

**Technical Specifications
Sewerage Networks
Bara Sanitation Scheme, District Khyber**

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INTRODUCTION

1 INTRODUCTION**1.1 GENERAL REQUIREMENTS****1.1.1 SCOPE OF WORK****1.1.1.1 LOCATION OF WORK**

The Project site areas are specified in Detailed Design Drawings and Contract/Bidding Documents.

1.1.1.2 WORK TO BE DONE

The extent of the work to be done is described in the relevant sections of the Contract/Bidding Documents. The drawings indicate the locations, type and extent of the work, generally, the work to be done, based on the drawings.

1.1.1.3 INTENT OF CONTRACT DOCUMENTS

It is the intent of the Contract Documents to provide for the execution and completion of all details of the work described herein, and it is understood that the Contractor, shall furnish all labor, material, equipment, tools, transportation and necessary supplies, such as may be required to execute the Contract in a satisfactory and workmanlike manner and in accordance with the Contract Documents.

The Specifications and other parts of the Contract Documents are intended to supplement, but not necessarily duplicate, each other. Any work exhibited in the one and not in the others shall be executed as if it had been set forth in all, in order that the work be completed according to the complete design as determined by the Consultant. Should anything be omitted from the Specifications and other Contract Documents which is necessary for a clear understanding of the work, or should it appear that various instructions are in conflict, then the Contractor shall secure written instructions from the Consultant before proceeding with the work affected by such omissions or discrepancies. It is understood and agreed that the work shall be performed and completed according to the true spirit, meaning, and intent of the Contract Documents.

1.1.1.4 PRECEDENCE OF CONTRACT DOCUMENTS

If a conflict arises between Contract Documents, the document, highest in precedence, shall control. Unless directed otherwise by the Client with the recommendation of the Consultant, the order of precedence shall be:

- First : Project Specifications
- Second : Drawings
- Third : Technical Specifications (C&W Dept., KP)

Variation orders, supplemental agreements and approved revisions to drawings and specifications will take precedence over documents listed above. Detailed plans shall have precedence over general plans.

1.1.1.5 INTERCHANGEABILITY OF STANDARDS

Whenever reference standards appear in these specifications, they are intended to be the latest available and materials meeting other internationally accepted standards, which ensure an equal or higher quality than the reference standards, are acceptable. Decisions as to equal or higher quality will be made by the Consultant.

The following is a list of internationally accepted standards. The respective abbreviation is given for each standard for clarity.

- AASHTO: American Association of State Highway and Transportation Officials
- ACI: American Concrete Institute
- ASTM: American Society for Testing and Materials AWWA : American Water Works Association
- BS: British Standards

DIN: Deutsche Industrie Normen

IEC: International Electro-technical Commission ISO:

International Organization for Standardization NEMA:

National Electrical Manufacturer's Association SSPC: General of Steel Painting Council

PS: Pakistan Standards

NSDWD: National Standard of Drinking Water Quality

PEPA: Pakistan Environmental Protection Agency, June 2008

1.1.1.6 MINIMUM STANDARD

The Specifications and Contract Drawings define a minimum standard of workmanship. The Contractor shall include in his Tender the cost of any additional work or improvements in the quality of the work that he may consider necessary to unconditionally guarantee the performance of the completed work in conformity with the Contract.

1.1.1.7 WORKMANSHIP

The quality of the workmanship and materials shall be first class and the work shall present a neat and attractive appearance when finished.

If ordered by the Consultant, the Contractor shall make enough openings in the work and/or materials as are necessary to inspect the work.

Should the Consultant find the work and/or materials so opened up to be faulty in any respect, the Contractor shall remove and make good all defective work and/or materials and shall bear the expense of all such openings, inspecting, and making good.

1.1.1.8 REQUIREMENTS OF AGENCIES

The Contractor shall be responsible for complying fully with the requirements of all Agencies which govern any or all of the work under this Contract. These requirements may affect installation and construction methods and may include a written notice to an Agency prior to the commencement of construction. In response to the written notice by the Contractor, an Agency shall notify the Contractor in writing with respect to his decision within two weeks. When a written notice to an Agency is required, a copy of the notice shall be submitted to the Consultant by the Contractor.

1.1.1.9 SPECIFICATIONS

The Contractor shall have a copy of these Project Specifications and Technical Specifications (C&W Dept., KP) or parts of Specifications referred to herein on the Site at all times. All Specifications shall be producible upon demand of the Consultant. Failure to have copies of all Specifications on the site will be considered an infraction to the Contract. Contractor to follow the specifications as per instruction by the Consultant.

1.1.1.10 GENERAL NOTES FOR DETAILED DESIGN

Contractor to comply all the general notes mentioned in the detailed design which are also listed below:

1. All dimensions are in meters and pipe diameters are in millimeters unless otherwise noted.
2. All elevations are in meters referenced to the topographic survey performed at site.
3. The contractor shall verify site conditions, prepare shop drawings, and secure approval of the engineer prior to commencement of works.
4. All joints between the pipes, and between pipes and sewer structure, shall be watertight.
5. Cover and frame shall be heavy-duty double triangular iron.
6. All materials, fabrication and construction shall be in accordance with technical

specification.

7. Where there is a discrepancy between the requirements of specifications and those shown on these drawings, specifications shall be followed.
8. Coordination with all relevant authorities, including, WSSC, KDA, etc., shall be undertaken regarding their requirements and precautions prior to commencing construction works.
9. The contractor shall respect all environmental, safety, and health regulations.
10. Levels are shown for information only. The contractor shall verify these levels against all proposed and existing utility lines prior to construction.
11. Minimum cover to pipes shall be 0.90m otherwise, concrete surround shall be provided.
12. The contractor shall verify the actual cover levels of manhole.
13. Coordinates of proposed manholes refer to the center of the manhole chamber.
14. Invert levels provided are reckoned from the center of the manholes. The contractor shall detail the actual level of the pipes as it joins the manhole.
15. The contractor shall make sure that all properties/plots surrounding the project are provided with house connections to the proposed sewer lines under this project.
16. The house connection shown on the layouts are indicative only, contractor shall carry out complete survey of house connections of all existing plots, and shall provide house connection to all the existing plots through the existing house chamber, contractor to build the house chamber if it is not constructed already. For vacant plots house connection shall be provided, capped at the plot boundary.
17. House connections shall be 160mm vitrified polyvinyl chloride (PVC-U) minimum internal diameter for typical villas. For large plazas, office complex, multi-storey apartment block, hotel, etc., the minimum diameter shall be 300mm vitrified polyvinyl chloride (PVC-U).
18. Sewer drainage pipes to be installed by open cut shall be vitrified polyvinyl chloride (PVC-U) for diameters up to and including 395.7mm(15"Ø), and reinforced cement concrete pipes (RCC) for diameters greater than 395.7mm(15"Ø).
19. Contractor is responsible to reinstate all the roads/streets damages during execution of project.
20. Contractor is responsible to provide temporary collection or disposal facility for the life sewage (if required) during execution of project. This will be required if the existing sewer lines are damages during execution in a street
21. Contractor is responsible to coordinate with all stake holders and utilities activities related to diversion of the existing utilities to be performed by the contractor.
22. The detail of the nominal sizes of the proposed sewer pipes, are shown in the layouts sheets.
23. Contractor to construct a back drop structure if the difference in invert level of crown of the incoming and outgoing pipe is more than 0.6m.
24. Contractor to reinstate all the damages to the public and private properties during execution of the project.
25. Contractor to follow the standard details for trenches, chambers, manholes, etc.
26. Backdrop structure to be provided at all the locations where the difference between pipe invert of the incoming pipe and pipe soffit of outgoing pipe is more than 0.6m.
27. Contractor is responsible for de-watering at all the structures during construction, including at the trenches of the proposed sewers
28. Contractor shall perform hydraulic modeling of each network or system, as per actual site conditions before execution. The system shall be adjusted if the hydraulic model results vary from the original design, after approval from the executing Engineers. There might be variation in the network based on actual site conditions during execution.
29. Contractor to ensure cleanliness of existing road pavement throughout the construction period including use of fine spray water jet to reduce dust pollution.

1.1.2 CONTROL OF WORK

1.1.2.1 CONTRACTOR'S EQUIPMENT

The Contractor shall furnish his equipment which will be efficient, appropriate and large enough to secure a satisfactory quality of work and a rate of progress which will ensure the completion of the work within the time stipulated in the Tender. If at any time such equipment appears to the Consultant to be inefficient, inappropriate or insufficient for securing the quality of work required or for producing the rate of progress aforesaid, he may order the Contractor to increase the efficiency, change the character or increase the quantity of the Contractor's equipment, and the Contractor shall conform to such order at no additional cost to the Contract. Failure of the Consultant to give such order shall in no way relieve the Contractor of his obligations to secure the quality of the work and rate of progress required.

1.1.2.2 LOCATIONS OF WORK

Pipelines and structures will be located substantially as indicated on the drawings, but the Consultant reserves the right to make such modifications in locations, after approval from supervision consultant, as may be found desirable to avoid interference with existing structures and utilities or for other reasons. Where fittings, pipe, bends and curves are noted on the drawings, such notation is for the Contractor's convenience and does not relieve him from laying and jointing different or additional items where required.

1.1.2.3 OPEN EXCAVATIONS

The Contractor shall comply with all provisions of the Clauses of the Conditions of Contract related to the Safety, Security and Protection of the Environment and Third Party Insurance. The length of open trench will be controlled by the particular surrounding conditions, but shall always be confined to the limits prescribed by the Authorities concerned. If the excavation becomes a hazard, the Authorities concerned may require special construction procedures such as limiting the length of open trench, prohibiting stacking of excavated material on the trench side, and requiring that the trench shall not remain open overnight.

1.1.2.4 TEST PITS

Test pits for the purpose of locating underground pipelines or utilities or structures in advance of the construction shall be excavated and backfilled by the Contractor at the direction of the Authorities concerned. Test pits shall be backfilled immediately after their purpose has been satisfied and the surface restored and maintained in a manner satisfactory to the Authorities concerned. The above work will be executed at no additional cost to the Contract.

1.1.2.5 GEOPHYSICAL SURVEYS AND ROUTING OF UTILITIES

It is the responsibility of the Contractor to conduct detailed geophysical surveys and route all existing and proposed utilities. Proposed Piping shall be routed in such a way so as not to interfere with other piping, equipment, instrumentation, electrical work or structures. Pipeline routing shall be in accordance with the guidelines presented in the Drawings and standard procedures. Minor changes due to differences in equipment, size or configurations will be permitted, provided that such changes do not interfere with other work. Any deviations from the layouts shown on the Drawings will be considered substitutions and shall require approval as such. All piping layouts shall be subject to approval by the supervising engineer prior to installation.

1.1.2.6 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

The Contractor shall assume full responsibility for the protection of all buildings, structures and utilities, public or private including poles, signs, services to buildings, utilities in the street, water pipes, hydrants, drains and electric and telephone ducts and conduits, whether or not they are shown on the drawings. The Contractor shall carefully support and protect all such structures and utilities from injury of any kind. Any damage resulting from the Contractor's operations shall be repaired at his expense.

The Contractor should choose to relocate any existing structure or utility, for his own convenience. All costs shall be borne by the Contractor.

The Contractor shall bear full responsibility for obtaining all locations of underground structures and utilities. Services to buildings shall be maintained, and any costs or charges resulting from damage thereto shall be paid by the Contractor.

1.1.2.7 MODELLING CHECK

Contractor shall perform hydraulic modeling of each network, nature based solution or system, as per actual site conditions before execution. The system shall be adjusted if the hydraulic model results vary from the original design, after approval from the executing Engineers. There might be variation in the network based on actual site conditions during execution.

1.1.2.8 OBSTRUCTION OF UTILITY SERVICES

The Contractor shall ensure that all existing hydrants, valve boxes, curb stop boxes, or other public utility controls shall remain unobstructed and accessible during the construction of the work.

1.1.2.9 OPERATION OF UTILITY SERVICES

The Contractor shall obtain written approval from the Authorities concerned before operating any valve, switch, or other control on existing utility services.

All consumers affected by such operation shall be notified by the Contractor, before the operation, of the date, time and probable length of time of service interruption.

1.1.2.10 MAINTENANCE OF FLOW

The Contractor shall at his own cost, provide for the flow of drains and water courses interrupted during the progress of the work, and shall immediately remove all offensive matter. The entire procedure of maintaining existing flow shall be fully discussed with the Authorities concerned well in advance of the interference of any flow.

1.1.2.11 PROVISIONS FOR TRAFFIC AND DETOURS

All operations necessary for the execution of the works and for the construction of any temporary works shall, in so far as compliance with the requirements of the Contract permits, be carried on so as not to interfere unnecessarily or improperly with the public convenience or the access to use and occupation of public or private roads and footpaths or to properties whether in the possession of the Client or of any other person.

The Contractor shall conduct his construction so that interference with the flow of traffic will be held to a minimum. He shall construct temporary bridging across his trenches where necessary for traffic and pedestrians. Should the adjacent road be required by the Contractor for working or stockpiling area, he shall obtain prior written permission from the road Authority. Where detours are permitted, the Contractor shall provide all necessary barricades and signs as required to divert the flow of traffic. While traffic is detoured the Contractor shall expedite construction operations, and periods when traffic is being detoured will be strictly controlled.

All excavation in public ways and adjacent thereto, excavated material, equipment and any other obstacle which may in any way be a source of potential danger to the public shall be well lighted at night.

1.1.2.12 COOPERATION WITH OTHER CONTRACTORS

All firms or persons authorized to perform any work under this Contract shall be cooperative with other contractors and their subcontractors and shall assist in incorporating the work of other contractors where necessary or required.

The Contractor in scheduling his work will familiarize himself with the other contracts in effect and in no way shall he interfere with the other contracts, nor shall he claim any delays because of the other contracts.

1.1.2.13 CLEAN-UP WORK TO BE DONE

The Contractor shall bear full responsibility for the protection of all finished exterior and interior surfaces, fixtures and equipment from stains, marks, dirt or damage of any kind, from the time of their construction, finishing, or installation until the time of handing over the fully completed project to the Client.

Before requesting an inspection of the completed works with the intent of final acceptance, the Contractor shall do all necessary cleaning, making good, and touching up that may be required to leave all finished surfaces, fixtures and equipment in acceptable condition, in accordance with the full intent and meaning of these specifications.

The following particular requirements shall be recognized as setting the standard for the final condition of the work.

1.1.2.13.1 BUILDING SITES

On or before the completion of the work, except as otherwise specially directed in writing, the Contractor shall remove all temporary buildings and structures built by him and all construction, machinery, plant, equipment, lumber and other construction materials and debris from the site of the Contract. The Contractor shall remove and acceptably disinfect all material containing organic matter, in, under and around buildings used by him and rubbish of all kinds from any ground which he shall have occupied within the limits of the property of the Client and shall leave the site in a neat and satisfactory condition.

1.1.2.13.2 ALL EXPOSED CONCRETE MASONRY AND SHEET METAL

The Contractor shall thoroughly clean and eliminate mortar droppings, marks of concrete leakage, formwork marks, tar spatters and paint droppings.

1.1.2.13.3 GLASS

The Contractor shall repair, if necessary, wash thoroughly and polish glass on all faces and free it from excess glazing compound, paint and scratches. Air spaces of double glazed sash shall be absolutely free from shavings, sawdust or dirt of any kind.

1.1.2.13.4 PAINTED, ENAMELLED AND VARNISHED SURFACES

The Contractor shall clean all such surfaces of all marks, stains, scratches, fingerprints, graffiti or other damage.

1.1.2.13.5 FLOOR SURFACES

The Contractor shall remove all temporary protective coverings and shall leave all surfaces clean, unmarked and free from stains, and where specified, properly waxed and polished.

1.1.2.13.6 INTERIOR GLAZED WALLS

The Contractor shall clean all glazed wall surfaces of stains or spattered paint.

1.1.2.13.7 FINISH HARDWARE, LIGHTING FIXTURES AND ELECTRICAL OUTLET PLATES

The Contractor shall clean and polish and leave free from paint, dirt or dust the above described surfaces. This particularly applies to all hinges.

1.1.2.13.8 DUCT WORK

The Contractor shall remove dust and debris from all ductwork.

1.1.2.13.9 ROOF SURFACES

The Contractor shall ensure that gravel topping is evenly spread and intact on all roofs and free from construction debris, carelessly dropped nails or any other foreign matter.

1.1.2.13.10 PLUMBING AND PLUMBING FIXTURES

The Contractor shall free all pipes and fittings from dirt and debris, clean and polish all fixtures and ensure that facilities are in proper working order.

1.1.2.13.11 ALL PIPE WORK

The Contractor shall check all pipe work for its proper support and water tightness, for cleanliness both on its exterior or interior, including the removal of interior rust.

1.1.2.14 PRIVATE LANDS

The Contractor shall not enter private lands unless he has the Client's written permission to do so and shall assume full responsibility for any and all claims which might arise as a result of such entry.

1.1.2.15 FLOTATION, SETTLEMENT, INCLINATION AND STRAIN

The Contractor shall take all necessary precautions against the flotation, settlement, inclination and strain of any structures during construction. The Contractor shall be responsible for any damage caused by the preceding and any expense incurred in making good such damage shall be borne by the Contractor.

1.1.2.16 INCONVENIENCE AND RIGHT OF ACCESS

The construction of the works shall be carried out in such a manner that a minimum of inconvenience is caused to the Clients and occupants of properties adjacent to the works.

1.1.2.17 PREVENTIVE MEASURES

The Contractor shall submit with his construction schedule, a list of procedures he intends to follow during construction, which shall include procedure and means to prevent interruption of service and contamination to the existing water supply system. The Consultant reserves the right to instruct the Contractor to re-submit any other proposed alteration or modification of the procedure.

1.1.2.18 EXCESS FILL MATERIALS

The Contractor shall be responsible for the disposal of all excess fill material from any excavation not considered in the grading and bear all costs associated with handling of this excess material.

1.1.2.19 PUMPING AND DRAINAGE

The cost of dewatering of excavations and of any other pumping and drainage necessary at the Site for the proper construction, curing, boarding and inspection of the works, shall be borne by the Contractor and included in the item rates. The Contractor shall dispose of all ground water and surface run-off in a manner approved by the Consultant and the Authorities concerned.

The cost of dewatering that is percolation water, Infiltration water, surface run-off water, seepage water tidal or fluctuating water table, capillary water and construction related water or water coming (surface water or sub-surface water) towards the site location or any other pumping and drainage necessary at the Site for the proper construction, curing, boarding and inspection of the works, shall be borne by the Contractor. The Contractor shall dispose of all ground water and surface run-off in a manner approved by the Consultant and the Authorities concerned.

1.1.2.20 OVERHEAD CONSTRUCTION

No machinery shall be employed which, in the opinion of the Consultant and the Authority concerned, will unduly interfere with wires and other overhead construction.

1.1.3 CONTROL OF MATERIALS**1.1.3.1 APPROVAL OF MATERIALS**

Only new materials and equipment shall be incorporated in the work. All permanent materials and equipment furnished by the Contractor shall be subject to the inspection and approval of the Consultant. No material shall be incorporated into the work without approval of the Consultant.

As soon as possible after the Contract has been executed, the Contractor shall submit to the Consultant data relating to materials and equipment he proposes to furnish for the work. Such data shall be of sufficient detail to enable the Consultant to identify the particular product and to form an opinion as to its conformity to the specifications. Facilities and labor for the handling and inspection of all materials and equipment shall be furnished by the Contractor.

The Contractor shall submit data and samples sufficiently early to permit consideration and approval before materials are necessary for incorporation in the work. Any delay of approval resulting from the Contractor's failure to submit samples or data promptly shall not be used as a basis of a claim against the Consultant.

In order to demonstrate the proficiency of workmen or to facilitate the choice among several textures, types, finishes, and surfaces, the Contractor shall provide such samples of workmanship of finish as may be required.

The materials and equipment used on the work shall correspond to the approved samples or other data.

Where name brands or specific suppliers are identified, and the intent is to provide a specific reference for quality and for functions, equivalent products will be considered acceptable. The Consultant will determine "the equivalent" of the substitute item.

1.1.3.2 HANDLING AND STORAGE OF MATERIALS

All materials and equipment to be incorporated in the work shall be handled and stored by the manufacturer, supplier, fabricator, and the Contractor before, during, and after shipment in a manner to prevent warping, twisting, bending, breaking, chipping, rusting, and any injury, theft or damage of any kind whatsoever to the material or equipment.

Cement and lime shall be stored, covered and off the ground, and shall be kept completely dry at all times. All structural steel, miscellaneous steel, and reinforcing steel shall be stored off the ground or otherwise to prevent accumulations of dirt or grease, and in a position to prevent accumulations of standing water and to minimize rusting. Beams shall be stored with the webs vertical. Precast concrete elements shall be handled and stored in a manner to prevent accumulations of dirt, standing water, staining, chipping or cracking. Masonry products shall be handled and stored in a manner to reduce breakage, chipping or cracking.

All equipment subject to corrosive damage by the atmosphere if stored outdoors (even though covered) shall be stored in a building to prevent damage. The building may be a temporary structure on the site or elsewhere, but it must be satisfactory to the Consultant.

Any materials which, in the opinion of the Consultant, have become so damaged as to be unfit for the use intended or specified shall be promptly removed from the site of the work, and the Contractor shall receive no compensation for the replacement of the damaged material or its removal.

Manufactured materials shall be delivered and stored in their original containers, plainly marked, with identification of material and manufacturer.

1.1.3.3 TESTING

When requested by the Consultant, and in his presence, the Contractor shall perform or make arrangements for all tests and analysis of materials, equipment, and structures in accordance with the relevant clauses of the specifications. All facilities, labor, and materials required for the satisfactory performance of these tests, analysis, and inspections, whether on the Site, at the place of delivery, at the manufacturer's testing laboratory, or at an independent testing laboratory shall be supplied by the Contractor at his own expense.

The Contractor shall furnish, without cost to the Client, samples of material to be used in the work. No material shall be used prior to approval by the Consultant.

The Consultant may require the Contractor to submit the material testing results for his approval before the material is used. The testing shall be performed at the independent laboratory approved by the Consultant. All the expenses incurred shall be borne by the Contractor.

1.1.4 TEMPORARY FACILITIES**1.1.4.1 TEMPORARY OFFICE**

A temporary office shall be established in proximity to each main job site and shall be adequately furnished, and maintained in a clean, orderly condition by the Contractor for the duration of construction. The Contractor or his authorized representative shall be present in the office at all time while work is in progress. Instructions received there from the Consultant shall be considered as delivered to the Contractor.

1.1.4.2 TEMPORARY TELEPHONE

Install in the temporary office a telephone for the Consultant and Contractor's use. The Contractor shall pay all bills charged against the telephone, including the installation charge and all monthly charges throughout the construction period.

1.1.4.3 TEMPORARY WORKSHOP AND DWELLINGS FOR EMPLOYEE'S FAMILIES

Prior to constructing workshop or dwellings at the job site, permission shall be obtained from the Consultant. Workshops shall be constructed in such a manner that they will not be an obstacle to public travel or an aesthetic and noisy nuisance and the area shall be kept clean at all times. If the Contractor provides living accommodation for those employed by him and their families, the dwellings shall be maintained in a clean and sanitary condition. Each dwelling unit shall be provided with lights, water supply and sanitary facilities and properly furnished.

1.1.4.4 SANITARY ARRANGEMENTS

The Contractor shall provide and maintain temporary sanitary facilities on the site for the use of all persons connected with the work. The Contractor shall keep the site in a clean and sanitary condition, and shall post notices and take such precautions as may be necessary to keep the site clean. The Contractor shall carry out any cleaning whatsoever as may be directed by the Consultant to maintain such sanitary condition.

1.1.4.5 FIRST AID

The Contractor shall provide all necessary first aid facilities, attendants and supplies for his labor force, regulations and all other statutory requirements, to the Client and the Consultant.

1.1.4.6 CONSULTANT'S OFFICE

The Contractor shall complete the installation and furnishing of an office for the exclusive use of the Consultant.

1.1.5 SPECIAL PROVISIONS**1.1.5.1 WATER**

The responsibility shall be upon the Contractor to provide and maintain at his own expense an adequate supply of potable water for his use and his subcontractors' work for construction and domestic consumption and to install and maintain necessary supply connections and piping for the same, but only at such locations and in such a manner as may be approved by the Consultant. Before final acceptance, temporary connections and piping, installed by the Contractor, shall be removed to the satisfaction of the Consultant, unless requested by the Consultant to be left, upon agreement on price.

