor shall provide and erect (at his cost) a suitable plain, dry, well ventilated, weatherproof and water proof shed of sufficient capacity to store the cement.

14.7. CAST-IN-SITU CONCRETE

14.7.1 Batching

a. All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement may be taken as 110 lbs. with the prior approval of the Engineer.

b. Aggregates shall be batched by weight, due allowance being made for moisture content. The apparatus for weigh-batching may be an 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 month.

c. The quantity of additives i.e. foaming and water proofing agents etc. shall be as prescribed by the manufacturer or as directed by the Engineer.

d. Where the batching plant is of the type in which cement and aggregates are weighed in the same compartment, the cement shall be introduced into the compartment between two sizes of aggregates.

e. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.

14.7.2 Mixing

a. The concrete shall be mixed in an approved batch mixer conforming to the requirements of BS 305. 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.

b. 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. If it is desired to use a mixing period of less than 1½ minute, the Engineer's approval shall be obtained in writing.

c. 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.

d. 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.

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

14.7.3 Transporting

a. 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.

b. During hot or cold weather, concrete shall be transported in deep containers, on account of their lower 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.

14.7.4 Placing

- a.** Before placing of concrete, formwork shall have been completed, water shall have been removed, reinforcement shall have been secured in place; expansion joint material, and other embedded items shall have been kept in position; and the entire preparation shall have been approved.
- b.** No concrete is to be placed into the foundation trenches until the ground to receive the same has been examined and approved by the Engineer for this purpose.
- c.** Concrete shall be deposited continuously, or in a layer of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the formation of seams or 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.
- d.** 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.
- e.** 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.
- f.** 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.
- g.** 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 not be used.
- h.** The 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. Concreting shall be carried on as a continuous operation using methods which shall prevent segregation or loss of ingredients.

- i.** The free fall of concrete shall not be allowed to exceed 5 ft. (1.5 m) and where it is necessary for the concrete to be lowered more than this depth, it is not to 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 size of the pipe shall be not less than 9-inch (225mm) diameter.
- j.** The workmen carrying concrete to the site, and all other workmen moving about on the reinforcement before the concrete is placed, shall move only along runways or planks placed for the purpose and no person shall be allowed to walk on the reinforcement itself.
- k.** Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by the Engineer, the surface will be brought to a true, hard, smooth, level surface using cement sand mortar in the ratio of 1-part of cement to 3-parts of sand. Two layers of building paper will then be laid flat to separate the concrete from the surface on which it is to be laid.

14.7.5 Construction Joints

- a.** Concreting shall be carried out continuously up to construction joints, the arrangement of which shall be predetermined by the Engineer.
- b.** Joints not shown on the Drawings shall be so made and located as to least impair the strength of the structure 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 not be at the underside of floor slabs or beams, and at the top of footings or floor slabs. Beams, brackets, columns, capital haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.
- c.** All reinforcing steel shall be continued across joints. Key and inclined dowels shall be provided as directed by the Engineer. Longitudinal keys at least 1½-inch (40 mm) deep shall be provided in all joints in walls and between walls and slabs or footings.
- d.** 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. Feather edges will be avoided.
- e.** 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.
- f.** 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 150 mm thick on horizontal surfaces. The fresh concrete shall be placed before

the grout has attained initial set.

g. Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristles and brushing, care being taken to avoid dislodgment 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 6-inch (150 mm) in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.

14.7.6 Expansion Joints

Expansion joints shall be provided wherever indicated on the Drawings. In no case shall the reinforcement, corner protection angles, 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 as approved by the Engineer. All materials for use in the expansion joints shall have prior approval of the Engineer before placing order for supply.

14.7.7 Embedded Items

a. The material, design and location of water stops in joints shall be as indicated in the Contract Documents. Each piece of re-moulded water stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum

b. 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 not less than 50 percent of the mechanical strength of the parent section, and shall permanently retain their flexibility

c. Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than four percent of the area of the cross section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location as not to impair unduly the strength of the construction; such sleeves, conduits, or pipes may be considered as replacing structurally in compression the displaced concrete, provided that they are not exposed to rusting or other deterioration, are of uncoated or galvanized iron or steel not thinner than standard steel pipe, have a nominal inside diameter not over 50 mm and are spaced not less than three diameters on centres except when Drawings of conduits and pipes are approved by the Engineer embedded pipes and conduits other than those merely passing through, shall not be larger in outside diameter than one third the thickness of the slab, wall, or beams in which they are embedded nor so located as to impair unduly the strength of the construction. Sleeve pipes, or conduits of any material not harmful to concrete and within the limitations of this section may be embedded in concrete with the approval of the Engineer provided they are not considered to replace the displaced concrete.

- d.** All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.
- e.** 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.
- f.** Expansion joint material, water stops and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

14.7.8 Mass Concrete

Mass-concrete shall be placed in layers approximately 18-inch thick. Vibrator heads shall extend into the previously placed layer.

14.7.9 Consolidation

a. All concrete shall be consolidated by vibration, spading, roding 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. Internal vibrators shall have a minimum frequency of 8000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. They shall be operated by competent workmen. Use of vibrators to transport within forms shall not be allowed. Vibrators shall be inserted and withdrawn at points approximately 18-inch 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.

- b.** 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 SECTION-14.5. **"NOMINAL CONCRETE MIXES"**
- c.** Vibrators shall not be allowed to contact the formwork for exposed concrete surfaces.
- d.** Mechanical vibrators shall be of a type suited in the opinion of the Engineer to the particular conditions.
- e.** Over-vibration or vibration of very wet mixes is harmful and should be avoided.

14.7.8 Curing and Protection

a. 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 snails are subject to approval of the Engineer.

b. For concrete surfaces not in contact with forms, one of the following procedures shall be applied immediately after completion of placement and finishing:

- Ponding or continuous sprinkling;
- Application of absorptive mats or fabric kept continuously wet;
- Application of waterproof sheet materials approved by the Engineer;
- Application of other moisture-retaining covering as approved; and
- Application of a curing compound conforming to ASTM C 309.

The compound shall be applied in accordance with the recommendations of the manufacturer immediately after- any water sheen, 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.

c. Moisture loss from surfaces placed against wooden forms or metal forms 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 for curing.

d. Curing in accordance with sub-clause 'a' & 'b' 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 cylinders kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated when the average compressive strength has reached 70 percent of the minimum specified works cylinder strength.

If one of the first four curing procedures of sub-clause 'b' is used initially, it may be replaced by one of the other procedures of that sub-clause any time after the concrete is one day old provided the concrete is not permitted to become surface dry during the transition.

e. When the mean daily outdoor temperature is less than 5 degree C (41 deg. F) temperature of the concrete shall be maintained between 14 and 20 degrees C (50 to 68 deg. F) for the required curing period of sub-clause 'd'.

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 without injury due to 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.

f. During hot weather when necessary, provision for wind-brakes, shading for spraying, sprinkling, ponding or wet covering with a light- coloured material shall be made, in advance of placement. Such protective measures shall be taken as quickly as concrete hardening and finishing operation will allow.

g. 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 deg. C (37 deg. F) in any one hour or 14 degree C (50 deg. F) in any 24-hour period.

h. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibrations. 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 over stress the concrete.

14.7.9 Application of Non-Shrink Grout

Concrete surfaces to receive non-shrinking 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 washed to prevent the formation of voids.

After non-shrink grout has received its initial set, it shall be kept damp for 24 hours.

14.7.10 Placing of Vapour Barrier

Vapour barrier shall be laid in position wherever shown on the Drawings.

The material shall be supplied in rolls and laid by rolling over the prepared surface at the levels and position in the areas shown on the Drawings. Where joint is necessary at the side or end of a sheet, this shall be a double weld folded joint made by placing the edges together and folding over twice continuously taking the top edge prior to concreting. The Contractor shall protect the film sheets from damages during laying and subsequent operations and shall replace at his own cost all damaged film sheets to the satisfaction of the Engineer.

14.8. WORKS IN EXTREME WEATHER

a. Unless adequate protection is provided and approval is obtained from the Engineer, concrete shall not be placed during rain.

Rainwater shall not be allowed to increase the mixing water nor to damage the surface finish.

b. 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 12-inch in any dimension nor 10°C for any other sections.

When necessary concrete material should be heated before mixing and carefully protected after placing, in general, heating or mixing

water alone to about 60°C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials containing ice shall be used. All 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 5.5 gallon/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 & aggregate having a temperature greater than 38°C.

c. 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 massive concrete, 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 flaked ice or well crushed ice of a size that will melt completely during mixing 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.

14.9. PRECAST CONCRETE

Precast concrete units shall be fair faced, cast to the sizes and dimensions as indicated on the Drawings. The concrete used for precast units shall conform to the specifications laid down for cast in situ reinforced cement concrete unless otherwise required and directed by the Engineer.

The Contractor shall be required to submit a sample of precast units for the approval of the Engineer all pre-cast units shall strictly conform to the approved sample.

Pre-casting platforms of the size and at the location approved by the Engineer shall be constructed. The concrete in one pre-cast unit shall be placed in one operation, in accordance with the details shown on the Drawings.

The material and design of formwork and the method of pre-casting the units shall be approved by the Engineer. The erection/installation and removal of the precast units from the pre-casting platform shall not be permitted until and unless they are properly cured to the satisfaction of the Engineer.

All precast units shall be smoothly finished to the required lines, grades, angles etc. Holes, grooves, pockets, hooks shall be provided as shown and/or as directed by the Engineer. The units shall be properly stacked on a platform without causing any cracks and damages. Curing of all the precast units shall be done in accordance with the relevant BS/approval of the Engineer.

14.9.1 Erecting Precast Units

All the precast units shall be transported and erected into position in a manner as approved by the Engineer.

The Contractor shall submit his proposal in this regard and obtain approval from the Engineer in advance.

The units shall be embedded or otherwise installed in their permanent positions as shown on the Drawings or as directed by the Engineer.

14.9.2 Lifting Beams

The Contractor shall use lifting beams at his own cost, for erecting pre-cast members where the Engineer so directs. Lifting beams shall be supplied and erected by the Contractor, at his own cost, at all points where lifting is necessary for maintaining the plant but is inaccessible to mobile cranes or alternatively, covered by overhead traveling cranes. The Contractor, however, is to supply the trolleys and erect them on the lifting beams, and to test operation of installed equipment.

14.10. CEMENT CONCRETE PAVEMENTS

For all concrete work relevant specifications of this section shall apply.

14.10.1 Side Forms and Construction

Side forms shall be of steel or any other suitable material and of a design as approved by the Engineer.

In general, only materials and methods that have proved their acceptability by past performance will be considered. All forms shall be constructed so that they can be removed without hammering or prying against the concrete.

Horizontal joints in the forms will not be permitted. Forms shall be thoroughly cleaned and oiled with linseed/mineral oil or shall be given two coats of nitro- cellulose lacquer each time they are used.

The forms shall be set on a thoroughly compacted base true to line and level and firmly secured in position by appropriate methods. Conformity with the alignment and levels shown on the Drawings shall be checked as and when required by the Engineer. Where necessary corrections shall be made immediately before placing the concrete; where any form has been disturbed it shall be reset and rechecked.

Pavements shall be constructed in panels of sizes as shown on the Drawings.

The panels shall be laid alternately, the adjoining panels being concreted when the side forms are struck and the jointing materials placed, inspected and approved by the Engineer. Each panel is to be concreted in one operation and no interruptions shall be permitted during the operation. The concrete shall be tipped from the trolley slightly in advance of the working place and then shovelled into position. The spreading shall be carried out very carefully. Compaction shall be done by means of vibro-compactors or approved surface vibrators. If a vibro-compactor is used, it shall be operated on the concrete and will not be allowed to strike or displace the forms. The spreading and compacting of the successive layers shall proceed without interruptions and as quickly as practicable so as to ensure that the slab is monolithic throughout its depth.

The wearing surface shall be laid while the base concrete is still wet and screeded to line and level. When the initial set takes place the surface shall be trowelled smooth with a steel trowel to provide a dense closed surface.

All the joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. The joint filler together with preformed groove shall provide complete separation of adjacent slabs. The joints shall all be sealed with bitumen as shown on the Drawings or/and as directed by the Engineer.

14.10.2 Protection and Curing

a. General Requirements

Concrete shall be protected adequately from injurious action sun, rain, flowing water and mechanical injury, and shall not be allowed to dry from the time it is placed until the expiry of the minimum curing periods specified hereinafter. Water curing shall be accomplished by keeping the surface of the concrete continuously wet by covering with water or with approved water saturated covering, where wood forms are left in place for curing.

They shall be kept sufficiently damp at all times to prevent openings at the joints and drying out of the concrete. All portions of the structure shall be kept moist for the full curing periods, specified hereinafter.

When liquid membrane curing compound is used the surface of the concrete shall be protected from traffic or other abrasive action that may break the membrane, for the full period of curing. The membrane curing compound shall be white coloured and shall be approved by the Engineer and shall comply with ASTM C 309, type 2.

b. Curing Periods

The curing period shall be at least 10 days, or as directed by the Engineer

c. Removal of Forms

The Contractor shall exercise great care in avoiding damage to joints, arises, dowel bars etc. while removing the forms. Under no circumstances will the use of pry bars between the forms and pavement be permitted. Side forms shall not be removed until at least 40 hours have elapsed from the time of completing the concreting of the slab which they contain. In no case shall forms be removed until the concrete has hardened sufficiently to permit removal without damage to the concrete. Concrete work shall be protected from damage during the removal of formwork and from injury resulting from the storage or movement of material during construction.

14.10.3 Finishing

All unformed surfaces shall be finished with a wood float except as otherwise specified. Visible vertical surfaces shall have all projections and irregularities removed. The entire surface shall be rubbed if required by the Engineer, with a No. 16 carborundum brick, or other abrasive until smooth and of uniform appearance, and shall be washed clean. Plastering of surface, application of cement or other coating will not be permitted.

All exposed corners shall be chamfered, 1-inch x 1-inch (25x25mm) unless otherwise mentioned or shown in the Drawings or directed by the Engineer. Concrete surfaces which will be covered with other materials shall be screeded without floating.

14.10.4 Spreading, Finishing and floating of concrete in pavements

a. General Requirements

The striking off, compacting and floating of concrete shall be done by mechanical methods, if approved by the Engineer. Where the Engineer determines that it is impracticable to use mechanical methods, manual methods of spreading, finishing and floating may be used on pavement lines as indicated on the Drawings.

b. Mechanical Methods

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine onto the finishing machine. Vibrators shall not rest on new pavements or side forms or in contact with any dowel bars, and the arrangement of power supply to the vibrators shall be such that when the

motion of the machine is stopped, vibration shall cease. The rate of vibration shall be not less than 8000 vibrations per minute. The concrete shall be spread to full width before being struck off and compacted so that the surface will conform to the finished grade and cross-section as shown on the Drawings and at the same time leave sufficient material for the floating operation. The spreading & finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer to ensure thorough compaction.

Except as otherwise specified, after the pavement has been struck off and compacted, it shall be finished with an approved longitudinal float. The Contractor may use a longitudinal float composed of one or more cutting and smoothing Floats, suspended from and guided by rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the forms.

The Contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre line and passing gradually from one side of the pavement to the other. Movements ahead, along the centre line of the road, shall be in successive advances of not more than half the length of the float.

Instead of using other types of longitudinal float a single machine which will affect satisfactory compaction, finishing and floating may be used. This machine may be towed by a spreading machine: This combination, finishing floating machine shall be equipped with screeds and vibrators as hereinafter specified for spreading and finishing machine Floating shall be accomplished by means of a non-oscillating float held in a suspended position from the frame.

If any spreading, finishing and floating equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or satisfactory equipment substituted or added at the direction of the Engineer.

c. Manual Methods

When striking-off and compacting by manual methods is permitted, the concrete shall be levelled and then struck-off to such an elevation that, when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process. While striking off, a slight excess of concrete shall be kept in front of the cutting edge at all times. Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated a manner

that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by 1 foot or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed with properly trussed roads to stiffen it and prevent sag and shall be shod with a heavy strip or metal for a tamping surface. The tamper shall be moved with a combined tamping and longitudinal motion, raising it forms side to side and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus material is compacted and rammed into front of the tamper or vibrating unit and tamping or vibrating shall continue until the true cross-section is obtained and the mortar flushes slightly to the surface. .

On grades in excess of 5 percent where hand methods are permitted, a light strike board shall follow at a speed of 25 ft to 50 ft per hour back of the heavy strike board, and shall be used in the same way, so as to remove waves caused by flow of concrete.

Where hand tamping is permitted, not less than two strike boards or tampers shall be used for production in excess of 350 cubic feet. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary, as directed by the Engineer.

d. Longitudinal Floating

Manual floats shall be at least 12 ft. in length not less than 6 inches in width and shall be properly stiffened to prevent bending or warping. In using the float, it shall be held parallel to the centre line of the pavement at all times and shall be moved laterally across the pavement from one side or edge to the other until all high areas are cut down and floated into depressions, leaving a surface that is smooth and true to grade. Batch transverse passage of the longitudinal manual float shall lap the proceeding passage by half.

e. First Straight Edge Testing

Immediately following final floating, the entire area of the pavement shall be tested with a 10-ft. (approx. 3-meters) straight edge. Any depressions found shall be immediately filled with fresh concrete which shall be struck off compacted and finished. High areas shall be worked down and refinished. The straight edge testing and re-floating shall continue until the pavement has the required surface contour.

f. Burlap, (Coarse Canvas) Dragging

After the first straight edge testing and when most of the water sheet has disappeared from the surface and just before the concrete becomes non-plastic, the surface shall be dragged with a strip of burlap (coarse canvas) 3

ft. to 10 ft. wide and having a length 4 ft. more than the width of the slab. The burl shall be dragged along the surface of the pavement in a longitudinal direction. Burlap shall be clean and kept free from coatings of hardened concrete. It shall be moist at the time of use.

g. Second Straight Edge Testing

After the concrete has hardened sufficiently to permit walking on it, the surface of the pavement shall again be tested with a 10-ft. straight edge. Any portion of the pavement which shows a variation from the testing edge of more than 1/8 inch shall be corrected by cutting, or shall be removed and replaced at the expense of the Contractor.

14.10.5 Expansion and Contraction Joints

a. All the expansion and contraction joints shall be carefully formed as shown on the Drawings or as directed by the Engineer. As regards dowel bars and joint assemblies, such stakes, brackets or other devices shall be used, as necessary to keep the entire joint assembly in true vertical and horizontal position. The joint filler together with the preformed groove shall provide complete separation of adjacent slabs. The joints shall be sealed with the specified non-extruding sealing compound set in a 3/4-inch wide preformed chase as shown on the Drawings. The preformed chase shall be thoroughly cleaned of all dust, debris, stone or other hard material prior to its sealing. The riser of all joints shall be rounded to a radius as shown on the Drawings before the concrete hardens.

b. The joint sealing compound shall be hot poured bitumen or approved sealing compound for concrete pavements complying with BS-2499 for hot tropical climates and heavy-duty industrial sites subject to severe exposure. All joints are to be filled with flexible expansion joint filler, or an approved elastic, compressible, durable and rot-proof equivalent of sufficient rigidity to enable it to be satisfactorily installed in the joint and resist deformation during the passage of the concreting equipment. The filler is to be of the same thickness as the joint width. Holes to accommodate the dowel bars shall accurately be drilled or punched out. Where shown on the Drawings, dowel bars of required diameter shall be placed at the specified spacing. The bars shall be lubricated with an approved lubricant. One end of the dowel bar at expansion joints shall be provided with a closely fitting sleeve 3-inch long, consisting of bitumen coated plastic or other approved material to permit expansion. A loose plug 1 inch deep of approved compressible filling material shall be inserted into the sleeve as shown on the Drawings at the end of the bar. All the dowel bars shall be mild steel bars of

the size shown on the Drawings and shall conform to the requirements as specified in the SECTION-8, REINFORCEMENT.

- c.** Contraction joints shall be provided as shown on the Drawings.
- d.** The assembly and method of constructing the expansion joints/contraction joints shall be subject to the approval of the Engineer.
- e.** In general, all PVC water stops/hydrofoil shall be placed in the centre of the structural member. Each piece of the water stop-hydrofoil shall be of maximum practicable length. An ordinary sharp knife saw or any other sharp tool can be used to cut the water stop. Joints at inter sections 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 and shall permanently retain their flexibility. For straight line connection, the melting method of connection can be used by passing two water stops intended for connection against a heated iron or copper sheet. When they are melted, the two are combined.
- f.** After joining, the water stop should be allowed to cool.
- g.** For all other connections such as T-type or L-type, the welding method of joining should be used. A welded rod of the same material as the water stop shall be used. The welding rod & the water stop shall be heated & melted at the same time, by means of heated air jetting from the hot jet gun.

14.11. TEST OF CONCRETE QUALITY

The Contractor shall provide samples of concrete for testing at the Engineer's direction. Proper facilities shall be provided for making and curing the test specimens. A competent person shall be employed by the Contractor whose first duty shall be to supervise all stages in the preparation and placing of the concrete. All test specimens shall be made at site and tests carried out under his direct supervision.

Cylinder test shall be performed in accordance with the discretion of the Engineer. The standard of acceptance for preliminary and works tests shall be as given below,

The usual test for concrete with maximum size of aggregate up to 1-112 inch is the 6-inch cylinder tested in compression. Details of the testing are given in ASTM C 39.

For all grades of concrete; preliminary cylinder strength test with the mixes and materials to be used shall be performed in accordance with ASTM C 31 before the work is begun and subsequently whenever any change is to be

made in the materials or in the proportions of materials to be used, or as required by the Engineer. The strengths shall comply with the standard of quality specified in accordance with Table 14.3 in accordance with ASTM C39. The cost of such testing shall be borne by the Contractor.

Test samples shall be taken at the mixer or as directed by the Engineer. The test specimens shall be cured in accordance with ASTM C 31.

Records shall be kept of all test cylinders identifying the mix used, the section of work for which the concrete was used and the date poured.

Five test cylinders are to be tested for compressive strength as specified in ASTM C 39. These tests shall be carried out at site or in a laboratory, approved by the Engineer. Two cylinders shall be tested at the age of seven days and three at 28 days and the strengths determined are to comply with the standard of quality specified. The laboratory tests shall be carried out by an independent organization, such as Government Testing' Laboratory or such other undertakings approved by the Engineer. The original test reports received from the above authorities should be submitted to the Engineer.

For all grades of concrete, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the cylinders is below the specified cylinder strength or if the average strength of the three cylinders is not less than the specified cylinder strength and the difference between the greatest and the least strength is not more than 20% of the average.

When the results of works cylinder tests show that the strength of any concrete is below the minimum specified* the Engineer may give instructions for the whole or part of the work concerned to be removed and replaced at the expense of the Contractor. The Contractor shall bear the cost of any other part of his, or any other contractor's worst, which has to be removed and replaced as a result of the defective concrete. If any concrete is held to have failed, the Engineer may order the proportions of that class of concrete to be changed in order to provide the specified strength.