1.1.5.2 ELECTRICITY

All electrical current required by the Contractor shall be furnished at his own expense. All temporary connections for electricity shall be subject to the approval of the Consultant. All temporary lines shall be furnished, installed, connected and maintained by the Contractor in a workmanlike manner satisfactory to the Consultant, and shall be removed by the Contractor in like manner, at his expense, prior to final acceptance

of the works, unless requested by the Consultant to be left, upon agreement on price.

1.1.5.3 WORK IN PUBLIC WAYS

The Contractor shall observe all applicable traffic regulations. The responsibility of conformance is that of the Contractor.

SITE WORKS

2 SITE WORKS**2.1 SITE PREPARATION AND MISCELLANEOUS WORK****2.1.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to do all clearing, grubbing and stripping of top soil, and the demolition of all existing structures and foundations, as shown on the drawings and as specified herein.

2.1.2 CLEARING AND GRUBBING

Except as otherwise directed by the Consultant, the Contractor shall cut, grub, remove and dispose of all trees, stumps, brush, shrubs, roots, rubbish, organic matter and any other objectionable material within the limits of the work of the Contract, including areas to be occupied by buildings, structures, roads and any area where excavation or backfilling is required.

Any trees or group of trees designated on the drawings or by the Consultant to remain shall be protected from damage during any construction operation by erecting suitable barriers or by other approved means. Trees that are designated to remain and are damaged by the Contractor shall be repaired or replaced as directed by the Consultant without cost to the Client. Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees designated to remain.

2.1.3 STRIPPING

Topsoil may be stripped from all areas to be occupied by buildings, structures and all areas to be excavated except areas to be filled or paved. Avoid mixing topsoil with subsoil and stockpile it in areas on the site as approved by the Consultant. Topsoil shall be stockpiled free from brush, trash, stones, other extraneous material and protected until it is placed. Any topsoil stockpile remaining after all work is in place shall be disposed of by the Contractor, if the Consultant so directs.

2.1.4 DISPOSAL OF MATERIALS

All tree trunks, limbs, roots, stumps, brush, foliage and other vegetation shall be removed and disposed of by contractor off the project site. Burning of debris may be allowed on the project site, under the supervision of the Contractor, provided that burning arrangements are approved by the Consultant. Notice of burning shall be given by the Contractor to the local fire department before burning. The remaining burnt materials after burning shall be disposed of by the Contractor.

2.2 EXCAVATION, DEWATERING, AND FENCING**2.2.1 SCOPE OF WORK**

The Contractor shall furnish all labor, materials, equipment and incidentals necessary to perform all excavation, dewatering, disposal, backfill, fill and grading required to complete the work indicated on the drawings and specified herein. The work shall include but not necessarily be limited to excavation for structures, manholes, vaults, ducts, pipelines and appurtenances, and paving; all backfilling and filling for embankments and grading, disposal of waste and surplus materials, and all related work such as sheeting, bracing and dewatering.

The Contractor shall be responsible for the removal and proper disposal of all types of waste materials, debris, and surplus items from the site before, during, and after the construction works and its cost shall be included in the item rates. This includes, but is not limited to, demolition waste, packaging materials, excavated spoil, and any other construction-related debris. The site must be maintained in a clean, tidy, and safe condition at all times, and left free from all

construction materials upon completion of the works. All waste shall be disposed of in accordance with applicable environmental regulations and best practices. Topsoil and sod excavated under this section may be stored by the Contractor for use as specified under Section 2.1 "Site Preparation and Miscellaneous Works."

It shall be the responsibility of the Contractor to inspect all trucks and vehicles that are used in transporting excavated soils, organic spoil, and other items from and to the construction sites. The truck beds shall be sufficiently tight, and shall be loaded in such a manner that objectionable materials will not be spilled onto the soil, streets, or highways. The Contractor shall observe all applicable traffic regulations.

The Contractor shall conduct his operations in such a fashion that trucks and other vehicles do not create a dirt nuisance in the streets. Any dirt, mud, or other materials that are spilled into the streets by the tires of vehicles or their tires shall be promptly cleared away by the Contractor.

2.2.2 CONSTRUCTION PROCEDURES TO STABILIZE EXCAVATIONS FOR STRUCTURES AND PIPELINES

The stability of excavations will be affected by factors such as the soil characteristics, the depth of the excavation, ground water elevation, surcharge loading (including building and traffic loads) rain and/or flooding, pile driving, construction activities including stockpiling of materials and equipment, traffic and rate of excavation. The following items form the minimum criteria which shall be observed by the Contractor unless otherwise specified when planning an excavation, sheeting and bracing and a pile driving schedule:

2.2.2.1 STRUCTURES

- (1) Open excavation will be permitted to a maximum depth of 4.0 m.
- (2) A maximum slope of two horizontal to one vertical may be used.
- (3) Any excavation carried to a depth greater than 4.0 m measured from existing ground level shall be a stepped excavation. Steps shall be prepared for every 4.0 m depth of excavation with a minimum 1.0 m width.
- (4) The excavation where required or ordered by the Consultant shall be sheeted to avoid collapsing of the excavation and to prevent structures located close to excavations from being damaged.
- (5) The stockpiling of excavated clay, backfill or construction materials within a minimum distance of 5 meters from the top of slope is prohibited.

2.2.2.2 PIPELINES

- (1) Excavations shall be completed in accordance with the limiting trench widths shown on the drawings.
- (2) Excavations less than 1.5 m in depth may at the Contractor's option and after approval by the Consultant be accomplished without sheeting.
- (3) Excavation to depths greater than 1.5 m shall be sheeted and braced.
- (4) The stockpiling of excavated clay, backfill or construction materials within a minimum distance of 5 m from the top of slope of un-sheeted trenches is prohibited. Pile driving activities, if applicable, can affect the stability of excavations in soft clay by remolding the soil and generating excess pore water pressure in the clay. These factors will be most important when excavations are completed prior to pile driving or when excavations are made immediately after pile driving.

The Contractor shall submit to the Consultant for approval his proposed methods of excavation, dewatering and bracing. Included shall be a schedule indicating the

rate and depth of excavations, a plan for disposal of excavated material, and details of proposed lateral supports and bracing.

Excavations, and the protection of side slopes and backfill are to be rigidly controlled by the Contractor to the approved schedule. If the Contractor fails to protect side slopes, any resulting damage from a slope failure shall be repaired at the Contractor's expense.

The Contractor shall take all necessary precautions against the subsidence, displacement, inclination, etc. of any existing structures during dewatering. The Contractor shall be responsible for any damage caused by the preceding and any expense incurred in making good such damage shall be borne by the Contractor.

2.2.3 DEALING WITH WATER

The Contractor shall not, without the consent of the Consultant, rely upon pumping from drainage sumps as the sole means of fulfilling his obligations in dealing with water.

The Contractor shall control the manner and quality of water dealt with by pumping from drainage sumps such that there shall be, in the opinion of the Consultant, no adverse effects to the works or to any adjacent property.

No new or existing pipes in any permanent work shall be used for the purpose of carrying water away from the excavation without permission, in writing, from the Consultant.

The Contractor shall provide the Consultant details of silt traps or other measures to be undertaken to minimize the discharge of solids arising from dewatering operations.

The Contractor shall take every precaution to ensure that his operations do not adversely affect the surrounding groundwater aquifer, or the stability of the surrounding ground or any adjacent structure.

During the construction of the Works the Contractor shall ensure the levels of the groundwater are lowered sufficiently below the proposed formation to provide a firm foundation.

The Contractor shall take all necessary measures to prevent groundwater rising during the construction of the pipelines and structures until sufficient mass of structure or backfill to pipelines has been completed to overcome any buoyancy effect.

2.2.4 TOPSOIL FOR RE-USE

All topsoil shall be stripped from those areas affected by temporary and permanent works including compound areas and stored for re-use.

Topsoil for re-use shall not be stacked more than 1.5m high and kept free of weeds.

The Contractor shall store topsoil for re-use local to the area of stripping so as to ensure it can be returned as near as possible to its point of origin. All other material or overburden is to be stacked separately.

2.2.5 TEMPORARY DRAINS

Grouting pipes shall be inserted in the line of the temporary drains at intervals not exceeding 25m and the drains shall be solidly filled with grout, the grout pipes being cut off on completion.

2.2.6 FENCING

2.2.6.1 SCOPE OF WORK

Provide all labor, materials, equipment and incidentals necessary to furnish and install all fences, as required by the drawings and as specified herein.

The work specified herein includes various types of security fences, walls, chain link fences, gates and appurtenances.

2.2.6.2 SECURITY FENCES

The Contractor shall furnish and install security fences of the various types to the limits indicated on the drawings. Included are pedestrian gates and double gates for vehicular traffic. These fences are constructed on a mat foundation or a wood pile

foundation with a reinforced concrete frame and either a masonry wall or metal grill and topped by 3 barbed wires. The vehicular gate includes roller bearing casters with a roll on metal surface which will ride on a metal surface set in a concrete beam in the pavement.

Barbed wire shall consist of 2 wire strand of No. 12 gauge galvanized wire with 4 point barbs spaced approximately 10 cm apart and the weight of zinc coating shall be in accordance with JIS G 3535 Class 1 or other internationally accepted standards or manufacturer's standards as approved by the Consultant. The barbed wires shall be installed on hooks embedded in the reinforced concrete extensions to the fence posts and steel extensions on the gates all as indicated on the drawings.

Shop and field painting of the grill and gates shall conform to Section 9.1.

2.2.6.3 CHAIN LINK FENCE

2.2.6.3.1 GENERAL

The chain link fence and chain link gates are to be completely galvanized. Ornamental iron gates are to be painted. It is the intent that the erection of the fence and gates will require very little welding. Where welding is required, the surface shall be cleaned and painted.

2.2.6.3.2 MATERIALS

Fabric shall be 2.10 meters high unless otherwise shown and shall be woven in a 5 cm mesh of No. 9 British Standard (BS) wire. The wire shall be zinc coated before weaving and the weight of zinc coating shall conform to local applicable Standard. Top salvage shall have a twisted and barbed finish; bottom salvage shall have a knuckled finish.

Pipe for posts, frames and bracing shall be conformed to BS 1387 medium class and shall be galvanized. Fittings shall be hot dip galvanized pressed steel, conforming to BS 1740.

Tension wire shall be No. 6 BS gauge single strand. Extension arms shall be 5/16 inch thick steel plate. Barbed wire of 2-wire stand No. 12 gauge with 4-point barbs spaced approximately 10 cm apart. Concrete for fence posts shall be Class B unless noted otherwise.

2.2.6.3.3 FENCE CONSTRUCTION

Pipes for the following purposes shall be the sizes noted.

	O.D. Millimeters	Length (Meters)
Line Posts	60	3.0
Terminal Posts*	89	3.0
Top Rail	43	as required
Bracing	43	as required
Gate Frames (pedestrian)	43	as required
Gate Frames (vehicular)	60	as required
Gate Posts	89	as required

*End, corner and straining posts Galvanized couplings of the outside sleeve type at least 18 cm in length shall be used to joint top rails. The top rail shall extend through all line posts to form a continuous brace from end to end of each stretch

of fence and secured to each terminal post with a receptacle fitting. Braces shall be installed horizontally midway between top rail and the bottom of the fence and shall extend from the terminal post to the first adjacent line post. End and gate posts shall have one brace; corner and straining posts shall have two braces (one each side).

Gate frames shall include galvanized malleable iron hinges, latch and latch catch. Gate latches shall be suitable for a padlock which can be attached and operated from either side of gate. Gates shall be furnished with suitable hinges permitting 90° swing both in and out and suitable hardware to hold the gates open. Double gates shall be furnished with drop bar locking device.

Tension wire shall be stretched taut along the bottom of the fabric and shall be securely attached to all terminal and line posts and to the bottom of the fabric at 45 cm intervals. Spacing between tension wire and finished grade shall not be less than 5 cm and not more than 16 cm.

Fabric shall be fastened to the top rails, posts, braces with suitable tie wires at approximately 45 cm intervals.

2.2.6.3.4 *SETTING FENCE POSTS*

Fence posts shall be set in cast in place concrete footings (Concrete Class B). Footings for line posts shall be 30 cm square by 90 cm deep and for terminal posts 35 cm square by 1 meter deep. Steel posts shall extend to within 10 cm of bottom of concrete, and shall be exactly in line, plumb and even across the tops. Concrete footings shall be allowed to set for at least 72 hours before fabric erection is started. Line posts shall be installed with a maximum spacing of 3.0 meters and at points where there is a change in grade.

BACKFILLING AND RESTORATION

3 BACKFILLING AND RESTORATION

3.1 BACKFILLING

If the Contractor's working space undermines any existing structure, he shall backfill under the structure with lean mix concrete.

Maximum allowed layer thickness for backfilling is 20cm. No backfilling shall be placed around water retaining structures until the structure has been satisfactorily tested or before the Consultant's consent is obtained.

If the Contractor places backfill around the walls of a structure before it is satisfactorily tested for water tightness then the Contractor shall excavate and replace any of the backfill which is necessary in order to search for any leakage and subsequent remedial work.

Small manually-maneuvered compaction plant will be required to ensure that the granular materials are well compacted up to the edges of the excavation.

The Contractor shall not leave timbering or other excavation-support materials in excavations after backfilling unless otherwise approved by the Consultant.

3.2 REINSTATEMENT OF HIGHWAYS ETC.

3.2.1 REINSTATEMENT OF CARRIAGEWAYS, FOOTWAYS, FOOTPATHS, CYCLE TRACKS AND VERGES.

Reinstatement shall be undertaken in accordance with the requirements of the relevant Authority, or Client Requirement and be of the same or superior construction to the original.

3.2.1.1 GENERAL

The road base compaction procedure and equipment shall be proved by trials at the commencement of the work to the satisfaction of the Consultant. Compaction trials shall be carried out at varying moisture contents. The weights, types and number of passes of compaction equipment shall also be varied to determine the optimum compaction effort.

Prior to placing the succeeding construction layer, the road-base shall be mechanically swept or cleaned with compressed air to remove all loose material and to leave a tightly knit close texture surface.

Traffic will not be allowed on the surfacing until it has been laid and cured to the satisfaction of the Consultant. Prior to the Consultant's approval no traffic other than that required to lay the succeeding layers will be allowed on layers laid earlier.

3.2.1.2 REINSTATEMENT OF UNMADE ROADS AND FOOTPATHS

The Contractor shall reinstate unmade roads and footpaths in the same material as encountered during excavation, except where directed otherwise by the Consultant, and shall replace the excavated materials in the proper order in well consolidated layers.

3.2.1.3 REINSTATEMENT OF UNPAVED LAND

Reinstatement of unpaved land shall be carried out by the Contractor as follows:

- a) Subsoil shall be ripped and broken up to an agreed depth (not exceeding 450 mm) over the whole area of stripped topsoil, as directed by the Consultant. Due regard shall be given to the location of shallow drains and services.
- b) Topsoil shall be replaced and graded to finished ground profiles including provision of any necessary additional topsoil.
- c) Stones and other debris shall be removed and disposed to tip.
- d) The work shall be carried out during weather conditions which the Consultant considers to be suitable.
- e) A general fertilizer shall be applied in accordance with the manufacturer's recommendations.
- f) The Contractor shall be responsible for the first mowing of all grassed areas.
- g) The Contractor shall at his own expense re-seed all areas in which seed is not, in

the opinion of the Consultant, thriving reasonably well.

3.2.1.4 FENCES, HEDGES AND WALLS

Where the works cross a line of fences the Contractor shall carefully remove, store for the duration of the Works, and re-erect the fences on their original line or as directed. Any fencing damaged during this operation shall be replaced. Where the works cross the line of hedges or walls these shall be removed, and any plants or materials suitable for re-use shall be stored for re-use. Hedges and walls shall be reinstated as closely as possible to the original condition.

Where the Contractor is required to remove part of a fence, hedge or wall, he shall ensure that the width removed is the absolute minimum necessary for the execution of the Works.

The resulting gap shall be made secure to the satisfaction of the Consultant.

Where a length of masonry wall is removed, the walling material shall be carefully set aside and stored for re-use.

Reinstatement of roadside verges shall be carried out in accordance with the Highway Authority requirements and comply with the following provisions:

- a) If the Contractor fails to keep the topsoil separate from the other excavated material he shall be required to provide and place suitable replacement material.
- b) The Contractor may, in order to allow for settlement, slightly overfill the backfilled trench but the overfilling shall not be so great as to cause danger or hindrance. Should the reinstated surface sink below the level of the adjacent ground the Contractor shall make good the sinkage with productive soil.

3.2.1.5 TREES

No trees shall be felled or removed from the working area without the concerned authority's written consent.

All timber will remain the property of the landowner and will be cut and disposed of in accordance with his reasonable requirements.

Where pipes or cable ducts are laid in close proximity to tree roots and branches the disturbance is to be kept to a minimum. Tree roots and branches are not to be cut unless absolutely necessary and backfill around roots is to be a 150 mm surround of topsoil. Roots and branches are only to be cut by hand after approval by the Consultant. All cut ends are to be painted with an approved sealant containing a fungicide to prevent rotting of the root or branch.

3.2.1.6 LAND DRAINS

Records shall be kept of all drainage reinstatement work carried out and a copy shall be given to the Consultant

Except for trench crossing, replacement pipes shall be the same type as those removed unless otherwise agreed with the Consultant. Land drains shall be cast iron where they cross backfilled trenches.

The Contractor shall not undertake the reinstatement of any land drain until the agreement of the Consultant has been given in respect of the size of the cast iron pipe to be used in the repair. The length of pipe is to be sufficient to span the trench plus 0.5m support on either side.

The Contractor shall give the Consultant 48 hours advance notice of the completion of land drain repairs to enable the Consultant to give the landowner or occupier the opportunity to inspect these repairs.

No repaired land drains shall be backfilled until the Consultant has inspected them and the repairs have been approved by the Consultant.

3.2.1.7 FILLING ABOVE GROUND

All topsoil, organic material and pockets of soft material shall be removed from all areas to be filled.

Material for filling shall be placed in layers not exceeding 250 mm.

3.2.1.8 DEMOLITION

Structures shall be demolished to 1m below ground level. Tanks, sumps and basements shall have holes broken through to allow equalization of water levels. Structures extending below 1m depth shall be filled with compacted hard-core. Above 1m depth fill shall be selected material from demolition or imported fill with particle size not exceeding 150 mm. The Contractor shall be responsible for the removal and proper disposal of all demolished materials and debris, etc. from dismantling of items from the site before, during, and after the construction works and its cost shall be included in the item rate.

3.2.1.9 MAINTENANCE OF REINSTATEMENT

Until the expiration of the Defects Notification Period the Contractor shall regularly and frequently inspect all reinstatements carried out by him in connection with this Contract to ensure the safety of the public at all times.

Where deterioration or settlement of a surface occurs, whether this be noted by the Contractor during a routine inspection or be reported to him in some other manner, the Contractor shall immediately make good the defect in a manner approved by and to the entire satisfaction of the Consultant and, if applicable, the relevant Highway Authority.

Where the Contractor, or a Specialist Sub-Contractor employed by him, has carried out the final reinstatement of trenches in roads and footpaths the trenches will be subject to a joint inspection by the Consultant, the Client and concerned Authority Engineer and the Contractor six months after completion of the works and the Contractor will be required to carry out, at his own expense, such works as may be ordered to remedy any deterioration other than fair wear and tear that may have occurred since completion.

Notwithstanding the requirement for an interim inspection the Contractor shall maintain a regular and frequent inspection of the reinstatements during the whole of the Defects Notification Period and make good any defects that may occur.

3.2.1.10 SITE CLEARANCE

Site clearance shall not commence until the Site fencing has been erected and is complete.

The Contractor shall not burn brushwood or other combustible rubbish on site unless otherwise approved by the Consultant.

Fences and gates, etc. shall be removed carefully and stored for re-use.

MATERIALS

4 MATERIALS

4.1 PIPES

4.1.1 GENERAL

Each pipe, fitting and special appurtenance shall be marked with permanent identification which shall include but not necessarily limited to the following:

- a) Nominal diameter
- b) Name or trade mark of manufacturer
- c) Serial number
- d) Class of pipe, pressure rating in compliance with referenced standards
- e) Date of manufacture
- f) Type of service
- g) Details of fittings such as angle of change and taper

The acceptability of the pipes and fittings on delivery to the Site will be based on the results of tests carried out by one or more of the following:

- a) The manufacturer at the place of manufacturer
- b) The Engineer
- c) A third party on behalf of the Engineer

The Engineer shall be permitted at all reasonable times to visit places of manufacturer to witness tests.

Transport, handling and storage of pipes and fittings shall be carried out as follows:

- In accordance with the manufacturer's recommendations subject to the approval of the Engineer.
- Effective precautions shall be taken to prevent damage to the pipe and fittings.

4.1.1.1 During Transport:

- Pipes and fittings shall be well secured and adequately supported along their length.
- Bolsters and binding of approved type shall be used
- Nesting of pipes (placing a smaller pipe inside a larger) may be permitted for pipes of certain materials and size provided that methods statements demonstrate that effective precautions will be taken to protect all pipe surfaces and coatings from damage
- No pipe shall overhang the end of a vehicle
- Pipes and fittings of plastic materials shall be covered. Handling shall be carried out as follows:
 - Pipes should be lifted singly and not handled as bunches
 - Pipes shall be handled only by means of
 - Approved hooks, of the type having a plate curved to fit the curvature of the inside of the pipe, on ends of sections.
 - Fabric slings not less than 250mm wide.
 - Other methods approved for the pipe used.
 - Use of wire rope, chains and fork lift trucks will not be permitted.
 - For strings of pipe longer than the standard length precautions shall be taken to avoid curvature and longitudinal stress in excess of allowable limits.
- Pipes and fittings of plastic materials
 - Smaller than 300mm diameter may be handled manually.
 - Larger than 300mm diameter and greater than 4m in length shall be lifted using fabric lifting straps or larger diameter rope slings positioned at a quarter of the pipe length from each end.
 - There should be enough slack in the slings to keep the hook approximately 600mm over the pipe.
 - Steel chain or hooks shall not come into contact with the pipe.
- Pipes and fittings shall not be dropped or bumped.

- Pipes shall not be dragged over the ground.
- If rolled, pipes shall be rolled only over adequate timber bearers to prevent damage.
- Where necessary, chocks shall be used to prevent lateral movement of pipes.

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

- Pipes may be stored in the open on a flat level area and raised above the ground on timber bearers so that the lowest point of any pipe or fitting is not less than 150mm above the ground.
- Timber bearers not less than 200mm wide and 75mm thick to be provided at 4m intervals maximum.
- If no pallets or crated, on the pallets or in their crates until required.
- If spigot and socket, stacked so that successive pipe layers have sockets protruding at opposite ends of the stack.
- With pipes of different sizes and thickness stacked separately.
- With maximum height of stacked pipes not exceeding 2m, or that recommended by the supplier if less than 2m.

Pipes and fittings of plastic materials shall be:

- Stored under cover and out of direct sunlight.
- Adequately supported along their length.
- Provided with a free flow of air around the pipe.
- Storage of jointing materials shall be as follows:
 - i. Under cover
 - ii. Rubber ring gaskets shall
 - iii. Be stored in their original packing
 - iv. Not be exposed to sunlight
 - v. Protected from exposure to greases and oils

a) Gasket lubricants shall be stored so as to prevent damage to the container.

Pipes and fittings shall be protected in storage to the approval of the Engineer by means of an impermeable membrane which shall cover the pipes and fittings and separate them from the ground on which they are supported. The membrane shall be strong and durable in the prevailing climate conditions.

Pipes and fittings shall be subjected to visual inspections after off-loading at site and before installation.

The following procedures shall be followed for dealing with damaged pipes and fittings:

- a) Pipes and fittings damaged during transportation handling and storage shall be set aside and the damage brought to the attention of the Engineer.
- b) Pipes or fittings that show signs of corrosion or deterioration during storage shall immediately be treated to arrest and prevent the corrosion or deterioration or removed from site, as the Engineer directs.
- c) Proposals for repair shall be submitted in writing for the Engineer's approval.
- d) No attempt shall be made to repair damage without the Engineer's approval.
- e) If in the Engineer's opinion the nature of a damage is such that the condition of a pipe has been impaired and cannot be repaired the pipe concerned shall not be incorporated in the works.
- f) All rejected pipes shall be immediately removed from the site.
- g) Damaged pipe shall be replaced or repaired by the Contractor at his expense and such repairs shall be to the approval of the Engineer. The Engineer may require that any GRP pipe or fittings found to be damaged to be subjected to a further hydraulic test which shall be carried out by the Contractor, at the Contractor's expense.

4.1.2 SHOP DRAWINGS

The Contractor shall submit detailed working and shop drawings and schedules of all

pipe, fittings and appurtenances in accordance with the Clause titled "Shop Drawings" of the General Conditions of Contract. Shop drawings shall include but not be limited to the following:

- a. Lists and schedules of material, linings and coatings.
- b. Schedules of pipe lengths and thicknesses.
- c. Details of proposed joints, harnesses and installation details.
- d. Names of suppliers and identification of materials and equipment to be supplied.
- e. Dates of delivery of materials to job site.
- f. Special enclosures.

For reinforced concrete pipe, the Contractor shall furnish all information related to placement of steel reinforcement, and a complete set of design calculations.

Installation manuals shall also be furnished when requested.

Shop drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The work of this section shall be completely coordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

The Contractor shall furnish a mill certified report, in triplicate, of the tests for materials to be specified in the work. The certifications shall contain the results of chemical and physical tests required by these specifications for the materials.

For both shop and field welds of steel pipe, the following information shall be submitted if necessary.

- a. Method of welding - automatic or manual.
- b. Type of welding rods.
- c. Method of preparing edges.
- d. Welding procedure.
- e. Cleaning of welds.

The Contractor shall submit samples of materials to be supplied under this section upon written direction of the Consultant.

The Contractor shall submit, for approval, exact details of various joints that are proposed for use on this project which originate in different countries and which differ from these specifications. In the event the Consultant approves these different joints, the Contractor shall assume all responsibilities regarding the coordinating and providing of proper joints and connections.

4.1.3 BEDDING

Wherever specifically called for by means of notes on the Contract Drawings or by written order of the Engineer, the Contractor shall furnish and place sand or crushed stone bedding under sewer lines, drain pipes and other structures as a separate item of payment.

Unless specified elsewhere in the Contract Documents, Sand and 3/8" size crushed stone in bedding shall be used from a source and of Specifications approved by the Engineer

The sand and crushed 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 mixture of any type of deleterious materials.

The material for bedding shall be placed to the specified thickness and compacted by mechanical rammers of approved weight.

4.1.4 UPVC PIPES AND FITTINGS

4.1.4.1 STANDARDS

UPVC pipes and fittings for sewers shall conform to BS 5481, BS 4660

The strength requirement and other features of particular application shall be as specified in this specification.

4.1.4.2 MANUFACTURE

UPVC pipes and fittings shall be capable of withstanding ultraviolet degradation and shall incorporate a rodent inhibitor.

For sewerage services, UPVC pipes 200mm in diameter may be supplied in lengths upto 4m. UPVC pipes 150mm in diameter and less shall be supplied in lengths not exceeding 2m and 50 percent in lengths not exceeding 4m.

Unless a higher class is noted elsewhere in the Contract Documents, UPVC Class B pipes shall be used. Any pipe or part pipe with discoloration, scratching, abrasion, pit marks or otherwise considered unsuitable by the Engineer shall be rejected.

The Contractor shall take due account of any specifications issued by and/or specific requirements pertaining to the respective adopting Statutory Authority. Should an instance arise where the Authority's specified requirements conflict with this project specification, and unless instructed to the contrary by the Engineer, the Authority's specified requirements shall prevail.

4.1.4.3 JOINTS

Solvent welded joints shall not be permitted for sewerage pipelines and all jointing shall be by socket and spigots with sealing rings which shall conform to BS 2494.

Joints shall be made by means of rubber ring seal connections, unless otherwise designated.

Unless otherwise designated, pipe work up to 100mm in diameter shall be solvent welded in accordance with BS 4346 Part 1.

4.1.4.4 INSPECTION AND TESTING

Inspection and testing for sewer pipes shall be in accordance with BS 5841 and BS 4660. The manufacturer shall provide test certificates.

Pipe and fittings shall not be stored directly exposed to sunlight handled or laid in conditions where ambient temperatures may cause distortion or damage. In extreme conditions, pipe and fittings may have to be stored under water.

4.1.5 REINFORCED CEMENT CONCRETE PIPE SEWERS

4.1.5.1 SCOPE OF WORK

The work covered by this Section of the Specifications consists in furnishing all reinforced pipes, plant, labour, equipment, appliances and materials and in performing all operations required for manufacturing, furnishing, installing and testing the sewer pipes in strict accordance with the Specifications of this Section and the applicable Drawings and subject to the terms and Conditions of the Contract.

4.1.5.2 REINFORCED CEMENT CONCRETE PIPES

4.1.5.2.1 General

All reinforced concrete pipes furnished and installed under this Contract shall conform to, to ASTM specification C-76-79 "Reinforced Concrete Culvert, Storm Drain and Sewer Pipe" and moulded with cement concrete 1:1-1/2:3 as per provisions of these Technical Specifications, using structural steel reinforcement.

4.1.5.2.2 Classes of Pipe

The reinforced cement concrete pipes to be furnished and installed under this Contract shall be of the strength Classes shown on the plans and designated in the Bill of Quantities of the Bid Documents.

The strength Classes shall be identified as one or more of: (1) Class I; (2) Class II; (3) Class III; (4) Class IV; and (5) Class V.

The reinforced cement concrete pipes to be furnished and installed shall be of the strength Class IV or specified otherwise on the Drawings.

The design requirements for these five classes of reinforced cement concrete pipe shall be as described in ASTM Designation C76, or its latest version, Tables I through V for

the respective strength classes. Unless otherwise called for in other parts of these Bid Documents or applicable Variation Order (VO), all reinforced cement concrete pipes under this Contract shall comply with the Wall B design requirements as set forth in said Tables I through V of ASTM Designation C76.

4.1.5.2.3 Basis of Acceptance

Acceptance of reinforced cement concrete pipes will be on the basis of three edge bearing and material tests as per ASTM Designation C76 and inspection of manufactured pipes for defects and imperfections. The Contractor shall bear the cost of such tests and pay fees etc., and also pay for the carriage of such samples and all other expenses contingent to tests. The Contractor can select a pipe manufacturing facility after approval of the Engineer. The manufacture of the pipes at approved facility or factory owned by Contractor shall be supervised and tested by the authorized representative of the Engineer.

4.1.5.2.4 Materials

All materials used in the manufacture of reinforced cement concrete pipes for use under this Contract shall conform to ASTM Designation C76-72a and also with the following specifications.

Cement

The Sulphate Resisting Portland Cement (SRPC) Portland cement which is required to be used in the manufacture of reinforced concrete pipes to be furnished and installed under this Contract shall conform to the requirements of BS 4027 and ASTM Designation C-150 (Type V) latest revision.

Aggregate

The fully crushed coarse and fine aggregate and washed shall be used in the manufacture of concrete pipes to be furnished and installed under this Contract and shall be generally in accordance with the provisions of Chapter-6 of these Specifications.

Steel Reinforcement

The material will conform to the Specifications contained in relevant Section of these Specifications in Chapter-5

4.1.5.2.5 Mixing of Concrete

The proper types and amounts of Sulphate Resisting Portland Cement (SRPC), mineral aggregates and water shall be thoroughly mixed in an approved type of Concrete Batch Plant which shall be kept in perfect working condition. Admixtures in the concrete will only be permitted with the approval of the Engineer and as explained in Chapter-6.

4.1.5.2.6 Pipe Dimensions

- i) The internal diameters and wall thickness of reinforced concrete pipes under this Contract shall be as set forth in ASTM Designation C76-72a in Tables I through V for " Wall B " pipe as required and shown on the plans.
- ii) The lengths of reinforced concrete pipes under this Contract shall be as required to provide the designated laying length shall be in full, and shall not be less than 6 feet, nor more than 8 feet, unless otherwise approved in writing by the Engineer.
- iii) Only one laying length shall be permitted for each size of reinforced concrete pipe under this Contract and pipes not of the approved uniform laying length shall not be used in the work.

4.1.5.2.7 Lift Holes not permitted

Lift holes in the walls of reinforced cement concrete pipes will not be permitted under this Contract for the purpose of handling and laying. Other approved lifting methods shall be employed.

4.1.5.2.8 Certified Plans and Data Sheets

- i) The Contractor shall submit in triplicate, for approval by the Engineer, certified plans and data sheets as required to provide complete information on all concrete sewer pipes, dimensions, type and dimensions of pipe ends, joint details, proposed concrete design mix for each different strength Class of reinforced or non-reinforced concrete pipe and any other information needed to demonstrate full compliance with these Specifications.
- ii) No concrete sewer pipe shall be delivered to the work site until the Engineer has formally approved the plans and data sheets and until all test requirements called for in the respective ASTM Standard Specifications C76-79 and C-14 have been met.

4.1.5.3 JOINTS FOR CONCRETE PIPE SEWERS

4.1.5.3.1 General

Joints for concrete sewer pipes of more than 150mm diameter shall be Rubber Gasket joints as provided in the plans. No other types of joints will be permitted under this Contract. For pipes of 150mm internal diameters collar joints will be used.

4.1.5.3.2 Rubber Gasket Joints

- (i) Rubber gasket joints shall be used for either tongue and groove or bell & spigot pipes.
- (ii) Rubber gasket joints shall be made using specially designed rubber gaskets, made to fit the applicable tongue and groove or bell and spigot pipes and adequately tested under operating conditions. Special care must be taken in the selection and handling of the concrete pipes for use with rubber gasket joints, to ensure that pipe ends shall be smooth and concentric with tolerance which closely conforms to the requirements of the manufacturer of the rubber gaskets. The tongue or spigot end of each pipe shall be specially designed to perform groove or offsets to fit the manufacturer's rubber gasket design.
- (iii) The rubber gasket joints shall conform to all applicable requirements of the latest revision of ASTM Designation C-443, entitled "Joints for Circular Concrete Sewer and Culvert Pipe, Using Flexible Watertight Rubber Type Gaskets", except that the test pressure need not exceed 10 feet of head at which the completed sewers shall meet the infiltration or exfiltration limits set forth hereinafter.
- (iv) The groove end of tongue and groove pipes of either the reinforced or non-reinforced concrete type, shall have at least one line of wire reinforcing of 8 gauge size placed in the center of the groove.
- (v) The rubber gasket shall be installed on the pipe in accordance with the instructions of the gasket manufacturer. In general, the gaskets shall be pre-assembled to the pipe at the pipe manufacturing plant. The pipes shall be handled with special care at all times to prevent damage to the pipe ends. A lubricant shall be used for jointing the pipes as recommended by the rubber gasket manufacturer. Care shall be taken to avoid contamination of the gasket and lubricated surfaces with earth or other undesirable material during installation.
- (vi) For either tongue and groove or bell and spigot pipes, mechanical means shall be used to pull the pipe home for all sizes of 12 inch or larger diameter in accordance with the recommendations of the rubber gasket manufacture. Pipes of 8 inch or smaller diameter may be coupled manually using a cross member

and bar. Under no circumstances will bars alone be used nor shall any motor driven equipment be used to force the pipe home.

4.1.5.4 INSTALLATION OF CONCRETE PIPE SEWERS

4.1.5.4.1 Handling of Pipes

- (i) Concrete sewer pipes shall be handled with special care at all times during the manufacture, while transporting to the site of work, and while installing. Each pipe shall be carefully inspected before being laid and no cracked, broken or defective pipe shall be used in the work.
- (ii) Chipping of the tongue and groove or bell and spigot pipe ends, which in the Engineer's opinion may cause defective joints, shall be sufficient cause for the rejection of any concrete pipe.

4.1.5.4.2 Excavation and Backfill

The excavation and backfill for sewer installations shall be as specified in applicable provisions of these Technical Specifications and will be paid for under separate Contract items as classified or and as per applicable Variation Orders (VO).

4.1.5.4.3 Trench Bedding

Wherever called for on the plans or where ordered in writing by the Engineer, the Contractor shall furnish and place bedding, and/or concrete encasement for the concrete pipe sewers under this Contract. The bedding shall be as specified in applicable provisions of these Technical Specifications and will be paid for under separate Contract item as classified, described and listed in the Bill of Quantities or and as called for in applicable Variation Order (VO).

The concrete encasement shall be placed in accordance with the details and notations on the plans or as ordered in writing. Concrete work shall be as specified in the applicable provisions of Item of these Technical Specifications and will be paid for under separate Contract items as classified, described and listed in the Bill of Quantities (BOQ) or as called for in applicable Variation Orders (VO).

4.1.5.4.4 Laying of Sewers

- (i) Neither any sewer pipe nor the bedding shall be laid or placed till the alignment of the sewer and its levels nor gradients, have been carefully checked and tested with the trench excavation and found correct.
- (ii) Each length of sewer pipe shall be checked for cracks and defects before placing in the line. Defects which in the opinion of the Engineer indicate imperfect placing, shall make the pipe liable to rejection.
- (iii) Each pipe shall be placed carefully to line and grade and in close contact with adjoining pipe. These specifications require rejection of the work if the sewer invert varies as much as 12mm from the proper elevation.
- (iv) As shown on plans, the bottom of the trench must be shaped to fit the pipe barrel, with holes left for the bells.
- (v) If excavation has been carried below the correct grade, refilling must be done with satisfactory materials as approved by the Engineer at no extra cost.
- (vi) The concrete pipe joints shall be of the types designated above and shall be made in accordance with the aforesaid specifications.
- (vii) When pipe laying is not in progress, the open pipe shall be closed with a tapered wooden plug to keep out foreign matter.

4.1.6 HIGH DENSITY POLYETHYLENE (HDPE) PIPES AND FITTINGS

High-density polyethylene pipes (HDPE) and fittings shall conform to ISO 4427/DIN 8075 standards. Material, diameters, wall thickness shall be as indicated in Din-8074/Din-8075/ISO- 4427. All pipes and fittings shall have the minimum initial

specific stiffness and be classed with pressure classification or else given in the drawings. Allowable pipe deflections shall be as per manufacturer recommendations

4.1.6.1 WALL THICKNESS

Every individual pipe's wall thickness shall be measured and recorded. Where the pipe's wall is less than the designed minimum, it shall be rejected unless it can be shown to meet the minimum stiffness value.

4.1.6.2 JOINTS

Pipes shall be joined by means of a butt fusion method or suitable couplings as advised by engineer and manufacturer specification.

Shall be plain ended, shall have a smooth outer surface and shall have a constant outside diameter throughout their length thus allowing them to be cut and jointed at any position along their length.

Where bends are fabricated in HDPE they shall be to the same standard as the pipes. Longitudinal angular deflections at the joints shall not exceed the maximum stated by the manufacturer.

Pipes may be joined by:

1. Thermal butt-fusion
2. Flange assembly which consists of polyethylene stub-end butt-fused to end of the pipe and metal slip-on flange
3. Coupling with special stub-ends designed to accept the coupling butt-fused to end of the pipes

4.1.7 DI PIPE

4.1.7.1 GENERAL

The work included in this Section consists of manufacture, factory testing and witnessing by the Employer and or the Engineer and supply and delivery of Ductile Iron pipes, fittings, valves, specials and other pipeline materials and installation as specified here-in.

All pipeline materials shall be supplied by the Contractor, unless otherwise indicated in these documents or instructed by the Engineer.

All materials and equipment supplied shall be suitable for use under conditions prevailing at the sites of the Works.

4.1.7.2 SHOP DRAWINGS

In addition to re-submitting all data required in the Tender the Contractor shall submit for approval detailed shop Drawings together with other required information specified in accordance with the requirements specified in this Section.

The Contractor shall submit for the Engineer's approval a detailed program for submission of drawings, manufacture, testing, witnessing and delivery of pipes, couplings, fittings, valves and other pipeline materials to achieve the completion of the Works within the Contract period. Any deviations from the program shall be notified to the Engineer, but will not relieve the Contractor of his obligations under the Contract.

Shop Drawings, complete with material, grade and class for all pipes, fittings, couplings, joints and coatings shall be submitted. Detailed catalogue and engineering data sheets shall be submitted for all components such as flexible couplings, rubber gaskets, and insulating joints.

Shop Drawings for miscellaneous components shall be complete with bill-of-materials showing kind and class of materials and catalogue and engineering data showing compliance with the specified requirements. In addition shall submit:

- a) Instructions and Certificates for each type and model:
- b) Assembly instructions and spare parts list

c) Preventative/ corrective maintenance instructions

d) Certificate of seat compatibility with entailed fluid exposure

Erection Drawings including the procedures to be used in setting, supporting, and/ or anchoring the valves, the fitting of line pipe to the valves for proper coupling and for adjusting and testing all valve assemblies.

4.1.7.3 PROTECTIVE COATINGS

Protective coatings schedules shall be submitted, showing shop and field surface preparations, materials, methods of application, dry film thickness and tests for defects, all in conformance with this Section.

All exposed pipe work shall be provided with a topcoat of blue colour paint compatible with the protective coating unless otherwise directed by the Engineer.

4.1.7.4 MARKING

Each length of pipe and fitting shall be marked with the following:

- a) Manufacturing standard
- b) Manufacturer's name
- c) Manufacturing date
- d) Nominal diameter in mm
- e) Inside and outside diameters in mm
- f) Pressure rating in bars
- g) Inspection mark
- h) Coupling "homeline" position on spigot ends
- i) Serial Number

4.1.7.5 NOT MORE THAN ONE MANUFACTURER

Pipes, couplings, fittings and valves for each component classification shall not be supplied by more than one manufacturer, except with the Employer's approval.

4.1.7.6 TEST CERTIFICATES

All pipes, fittings and valves delivered to the site shall have been tested (referred to hereinafter as "works test") in accordance with ISO standards or other approved equivalent or better standard. The Contractor shall furnish the Engineer with the manufacturer's test certificates for each consignment before each delivery begins.

The Engineer and/ or the Employer reserves the right to inspect the pipes, couplings, fittings and valves to be supplied for the works at the place of manufacture and to witness works tests. The Contractor shall provide the equipment and labour necessary for carrying out the inspection.

4.1.7.7 SERVICE CONDITIONS

All sanitary sewer pipes and appurtenant materials shall be suitable for carrying domestic wastewater at temperatures of up to 50 Celsius with sulphide concentrations up to 50 mg/L.

All buried pipes and appurtenant materials shall be suitable for immersion in corrosive groundwater. Groundwater characteristics shall be ascertained by the Contractor.

4.1.7.8 BASIS OF ACCEPTANCE

The acceptability of the pipes and fittings will be based on the results of tests carried out at the manufacturer's plant and/ or at the Contractor's expense and the result of any independent testing carried out by the Employer or his agent. The frequency and type of tests required for each pipe material are given in the following Sub-Sections and certified copies of all records of inspection and test results shall be submitted to the Engineer.

4.1.7.9 REFERENCE CODES AND STANDARDS

Pipe shall be centrifugally cast and shall be class-K12 conforming to specifications (ISO2531 and BS 4772) and relevant ANSI/AWWA standards amended to date, with flanges and laying lengths of at least 6 feet with B Class normal working Pressure.

Pressure rating of the pipe must be capable of handling 1.5 times the normal working pressure. Flanges for pipe, fittings, and valves, where shown, shall be furnished in accordance with D.O and shall be faced and drilled identical to specified Class flanges with rubber gaskets 1/8" thickness. Bolts and nuts for flanges shall be in accordance with ANSI/AWWA Standards.

4.1.7.10 UNLOADING, HAULING, DISTRIBUTING, AND STORING DUCTILE IRON PIPE AND RELATED MATERIALS

The Contractor shall unload, haul, distribute and store Ductile Iron pipe and related materials as follows.

4.1.7.10.1 Unloading:

Equipment and facilities for unloading, hauling, distributing and storing materials shall be furnished by the Contractor and shall at all times be available for use in unloading materials. Delays in unloading trucks, or hauling from freight terminal which incur demurrage, truck waiting charges or terminal charges shall be at the expense of the Contractor.

4.1.7.10.2 Handling:

Pipe, fittings and other material shall be carefully handled so as to prevent breakage and so as to prevent damage to pipe and fittings. Pipe shall not be unloaded by rolling or dropping off of trucks or cars, but shall be handled by carefully lifting and lowering into position, using approved slings or clamps which shall be provided for the purpose. Ductile Iron pipe fittings shall be carefully examined for cracks, broken lining or other defects. No pipe or fitting shall be laid which is known to be defective. If any pipe or fitting is discovered to be cracked, broken or defective after being laid, it shall be removed and replaced with sound material, without further charge. All pipe and fittings shall be thoroughly cleaned before being laid, and shall be kept clean until accepted in the completed work.

4.1.7.10.3 Distributing:

Materials shall be distributed and placed so as to least interfere with traffic. No street or roadway may be closed without first obtaining permission from the proper authorities. The Contractor shall furnish and maintain proper warning signs and obstruction lights for protection of traffic along highways, streets, and roadways upon which material is distributed. No distributed material shall be placed in drainage ditches.

4.1.7.10.4 Storage:

All pipe, fittings and other materials which cannot be distributed along the route of the work shall be stored for subsequent use when needed. The Contractor shall make his own arrangements for the use of storage areas.

4.1.7.10.5 Payment:

No separate payment will be made for the above work. The cost of such work, and all costs incidental thereto, shall be included in the prices bid for the item to which the work pertains.

4.1.7.11 ASSEMBLING, CUTTING, AND JOINTING DUCTILE IRON PIPE AND IRON FITTINGS

The Contractor shall assemble, joint and lay all pipe to accurately conform to the lines and grades established by the Engineer and in accordance with ANSI/AWWA C600 as amended to date and as follows:

4.1.7.12 Cutting Ductile Iron

Whenever Ductile Iron pipe or special castings are required to be cut, the cutting shall be done by skilled workmen using an abrasive wheel cutter. Use of oxyacetylene torch

will not be permitted. The plain end shall be beveled and inspected, any sharp edges which might damage the gasket shall be removed by means of a file or power grinder. Pipe that is cut in the field must be ground and beveled before assembly.

4.1.7.13 Jointing Ductile Iron Pipe

Joints shall be made only by experienced mechanics. All joints shall be flanged type. Flanged joints for ductile iron pipes and specials shall be made with rubber joint gaskets and steel bolts and nuts which shall include two washers per bolt. The use of jointing paste or grease will not be permitted. The gasket may be fastened to the bolts with cotton thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then be alternatively and progressively tightened with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all around the joint. The joint shall be moulded with suitable material as recommended by the manufacturer or directed by the Engineer.

During assembly of the pipe, the joint must be kept straight. Pipe may be deflected if desired but only after the assembly is completed.

4.1.7.14 TESTING OF D.I PIPE

4.1.7.14.1 Testing:

When a section of pipe of a length deemed adequate by the Engineer is ready for testing, the line shall be filled and thoroughly exhausted of air and a leakage test made. The Contractor shall furnish all labor, materials and equipment for carrying out these tests. Wherever conditions will permit, in the opinion of the Engineer, pipe lines shall tested before the trench is backfilled. All joints then shall be examined during open trench test and all leaks entirely stopped. The Contractor shall furnish a test pump, and means for accurate measurement of water introduced into a line during testing, and shall furnish and install corporation stops at all high points in the line and at the test pump location, as required for exhausting air.

4.1.7.14.2 Temporary Bulkheads

The Contractor shall furnish, install and remove all temporary bulkheads, flanges or plugs, to permit the required pressure tests, and shall furnish all equipment and labor to properly carry out such tests and to replace defective material.

4.1.7.14.3 Test Pressure and Leakages:

Test Pressure and leakage tests must be conducted in accordance with AWWA Standards C600. Test pressure shall be 200 lbs. per square inch or 1.5 times the maximum working pressure of the pipe, which ever is higher, as measured at the lowest point of elevation of the section of line being tested. Leakage shall not exceed the allowable leakage calculated by the following formulas:

4.1.7.14.4 For Ductile Iron:

$$L = [SD(P)^{1/2}] / 133,200$$

Where:

L = allowable leakage (gals. /hr.)

S = length of the pipeline tested (feet)

D = diameter of pipe (inches)

P = average test pressure (psig)

Minimum test period shall be two (2) hours, however, if in the opinion of the Engineer, additional testing is required, such additional testing shall be performed by the Contractor at no additional expense to the Owner.