14.12. FINISHING OF FORMED SURFACES

14.12.1 General

a. 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.

b. When finishing is required to match a small sample furnished to the Contractor, the sample finish shall be reproduced on an area at least 100 sq.ft. in an inconspicuous location designated by the Engineer before proceeding with the finish in the specified location.

c. Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 9. Tolerances

for concrete construction are defined as tolerances 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 advised 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 sheeting or lining or section, 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 is 2 metre for testing of formed surfaces and 3 metre for testing of unformed surfaces.

14.12.2 As-cast Finishes

Unless otherwise specified or indicated on the Drawings the classes of finish shall apply as follows:

a. Rough form finish

No selected form facing materials shall be specified for rough form finish surfaces. The holes and defects shall be patched. Otherwise, surfaces shall be left with the texture imparted by the forms.

b. 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 inspection. Surfaces of concrete structures requiring fair face finish as shown in the Drawings. Surface irregularities, measured as described in sub-clause 7.2.1, 'Rough form finish', shall not exceed 4 mm for gradual irregularities and 6mm for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints. Abrupt irregularities at construction joints and elsewhere in excess of 6 mm and gradual irregularities in excess of 1/8 inch. (3mm) shall be reduced by grinding so as to conform to the specified limits. Abrupt irregularities at construction joints shall be ground on a level of 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, tempered concrete form grade 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 other defects which will impair the texture of the concrete surface shall not be used. The holes and defects shall be patched. All fins shall be completely removed

c. Architectural Finish Concrete

Architectural finish to concrete formed surfaces as shown on the Drawings is required by the Engineer where the architectural appearance of surfaces of structures exposed to public view is of special consideration and importance. The Contractor shall use approved special material for formwork and design the forms in conformity with the specified architectural patterns, textures and finishes in order to obtain first class architectural finish on formed concrete surface without any defect, irregularities, blemishes, imperfections and encrustations.

i Sample approvals of precast & in-situ concrete

These samples will be reviewed and approved on the basis of colour, dimensional accuracy, and finish of surfaces and general appearance. The same requirements for sample approval will be required for both precast and in-situ concrete exposed surfaces.

ii Forms

The contractor must maintain the forms unusually tight and braces to prevent movement, mal-alignment and bleeding that will result in sand streaks, honeycomb, fins, stain or unsightly appearance.

If wood forms are chosen to be used by the Contractor they shall be constructed of 3/4 inch. (20mm) minimum thickness plywood constructed in a fashion to allow many re-uses with all surfaces sealed with a polyurethane varnish.

Edges, surfaces and corners of forms shall be sealed to prevent loss of any matrix or unequal absorption of water. Corners of wood forms shall be filled with suitable compound and all contact surfaces sealed with a polyurethane varnish.

Re-use of forms shall be subject to approval of the Engineer.

iii Curing

Curing shall be done in shade (out of direct sunlight) and shall be for a minimum period of 4 days.

iv Finishing procedures:

Finishing procedures for filling air void in smooth finished concrete developed by a formed surface.

While the concrete surface is still damp (not more than three days after removal of forms), apply a thin coat of medium consistency neat cement slurry by means of bristle brushes to provide a bonding coat within any pit or blemishes in the parent concrete; avoid coating large areas of the finished surface. Before slurry has dried or changed colour, apply a dry (almost crumbly) grout comprised of one-part cement, of the type and brand of cement used in the original concrete, to one and one-half parts clean masonry sand with a fineness modulus of approximately 2.25 and complying with the gradation requirements of the ASTM Specifications C144. Mix proper amounts of white cement and colouring with the parent mortar to produce a satisfactory colour match with the parent concrete after hardening. Use samples previously prepared.

Apply the finishing grout uniformly with damp (neither dripping wet nor dry) pads of coarse burlap approximately 6-inch square used as a float. Scrub the grout well into the pits to provide a dense mortar in all the imperfections to be filled. Allow the mortar to partially harden, from one to two hours, depending upon the weather. Avoid direct hot sunlight. If the air is hot and dry, keep the concrete surface damp during this period using a fine fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the edge of a steel trowel without damaging the grout from the small pits or holes, cut off all that can be removed with a trowel without delay; next allow the surface to dry thoroughly and rub it vigorously with clean, dry burlap to completely remove any dried grout. No visible film of grout shall remain after this rubbing. Complete the entire cleaning and grouting operation for the grout to dry after it has been cut with the trowel, so it can be wiped off clean with the burlap.

On the day after the repair work, the concrete surfaces should again be wiped off clean with dry burlap to remove any inadvertent dust leaving no built-up surfaces on the parent surfaces. Employ, if possible, a used piece of burlap containing old hardened mortar to act as a mild abrasive. Use of fine abrasive stone if needed to remove any remaining built-up film without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or changing the texture of concrete. Following the final bagging or stoning operation, provide a thorough wash down with stiff bristle brushes to remove all extraneous materials and spray the concrete surface

with a fine fog spray periodically to maintain a continually damp condition for at least three days after application of the pit repair grout.

v Rust Stains

All rust stains are to be removed employing the following procedure:

The rust stain shall be soaked for 10 minutes with a solution of (0.055 lb.) 25gm of sodium citrate in (0.33lb) 150 gms water (brushing the solution at short intervals is satisfactory). Then the surface is sprinkled with crystals of sodium hydrosulfite and covered with a paste of Fuller's Earth and water. On a vertical surface, the paste is applied with a trowel, with the crystals first sprinkled on the paste so they will be in direct contact with the stain. The paste is allowed to dry for 10 minutes then scraped off and the treatment repeated if necessary.

vi Repairing of Formed Surfaces:

It is the intention of Specification to require forms, mixture of concrete and workmanship so that concrete surfaces, when exposed, will require no patching. Any concrete which is not formed as required and conforming to approved samples or for any reason is out of alignment or level or shows a defective surface, shall be removed from the job by the Contractor at his expense unless the Engineer grants permission to repair the defective area. Permission to patch any such area shall not be considered as waiver of the Engineer's right to require a complete removal of defective work if the repair does not, in his opinion, satisfactorily restore the quality and appearance of the surface. The Engineer shall be the sole judge of acceptability of appearance.

vii Finishes of Unformed Surfaces

Where monolithic concrete floor finish is shown on the drawings, placing shall proceed continuously for the full thickness of the course or RCC slab without change in concrete mix. Mixing water shall be the minimum required for the proper area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wall, which will be exposed.

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 2 sq ft. in each 1000 sq.ft. of as-cast surface. This is in addition to form tie patches, if the project design permits ties to fall within as-cast areas.

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 colour match with the concrete when both patch and concrete are cured and dry. After the initial set, surfaces of patches shall be dressed manually to obtain the same texture as surrounding surfaces.

Patches in architectural concrete surfaces shall be cured for 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

viii Tie and Bolt Holes

After being cleaned and thoroughly dampened, the tie and bolt holes shall be filled solid with patching mortar.

ix 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.

14.13. TOLERANCES

Where tolerances are not stated in the 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 limits. These allowable tolerances shall not relieve the Contractor of the responsibility for correct fitting of indicated materials. Those tolerances are not cumulative.

a. Variation from the plumb (or the specified better for inclined walls)

i In the lines and surfaces of columns, piers, and walls and in arises.

In any 10 ft. (3 metre) of length or height: 1/4" (6 mm)

In any storey or 20 ft. (6 metre) maximum: 3/8" (10 mm) Maximum for
the entire length or height: 1" (25 mm)

ii For exposed corner columns, control joint grooves and other conspicuous lines.

In any bay or 20 ft. (6 metre) maximum 1/4" (6 mm) Maximum for the entire
length or height 1/2" (13 mm)

b. Variation from the level or from the grades indicated on the Drawings.

i In floors, ceilings, beams soffits and in arises.

In any 10 ft. (3 metre) of length 1/4" (6 mm) In any bay or 20 ft. (6
metre) maximum 3/8" (10 mm)
Maximum for the entire length 3/4" (20 mm)

ii For exposed lintels, sills, parapets, horizontal grooves and other

conspicuous lines.

In any bay or 20 ft. (6 metre) maximum length	1/4" (6 mm) Maximum for the entire length 3/8" (10 mm)
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c. Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

In any bay or 10 ft. (3 metre) Maximum	1/2" (13 mm) Maximum for the entire length 1" (25 mm)
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d. Variation in the sizes and locations of sleeves, Floor openings and wall openings. ± 1/4" (± 6mm)

e. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls.

Minus	1/4" (6mm)
Plus	1/2" (13mm)

f. Footings

i Variation in dimensions in plan Minus
Minus 1/2" (13 mm)
Plus (plus variation applied to concrete only, not to reinforcing bars or dowels).
2" (50mm)

ii 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).
2" (15 mm)

iii Thickness

Decrease in specified thickness limit	5% Increase in specified thickness	No
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g. Variation in Steps

i In a flight of stairs	
Rise	1/8" (3 mm)
Tread	1/4" (6 mm)

ii In consecutive steps:

Rise 1/16" (1.5 mm)

Tread 1/8" (3 mm)

h. Tolerances for Pre-Cast Concrete Constructions

Forms must be true to size and dimensions of concrete members shown on the Drawings and be so constructed that the dimensions of the finished products will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on structural-architectural Drawings:

i Overall dimensions of members 1/16" per 10 feet

ii Cross-sectional dimensions

Sections less than 3-inch	1/16" (1.5 mm)	Sections over 3-
inch and less than 18-inch	1/8" (3 mm)	Sections over 18-inch
1/4" (6 mm)		

iii Deviations from straight line in long sections

Not more than 1/8" per 10 feet

iv Deviation from specified camber 1/16" per 10 feet

v Maximum differential between adjacent units in erected position 1/4" (6 mm)

14.14. ACCEPTANCE OF STRUCTURE

14.14.1 General

a. Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the Contract Documents.

b. 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.

c. 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.

14.14.2 Dimensional Tolerances

a. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of SECTION-14.13 shall be considered potentially deficient in strength and subject to the provisions of SECTION-14.14.4.

b. Formed surfaces resulting in concrete outlines larger than permitted

by the tolerance of SECTION-14.13 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.

c. Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or if misplaced items interfere with other construction.

d. Inaccurately formed concrete surfaces exceeding the limits of SECTION-14.13 or SECTION-10 CONCRETE FORMWORK & ACCESSORIES and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

14.14.3 Appearance

a. Architectural concrete with surface defects exceeding the limitations of SECTION-17 CONCRETE FORMWORK & ACCESSORIES shall be removed and replaced.

b. Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods.

c. Concrete not exposed to view is not subject to rejection for defective appearance.

14.14.4 Strength of Structure

a. The strength of the structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions:

- Concrete strength requirements not considered to be satisfied in accordance with SECTION-14.5.2.
- Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements as listed under specification of 'Reinforcement' or in the contract documents.
- Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.
- Curing less than that specified.
- Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.
- Mechanical injury, construction fires, accidents or premature removal of formwork likely to result in deficient strength.
- Poor workmanship is likely to result in deficient strength.

- b.** Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- c.** Core tests may be required when the strength of the concrete in place is considered potentially deficient.
- d.** If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their result evaluated in accordance with British Standard, CP 110 or ACI 318.
- e.** Concrete work judged inadequate by structural analysis 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.
- f.** The Contractor shall pay all costs incurred in providing the additional testing and/or analysis required by this section.
- g.** All costs of additional testing and/or analysis which is made at the Employer request and which is not required by these Specifications, or by the Contract Documents shall also be borne by the Contractor.

14.15. MEASUREMENT AND PAYMENT

14.15.1 Measurement

Concrete will be measured for the number of cubic foot or cubic metre (whichever is included in Bill of Quantities) acceptably placed complete in all respects as per Drawings and in strict accordance with this section of specification.

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.

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under this specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account:

- Providing, fixing, striking, etc. of formwork.
- Providing, placing and fixing of anchor bolts or any other embedded parts.
- Providing and installing all types of joints in concrete structure, including expansion joints.
- Providing and fixing water stoppers.

14.15.2 Payment

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the specifications and shall constitute full compensation for furnishing all materials, shuttering, equipment and labour and for performing all operations necessary to complete the work.

Concrete shall be measured as executed but no deductions shall be made for the following:

- Volume of any steel embedded in the concrete;
- Volume occupied by water pipes, conduits etc. not exceeding 10 square inches each in cross-sectional area; and
- Voids not exceeding 4 square inches in work given in square feet. If any void exceeds 4 square inches, total void shall be deducted.

Voids, which are not to be deducted as specified above refer only to openings or vents which are wholly within the boundaries of measured areas.

Openings or vents which are at the boundaries of measured areas shall always be subject to deductions irrespective of size.

Concrete work shall be classified and measured separately as listed under items of Bills of Quantities.

Junction between straight and curved works shall in all cases be deemed to be included with the work in which they occur.

SECTION-15- REINFORCEMENT

15.1. SCOPE OF WORK

The work under this section of specifications consists of furnishing, cutting, fabricating, bending and placing steel reinforcement as shown on the Drawings or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

15.2. APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

15.2.1 Pakistan Standard

- PS 241, Tensile testing of steel
- PS 244, Bend test for steel
- PS 580, Rolled deformed steel bars (intermediate grade) for concrete reinforcement
- PS 605, Rolled deformed steel bars (hard grade) for concrete reinforcement
- PS 606, Rolled deformed steel bars (structural grade) for concrete reinforcement
- PS 607, General technical delivery requirement for steel

15.2.2 British Standard

- BS 693, General requirements for oxy-acetylene welding of mild steel
- BS 785, Hot rolled bars and hard drawn wire for the reinforcement of concrete
- BS 1856, General requirement for the metal arc welding of mild steel
- BS 4449, hot rolled steel bars for reinforcement of concrete
- BS 4461, Cold worked steel bars for reinforcement of concrete
- BS 4466, Bending dimensions and scheduling of bars for the reinforcement of concrete

15.2.3 ASTM Standard

- ASTM A 305, Minimum requirement for the deformations of deformed steel bars for concrete reinforcement
- ASTM A 615, Deformed billet steel bars for concrete reinforcement

15.2.4 ACI Standard

- ACI 315, Manual of standard practice for detailing reinforced concrete structure
- ACI 318, Building code requirements for reinforced concrete

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 standards as may be specified by the Engineer for Special Material and construction are also relevant.

15.3. SUBMITTALS

The Contractor shall submit the following to the Engineer for approval before commencement of work:

- Bar bending schedule prepared by Contractor on the basis of approved Drawings for the approval of the Engineer.
- Results of all tests performed upon steel reinforcement bars obtained from the site of work as per directions of the Engineer.

15.4. MATERIAL REQUIREMENTS

Reinforcement for concrete shall conform to the respective Pakistan, British, ASTM, or other Standards as specified in the Drawings and in the Contract Documents or as may be specified by the Engineer.

Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of BS 4449 for plain mild steel bars and shall have a minimum characteristic strength of 40,000 psi.

Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of BS 4461 for deformed cold worked new stock billet steel bars and shall have a minimum characteristic strength of 60,000 psi.

Steel wire mesh reinforcement shall conform to requirements of ASTM Designation A-185-64 or BS 4483. Standard Specifications for Welded Steel Wire Fabric for concrete reinforcement. It shall be used where shown on the Drawings.

Reinforcement shall be free from all loose or flaky rust and mill scale, or coating, including ice, and any other substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not be used.

15.5. DELIVERY & STORAGE

15.5.1 Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged.

15.5.2 Storage

The method of storage shall be approved by the Engineer. 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. Bars of different diameters and grades of steel reinforcement shall be kept separately.

15.6. BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and these bar bending schedules shall be submitted to the Engineer for approval. The Contractor shall obtain approval of the bar bending schedules before starting actual bar bending works.

15.7. FABRICATING, BENDING & PLACING

All metal for reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.

Reinforcement is to be accurately placed as shown in the Drawings, and secured against displacement by using 16-gauge G.I wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than 1 part of cement to 2 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.

Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer. The cutting tolerance for all bars shall be ± 1 inch. (± 25 mm).

Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as included in **Table 15.1**.

Table 15.1, Bending Tolerances for Reinforcement Bars

Sr. No.	Dimension of Bent Bars		Tolerance	
	Over Feet	Up to & Including Feet	Plus Inch	Minus Inch
1	-	3	1/5	1/5
2	3	6	1/5	1/5
3	6	-	1/5	1

Bars shall be placed to the tolerances as included in Table 8.2.

Table 15.2, Placement Tolerances for Reinforcement Bars

Sr. No.	Location of Bars	Tolerance
1	Concrete cover to formed surfaces	$\pm 1/4"$ (± 6 mm)
2	Minimum spacing between bars	$\pm 1/4"$ (± 6 mm)
3	Top bars in slabs and beams	
	Members 8 inch deep or less	$\pm 1/4"$ (± 6 mm)

Sr. No.	Location of Bars	Tolerance
	Members more than 8 inch but not over 24 inch deep	$\pm 3/8"$ ($\pm 10\text{mm}$)
	Members more than 24 inch deep	$\pm 1"$ ($\pm 25\text{mm}$)
4	Crosswise members spaced evenly within	$\pm 2"$ ($\pm 50\text{mm}$)
5	Lengthwise members	$\pm 2"$ ($\pm 50\text{mm}$)

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.

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.

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 Engineer reinforcement shall not be bent after being partially embedded in hardened concrete.

No splice of reinforcement shall be made except as shown on the working Drawings.

Welding shall be permitted for bars only under suitable conditions and with suitable safeguards in accordance with BS 693, PS 1856, or AWS D12.1, provided the type of reinforcement bar has the required welding properties. Tack welding may be used to fix position bars that cross each other, only with prior approval of the Engineer.

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.

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

Welding shall be done as in section 'Structural Steel Works'. All detailing shall be done as per ACI standards ACI-315 and ACI-318.

Concrete clear cover for reinforcing steel shall be as provided in Drawings. All reinforcing steel shall be held firmly in place before and during the placing of concrete by means of wires and supports adequate to prevent displacement during the course of construction.

15.8. MEASUREMENT & PAYMENT

15.8.1 Measurement

The measurement for acceptably completed works of reinforcement according to bar bending schedules approved by the Engineer shall be made by weight computed on the bases of Table 15.3.

The Contractor shall not claim for the difference in the actual weights of bars and their standard weights given in Table 15.3.

Table 15.3, Standards Weights of Reinforcement Bars

Sr. No.	Nominal Bar Diameter, Inch	Bar No.	Weight, lb/ft
1	3/8	#3	0.376
2	1/2	#4	0.668
3	5/8	#5	1.043
4	3/4	#6	1.502
5	7/8	#7	2.044
6	1	#8	2.670
7	1-1/8	#9	3.400
8	1-1/4	#10	4.303

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specifications in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

Providing and installing cover blocks, chairs, supports, hooks, spacers, binding wires, and laps not shown on Drawings including wastage and rolling margin and as such are not payable. Laps shown on Drawings shall be payable.

15.8.2 Payment

Payment will be made for an acceptable measured quantity of reinforcement on the basis of unit rate per metric ton or kg (whichever is included in Bill of Quantities and shall constitute full compensation for all the works related to the item.

The rate quoted include all lead/lift required for steel fabrication & placement at/in any floor or at any height as per Drawings.

SECTION -16- SULPHATE RESISTANT CEMENT CONCRETE

16.1. SCOPE OF WORK

This work shall consist of providing sulphate resistant cement in place of Portland cement to all classes of concrete subject to the contact with soil having sulphate content more than 0.1% and with ground water having sulphate content more than 1500 ppm or as mentioned in the drawing or directed by the Engineer. Maximum Chloride Ion Concentration (as a percentage of weight of cement) arising from all sources including aggregates should not exceed 0.1 for pre-stressed concrete, 0.2 for any concrete using sulphate resistance cement and 0.35 for all other cement containing matter. All requirements of concrete with sulphate resistant cement are same as mentioned in SECTION-14, PLAIN & REINFORCED CONCRETE except amended in this section

16.2. MATERIAL REQUIREMENTS

Sulphate resistant cement where required shall be sulphate resistant cement type 'A' fully conforming to Pakistan standard specification PS 612:1967 and satisfying to requirements for fineness, chemical composition, strength, setting time and soundness etc. The average compressive strength of three mortar cubes prepared with 1:3 cement and standard silica sand mortar shall not be less than 20.0 N/mm sq. at seven days. The initial setting time shall not be less than 45 minutes and final setting time not more than 10 hours.

16.3. MEASUREMENT AND PAYMENT

16.3.1 Measurement

The quantity of concrete with sulphate resistant cement shall be measured exactly in the same way as mentioned in SECTION-14 PLAIN & REINFORCED CONCRETE and subsequently paid as elaborated below.

16.3.2 Payment

The accepted quantity measured as provided above shall be paid only for the difference of cost for providing sulphate resistant cement in place of ordinary Portland cement at the contract unit price for particular pay item(s) as provided in the Bill of Quantities, which price and payment shall be full compensation for all the costs involved in the proper completion of the works.

SECTION-17-CONCRETE FORMWORK & ACCESSORIES

17.1. SCOPE OF WORK

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 in connection with the supply and installation of formwork for the purpose of shuttering in concreting work, complete in strict accordance with this section of the specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

17.2. APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

17.2.1 American Concrete Institute

- ACI 301, Specifications for Structural Concrete for Buildings
- ACI 318, Building Code Requirements for Reinforced Concrete
- ACI 347, Recommended Practice for Concrete Formwork

17.2.2 American Plywood Association:

- APA, High Density Overlaid Concrete Form, Class 1
- APA, Structural 1, Exterior Quality, Class 1
- APA, Plastic Overlaid Plywood Forms

17.2.3 American National Standard Institute

- A199.1, Construction and Industrial Plywood.

17.3. SUBMITTALS

- a. Product's Data: Submit manufacturer's specifications and installation instructions for proprietary materials and items as required, including form coatings, manufactured form systems, ties and accessories.
- b. Detail Shop Drawings: Submit data on sequence of the concrete placement, location of construction joints, camber details, bearing values of the soils supporting false-work under wet and dry conditions, the anticipated settlements as well as false-work release sequence.

17.4. MATERIAL REQUIREMENTS

17.4.1 Concrete Formwork

Unless otherwise specified construct formwork of plywood, metal, metal framed plywood faced or other panel type materials acceptable to Engineer to provide continuous, straight, smooth surfaces. Provide formwork in the largest practice sizes to minimize the number of

joints and to conform to the joint system indicated on Drawings. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection. Provide wood forms of minimum thickness of 16 mm.

17.4.2 Forms of Unexposed Finish Concrete

Provide forms of plywood, lumber, metal or glass fibre reinforced plastic or other acceptable material.

17.4.3 Form Ties

Provide factory fabricated, adjustable length, removable or snap off metal form ties, designed to prevent form deflection and to prevent spalling concrete surfaces upon removal. Use Plastic cone type, with threaded steel rod. For water tanks or other water retaining structures use watertight form ties as recommended by the manufacturer.

Unless otherwise indicated, provide ties so that the portion remaining within concrete after removal of exterior parts is at least 38 mm from the outer concrete surface. Provide form ties which will not leave a hole larger than 25 mm diameter in the concrete surface.

Form ties fabricated on Project Site and wire ties are not acceptable.

17.4.4 Form Release

Non staining, non-reactive, rust preventive guarantee not to affect bond of subsequent surface applications to concrete.