4.1.7.15 DEFECTIVE MATERIALS AND WORKMANSHIP

Any cracked or broken material, such as pipe, fittings, valves or hydrants, shall be removed and replaced with sound pieces at the expense of the Contractor. Joints which leak, shall be carefully remade. Remade joints and replaced material shall be retested under the same conditions of operation. If joints or materials are then found to be defective, they shall be remade and replaced until the line passes the required test.

4.1.8 TESTS FOR INFILTRATION OR EXFILTRATION**4.1.8.1 GENERAL**

All sewers built under this Contract shall be tested for infiltration or exfiltration as specified herein. The Contractor shall furnish labour, materials and equipment required for making the required tests with no extra compensation to the Contract Unit Rate for the sewers. The tests shall be made at times selected or approved by the Engineer. Sections of the completed sewer shall be isolated and measurements of the infiltration or exfiltration shall be made by approved methods.

4.1.8.2 INFILTRATION TESTS

- (i) The sewers which are constructed with the ground water level above the crown of the pipe shall be tested for infiltration after the sewers have been installed and backfilling has been substantially completed. The tests and measurement shall be performed by the Contractor in the presence of and in a manner approved by the Engineer.
- (ii) The duration of the tests shall be only long enough to establish the true rate of infiltration.
- (iii) The amount of leakage over a 25 hours period will then be calculated from the result of the measured true rate of infiltration.

4.1.8.3 EXFILTRATION TESTS

The sewers which are constructed with the ground water level below the crown of the pipe shall be tested for exfiltration by isolating a section of sewers between manholes by means of approved temporary type of water tight bulk heads. The method of testing for exfiltration shall be generally as follows:

- i) After isolation of sewer section, it shall be filled with water to a level which is 1m above the crown of the sewer at the higher end of the isolated section under test. The level will not be more than 6 feet above the crown of the sewer pipe at its lower end.
- ii) The duration of the exfiltration test shall be one hour after the filling with water has been completed.
- iii) Determination of the amount of exfiltration shall be made by measuring the total loss of volume of water in the manholes.
- iv) The amount of exfiltration over a 25 hours period will then be calculated from the measured loss of volume during the test observation period.

4.1.8.4 ALLOWABLE INFILTRATION OR EXFILTRATION

- (i) The calculated amount of infiltration or exfiltration over a 25 hours period shall not exceed 75 liter per mm of pipe diameter per km of sewer, which rate shall be applied to the actual sewer size and length tested to determine the allowable infiltration or exfiltration over the 25 hours period.
- (ii) If the measured infiltration or exfiltration exceeds the specified allowable limit, then the Contractor shall locate the points of leakage and make necessary repairs so as to reduce the leakage to less than permissible maximum stated above.

4.1.8.5 MEASUREMENT

- (i) Measurement will be made at site of the actual lengths of reinforced concrete pipes of different sizes and strength installed tested and approved as authorized for the payment under the Contract.

- (ii) The measurement will be made along the center line of the pipe and between the inside walls of manholes or junction chambers. The unit of measurement will be one linear foot.

4.1.9 Cast Iron (CI)

- (i) Cast iron, centrifugally cast or spun, conforming to IS 1536 / IS 1538 or ASTM A74 (for US) standards.
- (ii) Pipes are usually coated internally and externally with bituminous paint or epoxy to resist corrosion.

4.1.9.1 Classes & Sizes

- (i) Nominal Diameter (DN): 50 mm to 150 mm (vent pipes typically 75–100 mm).
- (ii) Available in different classes (A, B, C) depending on thickness and pressure rating.

Class A: Light duty

Class B: Medium duty

Class C: Heavy duty

4.1.9.2 Joints

- (i) Spigot & Socket (S&S) joints with rubber rings or lead caulking.
- (ii) Flanged joints for special connections.
- (iii) Mechanical / push-fit joints available in modern CI pipe systems.

4.1.9.3 Length

- (i) Standard length: 1.5 m to 3.0 m per pipe section.

4.1.9.4 Coating / Protection

- (i) Internal lining: bitumen/coal tar epoxy to prevent corrosion.
- (ii) External coating: bitumen, epoxy, or zinc coating for longer life.

4.1.9.5 Testing

- (i) Pipes are hydraulically tested for pressure and free from defects.
- (ii) Conform to standards for leakage and soundness.

STRUCTURES

5 STRUCTURES**5.1 GENERAL****5.1.1 DESCRIPTION**

This item contains a general description of the specific items of work, the materials, construction requirements, and methods of measurement and payment for all concrete structures including composite structures of concrete such as barriers, steel and all brick and stone masonry structures built as indicated on the drawings and in conformity with the lines, grade, dimension in conjunction with any instructions issued by the Engineer. Materials, equipment, workmanship and construction methods applied in the work shall conform to the requirements laid down herein and shall also follow the best modern construction practices with the approval of Engineer. This item shall also include construction of certain structural features and incidental items which are either common to all types of structures or which may apply to any of them.

5.1.2 CLEARING OF SITE

The contractor shall clear the sites for proposed structures of trees, bushes, stumps and debris, cost of which shall be deemed to be included in the price bid for the various items. Special clearing of site such as removal of existing buildings, concrete pavement etc., will be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with the special clearing shall be deemed to be included in the price tendered for various items of the structures in the Bill of Quantities.

5.1.3 SETTING OUT OF WORK

The Contractor shall set out the Works and shall be responsible for true and perfect levels and setting out of the same and for correctness of the direction, positions, levels, dimensions and alignments of all parts thereof. If any error in this respect shall appear during the progress of the Work, the Contractor shall at his own expense rectify such error to the satisfaction of the Engineer. Any checking by the Engineer shall not relieve the Contractor from his complete unshared responsibility for correct setting out of Works. The Contractor shall construct and maintain accurate bench marks so that the lines and levels can be easily checked by the Engineer.

5.1.4 FOUNDATION DATA

Foundation data including the location of all boreholes together with the records of ground conditions encountered have been obtained from soil investigation by test boring, test pits or other sources. It is the Engineer's responsibility to ensure by additional investigations through the contractor at the very beginning of construction work that the foundation levels given in the Drawings coincide with the local requirements. A detailed geotechnical investigation shall be conducted prior to the commencement of any civil works related to the construction of sewerage treatment plants and storage reservoirs.

5.1.5 MEASUREMENT AND PAYMENT**5.1.5.1 MEASUREMENT**

The quantities of various pay items which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

5.1.5.2 PAYMENT

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labor, equipment, tool and

all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

5.2 CONSTRUCTION OF MANHOLES

5.2.1 SCOPE OF WORK

The work consists of constructing manholes for sewers at positions shown on the Drawings or where otherwise directed by the Engineer, and in accordance with the Detailed Drawings supplied from time to time Circular or Rectangular sections, complete in all respects.

5.2.2 MATERIALS

Brick masonry, Sulphate Resisting Portland Cement (SRPC) concrete, and other materials shall meet the specified requirements of the relevant sections of the Specifications.

Manhole steps shall be of malleable iron conforming to B.S.S.1247.

A 4-inch diameter HDPE vent pipe shall be installed on manholes at an average spacing of 300 meters. The vent pipe shall extend 3 to 4 meters above ground level and shall be provided with proper anchoring support, protective cap at the top and sealed connection at the base.

5.2.3 CONSTRUCTION REQUIREMENTS

- (i) Manholes shall be constructed with brick masonry of specified wall thickness laid in specified cement sand mortar, built on concrete base and top slab.
- (ii) A 22" manhole cover with frame, Ductile Iron Heavy Duty cover with frame, designed and fabricated for 10 ton per wheel load.
- (iii) The outside of the walls of manhole shall be plastered with specified cement sand mortar, painted with two coats of bitumen.
- (iv) At the bottom of manholes for sewers, a proper channel as per plans, shall be constructed in the whole length of the manhole along with centre line of the sewers, to lead the sewage from one sewer to the other.
- (v) Galvanized iron steps shall be installed inside the manhole, during the construction of the manhole walls.
- (vi) Cutting holes into the wall for the steps or for installing the pipes after construction will not be permitted.
- (vii) Top rung shall be 26" below the manhole cover and the lowest not more than 12" above the benching (floor).
- (viii) Catch pits shall be covered with cast iron grating as shown in the plans. Catch pits shall be connected with the nearby drainage channel through a reinforced cement concrete pipe as per details provided.

5.2.4 INTERNAL AND EXTERNAL PAINTING OF RCC

5.2.4.1 SURFACE PREPARATION:

- Concrete is cured for 28 days or so
- Moisture content below 5% prior to coating application
- Concrete is free from curing compounds, laitance and effervescence
- Surface is prepared by sweep blasting preferably or grinding to create roughness
- Any cracks, voids, blow holes must be repaired after sealer coat with epoxy filler.

Sound – Concrete that has unsound areas (voids, hollow spots, and friable surface) may have to be removed, replaced or repaired with materials that are compatible with the selected coating system.

Dry – It is important to address dryness because most coatings require a dry surface for proper adhesion.

5.2.4.2 Abrasive blast cleaning:

Dry abrasive blast cleaning to SSPC-SP 13/NACE No. 6. All prepared surfaces should then have all “blow holes” and other surface defects filled with suitable filler that is compatible with the primer and finish coat system to ensure that the coating can be applied over a smooth and regular substrate.

5.2.4.3 PAINT SPECIFICATIONS:

A) Internal Painting for RCC Manhole

The Paint system should qualify resistance of toxic gases in sewage and should have durability of more than 20 years as a complete painting system. For the purpose of guidelines, required Dry Film Thickness (DFT) values are given below. Manufacturers may suggest different DFT as a whole painting system if test reports are sufficiently submitted for approvals and meet above basic minimum requirements. Such test reports / certificates should be authenticated by a third-party independent lab. Manufacturers should present evidence whether the product is resistant to subjected chemical of exposure.

Paint System	NDFT (μm)
Primer Coat*: 2-Component, high solids polyamine cured phenolic/novolac epoxy coating (more than 63% volume solids), It is a specially designed tank lining with excellent chemical resistance. It should provide resistance against subjected chemicals it's being exposed to.	150-160
Final Coat*: Should be compatible with primer coat and 2-Component, high solids polyamine cured phenolic/novolac epoxy coating (more than 63% volume solids), It is a specially designed tank lining with excellent chemical resistance. It should provide resistance against subjected chemicals it's being exposed to.	150-160
Nominal dry film thickness NDFT	300-320 μm

Please note products are recommended on the assumption of exposure to hydrogen sulfide gas, Phenyl Methane, sodium bicarbonate solution. Exact values of gases exposure to be shared before a final recommendation

5.2.5 MEASUREMENT

Measurement shall be made for the different items of manholes in the BOQ constructed at site as per plans and specifications laid down in this Section and to the approval of the Engineer.

5.3 WATER RETAINING STRUCTURES

5.3.1 SCOPE OF WORK

The Work covered under this subsection of Specifications consists of furnishing all

labor, tools, scaffolding, hoisting equipment, appliances and materials of every kind and character; and in performing all operations in connection with procurement, transportation and delivery, supply and installation of special provisions for water retaining structures to ensure water tightness in all possible respects in strict accordance with requirements of Drawings and Bill of Quantities as specified herein, and to the entire satisfaction of the Engineer and subject to the terms and conditions of the Contract.

5.3.2 GENERAL

Special consideration shall be given to the control of cracking and the provision of dense impervious concrete.

Special considerations shall be given to the design of the concrete mix and to the supervision of the placing and compacting in order to provide a dense impermeable concrete. The mix shall be of the stiffest consistency having workability which will ensure that it can be satisfactorily placed in the formwork and compacted without risk of segregation, honey combing, sweating or bleeding. Special care shall be given to the method and order of placing the concrete and to the construction of joints in order to achieve full continuity and complete water tightness.

The Contractor shall maintain an accurate record of ambient temperature at site.

Ambient temperatures shall be measured using mercury thermometers or other thermometers acceptable to the Engineer.

Throughout the concrete work, the Contractor shall employ full time on the works suitable number of qualified and experienced Engineers whose sole duties shall be as follows;

- Design of concrete mixes
- Control of quality of concrete
- Supervision of mixing, transporting, placing, compacting, finishing, curing and protecting concrete including thermal control of concrete pours
- Supervision of sampling and testing
- Preparation and submission of test certificates and reports
- Compilation and keeping of record
- Such other duties as the Engineer may direct

5.3.3 CEMENT CONTENT

The minimum cement content for all water retaining structures shall be 24pcf and the maximum cement content of 31 pcf. The maximum water-cement ratio shall not exceed 0.40.

5.3.4 ADMIXTURES

Suitable admixtures from approved manufacturer may be used in concrete mixes with the prior approval of the Engineer. The amount of admixtures added to each batch of concrete requires careful control and shall be added in the doses as recommended by the manufacturers and approved by the Engineer. The cost of the admixtures shall be deemed to be included in the unit rates.

For use of an admixture, the information required by the Engineer shall be submitted to him for each admixture for his approval.

Calcium chloride or admixtures containing chloride ions other than from impurities in admixture ingredients shall not be used.

5.3.5 JUNCTION OF FLOOR AND WALL

Where the walls are designed to be monolithic with the bottom slab and beam system, a continuous up stand section of the wall shall be cast at the same time integrally with slab. A suitable arrangement of the reinforcement and formwork shall be made to facilitate this. The height of this up stand, which shall not be less than specified shall be sufficient to enable the next lift of formwork to fit tightly and avoid leakage of the cement paste from the newly deposited concrete. Such leakage, where it occurs is liable to cause porosity in the finished concrete and is not acceptable.

5.3.6 PIPES THROUGH WALLS AND FLOOR

When it is necessary for pipes to pass through a wall or bottom floor, it is preferable to cast the pipes into the panel when it is concerned. If this is not practicable, it will be necessary to box out. In either case, it is desirable that the position of the pipe shall not coincide with a joint. When an opening has been boxed out of the sides of the opening shall be treated as construction joint.

All piping and fittings shall be tested as a unit for leaks immediately prior to concreting. The testing pressure above atmospheric pressure shall be fifty (50) percent in excess of the pressure to which the piping and fittings may be subjected but the minimum testing pressure shall be not less than 1.0 N/mm² (150 psi) above atmospheric pressure. The pressure test shall be held for four hours with no drop in pressure except that which may be caused by air pressure.

No liquid, gas or vapor, except water not exceeding 32°C or 0.135 N/mm² pressure, is to be placed in the pipes until the concrete has thoroughly set.

The concrete cover of the pipes and fittings shall be not less than 1½ inch. The piping and fittings shall be assembled by welding, brazing, solder seating, or other equally satisfactory method. Screw connections shall be prohibited. The piping shall be so fabricated and installed that it will not require any cutting, bending, or displacement of the reinforcement from its proper locations.

Drain pipes and other piping designed for pressure of not more than 1 psi above atmospheric pressure need not be tested.

5.3.7 ARRANGEMENT OF REINFORCEMENT

Particular attention shall be given to the spacing of reinforcement at points so that access to the concrete surface can be provided to enable it to be prepared to receive the following batch of concrete.

The length of lap and anchorage provided shall be in accordance with the requirements of ACI 350(06).

5.3.8 FORMWORK

Ties used to secure and align the formwork shall not pass completely through any part of the water retaining structure unless effective precaution can be taken to ensure water tightness after their removal. The ends of any embedded ties shall have cover equal to that required for the reinforcement. The gap left from the end of the tie to the face of the concrete shall effectively be sealed. Any steel left in the structure shall be adequately protected against corrosion.

5.3.9 CONSTRUCTION

The degree of success in achieving a watertight structure depends on the quality of workmanship in making and placing concrete, good on site organization, proper ground water control, clean and dry excavation, careful storage of materials, close-fitting formwork, correctly fixed reinforcement and clean joints. It is essential that the concrete, when placed, is thoroughly compacted to form a dense uniform mass. The mix shall be of adequate workability and compaction by vibration. Immediately after the removal of formwork, the concrete surface shall be carefully inspected and any defects made good as soon as possible.

5.3.10 CURING

Even after minimum curing period specified in the clause pertaining to curing in the Specifications for Plain and Reinforced Concrete, it may be desirable to prevent drying of the concrete and to restrict the range of temperature changes which it is subjected to.

5.3.11 INSPECTION AND REPAIR

As soon as possible after completion of the water retaining structures, the structure shall be examined for defects which may lead to water penetration or leakage. All

openings exposed to the weather shall be covered and all water on the floors shall be removed and the surfaces allowed to dry before the inspection. Water retaining structures shall be tested in accordance with BS: 5337 or other approved standard. Defects that are revealed through which water may penetrate or leak shall be repaired by the Contractor to the entire satisfaction of the Engineer. Where internal repairs are to be made, the areas of weakness shall be isolated by suitable means and any cracks sealed by an approved process by a specialist contractor experienced in this type of work.

5.4 CONCRETE

5.4.1 DESCRIPTION

This work consists of furnishing placing, curing, finishing including transport of cement concrete made from approved type of cement, water, fine and coarse aggregates all in accordance with the requirements in these specifications and conforming to the lines, grades, and typical sections shown on the Drawings and to the approval of the Engineer.

5.4.1.1 CLASSES OF CONCRETE

The classes of concrete recognized in these specifications shall be designated: A, B, C, D1, D2, D3, Y and Lean Concrete. The class of concrete to be used shall be as called for on the drawings or as directed by the Engineer. The following requirements shall govern unless otherwise shown on the drawings.

Class A1 concrete shall be used for underground structure up to ground floor, for non-reinforced and reinforced concrete structures, except as noted below or directed by the Engineer. All structure above ground floor level shall be Class A2. Concrete placed for piles, raft foundation, slab, column & ret. wall etc shall be class A3 with a minimum cement content of 24 pound per cubic feet if specified in BOQ. Class B concrete shall be used only where specified. Class C concrete shall be used for cribbing, or as specified on the drawings or as otherwise directed by the Engineer. Class D1, D2 or D3 concrete shall be used for pre-stressed and post-tensioned elements, as indicated on drawings. Class Y concrete shall be used as filler in thin reinforced sections, or as otherwise directed by the Engineer. Lean Concrete shall be used in thin layers underneath footings and when called for on the drawings or directed by the Engineer. The concrete of the various classes shall satisfy the requirements shown in Table 1.

Table 1: Portland Cement Concrete Requirements

Class of Concrete	Min. Cement kg /Cubic meter	Max. Size of Coarse Aggregate (mm)	28 days Compressive Strength (Min Cylinder) (Psi.)	Consistency (Range in Slump) Vibrated (mm)	Maximum Permissible Water-Cement Ratio
A1	300	20	3000	20-75	0.58
A2	350	25	3500	100-150	0.
A3	400	38	4000	100-150	0.58
B	250	51	2400	25-75	0.65
C	275	38	3000	25-75	0.58

D1	450	25	5000	50-100	0.4
D2	500	25	6000	50-100	0.4
D3	550	25	7000	50-100	0.4
Y	400	13	3000	25-75	0.58
Lean Concrete	175	51	1400	-	-

5.4.1.2 TYPES OF CONCRETE WORKS

Under Ground Concrete: Concrete poured below Natural Surface Level with or without shuttering and shoring.

On Ground Concrete: Concrete poured by erecting formwork with necessary bracings on ground.

Elevated Concrete: Concrete poured by erecting props, bracing and towers to support the formwork at higher levels.

5.4.2 MATERIAL REQUIREMENTS

5.4.2.1 PORTLAND CEMENT

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in local storage by contractor for more than three (3) months after shipment from the factory may be retested before use and shall be rejected if it fails to meet any of the specification requirements.

Portland cement shall conform to the requirements of the Standard Specifications for Portland cement, (ASTM C-150). The type of the cement to be used, unless otherwise shown on the drawings, shall be type I.

Sampling of cement shall be in accordance with AASHTO T-127. Mill certificates shall accompany delivery of the material to the work.

Cement shall be delivered in sufficient quantities to ensure that there is no suspension of the work of concreting at any time. Different brand or different types of cement from the same mill, or the same brand or type from different mills shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer, after preparing new mix design.

5.4.2.2 FINE AGGREGATE

The fine aggregate shall consist of sand, stone screening or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable, uncoated grains free from injurious amount of dust, lumps, soft or flaky particles, shale alkali, organic matter, material reactive with alkalis in the cement loam or other deleterious substances, and shall not contain more than three (3) percent of material passing the No.200 sieve by washing nor more than one percent of clay lumps or one (1) percent of shale. The use of beach sand is prohibited without the written approval of the Engineer.

For exposed work, the fine aggregates shall be free from any substance that will discolor the concrete surface.

The fine aggregates shall be uniformly graded and when tested in accordance with AASHTO T-11 and T-27 shall meet the following grading requirements:

Table 1.3-2: Grading of Fine Aggregates

Sieve	Percentage Passing
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Designation	by Weight
3/8 inch	100
No 4	95 – 100
No 8	80 - 100
No 16	50 – 85
No 30	25 - 60
No 50	10 – 30
No 100	2 – 10
No 200	0 - 3

In case any fine aggregate fail under Fineness Modulus or Gradation, however, material passing No.4 sieve in combined aggregate, qualifies for these requirements, then the material can be accepted.

Fine aggregate shall be of such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO T-71, shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.3 to 3.1. Natural aggregates if required shall be thoroughly and uniformly washed before use. Sand equivalent (AASHTO T-176) shall be 75 min. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus of greater than 0.20 either way from the fineness modulus of mix design samples submitted by the Contractor may be rejected till new trial mixes are prepared and tested by the Contractor.

5.4.2.3 COARSE AGGREGATE

The coarse aggregate shall consist of crushed or broken stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable unquoted particles, free from injurious amount of soft, friable, these elongated or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of these Specifications.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 1.3-3 and when tested in accordance with AASHTO T-11 & T-27 shall meet the following grading requirements.

Table 1.3-3: Grading of Course Aggregates

Designated Sizes	Percentage by Weight Passing Laboratory Sieves Having Square Openings, in Inches							
	2 ½	2	1 ½	1	¾	½	3/8	No. 4
1/2 in to No. 4	-	-	-	-	100	90-100	40-70	0-15*
3/4 in to No. 4	-	-	-	100	90-100	-	20-55	0-10*
1 in to No. 4	-	-	100	95-100	-	25-60	-	0-10*
1-1/2 in to No. 4	-	100	95-100	-	35-70	-	10-30	0-5
2 in to No. 4	100	95-100	-	35-70	-	10-30	-	0-5
1-1/2 in to 3/4 in	-	100	90-100	20-55	0-15	-	0-5	-
2 in to 1in	100	90-100	35-70	0-15	-	0-5	-	-

Not more than five 5 percent shall pass No. 8 sieve.

Coarse aggregate shall contain no more than one (1) percent by weight of material passing the No. 200 sieve by washing and not more than five (5) percent of soft fragments.

It shall have an abrasion loss of not more than forty (40) percent at five hundred (500) revolutions, when tested in accordance with AASHTO T-96.

When tested in accordance with AASHTO T-104, for five cycles, the loss with the sodium sulfate soundness test shall be not more than 12 percent.

Natural aggregates shall be thoroughly washed before use.

5.4.2.4 COMBINED AGGREGATE

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

5.4.2.5 RUBBLE OR CYCLOPEAN CONCRETE

Rubble or cyclopean concrete shall consist of tough, sound, and durable rock. The stone shall be free from coatings, seams, or flaws of any character. In general, the percentage of wear shall not exceed fifty (50) when tested in accordance with the standard method of testing for Abrasion of Coarse Aggregate by the use of the "Los Angeles Machine", ASTM C-535.

5.4.2.6 STORAGE OF CEMENT AND AGGREGATES

All cement shall be stored, immediately upon arrival on the site of the work, in weather-proof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity of a sufficient quantity of cement for at least thirty (30) days use. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. However, if approved, sacked cement on small jobs may be stored in the open, upon a raised platform provided that ample waterproof covering is ensured. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use all cement shall be free flowing and free of lumps. Cement bags shall be weighed at random to check for variation.

Copies of cement records shall be furnished to the Engineer showing such detail as, the quantity used during the day run or at each part of the work. Cement held in storage for period of over sixty (60) days, or cement which, for any reason the Engineer may suspect of being damaged, shall be subject to a retest before being used in the work.

The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of the concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stockpiles to prevent the material at the edges of the piles from becoming intermixed.

If aggregates are stored on the ground the bottom layer of aggregate shall not be disturbed or used without re-cleaning and approved by the Engineer.