17.5. DESIGN OF FORMWORK

Design, erect, support, brace and maintain formwork to safely support vertical and lateral loads applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by formwork system and in-place construction that has attained adequate strength for the purpose. Design and construct formwork of concrete members and structures to correct size, shape, alignment, elevation and position.

Design form and false-work to include assumed value of live load, dead load, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability and other factors pertinent to safety of structure during construction.

Design formwork to be readily removable without impact, shock or damage to cast in place concrete surfaces and adjacent materials.

Provide formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide back-up material at joints as required to prevent leakage and fins.

Design forms according to ACI 318, Parts 1, 2, and 3 requirements as well as ACI 347 requirements for loads, lateral pressure, and allowable stresses; in addition to other design parameters.

17.6. DELIVERY AND STORAGE

17.6.1 Delivery

The delivery of formwork materials shall be done in such a manner that damage can be prevented.

17.6.2 Storage

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

Material which can be affected by weathering shall be stored in appropriate buildings or under covers and shade.

17.7. QUALITY ASSURANCE

Design, construct, erect, support, brace, maintain and remove forms according to ACI 318, Parts 1, 2, and 3 requirements as well as ACI 347 requirements for loads, lateral pressure and allowable stresses; in addition to other design parameters such as wind loads.

Construct formwork so that cast concrete surfaces will conform to the requirements of ACI 301, Chapter 4, Paragraph 4.3 Tolerances.

Maximum allowable deflection of forming surfaces from concrete pressure will be length/360 between supports.

Provide surveys as required to check the lines and levels of the completed formwork for exposed concrete before concrete is placed. Make the required corrections or adjustments to formwork to correct deviations which exceed the specified tolerances.

Check formwork during concrete placement to ensure forms, shores, false- work, ties and other features have not been unduly disturbed by concrete placement methods or equipment. Report in writing to the Engineer deviations from the allowable tolerances

17.8. EXECUTION

17.8.1 Inspection

Examine substrate and conditions under which concrete formwork is to be performed. Correct any unsatisfactory conditions. Proceed with the work after unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

17.8.2 Form Construction

a. General

Construct forms complying with ACI 347, to sizes, shapes, lines and dimensions indicated and required to obtain accurate alignment, location, grades, level and plumb work in the finished structures. Provide for openings, offsets, sinkages, keyways, recesses, mouldings, rustication, reglets, chamfers, blocking, screed, bulkheads, anchorages, inserts, and other features required. Use selected materials to obtain the required finishes.

Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and assure ease of removal.

Provide temporary openings where the interior area of formwork is inaccessible for cleanout, inspection before concrete placement and placement of concrete. Securely brace temporary closures and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

Form intersecting planes to provide true, clean out corners, with edge grain of plywood not exposed as form for concrete.

b. False-work

Erect false-work and support, brace and maintain it to safely support vertical, lateral and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct false-work so that adjustments can be made for take up and settlement.

Provide wedges, jacks or camber strips to facilitate vertical adjustment. Inspect false-work and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure and make necessary adjustments to produce work of required dimensions.

Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Provide trussed supports when adequate foundations for shores cannot be secured.

Support form facing materials by structural members spaced sufficiently close to prevent deflection. Fit forms placed in successive units for continuous surfaces to an accurate alignment, free from irregularities and within allowable tolerances. Provide camber in formwork as required for anticipated deflections due to weight and pressures of fresh concrete and construction loads for long span members without intermediate supports.

Provide temporary openings in wall forms and at other locations necessary to permit inspection and clean out.

c. Forms for Exposed Concrete

Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Do not splinter forms by driving ties through improperly prepared holes.

Do not use metal cover plates for patching holes or defects in forms.

Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.

Use extra studs and bracing as required to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material which will produce a bow.

Assemble forms in a way to be readily removed without damage to exposed concrete surfaces.

Form mouldings shapes, recesses and projections with smooth finish materials and install in forms with sealed joints to prevent displacement.

d. Corner Treatment

Form exposed corners to produce square, smooth, solid, unbroken lines, except as otherwise indicated.

Provide chambers for surfaces where indicated on Drawings.

Unless otherwise indicated, form chamfers using wood strips 19 x 19 mm; accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Extend terminal edges to required limit and miter chamfer strips at changes in direction.

e. Provisions for other Trades

Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses and chases required for such work. Accurately place and securely support built-in items into forms.

f. Cleaning and Tightening

Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete placement. Re-tighten forms immediately after concrete placement as required to eliminate mortar leaks.

17.8.3 Form Coatings

Coat form contact surfaces with form coating compound before placing the reinforcement. Provide form coating compounds that will not bond with, stain, nor adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. Do not allow excess form coating material to accumulate in the forms or to come into contact with surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.

Coat steel forms with a non-staining, rust preventive form oil or otherwise protects against rusting. Rust stained steel formwork is not acceptable.

17.8.4 Installation of Embedded Items

a. General

Set and build into the work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast in place concrete. Use setting drawings, diagrams, instructions and directions provided by the suppliers of these items to be attached thereto.

b. Edge Forms and Screed Strips for Slabs

Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in the finished slab surface. Provide and secure units to support types of screed required.

c. Metal Inserts

Provide metal inserts for anchorage of materials or equipment to concrete construction, as required for the work.

Provide adjustable wedge inserts of malleable cast iron, complete with bolts, nuts and washers; 19 mm bolt size unless otherwise indicated.

Provide threaded inserts of malleable cast iron, furnish complete with full depth bolts; 19 mm bolt size, unless otherwise indicated.

Provide box out sections in concrete work as required for installation of equipment or other work.

Coordinate location of all required embedded weld plates and other items for attachment of precast concrete to cast in place concrete.

17.8.5 Shores and Supports

Shore floor directly under slab being placed so that loads from construction above will safely transfer directly to these shores. Space out shoring below this level in such a manner that

no member will be excessively loaded or will induce tensile stress in concrete members where no reinforcing steel is provided. Extend shores beyond minimum if required to ensure the proper distribution of loads and the safety of all concrete members.

Remove shores and reshore in a planned sequence to avoid damage to partially cured concrete, and to assure that the structure supported is not subjected to impact or loading eccentricities. Locate and provide adequate reshoring to safely support the work.

17.8.6 Removal of Forms

Formwork not supporting concrete, such as sides of beams, columns, walls, and similar parts of the work (vertical faces) may be removed not less than 24 hours after placing concrete provided that concrete is sufficiently hard and will not be damaged by form removal operations, and provided that curing and protection operations are maintained.

Formwork supporting weight of concrete, such as slabs and other structural elements must remain in place for the time period shown in ACI 347 (assuming design live load is less than dead load) and until concrete has attained design minimum 28-day compressive strength determined by field-cured specimens as defined below. Do not remove forms until the approval has been obtained from the Engineer.

Form facing material may be removed not less than 4 days after placement, provided shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports and provided that concrete has achieved adequate compressive strength to safely support the load.

Use necessary means and precautions to protect workmen, passer-by, the installed work and material of other trades and complete safety of structure.

Cut nails as well as form ties off flush leaving surfaces smooth and clean.

Remove metal spreader ties on exposed concrete by removing or snapping off inside the wall surfaces and pointing up and rubbing the resulting pockets to match surrounding surfaces.

Flush holes resulting from spreader rods and sleeve nuts, using water, solidly pack throughout the wall thickness with cement grout applied under pressure by means of grouting gun; grout shall be one part cement to 2-1/2 parts sand; apply grout immediately after removing forms.

17.8.7 Re Use of Forms

Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

When forms are extended for successive concrete placement thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces

17.9. MEASUREMENT AND PAYMENT

17.9.1 Measurement

No separate measurement shall be made for the works involved within the scope of this section of the specifications unless otherwise specifically stated in the Bills of Quantities.

17.9.2 Payment

No separate payment, unless otherwise included in the Bills of Quantities, shall be made. The cost thereof shall be deemed to have been included in quoted unit rates of relevant items of the Bills of Quantities.

SECTION-18-STRUCTURAL STEEL WORKS

18.1 SCOPE OF WORK

The work covered by this section, consists of supply of all material, labour, plant, equipment and appliances including welding, bolts, nuts, washers, anchor bolts, embedded parts etc., fabrication, erection and painting in accordance with the specifications, as per Drawings and as directed by the Engineer.

18.2. SUBMITTALS

- a.** Product Data: Submit manufacturer's product information, specifications and installation instructions for all structural steel components and accessories.
- b.** Shop Drawings: Submit complete shop drawings, including details and schedules for fabrication, assembly and erection of structural steel members, procedures, and diagrams. Include details of cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols and show size, length, and type of each weld. Provide setting drawings showing all anchor bolt locations on plan with column grids. Show projection of each bolt above foundation concrete, length of threaded portion of each bolt and orientation of shear lugs.
- c.** Design Analysis and Calculations: Provide design analysis and calculations for structural steel members of which sizes are not shown, and connections for beams, girders and other steel member intersections.
- d.** Test Reports: Provide reports for tests conducted on shop- and field-bolted and welded connections. Include data on type(s) of tests conducted and test results.

18.3. MATERIAL REQUIREMENTS

Except otherwise stated in the Drawings, the material specifications shall conform to the following:

- a.** Structural steel shapes, plates and bars shall conform to the requirements of ASTM A36.
- b.** Cold-Formed Steel Tubing: Comply with requirements of ASTM A500, Grade B.
- c.** Hot-Formed Steel Tubing: Comply with requirements of ASTM A501.
- d.** Steel Pipe: Comply with requirements of ASTM A53, Type E or S, Grade B; or ASTM A501.
- e.** Build-up Members Fabricated from Plate or Bar stock: Comply with requirements of ASTM A529, A570 or A572; minimum 50,000 psi yield

strength.

- f.** Members Fabricated by Cold Forming: Comply with requirements of ASTM A607, Grade 50.
- g.** Galvanized Cold-Formed Members: Comply with requirements of ASTM A446, Grade D, galvanized to ASTM A525, Class G90.
- h.** Steel forging shall conform to the requirements of ASTM A235.
- i.** Steel casting shall conform to the requirements of ASTM A27, Grade 65-35, medium-strength carbon steel.
- j.** Galvanized Steel Sheet: Comply with requirements of ASTM A446, Grade C, galvanized to ASTM A525, Class G90.
- k.** Welding Electrodes for manual shielded metal arc welding shall conform to AWS A 5.1 latest edition or the A 5.5 latest edition. Equivalent locally manufactured electrodes may be used subject to the approval of the Engineer.
- l.** Common Bolts, Anchor Bolts, Nuts and Washers Bolts and Nuts shall conform to the requirements of ASTM A307.
- m.** High strength carbon steel bolts including nuts and washers shall conform to the requirements of ASTM A325 latest editions and of AISI B18.2
- n.** Cut Washers shall be of structural grade steel and shall conform to the dimension of the manufacturer's regular standard for plain washers for the size of bolts used.
- o.** Cast iron shall conform to the requirements of the latest edition of ASTM A 48.
- p.** Structural Steel Primer Paint: SSPC - Paint 2, red lead-iron oxide, oil alkyd.

18.4. TRANSPORTATION, HANDLING AND STORAGE

Stack materials out of mud and dirt and provide for proper drainage. Exercise care to avoid abrasions and other damage to shop primer paint. Protect from damage or soiling by adjacent construction operations. Keep steel members off ground by using pallets, platforms, or other supports. Protect material against corrosion and deterioration.

18.5. FABRICATION

18.5.1 Straightening of Material

Rolled material, before being worked upon, must be straightened within tolerances, by 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 1100°F for A514 steel or 1200°F for other steels.

18.5.2 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.

18.5.3 Holes Punching Drilling

Holes shall be punched where thickness of the material is not greater than the diameter of bolt +3 mm. Where the thickness of the material is greater the holes shall either be drilled or sub-punched and reamed to size. The die for all sub-punched holes and the drill to all sub-drilled holes shall be at least 1.58 mm smaller than the nominal diameter of the rivet or bolt. Holes for A514 steel plates over 13 mm thick shall be drilled.

18.5.4 Welding

a. 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, D1.0. No welding for piping/electrical supports shall be made transversely to any tension flanges of trusses, beams or columns.

b. Automatic submerged Arc Welding

For all built-up members, i.e., sections fabricated from plates and flat bars or compound rolled sections, plate and box girders, where long continuous welding is to be done, should be executed by Automatic submerged Arc Welding process in accordance with relevant AWS specifications.

Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications.

The 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.

18.5.5 Tolerances

A variation of 1 mm is permissible in the overall length of members with both ends finished for Contact bearing. The bearing surfaces are prepared to a common plane by grinding.

Members without end finished for contact bearing which are to be framed to other steel parts of the structure shall have a variation from detailed length not greater than 3 mm.

18.6. SURFACE PREPARATION & PAINTING

18.6.1 Surface Preparation

All structural steel material i.e., rolled steel sections, plates, pipes, flat bars, chequered plates shall be cleaned free from loose scale, rust, burrs slag, etc. by means of sand blasting.

18.6.2 Painting

- a.** Immediately after surface preparation all material shall be given one prime coat of rust preventive paint.
- b.** After fabrication one shop coat of prime paint and then one coat of enamel paint shall be applied.
- c.** One final coat of enamel paint shall be applied after erection of all components.
- d.** The type of primer and enamel paints to be applied shall be as specified on the Drawings.
- e.** All other requirements for the specified paint system shall be in accordance with the paint manufacturer's specification recommendations.
- f.** The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.
- g.** Steel work/Surfaces not to be painted
 - Steel work to be encased/embedded in concrete or surface in coated with contact with concrete or grout shall not be painted, but shall be given a cement wash after sand blasting.
 - Machined finished surfaces shall not be painted but shall be coated with rust preventive compound, (approved by the Engineer) immediately after finishing. Such surfaces shall also be protected with wooden pads or other suitable means for transportation. Unassembled pins, keys, and bolt thread shall be greased and wrapped with moisture resistant paper.

18.7. INSPECTION AND TESTS

Manufacturer's Work Test Certificate for all material used shall be furnished by the contractor for Engineer's scrutiny and approval.

Rolling tolerance of all shapes and profiles according to AISC shall be in accordance with the provisions of the American Society for Testing and Materials Designation A.6. These shall be checked by the Contractor before being worked upon and shall be rejected if found not within limits.

The Contractor shall arrange for analysis and test of all material rolled locally at a testing laboratory selected by the Engineer.

a. Inspection of Welding

The inspection of welding shall be performed in accordance with the American Welding Society specifications, as directed by the Engineer.

b. Rejection

Materials or 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.

18.8. MEASUREMENT AND PAYMENT

18.8.1 Measurement

Measurement for miscellaneous items shall be made as per the units included in the Bill of Quantities.

18.8.2 Payment

Payment shall be made for the number of units of items as provided in the Bill of Quantities, measured as above, and at the Contract unit price to furnish, construct and shape¹⁴⁷ the item and shall constitute full compensation for all work related to that item.

SECTION-19- BRICK MASONRY

19.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances, scaffoldings and materials and performing all operations in connection with furnishing and installing brick masonry in position including Portland cement and sand for mortar & masonry, complete in strict accordance with this section of the specifications and applicable Drawings and subject to the terms and conditions of the Contract.

19.2. APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified:

- ACI 530, Building code requirements for masonry structures
- ACI 530.1, Specifications for masonry structures
- PS 208, Classification, strength and properties of bricks
- ASTM C67, Standard method for sampling and testing brick and structural clay tile
- ASTM C144, Standard specifications of aggregates for masonry mortar
- ASTM C150, Specifications for Portland cement

19.3. SUBMITTALS

The Contractor shall submit the following to the Engineer for approval before commencement of work:

- Methodology and sequence of work
- Specimen samples of bricks, aggregates for mortar or grout and Portland cement.
- Results of all tests performed upon the materials and masonry units obtained from the site of work as per directions of the Engineer.

19.4. MATERIAL REQUIREMENTS

19.4.1 Cement

Portland cement for mortar shall conform to the applicable requirements specified in the SECTION-20, PLAIN & REINFORCED CONCRETE.

19.4.2 Sand

Sand for mortar used in brickwork shall be furnished by the Contractor, and shall meet the requirements set forth in ASTM C144. The Fineness Modules of the sand shall range between 1.9 & 2.8 and the grading shall be within the limits

Sand shall be stored at the site in such a manner that it is not mixed with foreign matter. Methods employed by the Contractor for unloading, loading, handling and storage shall be subject to the approval of the Engineer. Sufficient quantity shall be maintained at the Site at all times to assure continuous work

19.4.3 Water

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, and shall conform to the applicable requirements as specified in the SECTION-14, PLAIN & REINFORCED CONCRETE.

19.4.4 Mortar

Mortar for all brickwork shall, except as otherwise specified in Drawings or directed by the Engineer, shall consist of one part Portland Cement to four parts of sand by volume for 4-1/2-inch thick walls, one part of cement to six parts of sand for 9-inch and over thick walls for building works and one part of cement to 5 parts of sand for other works. Where directed by the Engineer for increased workability, hydrated lime putty, approved by the Engineer, shall be added to the mortar but shall not exceed 25 percent, by volume of the dry cement.

Methods and equipment used for mixing mortar be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of water to the mix shall be rejected. Re-tempering of mortar shall not be allowed. The mixers shall be thoroughly cleaned and washed at the end of each day's work.

19.4.5 Bricks

All bricks, except otherwise specified, shall be of first-class quality made from good brick earth, free from saline deposit and shall be hand moulded. They shall be thoroughly burnt without being vitrified, shall be regular, uniform in shape and size with sharp and square edges, parallel faces and of deep red or copper colour. First class bricks shall be homogeneous in texture and shall emit a clear ringing sound when struck, and shall be free from flaws, cracks, chips, stones and modules of lime. First class brick in an oven dried condition shall not absorb more than 1/5 of its weight of water when immersed one hour in water at 21 to 27 degrees centigrade and shall show no signs of efflorescence on subsequent drying. The average compressive strength of five representative first class bricks shall be not less than 2000 psi and not less than 1500 psi for any individual brick.

All bricks shall be manufactured by the Trench Kiln Method or other standard methods approved by the Engineer. The earth used in manufacturing bricks

shall be carefully selected and shall be free from objectionable quantities of lime, gravel coarse sand, roots, or other organic matter. Salts shall not exceed 0.3 percent and calcium carbonate shall not exceed 2.0 percent.

The moulds used in the manufacture of bricks shall be thoroughly sanded before each use and shall be sufficiently larger than the size of the bricks being manufactured to allow for shrinkage in drying and burning. Over-size, irregular and worn moulds shall be destroyed. Each finished brick for brick masonry shall be 9 inch by 4-1/2 inch by 3 inch in size and shall weigh between 3.2 to 4.2 kilograms. All bricks shall have a "frog" 1/4-inch-deep on one face.

Bricks of approved samples shall only be used in the works. If at any time during the progress of the work, use of sub-standard material is found by the Engineer, such work shall be rejected and the Contractor shall replace the rejected work at his cost

19.5. PLACING

The methods and equipment used for transporting the brick and mortar shall be such as will not damage the brick nor delay the use of mixed mortar. Brick shall not be placed during rains sufficiently heavy or prolonged to wash the mortar from the brick. Mortar already spread which becomes diluted by rain shall be removed and replaced before continuing with the work. All bricks to be used in brick masonry shall be moistened with water for three to four hours before they are used by a method which will 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 with mortar joints and in English and Flemish bond as shown on the Drawings or as directed by the Engineer. Both bed and vertical joints shall be 1/4 inch in thickness completely filled with cement mortar as specified herein, and each brick shall be bedded by firmly tapping with the handle of the 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 with the edge of a trowel and a straight edge. All anchors and similar work required to be embedded in the brick masonry shall be installed as the work progresses. At the completion of the work all holes or defective mortar joints shall be cut out and repointed.

Where shown on the drawing the exterior faces of the walls shall be finished by striking the joints as the work proceeds. The joints shall be struck by raking the green mortar after the brick work has been laid and finishing the joint with a pointing tool. Horizontal joints shall be struck to form a weathered joint and vertical joint shall be struck with a V notch. 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.

The exposed faces of all brick masonry shall be thoroughly cleaned and left bear with struck joints as specified above.

19.6. CURING

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. Method to be utilised by the Contractor for curing of brick masonry shall be subject to the approval of the Engineer. Water used for curing shall meet the requirements of the Specifications for water used in the manufacture of bricks.

19.7. REPAIR

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 moved and replaced by the Contractor at his expense unless the Engineer grants permission, in writing, to patch or replace the defective area.

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 damages and excess mortar shall be cleared off the surfaces as the work progresses. All exposed masonry shall be clean, smooth, plumb and shall be of acceptable finish. In the event ordinary cleaning is not adequate, special methods such as sand blasting or otherwise as approved by the Engineer, shall be used to clean the surfaces

19.8. SCAFFOLDING

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 by workmen. Cost of scaffolding etc., shall be included by the Contractor in the unit rate for masonry items.

Damage to masonry from scaffolding or from any other cause shall be repaired by the Contractor at his own cost.

19.9. TOLERANCES

The nominal/standard dimensions of brick are 9-inch (length) x 4-1/2-inch (width) x 3-inch (thickness). No dimension of brick (width, height and length) shall differ from the specified standard dimension by more than 1/8 inch.

Moreover, all brick work shall be erected plumb and true to line and level having maximum variation in plumb in height up to 1/16 inch for 3-feet height and limited to 1 inch for the entire height.

19.10. MEASUREMENT AND PAYMENT

19.10.1 Measurement

The measurement for brick work shall be made in cubic feet or cubic metre (whichever is included in Bill of Quantities) of brick work provided within the limits as shown on the Drawings or as directed by the Engineer.

19.10.2 Payment

Payment for brickwork shall be made at the contract unit price per cubic feet or cubic metre (whichever is included in Bill of Quantities). Payment shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work.

SECTION-20- DAMP PROOF COURSE

20.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment and materials and performing all operations in connection with furnishing damp proof course (DPC) in position complete in strict accordance with this section of the specifications, applicable Drawings and as specified in the Bill of Quantities.

20.2. MATERIAL REQUIREMENTS

All materials i.e., cement, sand, aggregate, water polythene sheet and bitumen shall conform to the specifications given in respective sections.

20.3. HORIZONTAL DPC

20.3.1 In Walls

Unless specified in the Drawings, the horizontal DPC. shall consist of 2-inch thick, Class-C cement concrete mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications two floats of hot bitumen 10/20 penetration grade and intervening layer of polythene sheet.

20.3.2 Under Floors

Same as in walls except bitumen layers to be laid on 1/2" - 3/4" blinding screed (1:6) to even out the surface of Class-E hard core.

20.4. VERTICAL DPC

Unless specified in the Drawings, the vertical DPC shall consist of ½" thick cement sand plaster in 1:3, mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be applied at required levels as per Drawings and instructions by the Engineer, including two float of hot bitumen 10/20 penetration grade.

20.5. CONSTRUCTION REQUIREMENTS

The Contractor shall lay the DPC only when the level, quality of masonry work, etc. is approved.

The concrete work of DPC shall conform to the applicable requirements specified in SECTION-14, PLAIN & REINFORCED CONCRETE.

Horizontal DPC shall extend to the full width of the wall i.e., up to the external faces. No portion of doors opening, etc. shall be left while laying DPC. The period of curing of concrete shall be not less than 72 hours. Every care should be taken that concrete is not left dry during this period. The work of laying

DPC shall be carried out as follows unless otherwise described in Bill of Quantities:

- Placing 2-inch thick layer of Class-C cement concrete.
- Laying 2 coats of hot bitumen 10/20 penetration grade @ 20 lbs. per sq.ft. (each coat) over entire width and lengths of concrete after the concrete has been properly cured for at least 72 hours, and sand blinding where specified.
- Laying of polythene sheet 500 gauge over the entire width and length of concrete after the concrete has been treated with 2 coats of hot bitumen.

The application of bitumen coating in case of vertical DPC shall be the same as mentioned above.

20.6. MEASUREMENT AND PAYMENT

20.6.1 Measurement

Measurement shall be made in square feet or square metre (whichever is included in Bill of Quantities) of superficial area or surface damp proofed as per this section of specification and accepted by the Engineer.

20.6.2 Payment

Payment will be made for the number of square feet or square metre (whichever is included in Bill of Quantities) of superficial area damp proofed at the contract unit price and will include full compensation for furnishing and placing all materials and for all labour, equipment, tools and incidentals necessary to complete the work prescribed in the Bill of Quantities.

SECTION-21-CEMENT PLASTER

21.1. SCOPE OF WORK

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 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.

21.2. APPLICABLE STANDARDS

The work shall conform to requirements of latest editions of following standards, wherever applicable, unless otherwise specified.

21.2.1 Pakistan Standard

- PS 232, Ordinary Portland Cement

21.2.2 ISO (International Organization for Standardization)

- R 597 Definitions and terminology of cement.
- R 679 Method of testing strength of cements, compressive and flexural strength of plastic mortar (RILEM -Cembureau method).
- P 680 Chemical analysis of cement & main constituents of Portland Cement.
- R 681 Chemical analysis of cements-mixer Constituents of Portland cement.
- R 682 Chemical analysis of cements - determination of sulphur as sulphide.

21.2.3 ASTM (American Society for Testing and Material)

- ASTM C144, Aggregate for Masonry mortar
- ASTM C631, Bonding Compounds for interior plastering

21.2.4 BSI (British Standards Institution)

- BS 812, Methods for sampling and testing of mineral aggregates, sands and fillers.
- BS 1199, Sands for external renderings Internal plastering with lime and Portland cement and floor screeds.
- BS 1369, Metal lathing (steel) for plastering.
- BS 5262, External rendered finishes.
- BS 5492, Internal plastering.

21.3. SUBMITTALS

Sample materials shall be submitted to the Engineer for his approval prior to use in the works.

21.4. MATERIAL REQUIREMENTS

Portland cement for mortar shall conform to the applicable requirements specified in the SECTION-14, PLAIN & REINFORCED CONCRETE.

Sand for plaster shall comply with the requirements of BS 1199, BS 1200 or the Pakistan Standard "Sand for Plaster" as directed by the Engineer.

Water for plaster shall conform to the applicable requirements specified in the SECTION-14, PLAIN & REINFORCED CONCRETE.

All materials and workmanship for plaster not explained in these specifications, shall comply with the requirements of relevant BS CP 211 and CP 221 or as directed by the Engineer.

21.5. PROPORTIONING AND MIXING

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 and cement/sand ratio as shown on the Drawings.

Measurement of materials by volume shall be by containers of known capacity to maintain consistent proportions. No lumpy or caked material shall be used. Mixing equipment boxes and tools shall be clean. Materials shall be proportioned as specified on the Drawings or as directed by the Engineer. Mixing shall be continuous until all ingredients are evenly distributed and thoroughly mixed.

Only limited water shall be added for proper workability and such quantity of mortar shall be prepared which can be consumed in thirty minutes after preparation. Preparation of mortar in bulk quantity for use during the entire day or for any other time more than that stipulated above is expressly prohibited. Re-tempering shall not be permitted and all mortar which has begun to stiffen shall be discarded.

Plaster ingredients shall be thoroughly mixed either by hand on a clean cement concrete platform or by a mechanical mixer, as directed by the Engineer.

Additives for controlling the setting and working characteristics of plaster or for imparting anticorrosion, fungicidal or water proofing properties, shall be added to the plaster strictly in accordance with the particular manufacturer's written instructions. Good quality hair or manila fiber in reasonably well distributed proportion may be to the plaster to assist application and reduce droppings. No additives shall be used except as specified in the Contract Documents

21.6. PREPARATION OF SURFACE TO BE PLASTERED

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. Chiselling and repairing of cement plaster shall not be permitted without the approval of the Engineer.

Concrete surface to be plastered shall be cleaned to remove all grease, form oil and other surface impurities which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface of all concrete ceilings, beams and columns shall be lightly hacked by approved means to give the required key for plastering.

All masonry surfaces to be plastered shall be cleaned to remove all matter which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface shall be washed with clean water and kept damp for 24 hours before further treatment, the surface thus prepared shall be treated uniformly with cement and sand slurry. The slurry to be used shall be one-part cement to one-part sand by volume with water added to make a stiff. A spatter dash of slurry shall be applied on the surface to receive plaster and be left to cure for three days.

21.7. APPLICATION OF PLASTER

The plaster of a thickness less than the specified thickness shall be rejected. If the plaster is to be more than ½-inch thick, it shall be done in two coats. The surface of the first coat shall be made rough before the second coat is applied. Plaster shall not have a wavy surface and shall be perfectly plumb. The edges and corners shall represent a straight line. The plaster shall be kept wet continuously for at least ten days. No extra payment shall be allowed for jambs, junctions, corners, edges, round surfaces or plaster required due to any unevenness in the work done by the Contractor. The plaster work is to cover all conduits, pipes etc. fixed in the walls and ceiling. Wherever specified, metal lath shall be nailed firmly before plastering is commenced. The plaster surface shall be tested frequently with a 10-foot straight edge and plumb bob.

Plaster containing cracks, blisters, pits, discolouration or any defects shall not be acceptable. Any plaster giving hollow sound or loose plaster shall be removed and replaced with plaster in conformity with these specifications and as additionally directed by the Engineer. The contractor shall cut out and patch all defective work at his own cost. All damaged plaster shall be patched as directed by the Engineer. Patching plaster shall match appearance of and shall be finished level with adjoining plaster.

21.8. METAL LATH

Before plastering, wherever brick masonry meets with reinforced concrete members, 6-inch wide continuous strip of expanded metal lath shall be nailed to the masonry and the reinforced concrete member covering the joint completely to prevent cracking of the joint.

Metal lathing shall be fabricated from sheet steel, and shall be of uniform quality and free from flaws, broken strands, cracks and corrosive pitting, shall be rectangular and true to shape and shall comply with BS-1369.

All lathing shall be galvanized. Where plastering material depends entirely on the lathing for its key, these shall be not less than two complete mesh openings per 1.12-inch in one direction and the width of the aperture shall not be less than 0.2-inch.

Sheet shall be not less than 1.60 kg/m² when fabricated, using 0.7mm thick steel sheet. When used on smooth surfaces to form a key, it shall be not less than 1.20 kg/m² when fabricated, using 0.5mm thick steel sheet. Typing wire shall be 1.2mm diameter galvanized annealed iron wire.

21.9. BEADS & PROFILES

Angle beads, corner beads, stop beads, architrave beads, depth gauge beads, edging profiles, plaster dividing profiles, interior angle profiles, plaster borders and the like shall all be manufactured from sheet steel and galvanized after fabrication, all beads & profiles shall be perforated at edges to ensure good adhesion of the plaster work. Thickness and dimensions shall suit particular locations and plaster work thickness.

Nails for fixing lathing shall be galvanized and have either clout heads or small flat heads to suit particular locations.

All angle beads, stop beads, architrave beads, depth gauge beads, and the like are to be fixed in accordance with the manufacturer's instructions.

21.10. CLEANING AND PROTECTION

Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Engineer. As each room or space is completed all rubbish, debris, scaffolding and tools should be removed to leave the room clean.

Prior to plastering, all doors/windows, finished metals etc. should be covered by a sheet of plastic or tarpaulin to protect them from damage.

Protect finished plaster from injury by any source. The contractor shall also protect walls, floors and work of other trades from plaster materials.

21.11. TOLERANCES

Surfaces of plaster work shall be finished with a true plane to correct line and level unless otherwise specified and with walls revealing plumb and square.

Maximum permitted tolerances shall not exceed 1/8-inch in 6-foot variation from plumb or level in any exposed line or surface and 1/16-inch variation between planes of abutting edges or ends.

21.12. POINTING WORK

Joints of masonry work to be pointed shall be properly raked to 1/2-inch depth, cleaned and wetted.

For struck pointing the mortar shall be filled in the joints flush with masonry with a pointing trowel and then pressed with proper pointing tools to form weathered and struck horizontal and triangular or V-notched vertical joints.

For flush pointing after pressing mortar in the joints these shall be tilled up with mortar and finished level with edges.

After pointing the face of the work shall be cleared of all surplus mortar. No washing shall be done till the pointing has set. All defects shall be treated at Contractor's expense. All work shall be kept wet for 10 days and protected from extreme temperatures and weather.

21.13. MEASUREMENT AND PAYMENT

21.13.1 Measurement

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.

- Metal lath over reinforced concrete and masonry joints.
- Joints, junctions, corners, drip course, edges and rounding.
- More than one layer due to any unevenness in the finished works.
- Cutting & patching of all defective works.
- Surface preparation, cleaning and protection as specified.
- Water proofing agent for water proof plaster.
- Angles beads, corner beads, stop beads, architrave beads, depth gauge edging profiles, plaster dividing profiles, interior angle profiles and plaster borders used in plaster works as shown on Drawings.

Measurement shall be made of cement plastering for the actual area in square feet or square metre (whichever is included in Bill of Quantities) in accordance with this section of specification or as directed by the Engineer.

21.13.2 Payment

Payment shall be made for the number of square feet or square metre (whichever is included in Bill of Quantities) of surface area cement plastered at the contract unit price and shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work in strict accordance with this section of specification.

SECTION-22- POLYVINYLECHLORIDE WATERSTOP

22.1. SCOPE OF WORK

The work comprises of providing all labour, tools, equipment, to install, place and fabricate in position and locations rubber water stops together with all jointing and sealing materials as per recommendations, specifications of the Manufacturer and instructions. All embodiment in concrete, lapping, turning, sealing shall ensure absolute water tightness subjected to any pressures. The workmanship and operation shall be perfect and guarantee leak proof at places wherever used in the structure.

22.2. MATERIAL REQUIREMENTS

Polyvinyl chloride water-stop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride (PVC). The compound shall contain such additional resins, plasticizers, stabilizers or other materials needed to ensure that when the material is compounded and extruded to the shapes and dimensions shown, it will have physical characteristics as included in **Table 21.1**.

Table 21.1, Material Requirements for PVC Water Stopper

Sr. No.	Parameter	Test Method	Criteria
1	Tensile Strength	ASTM C 638	Min. 1750 psi
2	Ultimate Elongation	ASTM C 638	Min. 350%
3	Low Temperature Brittleness	ASTM D 746	No Failure @ -37°C
4	Stiffness in Flexure	ASTM D 747	Min. 400 psi
5	Specific Gravity	ASTM D 792	Max. 1.37
6	Hardness, Shore A	ASTM D 2240	70-80

22.3. CONSTRUCTION REQUIREMENTS

Splices in the continuity or at the intersections of runs of PVC waters-stops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations or as directed. A thermostatically controlled electric source of heat shall be used to make all splices. The correct temperature at which splices should be made will differ with the material used but should be sufficient to melt but not char the plastic. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the water-stop shall be used to reform the ribs at the splice. The continuity of the characteristic components of the cross-section of the water-stop design (ribs, tabular centre axis, protrusions, and the like) shall be maintained across the splice.

The expansion joints wherever indicated on Drawings shall have centre bulb rubber water stops or its equivalent as indicated on Drawings to be cast

integrally with the in-situ-concrete of retaining walls, beams, columns, slabs or at any locations marked on the Drawings incorporating junction places or as straight lengths with separate intersection pieces to be joined at Site as per Manufacturer's recommendations and Specifications. The water stops shall be installed so as to hold them securely in their correct position during the placement of concrete. The concrete shall be fully and properly compacted around the water stops to ensure that no voids or porous areas remain. Where reinforcement is present adequate clearance shall be left between water stops and the reinforcement to permit proper compaction of concrete. No holes shall be made through any water stops. Hot or cold vulcanizing for jointing places of water-stops at site shall be done with the prior Approval in accordance with the Manufacturer's recommendations and specifications.

22.4. MEASUREMENT AND PAYMENT

22.4.1 Measurement

Polyvinylchloride water stop of the size and gauge as shown on the Drawings will be measured for the number of linear feet or linear metre (whichever is included in Bill of Quantities) acceptably placed in the work. In computing the quantities, no allowance will be made for laps.

22.4.2 Payment

Payment will be made in accordance with the unit prices in the Bill of Quantities for the item as measured above in accordance with the specifications and shall constitute full compensation for furnishing all materials, shuttering, equipment and labour and for performing all operations necessary to complete the work.



The United Nations Human Settlements Programme

**“Harmonizing Afghan Refugees and Host Communities in Urban Slums in Pakistan
for Peaceful Coexistence and Social Cohesion”**

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Applicable Codes and Standards:

Solar PV Modules – **IEC 61215 / IEC 61730**

Inverters / Controllers— **IEC 62109**

DC Cables-**IEC 62930 / IEC 60228**

Earthing -**IEEE 80 / IEC 60364**

Lightning Protection-**IEC 62305**

Solar Pump Controller-**IEC 62116**

Solar Pumps-**ISO 9906**

PV System Installation-**IEC 62548**

Battery (if used)-**IEC 61427**

Street Light Luminaires-**IEC 60598**

Surge Protection-**IEC 61643**

AEDB Solar Guidelines

SECTION-1 PART "A"-GENERAL INFORMATION

1.1. SYSTEM INFORMATION

1.1.1 System Type: These specifications encompass Solar Based Water Pumping Systems, Solar Street Lighting Systems, and Solar Home and Building Power Systems, including all related equipment, components, balance of system (BOS), mounting arrangements, electrical connections, protection devices, and other common elements necessary for the complete solar photovoltaic system.

1.1.2 Operational Environment: All system components, including batteries, shall be suitable for reliable operation under local climatic conditions and shall perform effectively within an ambient temperature range of **-5°C to +50°C**.

1.1.3 Wind and Snow Loads: Solar panels shall be capable of withstanding a minimum snow load of 5400 Pa and a wind load of 2400 Pa, which may be increased to 3800 Pa if required by the Department. The mounting structures shall be properly designed and anchored to withstand wind speeds up to 150 km/h.

1.2. LAYOUT

1.2.1 Orientation: The surface azimuth angle for PV modules should be $180^{\circ} \pm 30^{\circ}$ with a preferred tilt angle of $33^{\circ} \pm 15^{\circ}$.

1.2.2 Clearance: A minimum ground clearance of 1.0 foot must be maintained for PV modules.

1.2.3 Shading and Spacing: To avoid shading, the distance between rows of panels and from walls must be at least 1.6 times the height of the structure or wall. A minimum space of 1 inch (2.54 cm) is required between modules to avoid air push.

1.3. SURVEY EQUIPMENT

Shading Analysis: Comprehensive shading analysis and layout planning must be executed using industry-standard software such as Helioscope, SketchUp, PVSOL, or PVsyst. Solar arrays shall be oriented toward true South (180° azimuth) with the tilt angle optimized for peak performance, or as otherwise directed by the Engineer In charge

1.4. PLANT, EQUIPMENT AND TOOLS

1.4.1 Structural Installation & Fabrication Tools

Since solar mounting structures are often customized or adjusted on site, the following tools are essential for mechanical integrity:

1.4.1(a)-Heavy-Duty Drill Machines & Magnetic Drills: Used for anchoring mounting structures into concrete pads or drilling through thick-gauge steel frames.

1.4.1(b)-Welding Units (Inverter Type): Required for on-site fabrication of

customized module supports or security fencing. Note that all welds must be cleaned and treated with cold galvanizing spray to prevent rust.

1.4.1(c)-Angle Grinders & Cutters: For precise sizing of mounting rails and trimming of threaded rods or struts.

1.4.1(d)-Torque Wrenches: Critical for tightening module clamps and structural bolts to the manufacturer's specified Newton meters (Nm) to prevent micro cracks in the panels or loosening due to wind vibration.

1.4.2. Electrical Integration & Safety Tools

These are the most critical tools for ensuring the system is "electrically sound" and meets the technical specifications for voltage and current handling:

1.4.2.(a)-DC & AC Clamp Meters: Used to measure the actual current (Amps) flowing from the strings to the inverter and from the inverter to the load. These must be capable of measuring DC current specifically, as standard AC-only meters will not work for solar strings.

1.4.2.(b)-Digital Multimeters (High Voltage): For verifying Open Circuit Voltage (\$Voc\$) and Operating Voltage (\$Vmp\$) of solar strings, ensuring they fall within the inverter's MPPT range.

1.4.2.(c)-Insulation Resistance Testers (Megger): Used to test the integrity of cable insulation. This prevents "leakage to ground" which is a common cause of system trips in high-humidity environments.

1.4.2.(d)-Earth Resistance Testers: To ensure the grounding/earthing pit meets the required Ohmic value (typically $< 5\Omega$) to protect the system from lightning and surges.

1.4.3. Solar-Specific Diagnostic Tools

To comply with the "Survey" and "Testing" requirements of the specification, these specialized tools are often required:

1.4.3.(a)-MC4 Crimping Tools: Standard pliers are prohibited. Professional crimpers ensure a weather-tight, low-resistance connection for DC cables, preventing arc-flash fires.

1.4.3.(b)-Irradiance Meters (Pyranometers): Used during commissioning to measure the available sunlight (W/m^2) at the time of testing, allowing the engineer to calculate the system's actual efficiency against its theoretical peak.

1.4.4. Maintenance & Access Equipment

As per your previous requirement regarding "Safe Operator Access," the plant and equipment must include:

1.4.4.(a)-Industrial Extension Ladders: For accessing roof-mounted arrays or high-structure elevated systems.

1.4.4.(b)-Portable Water Pressure Washers: For the initial cleaning and commissioning of the modules to ensure they are free of construction dust before the final handover.

1.5. STORAGE & HANDLING FACILITIES

1.5.1. Protection During Transport & Procurement: The Contractor shall ensure that all solar modules are delivered to the site in original, manufacturer-sealed industrial pallets. Modules must be securely vertical-stacked with edge protectors and wrapped in weather-resistant film. Pallets must be secured within the transport vehicle using heavy-duty tensioning straps/tightening ropes to eliminate "jumps" or longitudinal shifting during transit, which can cause micro-cracks or shattering of the tempered glass. Cabinets and sensitive electronic equipment (Inverters/Controllers) must be fully cushioned and wrapped to prevent vibration-induced damage.

1.5.2.. Handling During Installation: During the "fixing" or mounting phase, solar panels must be handled with extreme care to maintain structural integrity. Modules shall be lifted and supported by at least two personnel, holding the frame at all four corners simultaneously. This practice is mandatory to prevent "panel twisting" or torsional stress, which is a primary cause of micro-fractures in the silicon cells. Under no circumstances should pressure be applied to the glass surface or the junction box during handling.

1.5.3.. On-Site Storage & Installation Clearance: All electrical cabinets, inverters, and battery banks must be stored in a dry, shaded area prior to installation. Once fixed, cabinets must be mounted on a concrete plinth or metallic stand providing a minimum clearance of one foot (300mm) above the finished floor level (FFL). This elevation is critical to protect sensitive internal circuitry from floor-level moisture, rising dampness, dust accumulation, and accidental impact during site cleaning.

1.6. TEST LABORATORY TESTING AND TESTING REPORT

1.6.1. Mandatory Cable & Material Testing: Before installation, the Contractor shall provide third-party validation reports for all cabling and conductors. Mandatory tests include Conductor Resistance, Insulation Resistance, Spark Testing, and a Copper Purity Test to ensure compliance with the specified electrical conductivity and safety standards.

1.6.2. Factory & Laboratory Verification (Off-Site): The Contractor is responsible for ensuring that the PV modules have undergone rigorous quality control at an accredited laboratory. The following tests must be documented and submitted at the contractor's

expense:

1.6.2(a)-Performance & Flash Testing: Individual Flash Test Reports (IV Curve) for every panel to verify real power output at STC (Standard Test Conditions).

1.6.2(b)-Structural Integrity: Hail Impact Test, Module Breakage Test, and UV Preconditioning to ensure long-term durability against environmental stressors.

1.6.2(c)-Imaging & Internal Defects: Electroluminescence (EL) Imaging to detect micro-cracks or inactive cells not visible to the naked eye.

1.6.2(d)-Environmental & Safety Reliability: Wet Leakage Current Test, Climatic Chamber Testing (Thermal Cycling and Damp Heat), Salt Mist Corrosion Resistance, and Bypass Diode Thermal Testing.

1.6.2(e)-Electrical Insulation: Dielectric Withstand Test and Impulse Voltage Testing.

1.6.3. On-Site Commissioning & Field Testing: Upon completion of the "fixing" phase and prior to final handover, the Contractor shall perform the following on-site verifications in the presence of the Engineer In-charge:

1.6.3(a)-On-Site IV Curve Tracing: Minimum of 5 representative curves to verify installed performance.

1.6.3(b)On-Site EL Imaging: Minimum of 5 images to ensure no damage occurred during transport or installation.

1.6.3(c)Safety Checks: Water Spray Test (to verify IP rating of enclosures) and Reverse Current Overload Test.

1.6.3(d)LID Verification: Light Induced Degradation (LID) assessment to project first-year performance stability.

1.6.4. Accreditation & Compliance: All specialized laboratory testing—including purity, stress/strain, and efficiency—must be conducted through a ISO/IEC 17025 accredited laboratory in Pakistan. All reports must be signed, stamped, and cross-referenced with the unique serial numbers of the supplied equipment.

1.7. PROTECTION OF THE WORKS

1.7.1-Electrical Safety: Systems must include DC/AC circuit breakers, fuses, and surge protection devices.

1.7.2-Grounding: All frames, structures, and cabinets must be grounded via the shortest route to an effective earth point to reduce lightning and fault risks.

1.7.3-Device Protection: Solar charge controllers and inverters must provide comprehensive protection, including over-voltage, over-current, and short-circuit

protections.

1.8. RESTORATION AND CLEANING

1.8.1-Aesthetics: All wiring must be aesthetically neat, clean, and contained within proper conduits or ducts (no loose hanging wires).

1.8.2-Enclosures: Equipment stands and enclosures must have a professional appearance and be constructed to last at least 20 years without maintenance.

1.9. COORDINATION WITH OTHER WORKS

1.9.1-Engineering Approval: Any modifications to structure design, azimuth/tilt angles, or cable sizing must be approved by the Engineer In-charge.