5.4.2.7 WATER

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall contain no more than one thousand (1,000) parts per million of chlorides nor more than one thousand three hundreds (1,300) parts per million of sulfates (SO₄). In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than twenty five (25) percent nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five

(5) percent when compared to the result obtained with distilled water.

In non-reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than two thousands (2,000) parts per million of chlorides nor more than one thousand five hundreds (1,500) parts per million of sulfates as SO₄.

In addition to the above requirements, water for curing concrete shall not contain any impurities in a sufficient amount to cause discoloration of the concrete or produce etching of the surface.

When required by the Engineer, the quality of the mixing water shall be determined by the Standard Method of test for Quality of Water to be used in concrete, AASHTO T-26.

5.4.2.8 ADMIXTURES

Admixtures shall only be allowed to be used with written permission from the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer, and shall conform to the requirements for each of agents specified by the manufacturer.

5.4.3 CONSTRUCTION REQUIREMENTS

The manufacturing, transport, handling and placing of concrete shall conform to the requirements given hereinafter.

Unless otherwise specified, ordinary Portland cement shall be used for all types of concrete. When sulphate resisting cement or other type of cement is required, it will be specified on the Drawings and/or in BOQ or ordered by the Engineer.

5.4.3.1 PROPORTIONING OF CONCRETE

All concrete shall be proportioned by weighing, except as specified herein. The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and consistency shall be approved by the Engineer. Such approval may be withdrawn at any time, and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various materials to be used in the batch size adopted. The required consistency shall also be shown. Such lists are subject to approval by the Engineer, and shall be posted at the mixer. The amount of water in the mix is the total amount of free water, including the free water held by the aggregates.

No concrete shall be placed in the works until the results of the twenty eight (28) days test indicate that the design proportions are satisfactory as per requirements under item 1.3.10 "Testing of Compressive Strength". Adjustment of the proportions shall be subject to the following provisions.

- a) Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportion originally approved, the Engineer shall make such changes as are necessary.
- b) Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes.

The contractor's attention is drawn to the time required to prepare and test trial batches and the contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress for the work is not delayed.

5.4.3.2 CONSISTENCY

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be determined to be as dry as it is practicable to satisfy the requirements for transportation and placing of the concrete as described hereinafter.

Consistency of concrete shall be determined as specified in AASHTO T-119. The consistency of concrete at the time of delivery shall be designated by the Engineer.

5.4.3.3 MIXING CONCRETE

- a) Mixing General: The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall be rejected.

Concrete shall be thoroughly mixed in a mixer of an approved size and type that will ensure a uniform distribution of their materials throughout the mass.

All concrete shall be mixed in mechanically operated mixers. Mixing plant and equipment for transporting and placing concrete should be arranged with an ample auxiliary installation to provide a minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete should be disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to construction joint.

Equipment having components made of aluminum or magnesium alloys, which would have contacted with plastic concrete, during mixing, transporting or pumping of Portland cement concrete, shall not be sued.

Concrete mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the quantity of water used.

Materials shall be measured by weighting, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall ensure accurate measurement of each ingredient.

The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one (1) percent of the desired value. Cement in standard packages (bags) approved by the Engineer need not be weighed. The water measuring device shall be accurate to plus or minus half percent $\pm 0.50\%$. All measuring devices be subject to the approval of the Engineer. Scales and measuring devices shall be tested/calibrated at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.

Weighing equipment shall be isolated so that vibration or movement of other operating equipment do not affect the accuracy of reading. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer more than one (1) percent for cement one and half (1-1/2) percent for any size of aggregate, or one (1) percent for the total aggregates in any batch.

Where volumetric measurements are authorized by the Engineer, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowances shall be made for variations in the moisture condition of the aggregates, including bulking effect in the fine aggregates. Boxes or similar containers of the exact volume required shall be filled and struck off. Measurement by wheel barrow values will not be permitted.

b) Mixing at Site: Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixer shall be restored or replaced when any part or sections is worn two and half (2.5) cms. or below than the original height of the manufacturer's design. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used.

When bulk cement is used and volume of the batch is one cubic meter or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall also be interlocked against opening when the amount of cement in the hopper is underweight by more than one (1) percent or overweight by more than three (3) percent of the amount specified.

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The temperature of mixed concrete immediately before placing shall be not more than thirty two (32) degree C. Aggregates and water shall be cooled as necessary to produce concrete within this temperature limit. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result in loss due to the effect of wind, or in accumulation of cement on surfaces of conveyors

or hoppers, or in other conditions, which reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than one and half (1-1/2) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed. In case of failure of the timing device, the contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not repaired within twenty four (24) hours, further use of the mixer will be prohibited until repairs are made.

The first batch of concrete material placed in the mixer shall contain cement, sand, and water in excess to the requirement of mix, to ensure that the drum does not extract mortar from the mix changing its design characteristics. When mixing is to stop for a period of one hour or more, the mixer shall be thoroughly cleaned.

c) Plant Mixing: At central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.

d) The Plasticizer: Accelerator or retarder or water reducing admixture, if required, shall be fed separately at the rate recommended by the manufacturer, or as established by laboratory trials.

e) Transit Mixing: Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. The truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in case the concrete batch is poured within twenty five (25) minutes of adding water.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer, and stamped in metal on the mixer. Truck mixing shall be continued for not less than fifty (50) revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than six (6) rpm, nor more than ten (10) rpm.

Mixing shall begin within thirty (30) minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above thirty two (32) degree C, this limit shall be reduced to fifteen (15) minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

f) Partial Mixing at the Central Plant: When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at the stationary plant mixer may be reduced to thirty (30) seconds and the mixing completed in a truck mixer/agitator. The mixing time in the truck mixer or agitator

equipped with adequate mixing blades shall be as specified for truck mixing.

g) Stiff Concrete Mix: For mixing concrete of zero slumps to be laid by pavers, gravity mixer shall not be used. Only force mixer of moving blades shall be allowed to ensure homogenous mix.

h) Hand Mixing: Hand mixing of materials shall not be allowed in any case.

5.4.3.4 HAULING AND DELIVERY OF MIXED CONCRETE

a) Hauling: Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer's rated capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

Bodies of non-agitating hauling equipment shall be so constructed that leakage of the concrete mix, or any part thereof, will not occur at any time, and they shall be self-cleaning during discharge.

For zero slump concrete to be laid by paver, concrete will be allowed to be hauled in open trucks. However concrete hauled in open-top vehicles shall be protected during hauling against rain, or exposure to the sun for more than twenty (20) minutes when the ambient temperature exceeds twenty five (25) degree C.

No additional water shall be incorporated into the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixer agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before two hundred fifty (250) revolutions of the drum or blades, whichever comes first, after the introduction of cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, a time less than one hour will be required except when retarder is used in which case it shall be one hour.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, the time between the introduction of cement to the aggregates and discharge shall not exceed forty five (45) minutes.

b) Delivery: The organization supplying concrete shall have sufficient plant capacity and transportation vehicles to ensure continuous delivery at the rate required. The rate of the delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed twenty (20) minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum re-handling and without damage to the structure of the concrete.

c) Re-tempering: The concrete shall be mixed only in such quantities as are required for immediate use and any concrete that has developed initial set shall not be used. Concrete that has partially hardened shall not be re-tempered or remixed.

5.4.3.5 HANDLING AND PLACING CONCRETE

a) General: In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork, and struts, stays and braces serving temporarily to hold the forms in correct

shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under Item 1.3.4 “Hauling and Delivery of Mixed Concrete”.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes, and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. In any case the Engineer will reject the use of equipment for concrete transportation that will allow segregation, loss of fines, or in any other way will have a deteriorating effect on the concrete quality.

Open troughs and chutes shall be of metal or metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run; water used for flushing shall be discharged clear off the structure.

When placing operations would involve dropping the concrete more than one and half (1-1/2) meters, it shall be conveyed through sheet metal or other approved pipes. As far as practicable, the pipe shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and no loading of any kind shall be placed on the ends of projecting reinforcement bars.

The concrete shall be placed as nearly as possible to its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

b) Pneumatic Placing: Pneumatic placing of concrete will be permitted only if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine.

At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

c) Pumping: The Placing of concrete by pumping will be permitted only if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is obtained. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

d) Placing Concrete under Water: Concrete shall not be placed under water except where inevitable in which case approval must be sought from the Engineer and the work carried out under his immediate supervision. In this case the method of placing shall be as hereinafter specified.

Concrete deposited under water shall be Class A concrete with a minimum cement content of three hundred fifty (350) Kg per cubic meter of concrete.

The slump of concrete shall be maintained between ten (10) and fifteen (15) cm. To prevent segregation, it shall be carefully placed in compact mass, in its final position,

by means of a tremie, a bottom-dump bucket, or other approved means, and it shall not be disturbed after being placed. Water must not be allowed to flow past the fresh concrete surface.

A tremie shall consist of a tube having a diameter of not less than 25 cm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping or other means, which will not injure the surface of the concrete.

e) Compaction: Concrete, during and immediately after placing shall be thoroughly compacted, except lean concrete under footings and concrete deposited under water. Concrete in walls, beams, columns, etc. shall be placed in horizontal layers not more than thirty (30) centimeters thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer, which has not taken an initial set.

The compaction shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given by the Engineer or is provided herein. Vibrators shall be of a type, design, and frequency approved by the Engineer. The intensity of vibration shall be such as visibly to affect a mass of concrete with a 3 cm slump over a radius of at least half a meter. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freshly placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall not be applied directly to the reinforcement or to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to transport concrete neither in the forms nor in troughs or chutes.

Vibration shall be supplemented by such external vibrator as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the normal vibrators.

5.4.3.6 CASTING SECTIONS AND CONSTRUCTION JOINTS

a) General: The concrete in each integral part of a structure shall be placed continuously, and the Contractor will not be allowed to commence work on any such part unless sufficiency inspected and approved material for the concrete is at hand, and manpower and equipment are sufficient to complete the part without interruption in the placing of the concrete.

Construction joints shall be allowed only where specified on the plans or otherwise approved. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. When shear keys or inclined reinforcement are not provided, the concrete shall be roughened as directed. Joints in the concrete due to discontinuity of work shall be avoided as far as possible. Such joints, when necessary, shall be constructed to meet the approval of the Engineer. When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its shape shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. Where a “feathered edge” might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset form work shall be used to produce an edge thickness of not less than 15 centimeters in the succeeding layer. Work shall not be discontinued within fifty (50) centimeters of the top of any face, unless provision has been made for a coping less than 50 centimeters thick, in which cases, if permitted by the Engineer, the construction joint may be made at the underside of coping.

Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddle in to the unset concrete. Care shall be exercised, during the cleaning of the reinforcing steel, not to injure or break the concrete steel bond near the surface of the concrete.

b) Girders, Slabs, and Columns: For simple, spans, concrete shall preferably be deposited by beginning at the centre of the span and working from the centre towards the ends. For continuous spans, where required by design considerations, the concrete placing sequence shall be shown on the plans or as directed by the Engineer.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 24 hours before the caps are placed.

When friction collars are used to support cap forms, the concrete of columns shall have been poured at least seven (7) days earlier.

c) Construction Joints: Construction joints shall be made only where shown on the Drawings or called for in the pouring schedule, unless otherwise approved by the Engineer. If not detailed on the Drawings, construction joints, also in cases of emergency shall be placed to meet the approval of the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete, which has hardened, the forms shall be re-tightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not level loose particles of aggregate or damage concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance. When directed by the Engineer the surface of the hardened concrete which will be in contact with new concrete shall be washed with water to ensure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and watered surfaces, including vertical and inclined surface, shall first be thoroughly

covered with a coating of mortar of the same proportion of sand and cement as the class of concrete used against which the new concrete shall be placed before the grout or mortar has attained its final set.

The placing of concrete shall be carried out contiguously from joint to joint. The face edges of all joints, which are exposed to view shall be carefully finished true to line and elevation.

d) Rubble or Cyclopean Concrete: Rubble or cyclopean concrete shall consist of Class B concrete containing large embedded stones. The stone for this class of work shall be placed carefully so as to avoid damages to the forms or to the partially set adjacent concrete. Stratified stone shall be placed upon its natural bed. Stone shall be washed and saturated with water before placing.

The total volume of the stone not be greater than one third of the total volume of the portion of the work in which it is placed. For walls of piers greater than sixty (60) cms in thickness, stone of such size that one man can handle it, shall be used. Each stone shall be surrounded by at least fifteen (15) cms of concrete and no stone shall be closer than thirty (30) cm to any top surface nor any closer than fifteen (15) cms to any coping. For walls or piers greater than one (1) meter in thickness, larger stone (50 kg or more) may be used. Each stone shall be surrounded by at least thirty (30) cms of concrete, and no stone shall be closer than sixty (60) cms to any top surface nor closer than twenty (20) cms to any coping.

i) Concrete Exposed to Alkali Soils or Alkali Water: Where concrete may be exposed to the action of alkaline water or soils, special care shall be taken to place it in accordance with specifications herein. Wherever possible, placing shall be continuous until completion of the section or until the concrete is at least fifty (50) cms, above ground or water level. Alkaline water or soils shall not be in contact with the concrete during placement and for a period of at least seventy two (72) hours thereafter.

ii) Protection of Concrete from Environment Conditions

1. General: Precautions shall be taken as needed to protect concrete from damage due to weather or other environmental conditions during placing and curing operations.
2. Any concrete placed during hot weather or during cold weather shall be at the Contractor's risk and any damaged concrete shall be removed and replaced at the Contractor's expense.
3. Rain Protection: Under conditions of rain, the placing of concrete shall not commence or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.
Work in Hot Weather: The temperature of concrete shall not exceed thirty two (32) degree C at the time of laying, unless the Contractor incorporates in the mix a plasticizer, of a make and in proportion which he has shown by laboratory tests and full scale trial to be satisfactory, to eliminate detrimental effects of high temperature without introducing any other detrimental effect on quality.

The following may be used to keep the temperature of concrete below the above limitations.

- a. Chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water shall be free from ice at the time of entry into the mixer.
- b. Cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled shall be uniform.
- c. Reclaiming of aggregate from stock piles by the tunnel method to avoid using the surface layer of the stock pile with shade and wind protection of conveyor elevating to batching plant.
- d. Night work provided that (a), (b) and (c) are proved inadequate or unsatisfactory in their results and providing also that the Engineer has no other reason for refusing

permission for night work.

The Engineer shall have power to order the suspension of concrete production in case of not taking precautionary measures by the contractor as mentioned above. Under no circumstance will the Contractor be entitled to receive any additional payment for complying with the requirements of this clause.

Work in Cold Weather: Except by written approval of the Engineer, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below five (5) degree C, nor resumed until an ascending air temperature in the shade and away from artificial heat reaches two (2) degree C. In such cases, the mixing water and/or aggregates shall be heated to not less than twenty one (21) degree C nor more than sixty six (66) degree C, prior to being placed in the mixer by an approved type of heating device so that the temperature of the concrete shall not be less than ten (10) degree C, nor more than twenty seven (27) degree C, at the time of placing. No materials containing frost shall be used. Cement or fine aggregates containing lumps or crusts of hardened materials shall not be used.

5.4.3.7 CONCRETE SURFACE FINISHING/RENDERING

General: Concrete surface finishing shall be classified as follows:

1. Ordinary surface form finish
2. Class 1 surface form finish

The ordinary surface form finish shall be the final finish applied to all surfaces after removal of forms, unless otherwise specified or called for on the drawings.

The Class 1 surface form finish shall be applied only where specified, or as required by the Engineer when the ordinary surface finish did not produce the required smooth, even surface of uniform texture and appearances.

Ordinary Surface Form Finish: Ordinary surface finish shall consist of filling holes or depressions in the surface of the concrete, repairing all rock pockets, removing stains and discoloration visible from travelled ways. Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to the Class 1 finish. On surfaces, which are to be buried underground or surface, which are enclosed, such as the cells of box girders; the removal of fins will not be required.

Except as provided herein, all form bolts and any metal placed for the convenience of the contractor shall be removed to a depth of at least two and half (2.5) cms below the surface of the concrete. All rock pockets and other unsound concrete shall be removed. The resulting holes or depression shall be cleaned and filled with mortar. Form bolts projecting into the cells of box girders need not be removed unless permanent access is provided into the cells, in which case such bolts shall be removed flush with the surface of the concrete. Mortar used to fill bolt holes shall consist of one part cement and two parts sand. Other depressions and pockets shall be filled with either packed mortar or air blown mortar as directed by the Engineer.

If rock pockets or holes in the opinion of the Engineer, are of such an extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

Class 1 Surface Form Finish: Class 1 surface finish shall consist of finishing the surfaces of the structure as necessary to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections. The degree of care in building forms and character of materials used in form work will be a contributing factor in the amount of additional finishing required to produce even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections, and the Engineer shall be the sole judge in this respect.

After completion of the ordinary surface finish, areas which do not exhibit the required

smooth, even surface of uniform texture and appearance shall be sanded with power sanders or other approved abrasive means until smooth, even surfaces of uniform texture and appearance are obtained. The use of power carborundum stones or disks will be required to remove bulges and other imperfections.

Class 1 surface finish shall not be applied until a uniform appearance can be obtained.

Class 1 surface finish may be required to be applied as the final finish for the following surfaces, unless otherwise directed by the Engineer.

5.4.3.8 CURING CONCRETE

- a. **General:** All newly placed concrete shall be cured in accordance with these specifications, unless otherwise directed by the Engineer.
- b. **Method of Curing:** The curing method shall be one or more of the following as described hereinafter.
 - Water Method
 - Curing compound method
 - Reinforced waterproof paper method if required by the Engineer.
 - Forms-in-Place Method
 - Steam method
 - Polyethylene Sheeting Method
- c. **Water Method:** The concrete shall be kept continuously wet by the application of water for a minimum period of seven (7) days after the concrete has been placed.

Cotton mats, burlaps, rugs, carpets, or earth or sand blankets, may be used as a curing medium to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. The moisture from the nozzle shall not be applied under pressure directly upon the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period the concrete surface shall be cleared of all curing mediums.

When concrete bridge decks and flat slabs are to be cured without the use of a moisture retaining medium, the entire surface of the bridge deck or slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than seven (7) days.
- d. **Curing Compound Method:** Surface exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer.

The membrane-forming compound used shall consist of a practically colourless liquid. The use of any membrane forming compound that will alter the natural colour of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay in the application of curing compound which

results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under “Water Method”, shall be started immediately and shall be continued until application of the compound which shall not be applied over any free standing water surface. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compounds shall not hard settle in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within one hundred twenty (120) days after the date of manufacture, the Engineer may require additional testing before use to determine compliance to requirements.

An anti-settling agent or combination of anti-settling agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located at the job site. On site, storage tanks shall have a permanent system designed to completely re-disperse any settled material without introducing air or any other foreign substance. Containers shall be well sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be of a character that will resist the solvent of the curing compound. Each container shall be labelled with the manufacture’s name, specification number, batch number, number of gallons, and date of manufacture, and shall have also warn that the curing compound shall be well stirred before use. When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required here for container labels.

Curing compound may be sampled by the Engineer at the source of supply and at the job site.

- e. **Reinforced Waterproof Paper Method:** The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the waterproof paper shall be placed. The paper shall remain in place for a period of not less than 72 hours.

Reinforced waterproof paper shall with ASTM C-171 specifications. It shall be composed of two sheets of Kraft paper cemented together with a bituminous adhesive and reinforced with fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface. All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.

The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within seventy two (72) hours after being placed. The broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of sheets, which have lost their waterproofing qualities or have been damaged to such an extent as to render them unfit for curing the concrete, shall not be used.

- f. **Forms-in-Place Method:** Formed surfaces of concrete may be cured by retaining the forms in place. The forms shall remain in place for a minimum

period of seven (7) days after the concrete has been placed, except that for members over five (5) cms. in least dimensions, the forms shall be in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

- g. **Steam Method:** After placing and vibration the concrete shall be allowed to attain its initial set before steam is applied. During the placing of concrete and application of steam, provision shall be made to prevent surface drying by means of a coating of approved material. The optimum curing temperature shall not exceed sixty five (65) degree C.
- h. **Polyethylene Sheeting Method:** The wet surface of fresh concrete shall be covered with white polyethylene sheeting as soon as possible without marring the surface and should cover all exposed surfaces of the concrete. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than thirty (30) cms. And the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer to provide an air-tight cover.
- i. **Curing Structure:** All newly placed concrete for cast-in-place structures, other than highway bridge decks, shall be cured by the water method, the forms in place method or as permitted herein, by the curing compound method, all in accordance with the requirements in Item 401.3.8 (b), "Methods of Curing". The curing compound method may be used on concrete surfaces which are to be buried underground and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform colour is not required and which will not be visible from any public travelled way.
The top surface of highway bridge decks shall be cured by both the curing compound method, and by the water method. The curing compound shall be applied progressively during the deck finishing operation immediately after finishing operations are completed on each individual portion of the deck. The water cure shall be applied not later than four (4) hours after completion of the deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure be applied not later than 8.00 a.m. the following morning.
When deemed necessary by the Engineer during periods of hot weather water shall be applied to concrete surfaces being cured by the curing compound method or by the forms in place method, until the Engineer determines that a cooling effect is no longer required.

5.4.3.9 TESTING OF AGGREGATES

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source or sources of aggregate and to obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to begin.

Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods:-

(i)	Sampling aggregates	T-2
(ii)	Sieve analysis	T-27
(iii)	Amount of material passing the No. 200 sieve.	T-11
(iv)	Organic impurities	T-21
(v)	Mortar Strength	T-71

(vi)	Sodium Sulphate soundness	T-104
(vii)	Friable particles	T-112
(viii)	Abrasion loss	T-96
(ix)	Specific Gravity	T-84
(x)	Absorption	T-85
(xi)	Production of Plastic Fines.	T-210
(xii)	Fineness Modulus	T-27
(xiii)	Sand Equivalent	T-17
(xiv)	Potential Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method).	ASTM C 586
(xv)	Potential Alkali Reactivity of Cement - Aggregate Combinations (Morta-Bar Method).	ASTM C 227
(xvi)	Potential Reactivity of Aggregates (Chemical Methods)	ASTM C 289

No aggregate for testing during the production of concrete shall be sampled at the discharge gates of the bins feeding the weight hopper. The Contractor, at his expense, shall provide safe and suitable facilities for obtaining the samples. No concreting work on the project will be permitted until the Engineer signifies in writing his approval, following the performance of the necessary tests, on all the materials involved in making concrete.

5.4.3.10 TESTING OF COMPRESSIVE STRENGTH

Concrete compressive strength requirements consist of a minimum strength at the age of twenty eight (28) days and the minimum strength which must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 7-1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with ASTM

A set of six (6) cylinders shall be taken from each fifty (50) cubic meters of each class of concrete or fraction thereof placed each day, three (3) of the six (6) cylinders to be tested after seven (7) days and three (3) after twenty eight (28) days.

The minimum average 28 days test result of all samples tested at any time shall be the specified twenty eight (28) days strength.

No individual samples tested after 28 days shall show a test result lower than eighty five (85) percent of the required twenty eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor at his expense provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with the specifications of AAHTO T – 24.

Test results of the cores shall meet the following requirement.

Average test result of the cores shall be not less than the minimum required twenty eight (28) days strength.

1. No individual core shall show strength less than Ninety five (95) percent of the required twenty eight (28) days strength.

2. Should the above test results fail to comply with the requirements, concrete of that particular pour shall be rejected and removed as directed by the Engineer. Furthermore; Contractor shall redesign the concrete mix for approval of the Engineer.
3. In case, seven (7) days strength shows less than seventy (70) percent of the twenty eight (28) days strength (in case of type-I cement), Engineer may stop further work on that particular portion of concrete, unless twenty eight (28) days strength gives satisfactory results.

5.4.3.11 Trial Batches for Mix Productions

The placing of concrete shall not begin until trial batches of the mix design to be used have been produced by the Contractor and tested and approved by the Engineer. The trial mix proportions shall be such that the average strength of five (5) consecutive test cylinders shall be 20% higher than the specified twenty eight (28) days strength and no individual test cylinder shall be below the specified strength.

When concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member, test cylinders will be cured under conditions similar to those at the casting site. The compressive strength of concrete determined for such purposes will be evaluated on the basis of individual tests.

5.4.4 SURROUND TO PIPES

The filling to the pipeline shall be carried out in accordance with Earthworks related Clause Concrete Bed and Surround

Where concrete protection to pipelines is to be provided the Engineer may direct that a blinding layer of concrete Class D be laid over the full width of the bottom of the trench so as to satisfy the following requirements:

Details of Concrete Blinding P i p e Nominal Bore (mm)

	600 and less	700 900	to	1000 to 2000
Min. thickness of blinding (mm)	75	75		75
Min. extent of blinding each side of pipe barrel (mm)	150	150		230
Min. clearance between blinding and pipe barrel (mm)	150	150		230
Min. clearance between blinding and underside of pipe socket (mm)	25	25		25

Any concrete blinding shall be allowed to set and be thoroughly washed down before pipe laying commences.

The length of pipelines laid in any one operation before concreting the pipeline shall be as directed by the Engineer so as to permit accurate laying of the pipeline and proper compaction of the fill.

Pipes up to and including 1200 mm nominal bore shall be firmly supported on pre-cast concrete blocks and separated from them by a 25 mm thick saturated softwood packing.

After the pipeline has been tested by the Contractor and approved by the Engineer the concrete shall be thoroughly washed down and concrete Class C shall be carefully placed and compacted thereon to avoid disturbing the pipes or joints until the appropriate profile for the type of protection required has been reached.

Concrete protection to the pipelines shall be either bed or surround of concrete Class C along such lengths as ordered by the Engineer in writing.

The concrete protection shall be placed to the full width of the trench and never less than 150 mm wider on each side than the barrel of the pipe. When support of excavation is provided building paper shall be placed against that support before concreting to facilitate withdrawal of the support.

In the case of spigot and socket pipes with flexible joints the concrete protection at each joint shall be interrupted in a vertical plane at the edge of the socket by a strip of fibreboard or other material approved by the Engineer and of the following thickness:

Pipe Nominal Bore (mm)	Fibreboard Thickness (mm)
300 and less	12
350 to 600	24
700 to 1200	36
1400 to 2000	48

Where two or more pipelines are laid in the same trench, the joints shall coincide at the points where the continuity of the concrete surround is broken at the joints in the pipeline with the longest pipes, and any intermediate joints in the other pipeline with shorter pipes shall be surrounded in concrete

5.4.5 MEASUREMENT AND PAYMENT

5.4.5.1 MEASUREMENT

The quantity of concrete to be paid for shall be the number of cubic feet of concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimension to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes and conduits, etc., in case where their cross-sectional areas exceed 77.5 square inches.

The measurement shall not include any concrete used in the construction of cofferdams or false work.

The volume involved in fillets, scorings, or chamfers, 1.5 square inches in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

Concrete for railings etc. is not to be measured under this item, but under separate items.

5.4.5.2 PAYMENT

The accepted quantity measured as provided above shall be paid for at the contract unit price respectively for the pay items listed below that as per shown in the Bill of Quantities which prices and payment shall be full compensation also for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the item except works that are paid for under other pay items.

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the contract price paid under various items of concrete work.

5.5 FORMWORK

5.5.1 DESCRIPTION

The work shall consist of providing, erecting and removing concrete forms of sufficient strength with all necessary bracings, fasteners, etc. and in conformity with the requirements hereinafter specified.

5.5.2 MATERIAL REQUIREMENTS

Forms shall be of wood, metal or other approved materials and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations.

5.5.3 CONSTRUCTION REQUIREMENTS

5.5.3.1 FORMWORK DESIGN AND DRAWINGS

The contractor shall prepare working drawings, backup calculations and material data for the formwork and shutters to be submitted to the Engineer for approval unless otherwise directed.

5.5.3.2 FORMWORK CONSTRUCTION

Concrete forms shall be constructed and maintained so as to prevent warping and the opening of joints due to the shrinkage of the lumber and shall be true to the dimensions, lines and grades of the structure and with the sufficient strength, rigidity, shape and surface smoothness as to leave the finished works true to the dimensions shown on drawings or required by the Engineer and with the surface finish as specified.

Forms for exposed surfaces shall preferably be lined with metal, plywood, or other approved material, or may with the Engineer's permission, be made of dressed lumber of uniform thickness. Forms shall be filled at all sharp corners (Minimum two (2) cms triangular, fillets) and shall be given a level or draft in the case of all projections, such as girders and copings, to ensure easy removal.,

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placements. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Metal ties or anchorage within the forms shall be so constructed as to permit their removal to a depth of at least five (5) cms from the face without injury to the concrete.

Fitting for metal ties shall be of such design that, upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in colour. Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorages for fastening forms or form supports to concrete will not be permitted.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms, which will later be removed, shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolour the concrete. All exposed surfaces of similar portions of a concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, colour and appearance.

Concrete shall not be deposited in the forms until all work in connection with constructing the forms has been completed, all materials required to be embedded in the concrete have been placed for the unit to be poured, and the Engineer has inspected and approved said forms and materials.

The rate of depositing concrete in forms shall be such as to prevent deflections of the forms or form panels in excess of the deflections permitted by these specifications. Maximum deflection allowed due to prop settlement is 5 mm and due to bending of shutters is 3 mm, when measured with 3 meter straight edge.

Forms for all concrete surfaces, which will not be completely enclosed or hidden below the permanent ground surface, shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be considered to be completely enclosed surfaces.

Formwork for concrete placed under water shall be watertight. When lumber is used, this shall be planed and tongued and grooved.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding either two (2) mm or 1/270 of the centre to centre distance between studs, joints, form stiffeners, form fasteners, or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications, satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

Forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods, which shall be determined, as herein specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged lumber must be resized before being fused. Forms that are unsatisfactory in any respect shall not be reused.

For narrow walls and columns, where the bottom of the form is inaccessible, the lower form boards shall be adjustable so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

5.5.3.3 REMOVAL OF FORM WORK

In the determination of the time for the removal of false work and forms, consideration shall be given to the location and character of the structure, the weather, and other conditions influencing the setting of the concrete, and the materials used in the mix.

If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the temperature is below five (5) degree C, for removal of forms and supports shall be used as a minimum subject to the approval of the Engineer. Removing false work.

- **Centering Under Beams 14 Days**
- **Floor Slabs 14 Days**
- **Vertical Wall Surfaces 24 Hours**
- **Columns 24 Hours**
- **Side of Beams 12 Hours**

Side forms for cast-in-place beams, girders, columns, or other members where the forms do not resist dead load, bending shall remain in place for at least forty (40) hours after placing concrete for the members. Side forms for precast members may be removed the next day after placing concrete therein.

If high early strength cement is used or by the use of additional cement, these periods may be reduced as directed.

When field operations are controlled by cylinder tests, the removal of forms, supports and housing, and the discontinuance of heating and curing (where applicable) may begin when the concrete is found to have the required compressive strength, provided in no case shall supports be removed in less than seven (7) days after placing the concrete.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In general, arch centering or false work shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centres, as may be necessary to avoid jamming of the expansion joints. Centres shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centres shall be approved by the Engineer.

5.5.3.4 MEASUREMENT AND PAYMENT

For all concrete structures, pre-stressed concrete structures, precast concrete elements or portions thereof, no separate measurement or payment shall be made for formwork supporting such structures. All formwork costs shall be considered as included in the contract prices paid (cost/CM or LM of structural members or lump-sum) for the various items of concreter work and no additional compensation will be allowed thereof.

5.6 STEEL REINFORCEMENT

5.6.1 DESCRIPTION

This work shall consist of furnishing, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with these specifications, and in conformity with the requirements shown on the Drawings or as directed by the Engineer.

5.6.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given. Test reports from approved sources shall be submitted to the Engineer for all steel reinforcement used. These reports shall show the results of chemical and physical tests made.

- 1) Deformed Billet-Steel Bars (Grades 40 and 60) for Concrete Reinforcement, AASHTO M-31 (ASTM A-615)
- 2) Deformed Steel Wire for Concrete Reinforcement, AASHTO M-225 (ASTM A-496)
- 3) Welded Steel Wire Fabric for Concrete Reinforcement, AASHTO M-55 (ASTM A-185)
- 4) Steel Bar Mats for Concrete Reinforcement, AASHTO M-54 (ASTM A-184)
- 5) Cold-Drawn Steel Wire for Concrete Reinforcement, AASHTO M-32 (ASTM A – 82)
- 6) Welded Deformed Steel Wire Fabric for Concrete Reinforcement, AASHTO M-221 (ASTM A-497)
- 7) Structural Shapes for Concrete Reinforcement, (ASTM A-36)
- 8)

5.6.3 CONSTRUCTION REQUIREMENTS

5.6.3.1 FABRICATION OF BENT BARS

a) **Order Lists:** Before materials are ordered all order lists and bending diagrams shall be furnished by the Contractor, for the approval of the Engineer. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expenses incident to the revisions of material furnished in accordance with such lists and diagrams to make it comply with the drawings shall be borne by the Contractor.

b) **Storing and Surface Condition of Reinforcement:** Steel reinforcement shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose seals, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Surface seams, surface irregularities, or mill scale will not be cause for rejection, provided the minimum dimensions, cross-section area, and tensile properties of a hand-wire brushed specimen meets the physical requirements for the size and grade of steel specified.

c) **Fabrication:** Bent bar reinforcement shall be cold bent to the shapes shown on the drawings or required by the Engineer. Bars shall be bent around a pin having the following diameters (D) in relation to the diameter of the bar (d):

Stirrups 7 column tie bars $D = 4 \times d$ other bars having

$d < 3.5 \text{ cm (1-3/8")}$ (No.11 bar) $D = 5 \times d$

$d > 3.5 \text{ cm (1-3/8")}$ $D = 10 \times d$

5.6.3.2 PLACING AND FASTENING

a) **Protection of Material:** Steel reinforcement shall be protected at all times from injury. When steel, placed in position as shown on the Drawings, has easily removable and detrimental rust, loose scale, or dust, it shall be cleaned by a satisfactory method, approved by the Engineer.

b) **Placing and Fastening:** Reinforcing steel shall be accurately placed in the position shown on the Drawings and firmly held during the depositing and finishing of the concrete. Cover, the distance between the external face of the bar and the case of the finished concrete, shall be as indicated on the Drawings. Reinforcing steel bars embedded in concrete shall not be bent after they are in place. Abrupt bends shall be avoided except where one steel bar is bent around the other. Stirrups and ties shall always pass around the outside of main bars and be securely attached thereto. All reinforcing steel shall be securely held at the proper distance from steel forms, which remain in place by means of galvanized steel bars or chairs placed on the form. All reinforcing steel, except as mentioned above, shall be securely held at the proper distance from the forms by means of templates, concrete blocks or galvanized steel chairs.

Any broken or damaged concrete spacer blocks shall be removed before concrete is placed. The use of pebbles, pieces of broken stone or brick, metal pipe or wooden blocks as spacers will not be permitted. Reinforcing steel when placed in the work shall be free from flake rust, dirt and foreign material and before any concrete is placed, any mortar which may be adhering to the reinforcing steel shall be removed. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcing steel and given permission to place the concrete. The Contractor shall allow the Engineer four hours' time after the reinforcement and forms are in place to conduct the inspection. Any bar of incorrect size, length or shape shall be removed and replaced with correct bars. Any bar located or spaced incorrectly shall be relocated or spaced correctly before permission is given to place concrete and such replacements and corrections shall be at the Contractor's expense. All concrete placed in violation of these provisions shall be rejected and removed.

c) **Splicing:** All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Splicing of bars, except where shown on the drawings, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible and with a minimum separation of not less than forty (40) times bar diameters. Not more than one third ($1/3$) of the bars may be spliced in the same cross-section, except where shown on the drawings.

Unless otherwise shown on the drawings, bars shall be lapped with a minimum overlap of forty (40) times the bar diameter. In lapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide a minimum clear distance of one bar diameter or one and one third ($1-1/3$) the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and one half ($1-1/2$) turns or by butt welding unless otherwise shown on the Drawing.

d) **Lapping of Bar Mat:** Sheet of mesh or bar-mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one mesh in width.

e) **Covering:** The minimum covering, measured from the surface of the concrete to the face of any reinforcement bar shall, unless otherwise shown on the Drawings or directed by the Engineer, be not less than 2 in. except as follows:

- Bottom of 1st floor slab 1 in.
- Bottom of stairs & landing 1 in

5.6.4 MEASUREMENT AND PAYMENT

5.6.4.1 MEASUREMENT

The quantity to be paid for shall be the calculated theoretical number of metric tons of reinforcement steel bars, mesh or mats as determined from the approved bar bending diagrams and incorporated in the concrete and accepted, except when reinforcement is paid for under other pay items.

The weight of plain or deformed bars or bar mat will be computed from the theoretical weight of plain round bars of the same nominal size.

Clips, ties separators, and other material used for positioning and fastening the reinforcement in place and structural steel shall not be included in the weight calculated for payment under this item. If bars are substituted upon the Contractor's request and as a result more steel used than specified, only the amount specified shall be measure for payment.

When laps are made for splices, other than those shown on the Drawings or required by the Engineer and for convenience of the Contractor, the extra steel not be measured nor paid for.

When continuous bars are shown on the Drawings, without the splices being shown the necessary steel in the splices will be paid for on the basis of the individual bars not shorter than (3.66) feet.

For bent bars, the length along centre-line of bar will be paid.

5.7 BRICK MASONRY

5.7.1 DESCRIPTION

This work shall consist of furnishing all materials, equipment and labour required for constructing brickwork as shown on the drawings and in accordance with these specifications.

5.7.2 MATERIAL REQUIREMENTS

5.7.2.1 PORTLAND CEMENT

Portland cement shall conform to the requirements set forth under item 1.3.2.1

5.7.2.2 SAND

Sand for mortar used in brickwork shall conform to the requirement for the fine aggregate specified in item 1.3.2.2 except that the grading shall be according to ASTM C144-99.

5.7.2.3 WATER

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities. No water shall be used without the approval in writing of the Engineer.

5.7.2.4 MORTAR

The mortar for all brickwork shall consist of one (1) part of Portland cement to four (4) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use.

5.7.2.5 BRICKS

The size of the bricks shall be standard size (9"x4-1/2"x3") 22.86 cm x 11.43 cm x 7.62 cm. They shall be well burnt without being vitrified. They shall be of uniform colour, regular in shape and size with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall not be less than (2000 psi).

5.7.3 CONSTRUCTION REQUIREMENTS**5.7.3.1 MIXING OF MORTAR**

Methods and equipment used for mixing mortar shall be such that each ingredient entering into the mortar shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use. All mortar not use within thirty (30) minutes after addition of the water to the mix shall be wasted. Re-tempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

5.7.3.2 BRICK LAYING

Brick work shall not be placed during heavy or prolonged rain to wash the mortar from the bricks. Mortar already spread, diluted by rain shall be removed and replaced before restoring the work.

All bricks to be used in brickwork with mortar joints shall be immersed in water from three

(3) to four (4) hours before use.

All bricks shall be skilfully laid with level courses, uniform joints, square corners, plumb verticals and true surface, except where otherwise shown on the Drawings.

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets can be obtained and shall be spaced not more than two (2) meters centre to centre.

All surfaces exposed to weather, shall be struck pointed to give a good workmanlike appearance and to seal the cavities in mortar joints.

5.7.3.3 CURING

All brickwork shall be cured for at least seven (7) days after laying. The curing method shall be to the satisfaction of the Engineer.

5.7.4 MEASUREMENT AND PAYMENT**5.7.4.1 MEASUREMENT**

Measurement of brickwork shall be made to the lines of the structures as shown on the Drawings or as modified by the Engineer for the appropriate items in which such brickwork is incorporated. The quantities to be measured shall be the number of cubic meters of brickwork laid and accepted.

5.7.4.2 PAYMENT

The quantities measured as provided above shall be paid for at the contract unit price listed below and shown in the Bill of Quantities, which prices and payment shall be full compensation for furnishing all materials, labour, equipment and incidentals for performing all the work involved under this item:

Description	Unit of Measurement
Brickwork	CFT

5.8 STEEL STRUCTURES

5.8.1 DESCRIPTION

5.8.1.1 GENERAL

This work shall consist of steel structures and the steel structure portions of composite structures, constructed in conformity with the lines, grades and dimensions shown on the drawings or as established by the Engineer.

The work will include all labour, materials and equipment required to furnish, fabricate, erect and paint structural metals called for in these Specifications or as shown on the plans. Structural metals will include rivet, welding, special and alloy steels, metallic electrodes, steel forging, and castings, and iron castings. This work will also include any incidental metal construction not otherwise provided for all in accordance with these specifications, drawings or as directed by the Engineer.

5.8.1.2 DRAWINGS

The Contractor shall submit to the Engineer working Drawings for steel structures for approval prior to use in construction. Such working Drawings shall be submitted sufficiently in advance of the start of the related work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than six (6) weeks.

The working Drawings shall show details of any permitted options proposed in the work, details for connections not dimensioned on the plans, the direction of rolling the plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations shall be submitted with the working drawings.

5.8.1.3 INSPECTION

Structural steel will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least ten (10) days' notice before commencing the fabrication of any structural steel.

The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports and a Certificate of Compliance for all structural steel to be used in the work other than steel, which is to be used under the provisions in Item 413.2.6 "Unidentified Stock Material". Certified mill test reports for steels with specific impact values shall include, in addition to other test results, the results of Charpy V-notch impact tests. When fine grain steel is specified, the test report shall include the grain size. Copies of mill orders shall be furnished at the time, orders are placed with the manufacturer. Certified mill test reports and Certificates of Compliance shall be furnished prior to start of fabrication of material covered by these reports. The Certificates of Compliance shall be signed by the manufacturer and shall certify to the Engineer the specifications to

which the material has been manufactured and tested, and that the material is in conformation with said specifications and test requirements.

Material to be used shall be made available to the Engineer so that the each piece can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where said material is stored or where work on said material is being performed.

5.8.1.4 SHIPPING, HANDLING AND STORING MATERIALS

Members weighing more than two and one half (2.5) metric tons shall have the weight marked thereon.

In handling and shipping of the steel work, every care shall be taken to avoid bending, scraping, or overstressing the pieces. All pieces bent or otherwise injured will be rejected.

The loading, transporting, and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above the ground upon platforms, skids, or other supports, and shall be kept free from dirt, grease and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

5.8.1.5 FALSE WORK

False work for the erection of structural steel shall conform to the provisions in Item 402, "False work and Centering for Bridges", except that dead loads shall consist of the weight of the structural steel and any other portions of the structures, which are supported by the false work.

False work and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within fifteen (15) cms, of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girders.

Loads imposed on existing, new or partially completed structures by the Contractor's construction methods and equipment shall not exceed the load carrying capacity of the structure.

5.8.1.6 CONTINUOUS MEMBERS

Unless otherwise noted on the plans, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may at his option erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this item.

If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be pre-assembled in a non-load condition in a horizontal or an upright positions.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with calculations in sufficient detail to substantiate that girder capacity and geometry will be correct.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall after erection, have a load carrying capacity at least equal to the designed structure shown on the plans. The Contractor may increase the cross sectional area or change the steel grades to provide the specified load carrying capacity subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be made for the convenience of the Contractor and no additional payment will be made therefore.

5.8.2 MATERIAL REQUIREMENTS

5.8.2.1 DESCRIPTION

The various materials shall conform to the specifications of ASTM as listed in the following tabulation with certain modifications and additions as specified.

Material	ASTM Designation
Structural Steel	A 36
High strength low alloy structural manganese vanadium steel	A 441
High strength low alloy columbium vanadium steel	A 572, Grade 50
High-yield strength, quenched and tempered alloy steel plate suitable for welding	A 514
High strength steel bolts, studs and threaded rods for general applications.....	A 449
High strength structural steel bolts, nut and washers	A 325
High strength low alloy structural steel.....	A 588
Bolts and nuts	A 307
Carbon steel for forging, pins and rollers ...	A 668, Class G
Alloy steel for forging	A 668, Class G
Pin nuts	A 36
Carbon steel castings	A 27, Grade 65-35
Gray iron castings	A 48, Class 30B
Malleable iron castings	A 47, Grade 32510
Carbon steel structural tubing	A 500, Grade B or A 501
Steel pile (Hydrostatic testing will not apply).....	A 53, Type E or S.
Grade B; A 106, Grade B; or A 139, Grade B	
Stud Connectors	A 108, Grades 1010
Through 1020 either semi – or fully skilled	

Structural steel designed on the plans as high strength low alloy structural steel shall conform to the following:

Thickness

Materials – ASTM Designation

0 to 2 cms

A 441; A 572, Grade 50; A 588

2 to 5 cms A 572; Grade 50; A 588

5 to 10 cms A 588

All structural steel conforming to ASTM Designations; A 36, A 441 and A 572 shall be other than rimmed or capped steel.

Coiled steel plate shall not be used for the fabrication of flanges, eye-bars and hanger plates nor for flanges and eye-bars.

All structural steel pre-cut prior to arrival at the fabrication site shall be cut so that the plate orientation complies with the requirements of item 413.3.3, "Orientation of Plates".

All structural steel plate used for the fabrication of tension flanges, eye-bars and hanger plates and for splice plates of tension flanges and eye-bars shall meet the longitudinal Charpy V- notch impact value requirements specified herein. Sampling procedures shall conform to the provisions in ASTM Designation; A 673. The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM Designations: A 36, A 441, a 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM Designation: A 514. Charpy V-notch impact values shall be determined in accordance with ASTM Designation: E 23.

Charpy V-notch (CVN) impact values shall conform to the following minimum values:
(Note: all metric values in this test are rounded to closest decimal).

Material	Impact Value Ft. Lbs. at Temp. (Kg-m at Temp.)
A 36.....	15 at 40 deg. F, (2.07 at 4.45 deg. C)
A 441	15 at 40 deg. F, (2.07 at 4.45 deg. C)
A 572*	15 at 40 deg. F, (2.07 at 4.45 deg. C)
A 588* 2" and under in thickness (50.8mm & under in thickness)	15 at 40 deg. F, (2.07 at 4.45 deg. C)
A 588* Over 2" to 4" in thickness (Over 50.8mm to 101.6 mm in thickness) ...	20 at 40 deg. F, (2.77 at 4.45 deg. C)
A 514 2-1/2 & under in thickness (63.5mm & under in thickness)	25 at 0 deg. F, (3.46 at - 17.8 deg. C)

A 514 Over 2.1/2" to 4" in thickness (Over 63.5mm to 101.6mm in thickness)	35 at 0 deg. F, (4.84 at -17.8 deg. C)
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* If the yield point of the material exceeds 65,000 psi (4569.5 kg/sq.cm), the temperature for the CVN impact value for acceptability shall be reduced to 15 deg. F, (-9.45 deg.C) for each increment of 10,000 psi (703 kg/sq.cm) above 65,000 psi (4569.5 Kg/Sq.cm).

Stud connector's shall be produced by cold heading cold rolling or cold machining. Finished stud connectors shall be of uniform quality and free of injurious laps, fins, seams, cracks, twists, bends or other defects. Studs shall not have cracks or bursts deeper than one half (1/2) the thickness from the periphery of the head to the shaft. Tensile strength of stud connectors shall be determined by test of bar stock after drawing or of full diameter finished studs at the option of the Contractor. Strength requirements shall conform to the following:

Tensile Strength	Elongation	Reduction of Area (Min.)
(Min.) 60,000 psi (4218 kg/sq.cm)	(Min. 20% in 2 inches (50.8 mm)	50%

Stud connectors shall be furnished with arc shields (ferrules) of heat resistant ceramic or other suitable material for welding.

5.8.2.2 STRUCTURAL STEEL

Unless otherwise specified or shown on the plans, all structural steel plates, shapes and bars shall conform to ASTM Designation: A 36.

At the option of the Contractor, girder flange plates shown on the plans may be increased in thickness, and may be increased in length provided that the change does not involve a decrease in detailed thickness of any portion of said plates. For continuous girders, increases in length of girder flange plates, which involve changes in locations of butt welds between different thicknesses of flange plates shall be approved in writing by the Engineer prior to fabrication.

When stud type shear connectors longer than twenty (20) cms. are to be used, they may consist of two (2) or more shorter studs of the type shown on the plans connected together with full penetration welds.

Rolled shapes may be substituted for the welded sections, and welded sections may be substituted for the rolled shapes shown on the plans, provided that the shapes and sections to be substituted comply with the following provisions:

- a. The depth, width and average thickness shall be at least equal to those for the shape or section shown on the plans.
- b. For welded sections, the flanges shall be welded to the web with continuous fillet welds on each side of the web. All welding shall conform to the provisions in item 413.2.7, "Welding".
- c. The strength classification of the material shall not be reduced.