1.9.2-Fabrication Sequencing: All fabrication work (welding, cutting, drilling) must be completed prior to galvanization to ensure structural integrity

1.10.DEFINITIONS

1.10.1-Standard Test Conditions: This is the industry-standard laboratory environment used to test solar panels so that different brands can be compared fairly. It is defined as an irradiance of 1,000 W/m², a cell temperature of 25°C, and an Air Mass of 1.5 (AM1.5).

Practical Context: When you receive a "Flash Test Report" (mentioned in Section 1.6), the data must be recorded at STC. If a panel is rated at 550Wp, it must produce that power under these specific conditions.

1.10.2-Peak Watt: This represents the maximum power output a solar module can produce under STC.

Practical Context: In solar pumping or grid-tie systems, the total "System Capacity" is calculated by summing the Wp of all installed modules. It is the "Nameplate Capacity" used for billing and contract compliance.

1.10.3-Depth of Discharge: This indicates the percentage of a battery's capacity that has been used relative to its total capacity.

Practical Context: This is vital for the longevity of the energy storage system. For example, a GEL battery might have a recommended DOD of 50% to reach its rated cycle life, whereas a Lithium (LiFePO₄) battery can often handle 80% to 90% DOD. Exceeding these limits during "fixing" and programming of the inverter will void the battery warranty.

1.10.4-Voltage & Current Parameters (Performance Metrics)

1.10.4(a)-Volts Direct Current: The type of electricity produced by solar panels and stored in batteries.

Context: Specifications often require equipment (like inverters or cables) to handle ≥ 1500 Vdc for large-scale string configurations.

1.10.4(b)-Voltage at Maximum Power: The voltage at which the panel outputs its highest wattage under STC.

Context: This is used to calculate how many panels can be connected in a single "string" to match the inverter's input range.

1.10.4(c)-Current at Maximum Power: The amperage produced by the panel when it is operating at its peak efficiency point.

1.10.4(d)-Open Circuit Voltage: The maximum voltage a panel can produce when not connected to a load or circuit.

Context: This is a safety-critical value; if the Voc of a string exceeds the inverter's maximum limit, the inverter will be destroyed.

1.10.4(e)-Short Circuit Current: The maximum current the panel can produce if the positive and negative terminals are connected directly.

Context: Used to size fuses, circuit breakers, and DC disconnect switches.

1.10.5-Standards & Regulatory Bodies

1.10.5(a)-International Electrotechnical Commission: The global organization that prepares and publishes international standards for all electrical technologies.

Context: Panels must meet IEC 61215 (Design Qualification) and IEC 61730 (Safety).

1.10.5(b)-American Society for Testing and Materials: Used in the specifications for material testing, particularly for the structural steel and galvanization of the mounting frames.

1.10.5(c)-International Organization for Standardization: Specifically ISO 9001 for manufacturing quality and ISO/IEC 17025 for the accreditation of the testing laboratories in Pakistan.

1.10.6-System Components & Materials

1.10.6(a)-Surge Protection Device: A component that protects the system from voltage spikes caused by lightning or grid fluctuations.

1.10.6(b)Multi-Contact, 4mm: The industry-standard single-contact connector used to connect solar panels.

Context: These must be crimped using professional tools to prevent high-resistance connections and fire hazards.

1.10.6(c)American / Standard Wire Gauge: Measurements for wire diameter and metal sheet thickness.

Context: A specification of 18 SWG for a battery cabinet ensures it is approximately 1.2mm thick, providing sufficient mechanical protection.

1.10.6(d)Finished Floor Level: A reference point used in the "Storage & Handling" section.

Context: All electrical equipment must be installed at a specific height (e.g., 1 foot) above the FFL to prevent water damage.

1.10.7-Environmental & Operational Terms

1.10.7(a)-Light Induced Degradation: A loss of performance that occurs in the first few hours of a solar panel's exposure to sunlight.

Context: Quality panels must have low LID percentages to ensure the "Peak Watt" rating remains stable over time.

1.10.7(b)-Potential Induced Degradation: A phenomenon where voltage leaks from the cells to the frame, causing power loss.

Context: Your specification requires Anti-PID Certification (IEC TS-62804-1-1) to ensure the system lasts 20+ years.

1.10.7(c)-Air Mass: Refers to the thickness of the atmosphere that sunlight must pass through. AM 1.5 is the standard used for STC testing.

1.11.ABBREVIATIONS

STC -Standard Test Conditions
DOD -Depth of Discharge
Wp -Peak Watt
PV -Photovoltaic
NOCT -Nominal Operating Cell Temperature
MPPT -Maximum Power Point Tracking
BMS-Battery Management System
SWG- Standard Wire Gauge
Vdc - Volts Direct Current
Vmp- Voltage at Maximum Power
Imp-Current at Maximum Power
Voc -Open Circuit Voltage
Isc -Short Circuit Current
IEC -International Electrotechnical Commission
 IEC 61215 (Design Qualification) & **IEC 61730** (Safety)
SPD-Surge Protection Device
MC4-Multi-Contact, 4-6mm
FFL-Finished Floor Level
LID-Light Induced Degradation
PID-Potential Induced Degradation
AM -Air Mass

2-SPECIFICATIONS FOR SOLAR SYSTEMS-COMMON PART

2.1. SOLAR PANELS

- a. The PV module(s) shall contain N-Type Mono crystalline silicon Grade-A Solar cells (Bifacial Double Glass Modules due to its better performance will be given preference).
- b. The PV module should work well with high-voltage input Inverters/ charge controllers (≥ 1500 Vdc).
- c. The PV Panel must have a clear anodized aluminium frame with Anti-reflective, hydrophobic, low-iron Tempered cover glass.
- d. The Solar Modules shall meet the following valid IEC Standards or latest:
 - (IEC 61215-1:2021, IEC 61215-1-1:2021 & IEC 61215-2:2021) (Design Qualification)
 - IEC61730-1:2023 (Safety - Requirements for construction)
 - IEC61730-2:2023 (Safety - Requirements for testing)
 - IEC TS-62804-1-1:2020 (i.e. : TUV PPP-58042B or Equivalent) Anti-PID Certification.
 - IEC 61701:2020 Salt Mist Corrosion Resistance Test.
 - IEC 62716 Ammonia Corrosion Resistance Test (Latest).
 - IEC 60068-2-68 (PPP 59022A) Sand and Dust Erosion Resistance Test.
- e. Unique Serial number, Name / Logo of manufacturer and separate date of manufacturing (DD/MM/YYYY) should be laminated inside the module so as to be clearly visible from the front side / Factory Acceptance Test (FAT), for Verification of Manufacturing Facility / Process and Product.
- f. A properly laminated sticker containing the following details should be available at the back side of the module.
 - Name of the manufacturer / distinctive logo
 - Model Name and Type of Cell Technology
 - Peak Watt Rating (Wp) and Power Tolerance Range
 - Voltage (Vnp) and Current (Imp) at STC
 - Open Circuit Voltage (Voc) and Short Circuit Current (Isc)
 - Minimum System Voltage (Va.) (i.e. : ≥ 1500 Vdc)
 - Test Standard(s) to which the module has been tested and certified
- g. Following essential technical parameters of solar panel/modules should be provided with each panel supplied as well as in the technical proposal
 - I-V curve for the solar photovoltaic module/panel.
 - Date and year of obtaining IEC PV module standardization qualification certificate.
 - Electrical Data (i.e., Pmax, Voc/Vmp, Isc/Imp at nominal Cell Operating

Temperature (NOCT).

- PV Module efficiency at STC.
- Working temperature range of PV Module.

- h.** Each panel should have factory equipped weather proof terminal junction box having at least IP67 protection with provision of opening for replacement of DC cables, blocking diodes and easy debugging if necessary.
- i.** Limited performance guarantee: panel power, in standard conditions, will not be less than 90% of nominal power by the end of 10 years of operation and at least 80% at the end of 25 years of operation with 25-year limited power warranty.
- j.** The PV Module should have at least a 10-years warranty for any defects and efficiency as mentioned above.

It should be provided On Stamp Paper (Signed and Stamped by Contractor) at the time of Handing/Taking Over or signing of contract agreement.

- k.** The PV modules shall have a minimum efficiency of 22.0%, along with positive power tolerance. However, for solar street lighting projects, a module efficiency of 17.5% with positive power tolerance shall remain acceptable.
- l.** The PV modules offered should not be more than 12 months old from the date of issue of work order.
- m.** PV Module should have minimum Snow Load bearing of 5400 Pa and Wind Load Bearing of 2400 pa. However if department deem appropriate may go for 3800 pa wind loads depending upon their requirement.
- n.** The Solar Module should be free from visual and cosmetics defects.
- o.** The department/consultant on the expense of the contractor/supplier shall verify Flash test reports with serial numbers from the manufacturer for each panel (at the time of supply).
- p.** All information regarding solar panels with above mentioned featured data should be accessible and verifiable online on the manufacturer website.
- q.** IEC Certification should be accepted only from an IEC accredited lab for Solar Panels.
- r.** Electroluminescence (EL) test may . be performed randomly for each project at the cost of the contractor/supplier.

Note: For the purpose of verification/ third party validation the Electroluminescence (EL) and Flash testing of randomly sampled PV modules should be conducted.

2.2. CABLES, WIRING AND PROTECTION DEVICES:

- a. The AC/DC cables shall be made of 99,9% (allowing a tolerance of $\pm 0.1\%$) copper strands and flexible.
- b. From PV Panel to Junction Box / T-Branch / Inverter, use single-core, double-insulated (UV-stabilized cables with XLPO insulation and TIN CU/ XLPE OR XLPO/PVC sheathing). Cables must be stranded or flexible and shall preferably conform to EN 50618 or IEC FDIS 62930 standards.
- c. From JB to Inverter, the DC cable must have Single core, double insulated and suitable for minimum ≥ 1500 Vdc transmission.
- d. From Inverter to batteries, the DC cable can be single insulated, Single Core and suitable for minimum ≥ 600 Vdc transmission.
- e. DC circuit breakers / Fuse of $\geq$ Voc of String Voltage and suitable ampere rating (1.25 to 1.50 Times of Rated Current of all strings connected) must be installed between PV modules and controller / inverter.
- f. AC Circuit Breaker (s) of suitable rating (1.25 to 1.50 Times of connected Load) must be installed between Controller / inverter to Load and Grid to Controller / Inverter.
- g. AC / DC breakers should be marked with the manufacturer model number, rated voltage, ampere rating and batch/serial number.
- h. DC / AC breakers rating should be approved from Engineer In-charge before installation at site.
- i. To prevent solar panels from damage an appropriate size of DC Breaker / Fuse should be installed for each PV string and Surge Protection should be installed for combined Array (before Main DC Breaker / Inverter).
- j. DC Breaker, AC Breaker & Change overs should be placed in the Junction box. For outdoor installation Junction boxes should be Hot Dipped Galvanized with minimum thickness of 16 SWG.
- k. Cables shall be clearly labelled with essential electrical parameters including manufacturer name, Voltage Range, standards etc.
- l. All DC Wiring shall be aesthetically neat and clean, over-all wiring/connection losses shall not exceed 1% of the total rated output power.
- m. All connections/ socket outlets among array, controller, inverters, batteries, and pumping set etc must be made in junction boxes of adequate protection level.
- n. All wires/cables should be in standard flexible UV-Resistant conduits / HDPE of PN12, SDR 13.6, PE100 for outdoor installation & (1-3 feet deep) for underground wiring / Cabling and PVC ducts for indoor installation.
- o. The DC Combiner Junction Box should be properly earthed including earthing of door as well.
- p. The DC Combiner should contain proper bus bars of adequate size each for Positive, Negative and Earthing
- q. The Inverter Junction Box should be properly earthed as well as per vetted design of the Engineer in charge.

- r. All wiring should be in proper conduit of capping casing. Wire should not be hanging loose.
- s. All wires should be terminated properly by using lugs / thimble connectors / sleeves.
- t. The distribution board must be installed with proper screws.
- u. Electrical Hazards Safety Labels should be pasted on DC Combiner /VFD Enclosure / Charge Controller /Battery Enclosures.
- v. Following third party lab tests are mandatory:
Conductor resistance test, Insulation resistance test, Pressure test & Spark test, copper purity test, cable size test or any other necessary tests recommended by Engineer.
- w. DC Cable from PV Module to Junction Box / Inverter for each string should be 6 mm².
- x. DC Cable Sizing from Junction Box to Inverter (up to cable length of 200 ft) as per details below;

S.No	Nos of Strings	Cable Size (mm ²)	Remarks
1	1	6	If the cable length is >200 ft (one-sided) , then the cable The size should also be increased accordingly.
2	2	10	
3	3	16	
4	4 -5	25	
5	6-8	35	

- y. Over Voltage / Current Protection Device may be installed between Utility & Inverter.
- z. Surge Protection may be installed for combined Array (before Main DC Breaker / Inverter).
- aa. Cable colour coding should be adopted in accordance with relevant international standards.

Note: To ensure compliance with the above specification, the Conductor resistance test, Insulation resistance test, Pressure test, Spark test, copper purity test & cable size test may be conducted through any accredited laboratory in Pakistan.

2.3. PANEL MOUNTING & STRUCTURE:

- a. The panel mounting and structure should be made of hot dipped (80 microns Average) galvanized steel of minimum thickness of **12 SWG Channel / Pipe or 8 SWG Angle** or The solar panel mounting structure shall be fabricated using mild steel pipes of 16-gauge thickness, designed for strength, durability, and ease of adjustment under practical site conditions. The primary panel frame shall consist of rectangular steel

pipes of size 1.5" × 3", forming the main supporting structure. An adjustable tilting mechanism shall be provided using 1.5" × 1.5" steel pipe members acting as lever arms, connected through a hinge arrangement made from a 3" diameter circular steel pipe to facilitate smooth and secure angle adjustment. Secondary members of size 1" × 2" shall be fixed over the main frame to support and secure the solar panels. The entire panel frame shall be mounted on a base structure comprising steel girders of section 7" × 3", ensuring adequate load-bearing capacity and structural stability. (Sketch and Profile of channel /Angle is Attached for Reference)

- b.** A sketch of the mounting frame (As per Actual Site Requirements) showing dimensions of the frame parts should be provided at the time of supply.
- c.** PV to ground clearance must not be less than 1.0 feet. The height of the upper edge of the structure should be up to 10 feet above the ground / Roof top Installations.
- d.** To avoid Shading, Distance between two rows of PV panels and from walls should be maintained at a minimum of 1.6 times the height of structure/walls. PV shading analysis may be conducted using Helioscope, SketchUp, PVSOL, PVsyst, or any other suitable software or tool.
- e.** For ground-mounted installations, the concrete foundation pit size shall be a minimum of 1.5 ft x 1.5 ft x 2.0 ft for each individual leg, or 1.5 ft x 3.0 ft x 2.0 ft for a double-leg structure. The concrete must extend at least 1.0 ft above the ground level. For rooftop installations, the civil foundation blocks for each individual leg should be approximately 0.7 ft to 1.0 ft (length) x 0.7 ft to 1.0 ft (width) x 0.7 ft to 1.0 ft (depth), depending on structural requirements. The concrete mix ratio shall be 1:2:4 for all civil works.
- f.** The Surface azimuth angle of PV Module $180^\circ \pm 30^\circ$ and the Tilt angle (slope) of PV Module be preferably $33^\circ \pm 15^\circ$. As per site requirements, further azimuth / tilt angle changes (if required) can be made with the approval of Engineer In-charge.
- g.** The PV modules will be mounted on metallic structures of adequate strength and appropriate design, which can withstand loads of modules and high wind velocities up to 150 km per hour.
- h.** Due to land non-availability or any other problem, Structure design can be modified as per site requirement. Pole Mounted or manual Tracker or H beam Mounting Structure with (Enamel Paint & Red -Oxide) can be provided with the approval of Engineer In-Charge.
- i.** Array fasteners (nut/bolts/washers) between PV Module and Structure shall be stainless steel (Non-Magnetic). Washers should be installed on both sides of the Module frame.
- j.** The minimum space between two PV Modules should be 2.54 cm (1 inch), to avoid air push over PV/ Modules.
- k.** Mechanism / arrangement for cleaning of PV Panels should be provided. i.e. : Space / ladder between panels or at the back side of structure, so that the operator can safely climb and clean the panels.
- l.** All other array fasteners Structure shall be stainless steel (Non-Magnetic) or Hot Dipped galvanized steel that provides the required mechanical strength. Washers

should be installed on both sides.

- m.** The PV modules will be mounted on metallic structures at the inner holes for cantilevered installation, which will evenly distribute the load of the panel around the support structure on both sides and in the middle.
- n.** All fabrication work (welding, cutting, or drilling) and structural modifications must be completed prior to the galvanization.

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2.4. EARTHING/ GROUNDING:

- a.** The PV panel frame, supporting structure, electrical cabinet, protection devices, and all associated equipment should be grounded using the shortest practical route to an effective earth point with a low resistance (ohmic) value, in accordance with the equipment manufacturer's recommendations and site specific soil conditions. An uninterrupted grounding conductor shall be employed to maintain electrical continuity. Effective grounding significantly reduces the risk of damage from lightning induced surges and electrical faults.
- b.** The Sizing of Earthing conductor will be done as per NEC Table 250.122 (Mentioned at Appendix-VI).
- c.** The grounding conductor should be 99.9% (allowing a tolerance of $\pm 0.1\%$) copper and PVC insulated / Bare Copper if installed underground along a defined path where size & Design shall be approved from Engineer In-charge before installation at site.
- d.** Motor, inverter, Battery / Battery Box (if required), Main Distribution Board should be connected to an adequate earth contact / Grounding.
- e.** Ground enhancement material (GEM) shall be used below and above the Earthing plate for proper grounding. Gravel or coarse sand shall be poured along with soil in the pit.
- f.** Grounding / Earthing plate should be made of copper plate of 4mm thickness & Size minimum 1.0 x 1.0 Ft
- g.** Grounding / Earthing conductor should be connected to the plate / Rod / GI Pipe by proper connector of minimum depth of 6 feet.
- h.** All nut / bolt and Earthing clamp shall be stainless steel or galvanized steel or any other material as per approval of Engineer In Charge.
- i.** Alternatively, Earthing Rod/Plate of suitable size and length can be installed, if given / mentioned in the BOQ/Design and Engineer In-Charge Approval.

Note: The copper purity test for the Earthing Rod/ Plate/ Cable may be conducted through any accredited laboratory in Pakistan.

2.5. BATTERIES:

- a.** The battery should be Deep Cycle, GEL, OPzV/OPzS, Lithium LiFePO₄, Sodium-ion, Lead Carbon, Super Capacitor based Battery or equivalent.
- b.** The battery must ensure safe and reliable operation in the whole range of ambient

temperatures from -5°C to + 50° C.

- c. The maximum permissible self-discharge rate should not be more than 5 percent of rated capacity per month at 25° C.
- d. The battery shall have a certificate of compliance, issued by a recognized laboratory.
- e. The battery shall meet the requirements and recommendations given in IEC 61427, IEC 60896 21/22 (For VRLA) or equivalent. Lab Test Reports for battery/Cell cycle life (All Batteries Type) should be provided.
- f. The Battery must support parallel and series connection to allow for capacity expansion in the future. Each Battery should have followed minimum information printed on battery:
 - Model Number, Serial Number and Type of battery.
 - Rated Voltage and Capacity (AH) at 25°C at discharge rate of 10 Hours.
 - Origin of made.
 - Manufacturer Name / distinct logo.
- g. The following information must be provided in the data sheet while submitting a technical bid.
 - Certification/Test Standard(s) of the battery.
 - Information regarding cycles & self-discharge rate.
- h. In case of rechargeable battery banks (having more than one battery), the interconnection shall be made using lead plated copper bus bars or properly insulated flexible copper conductors.
- i. Battery disconnect switch / breaker of suitable size should be installed between batteries and inverter / charge controller.
- j. The Battery must have Low self discharge rate, No memory effect and No gassing.

Note: The battery Capacity (kWh) test along with charge & discharge curves may be conducted through any accredited laboratory in Pakistan.

2.5.1. GEL BATTERIES:

2.5.1.1 Cycle life of the GEL battery (12V) must be a minimum 1000 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

2.5.1.2 Cycle life of the GEL battery (2V Cell) must be a minimum 1300 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

2.5.1.3 The Batteries should have a two years Comprehensive replacement warranty.

2.5.2 LEAD CARBON:

2.5.2.1 Cycle life of the Lead Carbon battery (12V) must be a minimum 2000 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

2.5.2.2 Cycle life of the Lead Carbon battery (2V) must be a minimum 2500 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25C (before reaching 80% capacity of its Initial Capacity).

2.5.2.3 The Batteries should have a two years Comprehensive replacement warranty.

2.5.3 OPzV / OPzS BATTERIES:

2.5.3.1 Cycle life of the OPzV / OPzS battery (12V) must be a minimum 2000 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25C (before reaching 80% capacity of its Initial Capacity).

2.5.3.1 Cycle life of the OPzV / OPzS battery (2V Cell) must be a minimum 2500 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25C (before reaching 80% capacity of its Initial Capacity).

2.5.3.1 The Batteries should have a two years Comprehensive replacement warranty.

2.5.4 LITHIUM BATTERIES (LiFePO4):

2.5.4.1 Cycle life of the Lithium LiFePO4 battery must be a minimum 5750 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.5C@25°C (before reaching 80% capacity of its Initial Capacity).

2.5.4.2 The battery shall comply with the requirements and recommendations outlined in IEC 62619:2022 issued by a recognized and accredited laboratory.

2.5.4.3 Lab test reports from a third-party laboratory verifying the claimed battery/cell cycle life shall be provided.

2.5.4.4 The LiFePO4 battery shall be covered by a comprehensive replacement warranty for a minimum of five (05) years.

2.5.4.5 The battery shall be equipped with an integrated Battery Management System (BMS) (Preferably active BMS) to ensure operational safety, reliability and communication with inverter or Charge Controller.

2.5.4.6 The BMS of the battery must have the following features but not limited to :

- Temperature protection
- Over charge protection
- Low voltage disconnects
- High Voltage Disconnect
- Short circuit alarm function
- Self balancing function

- Over-current protection
- Over-discharge protection

2.5.4.7 The LiFePO₄ Battery must have LCD status and alarm indication.

2.5.4.8 The battery pack shall have a minimum ingress protection rating of IP30 or higher.

2.5.4.9 The charge and discharge rate shall be designed for 0.5 C minimum, but the battery must be capable of handling 1 C charge and discharge rates.

2.5.4.10 The battery shall be equipped with communication ports such as CAN/CAN/RS485/RS232 OR EQUIVALENT (one port for monitoring settings/data integration and one port for communication with inverter/Charge controller). Additionally, the BMS may have a wireless communication capability, such as Bluetooth, for monitoring, settings adjustment, and calibration purposes.

2.5.4.11 The above-mentioned specifications and details shall be clearly included in the data sheet, user manual, and all other relevant supporting documents submitted as part of the bid.

2.5.5 SUPER CAPACITOR BASED BATTERY BANK:

2.5.5.1 Cycle life of the Super Capacitor base must be a minimum 0.1 million cycles @ 100% depth of discharge (DOD) at discharge rate of 1C@25C (before reaching 80% capacity of its Initial Capacity).