5.8.2.3 CASTINGS

Steel, grey iron and malleable iron castings shall be provided with adequate continuous fillets cast in place in all re-entrant angles. The radius of curvature of the exposed surface of a fillet shall define the size of the fillet. The size of fillets shall not be less than one half (1/2) of the thickness of the thinnest adjoined member nor less than one and one quarter (1.25) cms.

The dimensions of the finished casting shall not be less than the specified. Castings shall not be more than seven and half (7.5) percent overweight. Large castings shall

be suspended and hammered over their entire area. No cracks, flaws or other defects shall appear after such hammering.

5.8.2.4 BEARING PADS

a) **Metal Bearing Devices:** Unless otherwise directed by the Engineer, the materials for metal bearing shall conform to the following requirements:
AASHTO M-107 for bronze bearings.

AASHTO M-108 for rolled copper alloy bearings. ASTM B-438 for sintered metal power bearings. AASHTO M 160 for galvanized steel bearings.

b) **Performed Fabric Pads:** The performed fabric pads shall be composed of multiple layers of two hundred and seventy (270) gms/SM (8-ounce) cotton duck impregnated and bound with high quality natural rubber, or of equivalent suitable materials compressed into resilient pads of uniform thickness. The number of ply shall be such as to produce the specified thickness, after compression and vulcanizing. The finished pads shall with stand compression loads perpendicular to the plane of the laminations of not less than seven hundred (700) kg/sq.cm without detrimental reduction in thickness or extrusion.

c) **Elastomeric Bearing Pads:** Elastomeric bearing pads shall conform to the requirements in Item 1.8.2.5, "Elastomeric Bearing Pads".

5.8.2.5 ASBESTOS SHEET PACKING (CONCRETE JOINTS)

Asbestos sheet packing shall be approximately fifteen (15) mm thick unless otherwise shown on the plans and shall be composed essentially of compressed white chrysotile asbestos fibres bound together with a synthetic rubber binder and fillers.

The deformation of the sheet packing under a load of three hundred and fifty (350) kg/sq.cm shall be not more than fifteen (15) percent. When tested between planed steel plates under a load of fifty five (55) kg/sq.cm the sheet packing shall show a static coefficient of friction less than 0.4 after 1.00-1.25 cm movements.

Where asbestos sheet packing is shown on the plans to be placed in joints in the concrete, the bottom layer of the packing shall be firmly attached to the concrete using water proof cement.

5.8.2.6 UNIDENTIFIED STOCK MATERIAL

Unidentified stock material, consisting of material which cannot be identified with certified mill test reports, may be used subject to the requirements in this item.

When unidentified stock material is proposed for use the Engineer may at his discretion, select random test specimens from each piece. The number of such test specimens shall be entirely at the discretion of the Engineer. Test specimens shall be cut and machined in accordance with ASTM requirements. Test specimens from unidentified stock material, including those required for retest, shall be furnished, machined and got tested by the Contractor from approved laboratory at his expense.

Fabrication shall not be commenced until the materials involved have been approved by the Engineer.

Not more than fourteen (14) metric tons of unidentified stock material may be used on one contract.

Unidentified stock material shall be segregated from all other materials to be used in the work.

5.8.2.7 WELDING

Welding material, welding, welder qualification, and inspection of welding shall conform to the requirements of the American Welding Society Structural Welding Code or other accepted codes as shown on the plans or as approved by the Engineer. Correction of weld faults shall be carried out in the presence of the Engineer.

5.8.2.8 GALVANIZING

When galvanizing is shown on the Drawings, such galvanizing of products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips three (3) mm thick or thicker, shall conform to the specifications of AASHTO M-111 (ASTM A-123), except that complete seal welding of tightly contacting surfaces of such products prior to galvanizing is required only where seal welding is shown on the plans. Except for pre-galvanized standard pipe, galvanizing of material 3 mm thick or thicker shall be performed after fabrication into the largest practical sections.

Galvanizing will not be required for stainless steel, mono metal and similar corrosion resistant parts.

All welded areas shall be thoroughly cleaned prior to galvanizing to remove all slag and other material that would interfere with the adherence of the zinc. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating.

Components of bolted assemblies shall be galvanized separately before assembly. Galvanizing of tapped holes will not be required. Galvanized surfaces, which are specified to be painted, shall not be chemically treated after galvanizing and prior to cleaning and painting.

5.8.2.9 CLEANING

All steel works shall blast cleaned after fabrication in accordance with the Drawings and to the satisfaction of the Engineer. Steel work which is to be in contact with concrete shall be after fabrication, wire brushed and cleaned to remove all loose rust, dirt and grease.

5.8.2.10 PAINTING

a) **Shop Coat (Prime Coat):** The shop or prime paint coat for metal structures including edges, nuts, bolts, etc. shall be a factory mixed red lead Ready-Mixed Paint, AASHTO M-72.

Red lead pigment in the dry form or as a paste in oil shall conform to ASTM D-83. The ninety seven (97) % grade shall be specified for dry pigment.

b) **First Field Coat (2nd Prime Coat):** The first field coat shall be a red lead paint as specified for the shop coat, tinted light brown as required with lamp black in an amount not to exceed 30 gms, per litre of linseed oil.

c) **Second Field Coat (Finished Coat):** The paint to be used for the second field coat shall be field mixed and conform, unless specified otherwise on the Drawings, to one of the following AASHTO Specification:

- | | |
|--|-----------------------|
| • Foliage Green Bridges Paint | M 67 |
| • Black Bridge Paint | M 68 |
| • Aluminium Paint (Paste-Mixing Vehicle) | M 69 White and Tinted |
| Ready – Mixed Paint | |
| • (Lead & Zinc Base) | M 70 |
| • Red Lead (Dry and Paste-in Oil), | M 71 |

- Red Lead Ready-mixed Paint
 - (Tinted with Lamp black as directed by the Engineer). M 72
- d) **Number of Coats and Colour:** Steel shall be painted with one shop or prime coat and with not less than two field coats. The colour shall be as specified or determined by the Engineer. Coats shall be different in colour to permit detection of incomplete application.
- e) **Weather Conditions:** Paint shall not be applied when the steel is damp, the air is misty, or when in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.
- f) **Application:** Painting shall be done in a neat manner and may be applied with hand brushes or by spraying (without the addition of a thinner). Aluminium paint shall preferably be applied by spraying. By either method the coating applied shall be smoothly and uniformly spread so that no excess paint will collect at any point.
- g) **Inaccessible Surfaces:** All surfaces which will be inaccessible after fabrication or erection, with the exception of contact surfaces shall prior to assembly received the full protective treatment specified for the component of the structure including and additional priming coat and finishing coats, which for accessible surfaces would be applied subsequent to erection.
- h) **Inspection of Cleaning and Painting:** The cleaning and painting of all structural steel parts shall be subject to detailed inspection and approval of the Engineer. Contractor shall be responsible for all defects or faults and the correction thereof at his own expense during fabrication, erection or subsequently discovered before or during the period maintenance.

5.8.3 CONSTRUCTION AND FABRICATION REQUIREMENTS

5.8.3.1 GENERAL

The Contractor shall submit as soon as possible to the Engineer for his prior approval, full details of their proposed fabrication and erection procedures together with details and calculations of any temporary works, which the Contractor proposes to install for the purposes of erection of the structural steel work. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

5.8.3.2 STRAIGHTENING MATERIAL

Rolled material before being laid out or worked shall be straight. Sub-assemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer. Details for methods proposed for straightening shall be submitted in writing to the Engineer prior to their use. After straightening, evidence of fracture or other damage will be cause for rejection of the material.

5.8.3.3 ORIENTATION OF PLATES

Steel plates for flanges, eye-bars, hangar plates, and splice plates for flanges and eye-bars shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile or compressive stress in the member.

5.8.3.4 CUTTING WITH TORCH

Torch cutting shall conform to the requirements for preparation of material to the American Welding Society's Structural Welding Code or equivalent.

5.8.3.5 FACING AND BEARING SURFACES

Surface of bearing and base plates and other metal bearing surfaces that are to come into contact with each other or with ground concrete surfaces or with asbestos sheet packing shall be flat to within three tenths (0.3)cm, and to within (1.6) mm tolerance overall. Surface of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric bearing pads or Portland cement mortar shall be flat to within three (3) mm tolerance in thirty (30) cm and to

within five (5) mm tolerance overall.

Steel slabs where not in contact with other metal bearing surface may be hot straightened in lieu of machining at the option of the Contractor, provided the above tolerances are met.

5.8.3.6 FITTING OF STIFFENERS

Girder stiffeners designated on the Drawings as bearing stiffeners shall be welded in accordance with details shown on the drawings. Where the end of a stiffener is shown on "Tight-fit" on the plans, the end of the plate shall be so fitted that it bears on the girder flange with at least point bearing. Local clearances between the end of the stiffener and the girder flange shall not exceed one and six tenths (1.6) mm. except where stiffener and the girder flange which are too great to be sealed by the paint film shall be caulked prior to painting.

5.8.3.7 BENT PLATES

Cold bent load carrying rolled steel plates shall conform to the following:

- a. They shall be so taken from the stock plates that the direction of bending will be at right angles to the direction of rolling.
- b. The radius of bend, measured from the concave face of the metal shall be as specified in the Manual of Steel Construction published by the AISC or equivalent.
- c. Before bending, the corners of the plate shall be rounded to a radius one and five tenths (1.5) mm throughout that portion of the plate at which the bending is to occur. If a shorter radius is essential, the plates shall be bent hot.

5.8.3.8 END CONNECTION ANGLES

Floor beams, stringers and girders having end connection angles shall be built to exact length back to tack of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detailed drawings.

5.8.3.9 FINISHED MEMBERS

Finished members shall be true to line and free from twists, bends and open joints.

5.8.3.10 SCREW THREADS

Screw threads shall make close fits in the nuts and shall be American Standard Form, except that for pin ends of diameters greater than 3.81 cm (1-1/2 inches) they shall be made with six (6) threads to 2.54 cms. (1 inch).

5.8.3.11 MATCH MARKING

Connecting parts pre-assembled for the purpose of setting up for welding or for drilling or reaming holes for field connections shall be match-marked and a diagram showing such marks shall be furnished to the Engineer.

5.8.3.12 FINISH

Portions of the work exposed to view shall be finished neatly. Shearing flame cutting and chipping shall be done carefully and accurately. All sharp corners and edges, and edges that are marred, cut or roughened in handling or erection shall be slightly rounded by grinding or other suitable means.

5.8.3.13 BOLTED CONNECTIONS

Bolted connections unless otherwise shown on the Drawings shall be made with high strength steel bolts conforming to ASTM Designation A- 325. All bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

Bolts may be tightened to the required tension by use of a calibrated manual torque wrench, the turn-of-nut method, or by tightening and using direct tension indicators. The torque value or the direct tension indicator gap needed to develop the bolt tension will be determined by the Engineer. Checking of bolts tension shall be done by the

Contractor in the presence of the Engineer and in such a manner that the Engineer can read the torque wrench gauge or direct tension indicator during checking.

Nuts shall be located, wherever practicable, on the side of the member, which will not be visible from the travelled way. Nuts or bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.

5.8.3.14 BOLT HOLES

Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed.

Attention is diverted to the provisions in Item 413.3.17, "Assembly", and details shown on the Drawings for connections where drilling or reaming is required after the joint is assembled.

The finished holes shall be cylindrical, perpendicular to the plane of the connection and shall not be more than one and half (1.5) mm larger than the nominal diameter of the bolt. Holes shall be clean cut, without torn or ragged edges. All burns, fins, sharp edges and hole irregularities which would prevent solid seating of the parts shall be removed.

All holes punched full size, sub-punched, or sub-drilled shall be located with sufficient accuracy so that after assembling (before any reaming is done) a cylindrical pin three (3.0) mm smaller in diameter than the nominal size of the punched, sub-punched, or sub-drilled hole may be passed through the hole without drifting in at least seventy five (75) percent of the holes for each connection. All holes shall pass a pin four and a half (4.5) mm smaller in diameter than the nominal size of the hole.

Mis-punched or mis-drilled holes shall not be corrected by welding unless approved by the Engineer.

Punching, drilling and reaming shall conform to the following:

a) **Punching:** Punching or sub-punching of structural steel conforming to ASTM Designation A-26 where the material is thicker than two and a quarter (2.25) cm, will not be permitted. Punching or sub punching of high-strength structural steel where the material is thicker than two (2.0) cm, will not be permitted.

Holes sub-punched for reaming shall be sub-punched decimal six five (0.65) cm less in diameter than that of the finished hole.

b) **Drilling:** Drilling full size shall be done with the parts assembled on to a steel template with hardened bushings or may be performed with gang drill equipment if approved by the Engineer. The Engineer may require a proof assembly to check the fit of major field connections.

Where bolt holes are sub-drilled for reaming, they shall be sub-drilled decimal six five (0.65) cm less in diameter than that of the finished hole.

Drilling through templates shall be performed only after the templates have been accurately placed and firmly clamped or bolted.

If members are drilled while assembled, the parts shall be held securely together while drilling is being done.

Stock drilling of plate parts with precision gang drills will be permitted if all parts are firmly clamped during drilling and if the drill bits remain perpendicular to the work during drilling operations.

c) **Reaming:** Reaming shall be done after the pieces forming a built-up member

are assembled and are firmly bolted together so that the surfaces are in close contact or after templates are securely located over the member. The pieces shall be taken apart before bolting, if necessary, and shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked in order that they may be reassembled in the same position. Reamed parts shall not be interchanged.

Reaming templates shall have hardened steel bushings and holes accurately dimensioned. Templates shall have reference lines, which will permit accurate location of the template on the member or members to be reamed. Templates used for reaming shall be properly located on the material and shall be firmly clamped or bolted in position. Templates used for the reaming of matching members, or the opposite faces of one member, shall be exact duplicates.

Holes through assembled materials that are to be reamed shall not consist of both sub-punched and sub-drilled holes and holes punched or drilled full size.

5.8.3.15 PIN CONNECTIONS

Pins shall be accurately turned to the dimensions shown on the plans and shall be straight, and free from flaws. The final surface shall be produced by a finished cut.

Pins and rollers shall be forged and heat treated in accordance with the designation shown on the plans.

If pins are larger than twenty three (23) cms., in diameter, a hole not less than four decimal seven five (4.75) cms. in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling and before being annealed.

Holes for pins shall be bored true to the specified diameter, smooth and straight, at right angles to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

Machined surfaces for pins and holes shall be coated with a rust inhibitor that can be easily removed.

The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that shown on the plans by more than decimal eight (0.8) mm.

The diameter of the holes for pins shall not exceed that of the pins by more than half (0.5) mm for pins thirteen (13) cm or less in diameter, or decimal eight (0.8) mm for larger pins.

Holes for pins in build-up members shall be bored after assembly of the member, or may be bored prior to assembly, provided procedures approved in advance by the Engineer are followed which result in such holes being positioned to the same degree of accuracy as would be obtained if the holes were bored after assembly.

Pin-connected hangar plates shall be bored in pairs or in stacks firmly bolted or clamped together so that each pair of hangar plates is matched. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin-nuts on pin connection shall be tightened and the threads burred at the face of the nuts with a pointed tool.

5.8.3.16 ANCHOR BOLTS

No anchor bolts shall be cast in the concrete.

Anchor bolts shall be set in round holes drilled or cast in the masonry. The size and length of bolts shall be as indicated on the plans.

Bolts shall be accurately positioned by means of templates set to correct location and alignment so as to ensure proper span lengths, and tops of bolts shall be carefully set to proper elevation. Unless otherwise noted, bolts shall be installed plumb or normal to the finished bearing surface of the masonry.

When anchor bolt holes are drilled, a template shall be used to locate the bolts accurately and permit reinforcing steel bars to be shifted clear of holes before pouring concrete to prevent cutting these bars during drilling. The drilling shall be done prior to the erection of structural steel.

Bolts set in holes drilled or cast in the masonry shall have the portion below the bridge seat swedged, and the drilled or cast holes shall have a diameter at least one 1 inch (25mm) in excess of the diameter of the bolt.

Anchor bolts for steel stringers for all bridges (weathering steel and / or painted steel) shall be A -36 galvanized steel and shall not be painted. The nuts and washers used on anchor bolts shall also be galvanized and shall not be painted.

Holes cast in the masonry for swedged bolts shall be formed with removable round sleeves sealed at their lower ends, and they shall be completely removed after the hole is cast. During cold weather, effective methods shall be used to prevent the freezing of water in anchor bolt holes.

After anchor bolts are finally and correctly positioned, the holes around them shall be completely filled. No grouting of anchor bolts will be permitted until all structural steel is set in its final position. After the masonry plates or shoes are set, the space between the bolts and the round holes through fixed plates or shoes shall also be filled with the same material. Slotted holes in expansion devices shall remain unfilled to allow free movement.

Mortar used for grouting anchor bolts shall be composed in accordance with one of the following:

- a. One part Portland cement and one part mortar sand by dry loose volume.
- b. Non shrink grout shall be used when specified. The grout shall have a minimum compressive strength of 350 kg/sq.cm (5000 psi) in seven days when tested in accordance with AASHTO T-106 except that the cube moulds shall remain intact with a top firmly attached throughout the curing period. The non-shrink grout shall have a minimum expansion of zero (0.0) percent after seven days when tested in accordance with AASHTO T-160.

When air temperature is below four (4) degree C, the Contractor shall provide adequate cold weather protection to maintain a minimum air temperature of four (4) degree C around surface of mortar for a period of three days.

If anchor bolts are mortared in place during cold weather, the bolts and surrounding masonry shall be kept at a minimum temperature of four (4) degree C for a period of three days.

When mortar filling is used for bolts inserted in holes drilled or cast in the masonry, the holes shall first be checked for depth by inserting and with drawing the bolts. They shall then be partially filled with mortar into which the bolts shall be forced by uniform pressure or light blows from a hammer (flogging and running will not be permitted) so

that excess mortar is pushed out at the top of the hole. The excess mortar shall be removed and finished off flush with the top surfaces of the masonry, masonry plate or shoe as the case may be.

Bolts shall be set to project approximately half (0.5) inch (13 mm) above the nut and shall be threaded to approximately half (0.5) inch (13 mm) below the nut in its final position.

Nuts shall be drawn up tight except over the slotted holes of expansion devices in which case they shall be positioned half (0.5) inch (13 mm) clear of the moveable parts. All anchor bolt threads shall be burred with a sharp pointed tool at the top of the nut. When nuts are set half (0.5) inch (13 mm) clear of moveable parts, the bolt thread shall also be buried immediately under the nut to prevent it becoming tight against the moveable parts.

Rockers or expansion plates with slotted holes shall be set with the proper tilt or offset as determined by the temperature prevailing at the time and so that they will be in their midway position at twenty (20) degree C or as indicated on the drawings.

5.8.3.17 ASSEMBLY AND ERECTION PROCEDURES

a) **General:** The Contractor shall submit as soon as possible to the Engineer for his prior approval full details of their proposed erection procedure together with details and calculations of any temporary works, which the Contractor proposes to install for the purposes of the erection of the structural steel work.

b) **Storage at Site and Handling:** The structural steel work after arrival on site shall be laid out in the area allocated by the Contractor. It shall be unloaded by crane or other appliance and carefully stacked on timbers and subsequently handled for erection in such a manner that no distortion or damage is done to the various members. No steel work shall be stored directly on the ground.

c) **Erection Generally:** The works on site shall comply with the requirements stated in these specifications and the Contractor shall be responsible for providing all materials, skilled and unskilled labour, plant, equipment, supervision and all other, things necessary for the erection of the steel work on the site as specified in the Contract Documents and shown on the drawings.

The Contractor shall ensure that suitable plant and equipment of adequate capacity is used on the Site.

d) **Supervision:** The erection of the steel work shall be under the direct charge of a competent Supervisor who has had sound experience in the erection of structural steel work and who shall work full time on the site from start to completion of the work.

e) **Security during Erection:** During erection the work shall be securely bolted or otherwise fastened and where necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions, including those due to the erection equipment and its operation.

Each part of the structure shall be aligned as soon as possible after it is erected. Members shall not be permanently connected until the structure has been sufficiently aligned, levelled, plumbed and temporarily connected to ensure that they will not be displaced during the erection or alignment of the remainder of the structure. All

temporary bracing shall be left in position until such time as erection is sufficiently far advanced for it to be no longer required.

f) **Temporary Connections:** Connections for temporary bracing and additional holes, members or cleats used to facilitate handling or erection shall be provided in a manner, which does not weaken the permanent structure or impair its serviceability.

g) **Erection Packs, etc.:** The Contractor shall provide and shall be deemed to have included in his rates and prices for providing a suitable range of steel erection packs, shims and wedges to be used as necessary to ensure the accurate adjustment of line and level of the steel work erected on site and for the temporary works referred to in the previous sub-item.

h) **Setting Out:** The Contractor shall be responsible for the final positioning, levelling, plumbing and alignment of all steel work and the accurate placing of every part of the steel work in accordance with the drawings and his own fabrication drawings.

No steel work shall be finally concreted until the positioning, levels, plumbing and alignment of the steel work (or part of the steel work if agreed by the Engineer) has been finally checked by the Contractor.

i) **Work on Site:** All work on site shall comply with the following:

The steel work after erection and fixing complete shall comply with the following maximum permissible dimensional tolerances:

- Departure from overall plan dimensions at any level... ten (10) mm.
- Departure from theoretical centres of adjacent beams or girders in any floor or roof ... five (5) mm.
- Departure from the true alignment of any plate girder relative to the associated setting out geometry shown on the drawing ... five (5) mm.
- Departure from the true vertical centre line or any girder throughout its length of height five (05) mm.
- Departure from the specified level of the top of any beam..... five (5) mm.

j) **Site Connections:** The Contractor shall make all site connections in accordance with the details shown on the Contractor's detailed fabrication drawings, which shall comply with the requirements of these Specifications.

Drifting shall not be used to correct a bad alignment.

Any additional holes required in the steel work (which must first be approved by the Engineer) shall be drilled on the site. Burning holes in the steel work will not be permitted.

k) **Contact Surfaces:** All steel to steel contact surfaces shall be thoroughly cleaned and painted with two coats of primer as described in clause No.413.2.10 in this specification. The surfaces shall be brought together while the second coating is still tacky.

l) **Site Welding:** Site welding will only be permitted where shown on the drawings and with prior consent of the Engineer.

m) **Inspection of Site Works:** All parts of the steel work will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for

inspection during the progress of the works.

The Contractor shall whenever possible, give the Engineer at least twenty four hours' notice of when materials or parts of the steel work will be ready for inspection.

Materials or workmanship or parts rejected shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the contract.

Inspection as aforesaid by the Engineer shall not absolve the Contractor from being responsible for any error or fault that may be discovered subsequently and for the final accuracy of the Works.

n) **Painting after Erection:**

- All paints shall be applied in accordance with the manufacturer's instructions and as specified under clause 413.2.10.
- Damaged areas of paint work shall be thoroughly scraped, wire brushed and cleaned to remove all rust, dirt, grease and loose primer, back to sound paint.
- All surfaces shall be thoroughly cleaned prior to further painting.
- Damaged areas shall then be treated as described in the cleaning and painting section.
- The second priming coat shall be allowed to dry for at least twenty-four hours before application of the finishing coat.

o) **Inspection:**

- The structural steel work shall be subject to inspection by the Engineer. That inspection will as far as possible be carried out at the Contractor's workshops, but the Engineer may at his discretion defer inspection of any parts of the structural steel work until after those parts have been delivered to the Site. The Contractor and his suppliers shall afford the requisite facilities at all reasonable times and at all places for inspection and testing to be carried out by the Engineer.
- All parts of the works done on the site will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for inspection as aforesaid during the progress of the site works and until the completion of the contract.
- Materials or workmanship or parts rejected on inspection as aforesaid shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the whole or any part of the works.

5.8.4 MEASUREMENT AND PAYMENT

5.8.4.1 MEASUREMENT

The quantity to be paid for shall be the calculated theoretical number of kilograms of different shapes of members.

5.8.4.2 PAYMENT

The pay item shall include fabrication, erection and protective coating (painting). The measurement shall be the total weight of the finished member comprising plates, rolled sections, shear connector, stiffeners, cleats, packs, splice plates and all incidentals, necessary to complete the item, without allowance for tolerance for rolling margin and other permissible deviations from standard weights, and excluding the weights of welds, fillets, bolts, nuts, washers and protective coatings. No deductions shall be made for notches, holes and the like each less than 0.01 square meter measured in area.