2.5.5.2 The battery must have an Active Integrated Battery Management System (BMS) to ensure battery safety and reliability.

2.5.5.3 The Battery must have a Display LED for battery Voltage, Amperes etc and should have alarm indications.

2.5.5.4 The charge and discharge rate of the battery must be designed at 1C minimum and also capable of handling continuously 1C Charge and discharge currents.

2.5.5.5 Warranty of battery for free repair & replacement should be minimum Five years.

2.5.5.6 Nominal Temperature for Super Capacitor battery shall be minimum -10 to +55 degree Celsius.

2.5.5.7 Super Capacitor battery shall be Non-flammable. (i.e, Super Capacitor Cells should be non-petroleum based).

Note:

- Product brochure, Catalogue and certificates must be attached with the Technical Bid.
- Battery Capacity test should be conducted by the contractor through accredited third-party laboratories within Pakistan

2.6. BOX FOR BATTERIES, CHARGE CONTROLLER/INVERTER AND PROTECTION DEVICES:

- a.** The batteries should be housed in a vented compartment/stand that prevents users from coming in contact with battery terminals. This compartment/stand should be strong enough to accommodate the weight of the battery.
- b.** A locking mechanism shall be provided to restrict unauthorized access to the battery compartment.
- c.** The enclosure shall be manufactured from mild steel of at least 18 SWG thickness.
- d.** The cabinet shall be hot-dip galvanized or powder-coated or Enamel Paint with Red Oxide, as mentioned in the BOQ.
- e.** The entire enclosure/stand must be constructed to last at least twenty years without maintenance and should be protected against corrosion. The enclosure should have a clean and neat appearance. The entire enclosure/stand must have a neat, clean, and professional appearance, and the battery box/stand should be installed at a location suitable to the user's preference.
- f.** The cabinet must be insulated with rubber corks/covers at each cabinet leg to prevent direct contact with metal surfaces, ground, or other objects, enhancing safety and stability.
- g.** The cabinet shall have a designated area for mounting a user manual or instruction guide, along with the Site ID label.
- h.** Provisions shall be made for the installation of protection devices such as fuses, breakers, and disconnect switches, as well as a clearly marked earthing point.
- i.** All internal wiring shall be done in proper ducts and labeled for easy identification and maintenance.
- j.** The cabinet shall include designated areas for labeling/stickering of all internal and external components for quick reference and identification,
- k.** The cabinet shall incorporate sufficient ventilation slots or louvers to allow for natural airflow and heat dissipation, while protecting against dust and moisture.
- l.** Cable glands shall be provided at appropriate locations to ensure secure and protected cable entry/exit.
- m.** The design shall feature rounded corners or edge protectors to reduce injury risk during handling or maintenance.
- n.** The cabinet shall have minimum Ingress protection of IP-21 or above.
- o.** The cabinet may optionally support transparent panels to facilitate visual inspection and operational visibility.
- p.** Pre-drilled mounting holes or brackets shall be available inside the cabinet for optional installation of circuit protection accessories.
- q.** Clear and permanent safety signage such as polarity indicators, high voltage warnings, and earthing symbols on steel stamps shall be displayed on cabinets.
- r.** Cabinets shall be properly wrapped and protected before shipment from the warehouse to the site to prevent any unnecessary damage during transportation and handling.

- s. The cabinet shall be installed with a minimum clearance of one foot above the finished floor level to ensure protection against moisture, dust, and other potential hazards.
- t. The Cabinet for modular installation should be in racks with proper insulation (preferably rubber insulation).

2.6.1 SOLAR CHARGE CONTROLLER (FOR SOLAR DC SYSTEM):

- a. The controller shall support multiple battery types, including:
 - Flooded Lead-Acid (FLA)
 - GEL
 - Absorbent Glass Mat (AGM)
 - OPzV
 - OPzS
 - Lithium Iron Phosphate (LiFePO₄)/Super Capacitor
- b. The charge controller shall be certified in compliance with international safety and performance standards, including but not limited to:
 - IEC 62109-1/ IEC 62509
- c. The controller shall meet the following Ingress Protection (IP) ratings:
 - IP30 or higher for indoor installation
 - IP65 or higher for outdoor installation
- d. The controller shall utilize Single MPPT (Maximum Power Point Tracking) technology to optimize solar input performance.
- e. The MPPT tracking efficiency shall be > 99%, and the overall energy conversion efficiency shall be ≥ 95%.
- f. The controller shall include automatic temperature compensation functionality to adjust charging parameters based on ambient temperature conditions, protecting battery health.
- g. The device shall provide comprehensive protection features, including but not limited to:
 - PV short-circuit protection
 - PV reverse polarity protection
 - PV over-voltage protection
 - PV over-current protection
 - Battery overcharging protection
 - Battery over-discharging protection
 - Battery reverse polarity protection
 - Load short-circuit protection
 - Overload protection
 - Reverse current flow protection from battery to PV modules
- h. The controller shall be equipped with an efficient thermal management system, including a properly dimensioned passive or active heat sink, to maintain safe operating temperatures.
- i. The charge controller shall include an CAN/RS485/RS232 OR EQUIVALENT

communication port as standard. Support for additional communication protocols such as CAN, RS232, Wi-Fi, or Bluetooth shall be considered an added advantage.

- j. The controller shall be capable of operating in battery-less mode, delivering power to DC loads directly from PV modules where applicable.
- k. The controller shall be capable of communicating with LiFePO4 batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
- l. The controller shall feature a digital interface, either integrated (LCD) or external, capable of displaying real-time operational parameters including:
 - PV voltage and current
 - Battery voltage and current
 - State of Charge (SOC) Preferred
 - Load status
 - Faults and alarms
- m. The controller may support data logging and remote monitoring features through compatible software or web-based platforms.
- n. The controller shall support user-configurable charging algorithms or automatic detection for the connected battery type.
- o. Operating temperature range shall be -20C to +60C.
- p. The charge controller should allow for wall, DIN-rail, or panel mounting, with proper size and clearly labelled wiring terminals. Mounting accessories should be included.

Note: The efficiency test along with all protection features test may be conducted from the accredited laboratory in Pakistan.

2.6.2 ALL IN ONE / SOLAR KIT / STANDALONE SOLAR SYSTEM MUST INCLUDE THE FOLLOWING FEATURES:

- a. The all-in-one solar solution must include an MPPT charge controller (DC) or a hybrid inverter (AC), a LiFePO4.battery, and properly sized protection devices (breakers/fuses) for the PV modules, battery bank, and load connections, as per requirements and specifications in Section A(2), The type of solution-whether DC or AC-shall be specified in the BoQ.
- b. BMS (preferably active) communication between LiFePO4 Battery and MPPT Charge Controller/ Hybrid Inverter.
- c. Heat dissipation with proper heat sinks and cooling fans equipped with a fan controller must be available in case of IP-30 enclosure with proper heat sinks mechanism must be adopted.
- d. USB Mobile Charging Port must be available.
- e. The all-in-one must have individual ports for various load connectivity.
- f. DC All-in-One/Solar kit/Standalone. Solar Systems, shall comply with relevant and applicable IEC standards (IEC 62257-9-5:2024) or latest.
- g. The All-in-one shall be equipped with a communication port such as CAN/RS485/RS232

or equivalent for monitoring settings/data integration. Additionally, the BMS may have a wireless communication capability, such as Bluetooth, for monitoring, settings adjustment, and calibration purposes.

- h.** The All-in-one shall feature a digital interface, either integrated LCD/LED, capable of displaying real- time operational parameters including:

 - PV voltage and current
 - Battery voltage and current
 - State of Charge (SOC)
 - Load status
 - Faults and alarms
 - Any other parameters as per project requirement
- i.** Wide PV voltage input range to support various panel configurations under IEC standards.
- j.** The all-in-one enclosure shall be manufactured from mild steel of at least 16 SWG thickness for durability and rigidity.
- k.** The all-in-one enclosure shall be hot-dip galvanized/ Powder-coated/ Enamel Paint with Red Oxide with technical parameters tag including Brand Name, Product name, Model, Serial number, Manufacturing date, Input/ Output Power range, Input/ Output Voltage range, Input/ Output current range and Battery capacity.
- l.** The enclosure must be insulated with rubber corks/ covers at each enclosure leg to prevent direct contact with metal surfaces, ground, or other objects, enhancing safety and stability.
- m.** The all-in-one enclosure design shall feature rounded corners or edge protectors to reduce injury risk during handling or maintenance.
- n.** The all-in-one enclosure shall be properly packed and protected prior to shipment from the manufacturer's warehouse to the site, to prevent any damage during transportation and handling.
- o.** The requirements for LiFePO₄. MPPT Charge Controller (DC) / Hybrid inverter (AC) detail are as under:

2.6.2.1- Battery Bank (LiFePO₄):

- a.** Cycle life of the Lithium LiFePO₄ battery must be a minimum 5750 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.5C@25°C (before reaching 80% capacity of its Initial Capacity).
- b.** Lab test reports from a third-party accredited laboratory verifying the claimed battery/cell cycle life shall be provided.
- c.** The maximum permissible self-discharge rate shall not exceed 5% of the rated capacity per month at 25C.
- d.** The LiFePO₄ battery shall be covered by a comprehensive replacement warranty for a minimum of five (05) years.

- e. The battery shall be equipped with an integrated Battery Management System (BMS) (Preferably active BMS) to ensure operational safety, reliability and communication with MPPT Charge Controller/On-Grid Hybrid solar system.
- f. The BMS of the LiFePO₄ battery must have the following features but not limited to:
 - Temperature protection
 - Over charge protection
 - Low voltage disconnects
 - High Voltage Disconnect
 - Short circuit alarm function
 - Self-balancing function
 - Over-current protection
 - Over-discharge protection
- g. The charge and discharge rate shall be designed for 0.5 C minimum, but the battery must be capable of handling 1 C charge and discharge rates.

2.6.2.2- In Case of DC all in One / Solar Kit / Standalone Solar System:

- a. The controller shall be capable of communicating with LiFePO₄ batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
- b. The controller shall utilize Single MPPT (Maximum Power Point Tracking) technology to optimize solar input performance.
- c. The controller shall include automatic temperature compensation functionality to adjust charging parameters based on ambient temperature conditions, protecting battery health.
- d. The device shall provide comprehensive protection features, including but not limited to:
 - PV over-voltage protection
 - PV over-current protection
 - Battery overcharging protection
 - Battery over-discharging protection
 - Battery reverse polarity protection
 - Short Circuit Protection for PV, battery bank and load connections
 - Overload protection
 - Reverse polarity protection for PV & battery bank connections
 - Low Voltage Disconnect (LVD) and Reconnect (LVR) to protect battery from deep discharge and allow safe reconnection
- e. The controller shall be equipped with an efficient thermal management system, including a properly dimensioned passive or active heat sink, to maintain safe operating temperatures.
- f. The controller shall be capable of operating in battery-less mode, delivering power to DC loads directly from PV modules where applicable.
- g. The controller shall support data logging and remote monitoring features through

compatible software or web based platforms.

- h.** The controller shall support user-configurable charging algorithms or automatic detection for the connected battery type.
- i.** The MPPT tracking efficiency shall be $\geq 99\%$, and the overall energy conversion efficiency shall be $\geq 95\%$.

2.6.2.3- In case of AC all-in-one/solar kit solar systems:

- a.** The inverter shall be capable of communicating with LiFePO₄ batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
- b.** Minimum 95% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
- c.** The Maximum power point tracking MPPT efficiency $\geq 99\%$, and converter efficiency $\geq 92\%$.
- d.** The inverter should have a built-in single MPPT controller.
- e.** Hybrid Inverter (If quoted along with Lithium Batteries) may be capable of communication with the BMS of Lithium Batteries.
- f.** Rated output voltage of inverter / Controller shall be pure sine wave AC.
- g.** Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
- h.** Wide input voltage range capability. (i.e. $\therefore$ Voltage Range can be adjustable / selectable)
- i.** The device shall provide comprehensive protection features, including but not limited to:
 - PV over-voltage protection
 - PV over-current protection
 - Battery overcharging protection
 - Battery over-discharging protection
 - Battery reverse polarity protection
 - Short Circuit Protection for PV, battery bank and load connections
 - Overload protection
 - Reverse polarity protection for PV & battery bank connections
 - Low Voltage Disconnect (LVD) and Reconnect (LVR) to protect battery from deep discharge and allow safe reconnection.

2.6.3 BRACKET FAN SPECIFICATIONS:

- a.** Fan Size: 14-16 inches
- b.** Sweep Size: 350 mm
- c.** Air Delivery: Minimum 75 m³/min
- d.** Service Value: Minimum 1.65
- e.** Operating Voltage: 230V $\pm 10\%$
- f.** Frequency: 50 Hz
- g.** Insulation Class: Class 155 (F-class) for safe and reliable operation

- h.** Bracket Fan should be marked with the manufacturer name, model number, rated voltage & Wattage

2.6.4 AUTO VOLTAGE STABILIZER:

- a.** The stabilizer shall operate automatically and may be either block-based or servo-based (preferred). The type and size of the stabilizer shall be specified in the Employer's Requirements.
- b.** The winding material of the transformer core and all internal wiring shall have a minimum copper purity of 99.9%, with an allowable tolerance of $\pm 0.1\%$. A copper purity test certificate from a government approved laboratory must be provided.
- c.** A circuit breaker of appropriate rating (1.25 to 1.50 times of the input utility/grid current) shall be installed between the grid and the stabilizer for protection.
- d.** The stabilizer should automatically cut off the power if the grid or utility input voltage is 270V.
- e.** A three-pin plug and switch shall be installed on the output side of the stabilizer for operational convenience and safety.
- f.** The stabilizer must be compatible with a frequency range of 50 Hz to ensure proper functioning in local grid conditions.
- g.** The stabilizer shall maintain an efficiency of not less than 90% at any point when the input voltage is $\geq 120V$.
- h.** At input voltage of $\geq 120V$, the stabilizer must be capable of running at 50% of its rated capacity (in Watts)
- i.** The stabilizer shall be capable of providing a regulated output voltage in the range of 210V to 250V when the input voltage is $\geq 120V$.
- j.** The stabilizer must have a digital Voltmeter for both input and output measurement.
- k.** The stabilizer must have the exhaust fan installed inside and shall have automatic temperature control through imbedded sensors.
- l.** The block-based stabilizer must have relays capable of handling voltage fluctuations, ensuring fast response times to protect the load, and shall feature high-quality contacts, thermal resistance, and best coil insulation.
- m.** The stabilizer may be equipped with LED indicators to display system faults and warnings for ease of monitoring and maintenance.

Note: The copper purity test from any accredited laboratory of Pakistan.

2.7. LED FLOOD LIGHTS:

- a.** Solar Based LEDs/Light fixtures shall conform to the latest IEC/ISO internationally recognized standards.

- b. LEDs/Light fixtures should not be Chip-on-board (COB) single chip type due to their poor heat dissipation.
- c. LEDs/Light fixtures shall be modular type with proper heat sinks.
- d. Solar based lights (LED fixtures etc) should provide at least 120 Lumen/watt.
- e. The Colour rendering Index (CRI) must be equal or greater than 70
- f. LEDs/Light fixtures should be designed to deliver at least 10 years of service.
- g. The complete lightning unit shall be weather proof (Protection Class IP67).
- h. The output from the LEDs/Light fixtures should be constant throughout the duty cycle.

2.8. AC ENERGY EFFICIENT LED LIGHT BULBS:

- a. Cap/Fitting/Base Type: E27
- b. Colour Temperature: Cool White
- c. Luminous Efficacy: Minimum 120 lumens per watt (L/W)
- d. Lamp Life Time: $\geq 10,000$ hours
- e. Power Factor: ≥ 0.90
- f. Rated Voltage: 220-230 Vac
- g. Rated Power: 14 to 18 Watts
- h. Must be NEECA certified.
- i. LED Light Bulbs should be marked with the manufacturer name, model number, rated voltage & Wattage as per NEECA guidelines.

2.9. AC ENERGY EFFICIENT CEILING FANS:

- a. Must have rated Power: 45 to 55 Watts
- b. Sweep Size: 54" to 56"
- c. Rated Voltage: 220-230 Vac ($\pm 10V$)
- d. Service value ($m^3/min/W$): ≥ 4.5
- e. Insulation Class: ≥ 155 (F-Class)
- f. Noise Level: Should be within acceptable comfort levels
- g. $\pm 10\%$ variation in power consumption is allowed as per PSQCA/NEECA standard
- h. Motor Core: Made of electrical steel sheet
- i. Winding Wire: 99.9% super enamelled copper CA wire or 99.9% pure copper wire
- j. The fan must be energy-efficient and clearly marked with the manufacturer's model number, rated voltage and wattage as per NEECA guide line.
- k. Must be NEECA certified.

2.10. DC ENERGY EFFICIENT LED LIGHT BULBS:

- a. The LED lamps must have luminous efficacy of at least 100 Lumens/Watt.
- b. The LED lamp must be protected against reversed polarity of the operation voltage.

- c. Base shall be an E-27 thread type.
- d. The emitted light shall be cool or warm white.
- e. The wide angle shall be between 120 degree to 125 degree.
- f. f. Operating Voltage 12Vdc / 24Vdc.
- g. Lamps should be marked with the manufacturer model number, rated voltage, wattage and or batch number.

2.11. PVC CHANNEL DUCTS & PIPES

- a. A product of good quality standard material from standardized firms/manufacturers with suitable size to be provided / used, as per direction / approval of Engineer In-charge.
- b. Ducting must be done with proper steel nails/ screws and clips.
- c. The PVC duct shall be flame retardant.
- d. All ducting (wiring) must be aligned.

2.12. FLEXIBLE PVC PIPE

- a. The flexible PVC pipe should be of good quality material from standardized firms/manufacturers with suitable size should be provided / used, as per direction / approval of Engineer In-charge.

2.13. CIVIL WORK:

The following Civil Works should be carried out for ground installation of SPV Modules/mounting structures.

- a. Minor Cutting and clearing of trees/plantation to avoid shadows.
- b. Civil work for the earthing system as per the statutory requirements.

2.14. REFLECTIVE/ INSULATING PAINT

The Roof Paint should be ultra white, high reflective 100% acrylic elastomeric roof sealer designed for fixing leaks in roofs the paint should contain heat reflective pigments and additives that provide an excellent, highly protective barrier which reflects the sun's heat and destructive UV rays leaves a brilliant ultra white finish, reducing surface heat absorption up 20°F.

The Reflective paint should comply with ASTM D6083, Fiber Reinforced for more protection, strength and durability which allows for contraction and expansion, Resisting surface fungal growth.

SECTION-3-PART "B" -SPECIFICATION FOR SOLAR PUMPING SYSTEM

3.1 PUMP (SUBMERSIBLE) :

Pump should be supplied having standard ISO-9906 specifications. The pump must be submersible, made of stainless steel. The characteristic curves (Original from Manufacturer) showing the efficiency at duty point and performance of the pump should be provided in the technical proposal and also at the time of pre-supply testing.

The quoted pump should be tested for its performance and certified as per ISO-9906 standard. The pump should be suitable for installation and operation in tube wells/dug wells/open wells with clear water discharge. Pump shall comprise of bowl assembly and non-return valve as integral part of pump's parts. Pump and motor shall rigidly couple through NEMA standard coupling. The stage casings of pumps should be connected as per NEMA/ANSI/AWWA /ASTM/BSS standard. Each stage casing must have a replaceable wear ring.

The impellers shall be secured to the pump shaft with tapered conical sleeves pressed into the taper bore of impeller or impeller secured through chrome plated stainless steel hexagonal sleeves. Suction casing must be between pump and motor with suction strainer as protection of pump against coarse impurities of the liquid handled.

Specification for main components of the Pumps:		
S.No	Components	Specifications
1	Casing/Diffuser	The Casing/Diffuser should be in fabricated stainless steel AISI 304 / 316.
2	Impellers	Stainless steel AISI 304 / 316.
3	Driving Shaft	Stainless steel 304/420 / 316
4	Sleeves	Stainless steel AISI 329/ 304 / 316
5	Gaskets	Rubber Gaskets
6	Bearings	AISI 329 stainless steel
7	Coupling & Screen + Cable Guard	Stainless steel AISI 316/319/304/420
8	Non-Return Valve	As per British standard specifications (BSS),

9	Pressure Gauge	N/A
10	Clamps	Steel - Pressed
11	Pump Efficiency	Minimum efficiency of the pump (For discharge of more than 3000 iGPH) should be 70% ensured at duty point. (Duty Point of the Pump be preferably selected at the peak efficiency point or (Within $\pm 20\%$ of discharge) of Pump Peak efficiency Point)

3.2 MOTOR:

The winding material should be 99.99% copper. The motor should have wet type, water cool rewind able/repairable stator. The motor should have non-disposable/non-hermetically sealed winding / High Efficiency Water Cooled Rewindable Permanent Magnet Synchronous motors that can be supplied for enhanced efficiency and other added advantages. The insulation class of the winding material should be mentioned. For each model quoted, all the technical parameters such as rated voltage, power factor, efficiency, full load ampere, speed and other similar parameters should be provided at the time of pre-supply testing. The testing report with all basic parameters should also be provided at the time of pre-supply testing.

The motor shall be manufactured in compliance with National Electrical Manufacturer Association (NEMA) standards. The motor shall be three-phase submersible and shall be capable of operating at rated voltage of 380 - 415 Volts at 50 Hz - and 100 Hz in case of Permanent Magnet motor. (or as per VFD / Motor requirements). The motor should be capable of operating with variable speed through V/F control or Sensor less Vector Control. Winding of the motor shall be of a rewindable type with class - IC40 insulation and IP68 protection. The synchronous speed should be 2850-3000 RPM.

The motor shall be capable of operating in well water with temperature normally starting from 40C. The motor should be designed for continuous operation. The motor must be filled with water without applying chemical additives hazards to health for cooling. The motor must be properly protected against the entry of well water sand etc by double mechanical seal, one is rotating and other stationary and must be made of Silicon carbide/ Tungsten carbide and must be protected with sand protection guards.

All supports shall be high grade cast iron and stator outer side jacket body should be in stainless steel in AISI 304. The excessive pressure due to heating up of the filled water must be compensated by a pressure equalizing rubber diaphragm in the lower part of the motor. The axial thrust of the pump shall be countered by oscillating sliding block type thrust bearing. The thrust bearing of the motor should be able to bear a downward thrust force from the water pump and the upward thrust force produced while starting the water pump. Motor in open well / water tank should be installed with cooling jacket / shroud / sleeve and when motor is installed in bore then installing of cooling jacket is also required.

Technical specification of rewind-able wet stators, three phase squirrel cage water filled submersible motor.

S.No	Components	Specifications
1	Winding	Made of pure electrolyte copper and the winding insulation should be suitable for > 1000 Volts and must have a full fill resistant test range.
2	Stator	Energy efficient low-losses electrical magnetic sheet M800 or superior should be fixed in stainless steel casing. M800 or M600 magnetic sheet are preferable to use.
3	Rotor	Energy efficient low-losses electrical magnetic sheet M800 or superior fixed with high grade copper bars or High-Grade Neodymium (or equivalent or better) Permanent Magnets in case of Permanent Magnet motor.
4	Spline Shaft	AISI 420 stainless steel, flange dimension according to NEMA standard, over size design to ensure stiffness in severe conditions.
5	Shaft bearing	Water lubricated guide/general bearings fixed in upper and lower brackets should be made of metal impregnated carbon.
6	Lower thrust bearing	Thrust sliding block bearings, self-aligning Mitchell type, should be able withstand 15500/20000N axial load.
7	Mechanical (Stationary & Rotary)	Silicon carbide or tungsten carbide mechanical seal.
8	Cooling filling fluid	Water mixed with non-toxic anti-freeze provide cooling and lubrication also protect and prevent inside parts from corrosion.
9	Degree of protection	IP68
10	Insulation Class	Insulation Class B (130C) NEMA Insulation Class F (155C) NEMA or above Will be given Preference.
11	Voltage Tolerance	+.6% to -10%
12	Mounting position	Capable of both Vertical or horizontal Installation
13	Class	IC40
14	Maximum Immersion	150 Meters
15	Starting per hour	The motor shall be capable of 10 starts in an hour.
16	Motor Efficiency	Efficiency of motors 7.5 HP and above should not be less than 75% at Full Load and Motor Rated Voltage.

3.3. SUBMERSIBLE FLATE ELECTRIC CABLE (4-Core):

The Submersible cable (4-Core) should be made of 99.9% copper strands with double PVC insulation for 1000Vac, should be adequately flexible and environment friendly. Stranded and flexible insulated copper wires and cables must be used for all outdoor and indoor installations. The wiring that leads into the building shall be protected in a conduit.

The cable must have undergone quality tests as per BSS standards. Cable size should be selected so that the Voltage drop Losses in the drop cable should not be more than 2.5%.

Refer to Table-02 For Cable Sizing. Following lab tests are mandatory.

- Conductor resistance test.
- Insulation resistance test.
- Pressure test.
- Spark test.

Note: The Supplier should provide the quality tests certificates at the time of pre-supply testing and inspection.

3.4. COLUMN PIPE:

The column pipe shall be flanged ERW steel pipes confirming to ASTM designation A-53 with a minimum thickness of 3.6 / 4.0 mm (3.6 mm for pipes up to 2.5" dia and 4 mm for pipes above 2.5") and shall be painted with corrosion resistance paint of suitable thickness. Flanges thickness of 19-20 mm shall have grooves for cable passage. Each column pipe shall be complete with gaskets, bolts/studs, washers and nuts. All nuts, bolts, and washers shall be made of minimum A2 grade stainless steel.

The column pipe shall be supplied in an interchangeable section having an approximate length of 10 feet column pipe shall be flanged perpendicular to the axis of pipe.

Column pipe size should be selected so that the Head Losses in the column pipe should not be more than 5%.

HDPE Pipe of ≥ 0.75 Inch diameter, SDR 13.6, PE100, conforming to ASTM F-2160 Standard without Joints to be installed/included along with and equal to Column pipe for confirming Water Level testing purpose.

FEATURES:

- Manufacturer's pipes should meet international standards like BS EN 10255 & ASTM A 53.
- Dimensional accuracy circularity and plan end cut should be observed,
- Weld strength of pipe and mechanical properties or raw material should be tested as per manufacturing standards.
- Pipes should be NDT tested (Non-destructive - Eddy current)
- Pipes should be hydrostatically pressure as per manufacturing standard.
- Pipes should be gone through the straightening process to remove bendiness.

TABLE-01: COLUMN PIPE SIZE WITH MAXIMUM DISCHARGE.

S.No	Column Pipe Diameter (Inch/mm)	TYPE	COLUMN PIPE DIMENSIONS (Minimum)	MAX DISCHARGE ALLOWED	
				Litres / Hour	iGPH
1	25 mm	HDPE	PN12/ SDR 13.6/ PE100	1,300	286
2	32 mm	HDPE	PN12/ SDR 13.6/ PE101	2,300	506
3	40 mm	HDPE	PN12/ SDR 13.6/ PE102	4,650	1,023
4	50 mm	HDPE	PN12/ SDR 13.6/ PE103	8,250	1,815
5	2"	MS	3.6/4 MM Thickness	12,000	2,640
6	2.5"	MS	3.6/4 MM Thickness	21,000	4,619
7	3"	MS	≥4 MM Thickness	33,500	7,369
8	4"	MS	≥4 MM Thickness	70,000	15,398
9	5"	MS	≥4 MM Thickness	124,000	27,276
10	6"	MS	≥4 MM Thickness	200,000	43,994

3.5. TOPSET:

Top set shall comprise of Bore covers plate, (covering bore hole completely and securely), installation/suspension clamps (2-Nos), Sluice Valve (BSS/ASTM), Reflex Valve (BSS/ASTM), Washout Valve approx. 3-4 feet above the ground (T-Connection For Testing Pump's discharge), connector and cable jointing material (Cable connection from motor to switching device shall be joint free), Liquid Filled Pressure gauge minimum 4 Inch diameter suitable / appropriate for the required head pressure and cable ties. Bore Cover Plate should have provision for water level testing facility (i.e .: Hole for Sonic Water Level Meter / HDPE Pipe insertion).

- **Non-Return Valve / Sluice Valve**

As per British standard specifications (BSS), Minimum PN16 (16 Bar) or above (As per Site Requirements). PN Value / Bar Capacity of Valves must be more than Installed

Pump Max/Shut-off Head minus Static Water Level of Bore. (Leakages in Valves are NOT acceptable).

- **Pressure Gauge**

As per British standard specifications (BSS), having PSI or Bar scale (4 Inch Size), Liquid Filled, minimum 500 PSI Range or Above (As per Site Requirement), Looped Siphon tube Pipe, Stainless Steel/polypropylene Casing.

For Cleaning of solar Panels, Plastic pressure pipe should be provided of suitable length to reach the furthest / last Solar Panel.

Every Water Supply Scheme should have a non-removable name plate fitted at a suitable place / box having essential information and bearing the name of supplier, Consultant and client.

3.6. SOLAR PUMP INVERTER / CONTROLLER:

- a. The solar pump inverter/controller should have built-in advance version of Auto MPPT controller, over load protection, soft start/Soft Stop Features and Variable Frequency Drive (VFD) with integrated Gate Bipolar Transistors (IGBTs) of European, USA or Japanese origin or at least equivalent.
- b. The make and origin of the inverter/controller should be clearly mentioned in the catalogue and submitted in the technical proposal.
- c. The inverter offered should comply to or Equivalent standards:
 - c(i). CE/RoHS
 - c(ii). Low Voltage Directive 2014/35/EU
 - c(iii). EMC Directive 2014/30/EU
 - c(iv). IEC 62109-1 (Safety of Power Converters for use in PV Systems)
- d. The complete datasheet showing all the electrical parameters like input & output voltage ranges should be provided in the technical bid.
- e. All the electrical parameters like input & output voltage ranges, and efficiency should be provided at the time of pre-supply testing and inspection.
- f. Efficiency of the inverter should be 96% and above at Rated Capacity.
- g. Efficiency of MPPT should be 98% and above.
- h. The inverter <25kW ingress protection of inverter must be minimum IP 65 Rating or above and for inverter ≥ 25kW ingress protection of inverter / enclosure will be minimum IP 54 Rating or above.
- i. Inverter / Controller having the capability to run both on AC and DC Power would be

given preference.

- j. Inverters should have at least three (3) years product and performance warranty.
- k. The Pump Controller/Inverter should have an ON/OFF Switch/Button to Start and Stop the Pump.
- l. Inverter should have active RS232/485 etc communication port available, the Data available through this port can be used for Remote Monitoring.
- m. Inverter circuit must include protection against:
 - I(i). Over or Low voltages and currents beyond critical level of the inverter's circuits.
 - I(ii). Protection against accidental short circuits & reverse polarity connections.
 - I(iii). Protection against lightning induced transients.
 - I(iv). Overload protection.
 - I(v). Low RPM Protection (i.e. : Frequency < 30 Hz or as per pump characteristic curve) Motor Should Stop.
 - I(vi). Dry run protection. (PF / Current Based).
- n. In the case of Permanent Magnet Motor. The inverter shall be capable of operating motors through V/F Control and sensor-less vector speed/ torque control; and shall have the feature of auto-learning necessary motor parameters.

3.7. dV/dT or SINE FILTERS WITH INVERTER (VFD)

- a. The use of load reactors (dV/dT Filter) increases the reliability, performance, and efficiency of VFD systems, extends the life of both drives and motors, and reduces the amount of energy consumed by the motor/drive system.
- b. Output dV/dT or Sine Filters (between VFD and Motor) of appropriate size (for 3-phase $\geq 380\text{Vac}$ Motor of Class $\leq B$ Insulation) should be used where the cable length between motor and inverter is more than Fifty (50) Feet or as advised / recommended by the inverter manufacturer in their Technical Documentation. For Cable lengths of more than 150 meters sine filters should be used.
- c. Filter should be enclosed in a vented box.
- d. Filter Efficiency should be a minimum 97%.
- e. Filter should have a current rating of equal or greater than Motor FLA Rated Current.
- f. The distance between the filter and the pumping inverter should not be more than 2 meters.
- g. Motors with Insulation Class F, H or above are exempted from the requirement of dV/dT Filter.

3.8. SYSTEM DESIGN FOR PUMPING SYSTEM

- a. A suitable factor of safety should be applied while designing the system in order to have compensations for variations in irradiations.
- b. For Fixed Structure, the PV panel peak power at STC (Wp) should be 75% more than the Motor basic input power (PV Loss Compensation Factor = 1.75).

- c. For Auto / Manual Tracker, the PV panel peak power at STC (W_p) should be 50% more than the Motor basic input power (PV Loss Compensation Factor = 1.5) or as per approval of Engineer In charge.
- d. If Single Axis Auto Tracker Structure is installed on the above factor, then daily operational timings of pumping can be increased by 10-20%, as compared to fixed structure installation.

e. Total PV Power (W_p) (Imperial Gallons) =
$$\frac{Q \text{ (iGPH)} \times \text{TDH (ft)} \times 746 \times \text{PV Loss Factor}}{60 \times 3300 \times \eta_{\text{pump}} \times \eta_{\text{motor}}}$$

Variable Definitions

- PV Power (W_p) - Required photovoltaic power (Watts peak)
- Q (iGPH) - Flow rate in Imperial gallons per hour
- TDH (ft) - Total Dynamic Head in feet
- 746 - Conversion factor from horsepower to watts
- PV Loss Factor - Factor accounting for PV system losses
- 60 - Conversion from minutes to hours
- 3300 - Unit conversion factor related to hydraulic power
- η_{pump} - Pump efficiency
- η_{motor} - Motor efficiency

f. Total PV Power (W_p) (US-Gallons) =
$$\frac{Q \text{ (US-GPH)} \times \text{TDH (ft)} \times 746 \times \text{PV Loss Factor}}{60 \times 3960 \times \eta_{\text{pump}} \times \eta_{\text{motor}}}$$

g. Total PV Power (W_p) (Metric Units) =
$$\frac{Q \text{ (m}^3\text{/hr)} \times \text{TDH (m)} \times 9.81 \times 1000 \times \text{PV Loss Factor}}{3600 \times \eta_{\text{pump}} \times \eta_{\text{motor}}}$$

- h. Voltage (V_{mp}) of each String of PV Panels should be as per details given below and String Voltage (V_p) should be within the MPPT range of Inverter.

h(i). For 380 Va 3-Phase Motor = $380 \times 1.414 \times 1.06 = 570 \text{ Vdc String, minimum}$

h(ii). For 220 Vac 3-Phase Motor = $220 \times 1.414 = 310 \text{ Vdc String.}$

h(iii). Small Inverters (i.e: 3-Phase, 220 Vac) with voltage boost function and DC Motors are exempted from the above string voltage requirements. String can be made as per boost Inverter / Controller recommended String DC Voltage and should not be less than 240 Vdc in any case.

- i. Details of each PV Panel string should be submitted in technical proposal (i.e: Nos of total strings and Nos of PV panels in each string along with wattage and **V_{mp}** of each PV panel).
- j. Unjustified Oversizing in PV Panels Wattage is not allowed.
- k. To avoid any oversizing, all commercially available PV Panels should be considered.
- l. A Solar Pump Inverter should have a kW capacity equal or greater than the Motor Rated Input Power.
- m. Solar Pump Inverter / Controller Size (**kW**) $\geq$ (Motor Rated Power in kW / Motor Efficiency).
- n. Solar Pump Inverter / Controller should have a current rating of 1.15 Times (minimum) of Motor FLA Rated Current.
- o. The motor should not be loaded more than 90%. (i.e: Design / Calculated BHP should not be more than 90% of Motor Rated Horse Power)
- p. Along with this specification, contractors should also satisfy manufacturer's recommendations for all major components of the Solar Pumping System.
- q. Requirement of Efficiency for Motor i.e. 75% will not apply on Motors smaller than or equal to **5.5HP** and the requirement of efficiency for pump i.e. 70% will not apply on pumps having discharge equal to or lower than **3000 GPH**.

3.9. PRESSURE PUMPS (UP TO 5.5 HP)

- a. Submersible pump confirmed to ISO-9906 Standard.
- b. Pump + AC Motor (3-Phase-220V/380V) or DC Motor and Pump with Display Unit.
- c. The solar pump inverter/controller should be MPPT based and Minimum Ingress Protection of IP65.
- d. In case, where the column pipe diameter is less than or equal to 50 mm (For discharge equal or less than 8250 LPH and/or for Motor 5.5 HP and below), HDPE pipe of at least PN12 / SDR 13.6 / PE100 (For TDH of equal or less than 300 ft) without joint may be used instead of MS pipe for better economics and to avoid hydraulic losses. However stainless-steel rope of minimum diameter of 6 mm (28 mm²) for suspension of pump-set must be supplied with HDPE pipe. (Note: For TDH of more than 300 ft, HDPE Pipe type / thickness may be increased/changed accordingly)
- e. Top set shall comprise of Suitable Galvanized stand (Design should be verified from Engineer In-Charge before start of work)
- f. Connection to overhead water storage tank. Top bend, S.S Fasteners & Erection clamps.
- g. Civil work to protect borehole i/e foundation.
- h. The pump should operate safely with Sand particles up to (50) gram/m³.

3.9.1 PRESSURE PUMPS (25 HP SUBMERSIBLE PUMP)

- a. Submersible pump confirmed to ISO-9906 Standard.
- b. The pump shall be designed to deliver a discharge of 8000 GPH ($\approx 30 \text{ m}^3/\text{hr}$) against a Total Dynamic Head (TDH) of 400 ft ($\approx 122 \text{ m}$) with a minimum pump efficiency of 60%.
- c. The motor shall be a 25 HP submersible motor, suitable for 3-phase 220V/380V, 50 Hz supply (or compatible DC motor where solar systems are used). The motor shall be of rewindable or water-filled type, with Class F insulation (minimum), and designed for continuous duty (S1). The motor shall be provided with adequate protection against overload, overheating, dry run, and voltage fluctuations.
- d. The system shall include a solar pump inverter/controller (where applicable), which shall be MPPT-based for optimized energy utilization and shall have a minimum Ingress Protection rating of IP65.

The controller shall include protections for dry run, reverse polarity, overload, short circuit, and over/under voltage conditions.

- e. Due to the high operating head (400 ft), the column pipe shall be of MS/GI (medium or heavy class) or HDPE PE100 PN20 / SDR 9, as per approved design calculations. All joints shall be leak-proof and capable of withstanding the operating pressure. A stainless steel suspension rope of minimum 8 mm diameter shall be provided for safe installation and retrieval of the pump assembly.
- f. The top arrangement shall consist of a galvanized steel support structure, designed to safely carry the load of the pump, column pipe, and water column. The design and shop drawings shall be submitted by the contractor and approved by the Engineer In-Charge prior to execution
- g. The installation shall include all necessary accessories such as non-return valve, gate valve, pressure gauge, flow meter (if specified), top bend, cable guards, stainless steel fasteners, and erection clamps, along with proper connection to the overhead storage tank. Suitable submersible cables of appropriate size and insulation grade shall be provided.

3.10. DC SOLAR WATER PUMP-SETS (UP TO 5.5 HP)

- a. DC Motor can also be provided for Equal or less than 5.5 HP.
- b. The motor should be capable of both AC and DC operation. There must be an auto power source recognition feature.
- c. The motor should be brushless (BLDC), permanent magnet type.
- d. The Controller must have a display Unit, showing all essential parameters (i.e: Current, Voltage etc).
- e. The Controller must be of MPPT type. MPPT efficiency should be equal to or more than 98%
- f. The pump should have auto and soft start / stop features.
- g. The pump-set should have following protections
 - g(i)-. Dry Running Protection
 - g(ii). Reverse Polarity Protection
 - g(iii). Over phase protection
 - g(iv). Over Head Protection
 - g(v).Lose Phase Protection
 - g(vi). Electronic Protection
 - g(vii).. Over Current/ Overload Protection

3.11. SOLAR AUTO TRACKER

- a. The solar tracker offered should be fully automatic and intelligent, and must be capable of Single axis tracking (from east to West) and should have its own power supply (PV Panel, Battery and Charge Controllers) other than PV Panel used for Pumping Setup.
- b. Individual Auto-Tracker should be ≥ 6 kW each and Tracking Accuracy should be within $\pm 5^\circ$.
- c. The auto Tracker should also have manual control mode to adjust the tracking angle manually. All Structure Material Should be Hot Dipped Galvanized Steel (Minimum 80 Microns).
- d. The auto Tracker should also have manual control mode to adjust the tracking angle manually. All Structure Material Should be Hot Dipped Galvanized Steel (Minimum 80 Microns) or epoxy coating with red oxide (as per direction of Engineer incharge).
- e. All nuts, bolts, washers and other fasteners for mounting structure shall be made of minimum A2 grade stainless steel.
- f. Foundation and other details will be separately provided.

- g.** Three years Comprehensive Free Replacement, Repair and maintenance Warranty (Free of Cost) should be provided for all the components of auto Tracker (including Batteries).

3.12. PV MOUNTING FRAME WITH MANUAL TRACKING

- a.** Suitable for Up to 6.5 KW PV Panels easily movable in multi directions having flanges with bearing balls 7/16" and having angle adjustment.
- b.** Base steel cage 7/8", MS rod 3.5 feet length with nut-bolts system for strong anchoring.
- c.** Pillar pipe 5 mm with 6" dia, base plate 15"x15"x16mm size with 04 numbers of supports.
- d.** Support for PV, 4mm thickness 5" dia pipe and 24"x61/2"x1/4" side plates.
- e.** MS I Beam/Garter side bracing 3"x7"x1/8". C Channel frame 3"x11/2"x1/8" for panel mounting.
- f.** Steel structures/frames shall be enamelled paint with lead oxide.
- g.** Galvanized nuts, bolts and washers for tracker fitting.
- h.** Steel frame shall be properly designed and shall withstand wind speed/load of at least 130km/hr and tough weather conditions..

3.13. PRE-SUPPLY TESTING & INSPECTION

The firm prior to procuring, has to provide the recent test bed reports from the pump/motor manufacturer or any other third party as per ISO-9906 standard. Each of the offered pump set models must undergo these tests prior to supply and installation, in order to ensure the quality and standard of the equipment contractor may be asked to provide test results conducted by a third party for re-verification.

SECTION-4-PART "B" -SPECIFICATION FOR SOLAR HOMES & BUILDING SYSTEM

4.1. GRID TIE INVERTER (ON-GRID WITHOUT BATTERY BACKUP / HABRID WITH BATTERY BACKUP)

- a.** UL-1741 Certified or IEC 62109-1 and IEC 62109-2 or Equivalent Certificates.
- b.** Minimum 95% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
- c.** Minimum 87% Efficiency for Transformer based inverters (Low frequency Inverters).
- d.** The inverter should have a built-in MPPT controller.
- e.** The Priority of the inverter should be set that load will be running from the solar energy then Grid and, in the end, will be running from the Battery Backup.
- f.** Inverter (Hybrid Only) must be capable of configuring for Charging GEL, Lead Carbon, OPzV/OPzS Batteries and Lithium Iron Phosphate batteries (LiFePO₄).
- g.** Hybrid Inverter (If quoted along with Lithium Batteries) may be capable of communication with the BMS of Lithium Batteries.
- h.** Rated output voltage of inverter / Controller shall be pure sine wave AC.
- i.** Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
- j.** The degree of protection of the inverter Installation should be IP-65 or above.
- k.** Wide input voltage range capability. (i.e. ∴ Voltage Range can be adjustable / selectable)
- l.** Natural convection cooling for maximum reliability
- m.** Outdoor enclosure for unrestricted use under any environmental conditions
- n.** Capability to connect external sensors for monitoring environmental conditions.
- o.** The output of the inverter must synchronize automatically its AC output to the exact AC voltage and frequency of the grid.
- p.** The Inverter should have the capability of Parallel operation up to three units. (Only For projects, where more than one inverter should be installed).
- q.** Inverter should have active CAN/RS485/RS232 or equivalent etc communication port, the Data available through this port can be used for Remote Monitoring.
- r.** Liquid crystal display should at least be provided on the inverters front panel or on separate data logging/display device to display following
 - DC Input Voltage

- DC Input current
 - AC Power output (kW)
 - Current time and date
 - Temperatures(C)
 - Converter status
- s.** Inverter circuit must include protection against:
- Over or Low voltages and currents beyond critical level of the inverter's circuits.
 - Protection against accidental short circuits.
 - Protection against lightning induced transients.
 - Overload protection.
- t.** The Maximum power point tracking MPPT efficiency > 99%, and converter efficiency up to 98% of MPPT charge controller.
- u.** The inverter shall be equipped with certified anti-islanding protection in compliance with international standards (e.g., IEEE 1547, IEC 62116), to ensure immediate disconnection from the grid during outages or abnormal grid conditions.

4.2. OFF-GRID / HYBRID INVERTER

- a.** The Inverter must be pure sine wave output suitable for 220 Volt, 50 Hz.
- b.** The inverter must be capable of configuring for Charging GEL, Lead Carbon, OPzV/OPzS Batteries and Lithium Iron Phosphate batteries (LiFePO₄) (If Applicable).
- c.** The Inverter / system must have a MPPT Solar Charge Controller.
- d.** Minimum 92% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
- e.** Minimum 87% Efficiency for Transformer based inverters (Low frequency Inverters).
- f.** Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
- g.** The inverter must be user programmable for selecting PV, Grid and Battery Priority as well as Built-in programmed and user defined voltage and current settings of the charge controller for GEL, Lead Carbon, OPzV/OPzS batteries and Lithium Iron Phosphate batteries (LiFePO₄).
- h.** The Inverter must have Protective function limits for:
 - AC under voltage protection
 - AC over voltage protection
 - Battery under voltage Alarm
 - Low Voltage Disconnect
 - High Voltage Disconnect
 - Overload and Short Circuit Protection
 - Over Temperature Protection
- i.** The inverter must be ISO 9001, ISO 14001 and CE Certified.
- j.** The inverter must have IEC 62109-0 1 and IEC 62109-2, or Equivalent Certificates.
- k.** The degree of protection of the inverter Installation should be IP-65 or above.
- l.** Wide input voltage range operation capability. (i.e .: at least 170 V to 270V for Operation)
- m.** The inverter should have an active CAN/RS485/RS232 or equivalent etc. communication port, the Data available through this port can be used for Remote Monitoring.
- n.** Inverter (If quoted along with Lithium Batteries) must be capable of communication with the BMS of Lithium Batteries.
- o.** Inverter settings are preferably password protected.
- p.** Inverter should be capable of battery less operation (preferred or as per BoQ requirement).

- q.** Discharge Current should be preferably programmable (i.e. ∴ discharge battery Current can be limited to user desired values).
- r.** The Maximum power point tracking MPPT efficiency $\geq 99\%$, and converter efficiency up to 96% of MPPT charge controllers.

Note:

The THD (Total Harmonic Distortion), inverter capacity and efficiency may be conducted from the accredited laboratory in Pakistan.

SECTION-5-PART "B" -SPECIFICATION FOR SOLAR STREET LIGHTS

5.1. SOLAR STREET / ROAD LIGHT SYSTEM DESIGN:

- a.** The assessment of Wattage of the LED Luminaire, Pole Height, Pole thickness, Pole top diameter, Pole base diameter, Base plate size, Base Plate thickness, Stiffener size, Stiffener thickness, Pole arm design, Pole Arm Length, Pole arm thickness, Pole arm diameter, Pole arm Placement / Fixing position, RCC foundation size, Anchor / J-bolt size, Steel Rebars cage (Mesh) and Number of Poles (Pole to Pole distances), should be according to the design provided / approved by the Engineer In-charge.
- b.** Round Conical or Octagonal Hot Dipped Galvanized Pole of average 80 Microns should be installed.
- c.** All Nuts, Bolts and Washers should be stainless steel.
- d.** The pole base plate should be tightened in between two stainless steel nuts and washers (one nut and washer at upper and one nut and washer at lower side of the base plate).
- e.** All Anchor / J-bolt shall be in level and align to each other.
- f.** All Anchor / J-bolt shall be galvanized.
- g.** All Anchor / J-bolt shall have at least 150 mm minimum threads.
- h.** All poles shall be installed on levelling nuts secured to the anchor bolts and with locking nuts on the top of the base flange.
- i.** The concrete ratio should be 1:2:4 for the RCC foundation.
- j.** Proper sketches of Pole, base plate, RCC Foundation and Steel Rebars cage (Mesh) should be provided and approved by the Engineer In-charge.
- k.** In order to focus on winter sun availability and Easy cleaning of Solar panel from dust etc with Rain water, Solar Panels should be installed at 180° Azimuth Angle and the Tilt angle (slope) of PV Module should be between $45^\circ \pm 5^\circ$ (Only for Solar Street Lights).

5.2. LED SOLAR ROAD/STREET LIGHT FIXTURE:

- a.** LED Efficacy must be greater than or equal to 130 Lumens/Watt.
- b.** The fixture must be IP-66 Rated or above.
- c.** The Colour temperature of the LED should be Pure white in the range of 5000-6000 K.

- d. The LED Light distribution must be IESNA Type-II
- e. The LED must be suitable for working Temperature from -40 ~ + 60C with relative humidity of 15% ~ 90%
- f. The Colour rendering Index (CRI) must be equal or greater than 70.
- g. The LED Light Fixture must be LM79 and LM80 Tested.
- h. LEDs/Light fixtures should not be Chip-on-board (COB) single chip type due to their poor heat Dissipation.
- i. LEDs/Light fixtures shall be modular type with proper heat sinks.
- j. The output from the LEDs/Light fixtures should be constant throughout the duty cycle
- k. LED Life should be greater or equal to 50,000 Hours.
- l. The LED Light Fixture must have the following certification:
 - ISO 9001
 - ISO 14001
 - CE (EMC and LVD) Certified or equivalent.
 - International standard Certifications

Note: Product Brochure, Catalogue and certificates must be attached with the Technical Bid

5.3. SOLAR CHARGE CONTROLLER (FOR STREET / ROAD LIGHTS):

- a. The charge controller must be suitable for the required battery voltage, auto voltage recognition feature and capable of charging Flooded, GEL, AGM, OPzV, OPzS & Lithium Ferrous Phosphate (LiFePO4) Batteries.
- b. The charge controller must be IP-67 rated or above for outdoor installation
- c. The charge controller must be Remote Controlled for parameter setting. The system must have the following feature:
 - Remote Parameter Setting and Monitoring
 - Remote control of the Lights (on/off, timer setting etc)
- d. The charge controller must have MPPT Technology and Automatic Battery Voltage Recognition.
- e. The charge controller must have at-least three stage Flexible dimming function (0-100%).
- f. The Maximum power point tracking MPPT efficiency $\geq 99.0\%$, and converter efficiency up to 98%
- g. It must have temperature compensation for charging batteries in higher temperatures.
- h. Charge controller must have the following protections:
 - PV Short circuit
 - PV reverse polarity
 - PV over voltage
 - PV over current
 - Battery over charging
 - Battery over discharging
 - Battery reverse polarity protection
 - Load short circuit
 - Load overload protections
- i. It must have proper heat sink to dissipate excessive heat
- j. The charge controller must have protection for reverse flow of current through the PV modules
- k. The controller should have an active port for GSM based communication for Remote Monitoring.
- l. Mid Night based timing controller will be preferred.
- m. The Solar Charge controller must have the following certification:

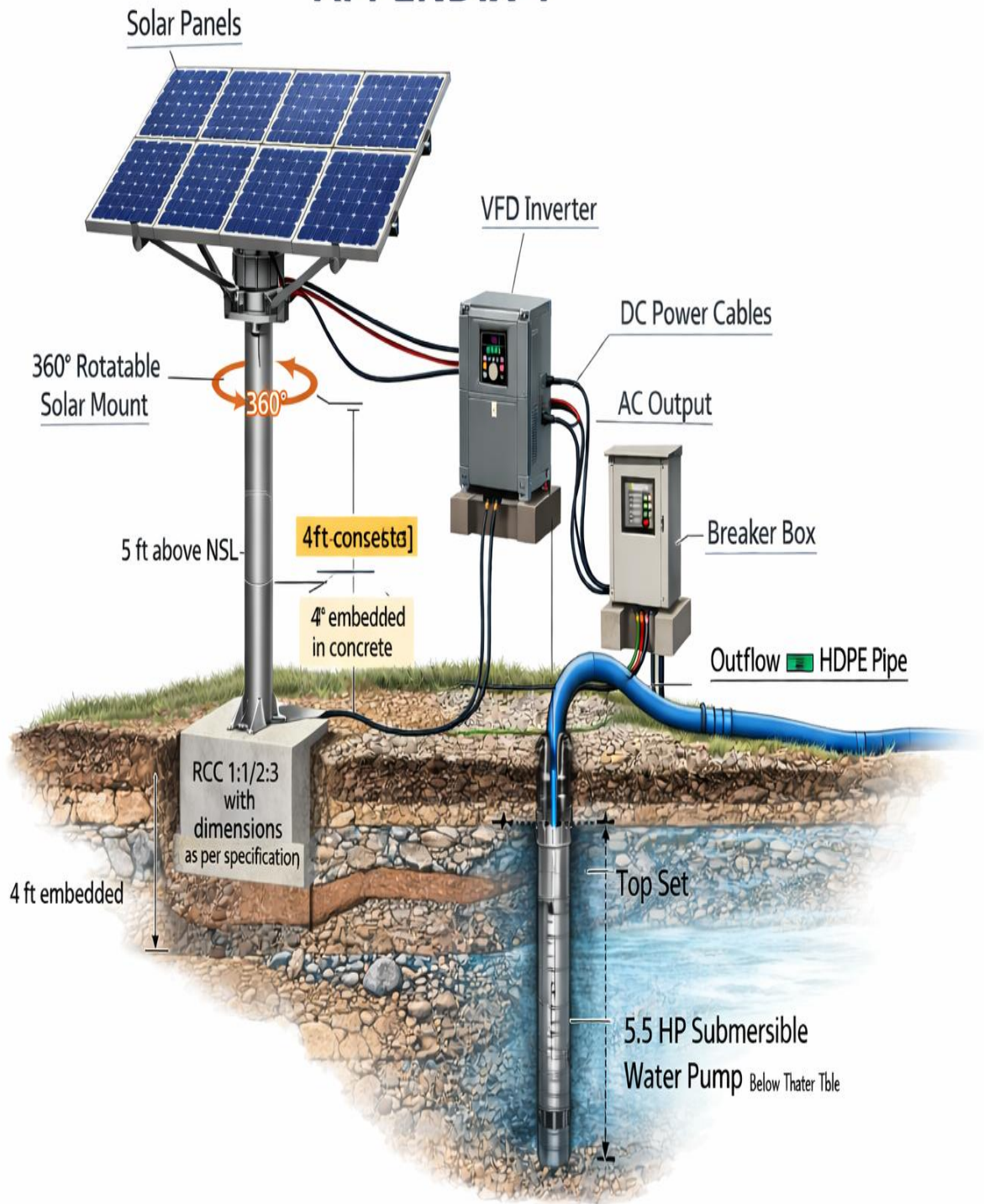
- ISO 9001
- CE Certified

Note: Product Brochure, Catalogue and certificates must be attached with the Technical Bid

5.4. BATTERY AND CONTROLLER BOX:

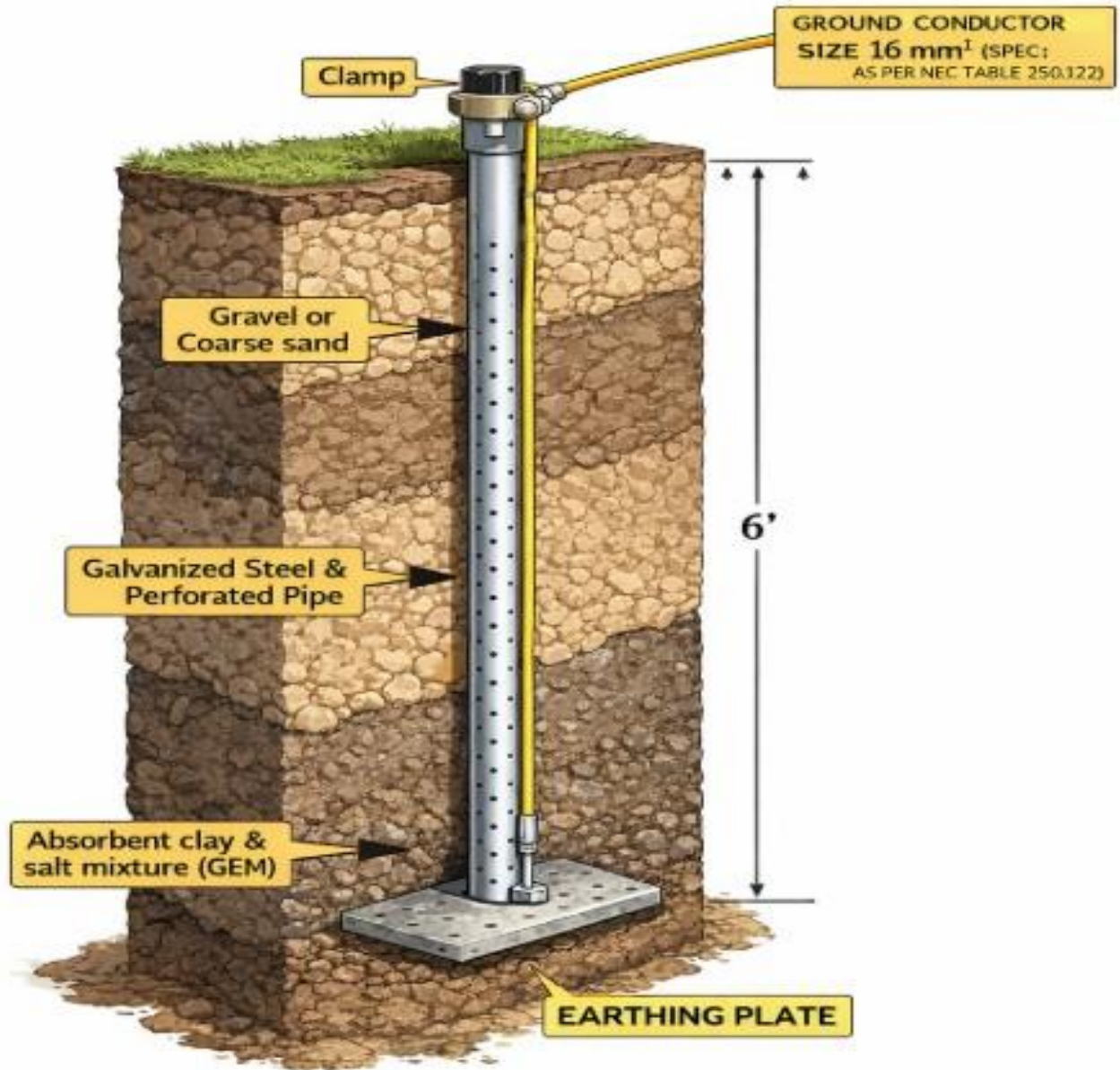
- a.** The battery box should be made of Hot Dipped Galvanized Sheet of average 80 Microns.
- b.** For Pole Mounted batteries Battery boxes must be made of minimum 16 SWG sheet and must have proper locking arrangement for protection against theft.
- c.** For underground battery installation, the battery box should be made of minimum 16 SWG sheets and should be properly sealed to ensure protection against water. Proper cable glands and packing material should be used to ensure water proofing of the box.
- d.** The battery and Controller Box should be at least IP65 ingress protection.

APPENDIX-I



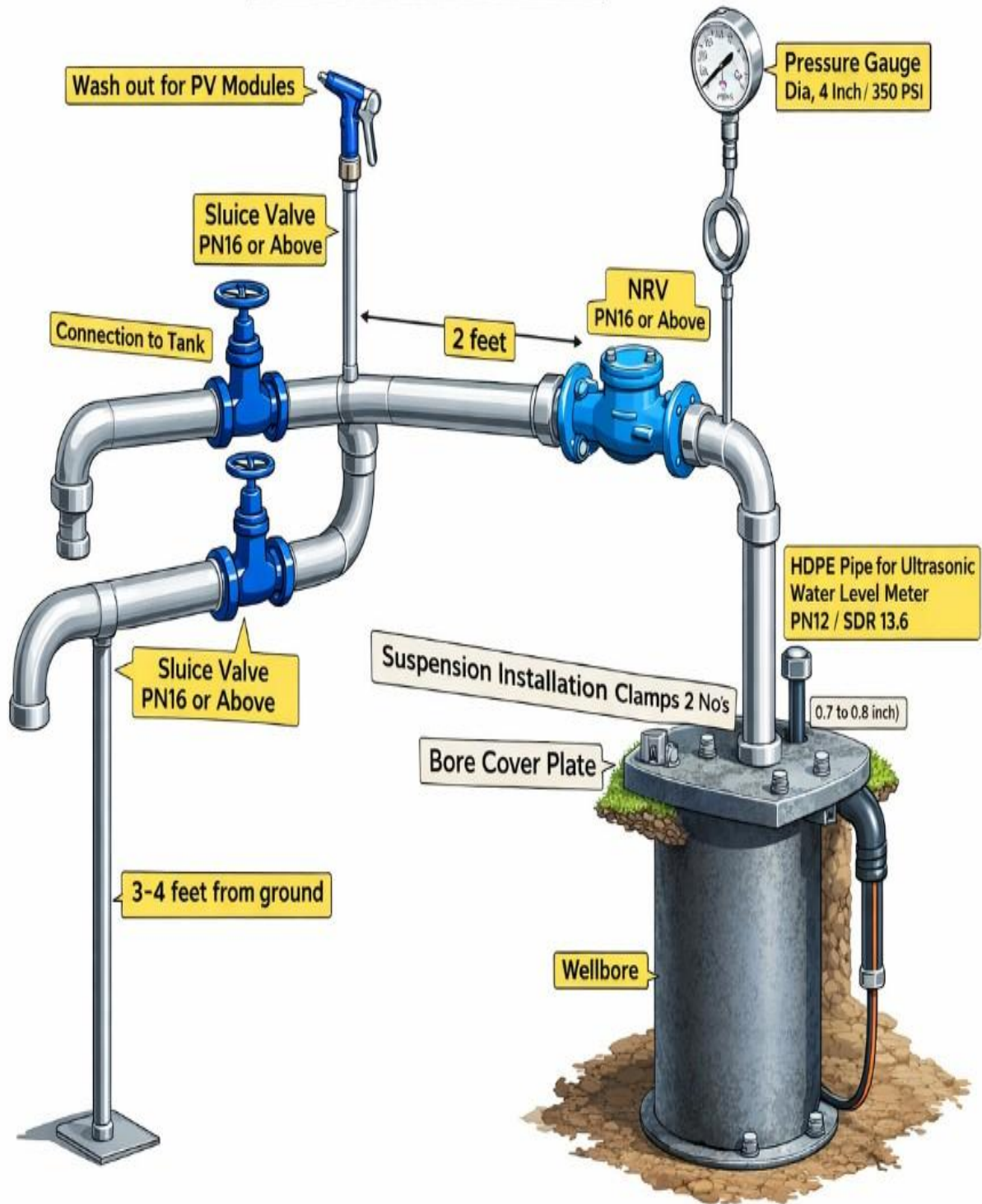
APPENDIX-II EARTHING / GROUNDING DRAWING

LAYOUT FOR EARTHING/ GROUNDING

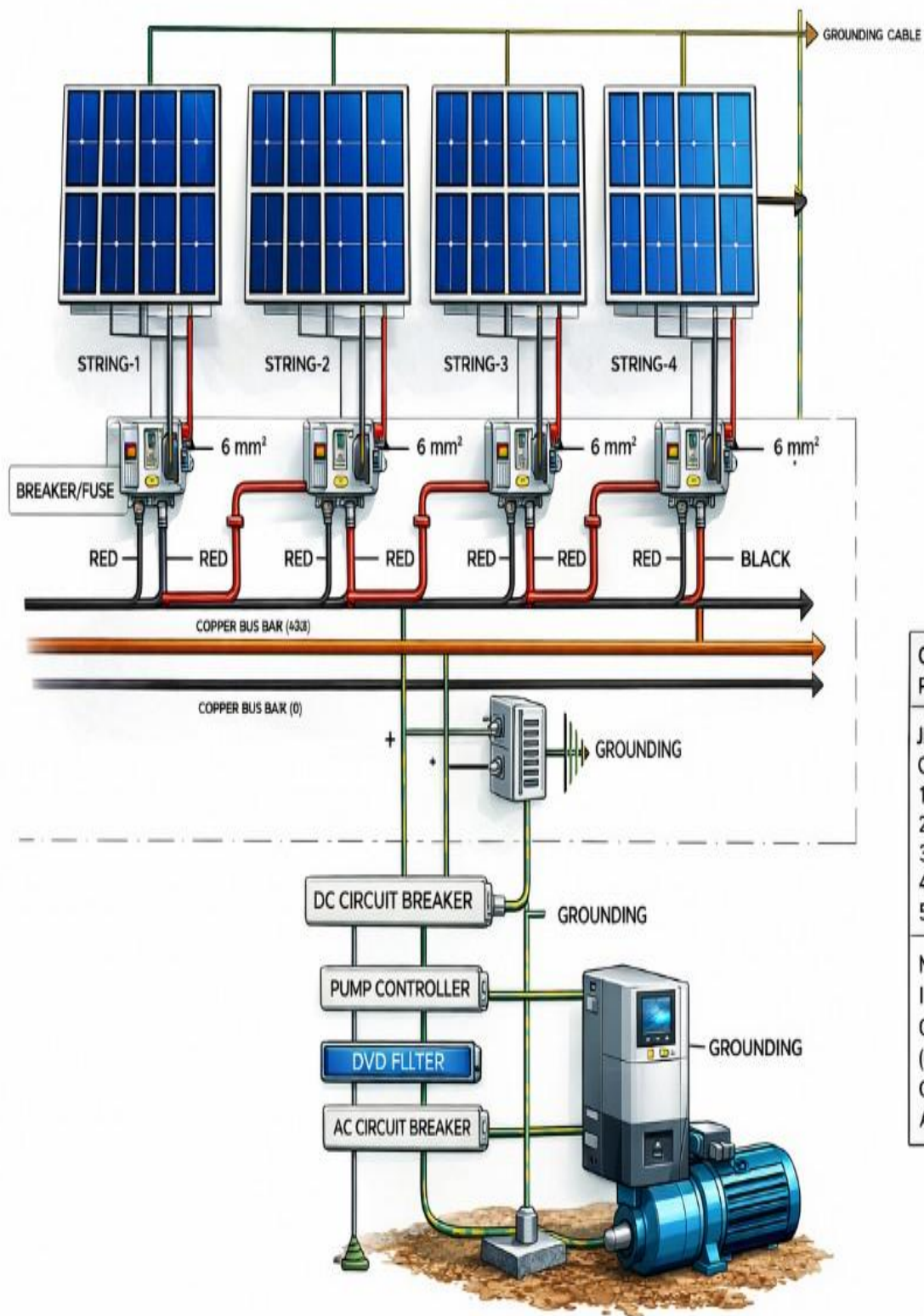


Setup Conforms To IEC 62561-7

APPENDIX-III TOPSET LAYOUT:



SINGLE LINE DIAGRAM FOR SOLAR PUMPING SYSTEM



CABLE SIZE :
PANEL TO JB = 6 MM²

JB TO INVERTER
CABLE SIZE, IF :

- 1) 1 STRING = 6 MM²
- 2) 2 STRINGS = 10 MM²
- 3) 3 STRINGS = 16 MM²
- 4) 4 STRINGS = 25 MM²
- 5) 5 STRINGS = 35 MM²

NOTE:
IF LENGTH OF CABLE IS
GREATER THAN 20FT
(ONE WAY) THEN SIZE OF
CABLE WILL BE INCREASED
ACCORDINGLY

NOTE:
Fault current rating of all protective devices i.e. MCB, Surge arrester and MCCB should be same

Connected to Box Door

Negative Inputs of the Strings

Output DC cable to Inverter Box

Positive Inputs of the Strings

Mounting Rail

APPENDIX -VI

MINIMUM SIZE OF BONDING/EQUIPMENT GROUNDING/GROUNDING ELECTRODE CONDUCTORS AND GROUND BUS

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

S.No	Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Copper	Aluminum or Copper-Clad Aluminum
1	15	14	12
2	20	12	10
3	30	10	8
4	40	10	8
5	60	10	8
6	100	8	6
7	200	6	4
8	300	4	2
9	400	3	1
10	500	2	1/0
11	600	1	2/0
12	800	1/0	3/0
13	1000	2/0	4/0
14	1200	3/0	250
15	1600	4/0	350
16	2000	250	400
17	2500	350	600
18	3000	400	600
19	4000	500	800
20	5000	700	1200
21	6000	800	1200

APPENDIX -VII