Fabrication shall include:

1. Preparation and supply of shop drawings.
2. Examining and checking steel plates for segregation, laminations, cracks and surface flaws and carrying out any remedial measures required by the Engineer in respect of such defects.
3. Cutting, marking off, bolting as the case maybe, assembling and pre-heating.
4. Welding, riveting, bolting as the case may be assembling and pre-heating.
 - a) Bolts, nuts and washers required to fabricate the steel work and to complete the erection and installation of steel work onsite, together with spares and service bolts, drifts, draw-up cleats and the like.
 - b) Welding shear connectors to steel members either at the place of fabrication or on site and preheating.
 - c) Approval testing of welders.
 - d) Production tests of welding during fabrication including non-destructive testing.
 - e) Marking members for identification and delivery in matching sequence.
 - f) Permanent erection shall include:
 - Temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments.
 - Approval testing of welders.
 - Permanent bolted and welded connections required on site including the provision of preheat and shelters for welding.
 - Production tests of site welding including non-destructive testing. Protective coating shall include:
 - a. Specimen panels of blast cleaning.
 - b. Paint samples and dispatching to testing Authority.
 - c. Paint application procedure trials.
 - d. Testing
 - e. Masking and other measures to protect adjacent untreated steel work.
 - f. Joint fillers and sealing of bolted joints.
 - g. Preparing materials for application.
 - h. Preparation of surfaces and painting of steelwork at the place of fabrication and on site.
 - i. Complying with any special requirements in respect of ambient conditions for the application of protective treatment and for intervals between successive operations and applications.
 - j. Strip coats.

Pay Item	Description	Unit of
No.		Measurement

1.15

Structural Steel work

Kg.

EQUIPMENT

6 EQUIPMENT**6.1 TRUCK MOUNTED JETTING UNIT, 4500 LITRES**

The jetting unit shall be designed to clean and clear sewerage lines by means of a powerful water jet. The system shall have jetting nozzle designed to move in sewerage pipes to clean it and clear any blockage. The unit shall consist of the following:

- a. A sub frame connected to the vehicle
- b. Specially designed water tanks of steel sheet having total capacity 4500 liters for sewer jetting unit
- c. Jetting pump directly coupled with engine through flexible coupling.

All the functions and the load distribution of the equipment shall be properly arranged to the technical specifications of the chassis on which it is mounted.

6.1.1 SUB FRAME

The sub frame in the form of U profiles shall be made using 6 mm thick steel and mounted to the chassis with mounting brackets.

6.1.2 JETTING TANK

Jetting tank of capacity minimum 4500 liters shall be made from steel Sheet of 5 mm thickness. The steel used shall be ASTM A 36, equivalent or better grade steel.

6.1.3 JETTING PUMP

Flow 150~200 Liter / minute

Max. Pressure 190~200 bars Working Pressure 150~170 bars Driven by 90~100 HP Diesel auxiliary engine

Jetting Unit Accessories

Suction Connection: Two (2) inlet connections of 50~70 mm diameter.

Inlet water supply hose about 70~80 mm diameter to ensure adequate water supply to pump. Discharge Connection: 2 x 1-1/4"

6.1.4 WATER FILTER

Filter to ensure complete removal of solid particles down to 300 microns and protect the wear parts in the High Pressure Pump.

Pressure Control & Regulator Valve

Two way design relief valve to prevent pump from over pressurization, regulate the operating pressure of the system and release excess water. The system shall be fitted with Safety Valves.

6.1.5 PRESSURE GAUGE

Rated to about 250 bar, Glycerin filled, fitted with Snubber, 1/2" NPT Connection.

6.1.6 HOSE REEL

Two hundred feet hydraulic powered hose-reel (Dia 3/4") with hose feed guide with followings accessories:

- 1 no. 200 ft long high pressure hose
- 2 nos. 1/2" standard drain jets

3 ½" drain jet extension

6.1.7 TRUCK CHASSIS

Type Right Hand Drive 4x2

GVW 8800 ~ 9000 kg on 6 tires

Engine Emission standards: Euro II (minimum)

Type: Diesel, 4 stroke, 4 cylinders inline, water cooled, direct injection, turbocharged with intercooler

Power: 120 ~ 140 PS Torque: 25 ~ 40 kgf-m Displacement: 3500~4500 cc Clutch Dry single plate diaphragm type, hydraulic control

Transmission min. 5 forward & 1 reverse

Axle Front: Reverse Elliot "I" section beam Rear: Full floating type

Brakes Service: Hydraulic with dual circuit Exhaust: Vacuum operated

Parking: Mechanical expanding type on shaft Wheel base: 3800 ~ 4000 mm

Width: 1900 ~ 2100 mm

Ground clearance: minimum 200 ~ 210 mm Electrical Batteries: 2 x 12 V, minimum 65 AH

Generator: 24 V Steering RHD

Suspension Semi-elliptic, laminated leaf springs,

Hydraulic double acting telescopic type shock absorbers on front and rear Wheels Tire size: 7.50-16 with 14 PR

No. of tires: 7 including one spare Fuel tank minimum 100 litres

6.1.8 SAFETY EQUIPMENT AND DRIVE

According to Pakistan Law on technical conditions of vehicles.

6.1.9 SUPPLEMENTS

First aid kit and safety equipment as required according to Pakistan legislation Tool set (jack and spanner for change of wheel)

Side and rear protection for truck.

A Spare wheel (mounted on suitable place on the truck chassis).

PUMPING MACHINERY

7 PUMPING MACHINERY

7.1 GENERAL

All pumping units shall be provided complete, as indicated on the Drawings and specified herein, including pumps, bases, motors, anchor bolts, controls, and necessary appurtenances.

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow required ranges. The pumps shall not overload the motors for any point on the pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To insure vibration-free operation, all rotative components of each pumping units shall be statically and dynamically balanced. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standard. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. All components of the pumping systems shall be provided by a single pump manufacturer such that pumps, drive motors, system controls and accessories shall be the unit responsibility of the pump manufacturer.

This specification covers several types of pumps which may be broadly classed as a centrifugal type. Each has constructional features in common. The general requirements shall apply to the applicable types unless otherwise described or modified by the individual pump specifications which are included later in this section.

7.2 MATERIALS

Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range. Service factors, where applicable shall be assumed to be 1.0.

- a) Bearings: Bearing shall be of the anti-friction type designed for 50,000 hour B-10 life per AFBMA test procedures.
- b) Cast Iron: All cast iron used in pump construction shall be close-grained, grey cast iron conforming to the requirements of ASTM Designation A48 and consist of at least 3 percent nickel/iron alloy.
- c) Fabrication: Fabrication shall conform to the requirements of ASTM Designation A36 for fabricated steel.
- d) Flanges: Pump suction and discharge nozzle shall be provided with DIN 2532, PN 16 flanges.
- e) Guards: Guards shall be provided at all exposed couplings, drives and shafts.
- f) Gauges: All pumps shall have discharge gauges of approved quality.

- g) **Nameplates:** Pumps shall have Type 316 stainless steel plates, permanently attached to the pump frame, onto which the following information shall be impressed, engraved or embossed: Manufacturer's name, pump size, serial number, impeller diameter, capacity, head rating and speed. Nameplates shall also include information unique to each item of equipment and device to identify its function as described herein. Function nameplates shall be approximately 25mm by 75mm if made separately. Letters of function titles shall not be smaller than 5mm high.
- h) **Motors:** Unless otherwise required in the individual pump specification, motors shall be of the constant speed, splash-proof type conforming with the specifications. Motors shall be sized to be capable of starting and running the pump throughout the operational range of the particular impeller which is selected.
- i) **Galvanizing:** Galvanizing shall conform to the applicable requirements of these Specifications.
- j) **Anchor Bolts:** All anchor bolts, nuts, and washers shall be type 316 stainless steel.

7.3 INSTALLATION AND START UP

The Contractor shall arrange to have the pump manufacturer or supplier of the equipment provided under this section, furnish the services of competent factory-trained personnel to supervise the installation and initial operation and this allowance should be included in the price of the equipment.

7.3.1 INSTRUCTION

After the equipment has been installed, tested, adjusted, and placed in satisfactory operating condition, the Contractor shall provide the services of a representative of the manufacturers to instruct the operating personnel in the use and maintenance of the equipment. At least one week prior to commencement of the erection period, the Contractor shall give the Engineer formal written notice of the proposed time of instruction. The Manufacturer shall provide a level of instruction which is adequate to train the Employer's personnel regarding use of the equipment. During this instruction period, which shall be for not less than 2 working weeks, it shall be the responsibility of the Manufacturer to answer any questions from the Employer's operating personnel.

7.3.2 SHOP TESTING

Each major component of the pumping equipment shall be subjected to a complete witnessed shop test as specified herein. Certified test reports, in triplicate, shall be submitted to the Engineer. No equipment shall be shipped until receipt of the Engineer's written approval. All costs for the shop tests shall be borne by the Contractor and shall be included in the Contract Rates.

Certified laboratory reports shall be submitted indicating the percentage of nickel iron in the wetted portions of the pump.

Each assembled pump and drive unit shall be shop tested to determine the following characteristics at both the maximum speed, and the design speed, if they are different, at which the pumps are to be operated.

- i. head-capacity curve
- ii. brake power curve
- iii. efficiency curve

- iv. balance
- v. vibration
- vi. bearing temperature
- vii. percent slip at motor full-load torque
- viii. Load test at 115 percent of motor full load torque and minimum load speed of 96 percent of motor speed with normal field excitation and determination of the motor current; output speed; and drive excitation.

All tests shall be performed in accordance with the latest Hydraulic Institute Standards.

If any pump does not meet the specified requirements, it shall be modified by the manufacturer to meet the requirements of the Specifications and shall be retested in accordance with the provision of the Specifications. All costs of retesting shall be borne by the Contractor.

Each motor shall be subjected to the manufacturer's recommended shop tests in accordance with the requirements of the applicable sections of IEEE, ANSI, and NEMA test Standards.

7.4 FIELD TESTING

Following completion of the installation and satisfactory start-up of the equipment, the Contractor shall provide the services of the pump manufacturer's representative to operate each pumping unit over the entire specified range. The operation, over the entire speed range, shall be free of cavitation or excessive vibration or noise.

Vibration shall be checked and recorded. The full speed vibration of all pumps shall be within acceptable limits as set out in the latest edition of the Hydraulic Institute Standard. Excessive vibration shall constitute sufficient cause for rejection of the equipment.

Each pump performance shall be documented by obtaining concurrent readings showing motor voltage and amperage, pump suction head and pump discharge head. Readings shall be documented for at least three pumping conditions to ascertain the actual pumping curve. One test shall be at shutoff head. Each power lead to the motor shall be checked for proper current balance.

Bearing temperatures shall be determined by a contact type thermometer. A running time of at least two hours shall be maintained at the maximum specified operating head.

In the event any of the pumping equipment fails to meet the above test requirements, it shall be modified and retested in accordance with the requirements of these Specifications.

7.5 SPARE PARTS AND LUBRICANTS

The Contractor shall provide spare parts and lubricants for all mechanical equipment provided under this project. The quantity of spare parts and lubricants shall be sufficient to cover all items necessary to perform all scheduled routine maintenance for a period of 2 years as recommended by the equipment manufacturer or specified in the operation and maintenance manuals. The spares shall be boxed or packaged for long term storage and shall be plainly marked for identification and reordering.

7.6 CENTRIFUGAL PUMPS**7.6.1 DESCRIPTION**

Provide all the horizontally mounted centrifugal pumping units complete, as indicated on the Drawings and specified herein including pumps, bases, motors, controls, anchor bolts, and necessary appurtenances. The pumps and motors shall be provided with lifting rings.

7.6.2 SUBMITTALS

Shop / Construction drawings showing fabrication, assembly, foundation, and installation drawings, together with detailed specifications and data covering performance and materials of construction, power drive assembly, parts, devices, and other accessories forming a part of the equipment furnished shall be submitted and the supplementary requirements specified herein. Data and specifications for the equipment shall include, but shall not be limited to the following:

7.6.3 PUMP DATA

Before preparation of Shop/ Construction drawings, the Contractor shall submit the following information for each pump.

- a) Pump curves indicating total dynamic head, flow rate, brake horsepower, shutoff head, net positive suction head, and efficiency.
- b) Motor data, including the manufacturer; the minimum guaranteed efficiency and power factor at full load, 3/4 load, and 1/2 load; locked rotor current in amps; full load current in amperes; the motor speed in RPM; and mounting details.

7.6.4 ASSEMBLY AND INSTALLATION DRAWINGS

After the above equipment submittals have been approved, complete fabrication, assembly, foundation, and installation drawings, together with detailed specifications and data covering materials of construction, weight of the pump, power drive assembly, parts, devices, wiring diagrams, and other accessories forming a part of the equipment furnished, shall be submitted for approval. Drawings, Specification, and other data required to be submitted hereunder shall include, but shall not be limited to, the following:

- a) Anchor bolt placement and anchor bolt details including projections from concrete.
- b) Materials of pump construction including shafts, bearings, impellers, castings, pump base, stuffing boxes, and shaft guards.
- c) Electric motor data including size, make, type, designation, and mounting details.

7.6.5 QUALITY

All pumping equipment furnished under this section shall be (1) of a design and manufacture that has been used in similar applications and (2) be demonstrated to the satisfaction of the Engineer that the quality is equal to equipment made by those manufacturers specifically named herein.

Pumps shall be the product of a single manufacturer and shall be of following specifications.

7.7 SUBMERSIBLE SUMP PUMPS

The Contractor shall furnish and install a sump pump system complete as indicated on the Drawings. The pump shall be submersible type with starter, control panel and instrumentation driven by an electric motor.

The pump delivery main shall be 100 mm nominal bore galvanized mild steel with 100mm nominal bore reflux and gate valve and shall be in convenient lengths connected with unions, one of which shall be just above the pump chamber floor level. The reflux valve shall be fitted in the delivery pipe immediately below the gate valve. Tees and crosses shall be used at each change of direction, the unused branches being plugged.

The pump shall operate automatically from float switches, with a provision for manual override by means of a hand-off automatic selector switch. The control system shall and operate with the following sequence:

- o start pump
- o high level alarm
- o stop pump (on pump down)

7.7.1 TILTING FLOAT LEVEL SWITCHES

Tilting float level switches shall use the tilting movement of a float, whose specific weight is less than that of the process liquid, to actuate switches as the level changes. The switch shall be integrally mounted in the float and connected to a control box by an appropriate, waterproof electric cable. A movable weight shall be mounted on the cable to allow adjustment of the set point. Sufficient cable length shall be provided to facilitate termination in a control or electrical room unless otherwise stated in the Particular Specification. The float shall be of polyethylene, stainless steel or other approved material.

The desired fail-safe switching action, level set points, cable length and optional features shall be as required for the application.

The switch shall be rated for 1A, 220 V AC, 50 Hz.

Cable for the float switch shall be secured by a stainless steel S16 or non-corrosive support at a distance no greater than one metre above the actuation point.

7.7.2 STARTERS

The motor starter shall be of Star/Delta type. It shall be accommodated in the switchboard panel. The starter of each motor shall be provided for manual and automatic starting according to the level of water in the wet well and rated for not less than 15 starts per hour against 100% full load torque. Each starter shall have "Hand-Off-Auto" switch.

7.8 PUMP MOTORS

7.8.1 GENERAL

The Contractor must ensure that the pump motors provided shall be of sufficient power, without overloading to drive the pumps when operating at the worst static head conditions and when operating against worst pressure conditions on site at an ambient temperature of 50°C, Motors shall be designed and applied in compliance with IEC Standards or equivalent for the specific duty imposed by the driven equipment. The

effect of the shaft between the pump and motor should be also considered.

The Tenderer shall in his offer give details of motor power requirements pump configuration and pump-motor assembly dimensions.

Where frequent starting occurs, motors shall be designed for frequent starting duty, equivalent to duty service required by the driven equipment.

The motor shall be TEFC IP 55, IEC 34-1 without affecting the efficiency. It shall provide low vibration level and reduction of the noise level without reducing the efficiency. The noise level at full load shall be less than 85 dB at 1 meter distance. The efficiency of the motor at full load or at partial load should not less than 97%. The frame and end shields shall be made of cast iron.

Screws, washers and all surfaces made of steel, aluminum alloy, or cast iron shall be treated with a method appropriate to each material, and give reliable anticorrosion protection under most severe environmental conditions.

The bearing shall be preferably of self lubricating type, but can also be connected to an oil circulating system, if required.

7.8.2 ACCESSORIES

The following accessories shall be included as standard:

- i) Temperature detectors embedded in the stator winding, two (1) per phase
- ii) A shock-pulse meter for checking the condition of bearings.
- iv) Jacking screws and lifting lugs.
- v) Rating plate.
- v) Earthing bolts in the terminal box and on the frame.
- vi) Insulated cable terminal.
- vii) Anti condensation heater.

7.8.3 INSULATION

Insulation shall be Class (F), the motor temperature rise shall be Class (B). It is preferable to use vacuum pressure impregnation (VPI).

7.8.4 ROTOR

The rotor cages shall be made of deep copper bars bonded into slots by heat resistant epoxy resin to avoid bar vibration in the slots and to eliminate rotor failure.

7.8.5 TERMINAL BOX

Boxes shall be made or fabricated steel welded constructions, equipped with pressure relief valve. All auxiliaries shall be wired to a separate connection box.

7.9 ELECTRIC ACTUATORS FOR VALVES

Electric actuators for valves shall be sized to guarantee closure at the maximum possible differential pressure across the gate. The safety margin of motor power available for unsealing the valve shall be at least 50% in excess of maximum closing torque at the nominal supply voltage. The operating speed shall be such as to give valve closing and opening speed at approximately 200-300 mm per minute unless otherwise specified.

Electric motors shall conform to the electric specification.

The trip shall be self- resetting and shall include a changeover volt- free contact for remote indication of motor tripped.

The actuator gearbox shall be of the totally enclosed oil bath lubricated type, suitable for operation at any angle, provided with the appropriate filling and drain plugs. Thrust bearings of the bail or roller type shall be provided in such a way that the gear case can be opened *for* inspection or disassembled without releasing the stem thrust or taking the valve out of service.

A Hand wheel shall be provided for emergency operation when the motor is detached by a lever or similar means. Drive will restored to power automatically by starting the motor. The handwheel drive shall be mechanical, independent of the motor drive and gearing shall be such as to permit emergency manual operation in a reasonable time.

The valve actuator shall be furnished with a drive bushing easily detachable for machining to suit the spindle or gearbox input shaft. The drive bushing shall preferably be positioned to enable standard length stems to be used.

Electric actuators shall be provided with open and close torque and position limit switches with changeover volt-free contacts at each end of travel for remote indication and interlocking. Means shall be provided to prevent the open torque switch tripping while the initial unseating hammer-blow effect is applied.

Provision shall be made in the design for two extra sets of limit switches to be available, if required.

A mechanical dial indicator shall be provided to indicate whether the door is fully open, fully closed or in an intermediate position.

Provision shall be made in the design for the addition of a sealed potentiometer for continuous remote position transmission where required by the specification. When so fitted, the mechanical dial indicator shall also show continuous valve movement.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating to the motor size, fed from a 110 volts control transformer. The common connection of the contactor coils at the transformer shall be earthed so that the contactors drop out in the event of leakage to earth. The primary winding shall be separated from the secondary by an earthed screen. Two primary fuses and one secondary fuse or an easily replaceable pattern shall be provided.

Internal wiring shall be of tropical grade PVC insulated stranded cable of 5 amps minimum rating for control circuits and of appropriate size for the motor three- phase power.

Each wire shall be clearly numbered and identified at each end... The terminals shall be of the stud type and the three-phase power terminals compartment shall be designed so that the integral controls are not adversely affected by heavy rainfall while the terminals cover is off for wiring on exposed job sites. Cable entries shall be suitable for PVCSW APVC cables. A separate terminal box shall be provided for the heater.

The starter housing shall be complete with an integral anti-condensation heater, for 110 or 240 AC operation.

The actuator shall be weather proof and watertight and NEMA6, (4 hours submergence under 3 m head) with sealing "O" rings. The terminal compartment shall be separately sealed from the rest of the enclosure so that wiring and integral controls are not

adversely affected by water, while the cover is removed for site cabling and maintenance.

SOLARIZATION COMPONENTS

8 SOLARIZATION COMPONENTS**8.1 SOLAR PANELS****8.1.1 GENERAL SPECIFICATION**

1. The PV module(s) shall contain mono crystalline silicon Grade-A Solar cells. (N- Type Mono PV Cell Modules and Bifacial Double Glass Modules due to its better performance will be given preference).
2. The PV module should Work well with high-voltage input Inverters/ charge controllers (1000 Vdc).
3. The PV Panel must have clear anodized aluminium frame with Anti-reflective, hydrophobic, low-iron Tempered cover glass.
4. The Solar Modules shall meet the following valid IEC Standards or latest:
 - a. IEC 61215-1, IEC 61215-1-1, IEC 61215-2 :2016 (Design Qualification)
 - b. IEC61730-1:2016 (Safety - Requirements for construction)
 - c. IEC61730-2:2016 (Safety - Requirements for testing)
 - d. IEC TS-62804-1. (i.e.: TUV PPP-58042 or Equivalent) Anti-PID Certification.
 - e. IEC 61701 Salt Mist Corrosion Resistance Test (Latest)
 - f. IEC 62716 Ammonia Corrosion Resistance Test (Latest)
 - g. IEC 60068-2-68 Sand and Dust Erosion Resistance Test.
5. 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.
6. A properly laminated sticker containing the following details should be available at the back side of the module.
 - a. Name of the manufacturer / distinctive logo.
 - b. Model Name and Type of Cell Technology.
 - c. Peak Watt Rating (Wp) and Power Tolerance Range
 - d. Voltage (Vmp) and Current (Imp) at STC
 - e. Open Circuit Voltage (Voc) and Short Circuit Current (Isc)
 - f. Maximum System Voltage (Vdc) (i.e.: This should not be less than 1000 Vdc)
 - g. Dimensions of PV Module
 - h. Test Standard(s) to which the module has been tested and certified.
7. Following essential technical parameters of solar panel / modules should be provided with each panel supplied as well as in the technical proposal.
 - a. I-V curve for the solar photovoltaic module/panel.

- b. Date and year of obtaining IEC PV module standardization qualification certificate.
 - c. Electrical Data (i.e.: P_{max} , V_{oc}/V_{mp} , I_{sc}/I_{mp} at nominal Cell Operating Temperature (NOCT).
 - d. PV Module efficiency at STC.
 - e. Working temperature range of PV Module.
8. Each panel should have factory equipped weatherproof terminal junction box having at least IP67 protection with provision of opening for replacement of DC cables, blocking diodes and easy debugging if necessary.
 9. 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.
 10. The PV Module should have at least 10-years warranty for any defects and efficiency as mentioned above. It should be provided On Stamp Paper Signed and Sealed by Contractor at the time of Handing / Taking Over.
 11. The PV Module should have at-least 17.50% Module efficiency with Positive Power Tolerance.
 12. The PV modules offered should not be more than 12 months old from the date of issue of work order.
 13. PV Module should have a Snow Load bearing of 5400 Pa and Wind Load Bearing of at least 2400 pa however if department deem appropriate may go for 3800 pa wind load depending upon their requirement.
 14. The Solar Module should be free from visual and cosmetics defects.
 15. The department/consultant on the expense of contractor/supplier shall verify Flash test reports with serial numbers from manufacturer for each panel (at the time of supply).
 16. All information regarding solar panel with above mentioned featured data should be accessible and verifiable online on the manufacturer website.
 17. IEC accredited lab test for solar panels is mandatory.
 18. EL (Electro-Luminous) test will be performed randomly for each individual project at the cost of contractor/supplier.

8.1.2 CABLE & WIRING

1. The AC / DC cables should be made of 99.9% copper strands and Flexible.
2. From PV Panel to Junction Box, XLPE or XLPO insulated & XLPE/PVC

Sheathed, UV stabilized single core, Double Insulated. Stranded /flexible cables (Conforming preferably to EN 50618 or IEC FDIS 62930) be used.

3. From JB to Inverter, the DC cable must have Single Core, double insulated and suitable for minimum 1000 VDC transmission.
4. From Inverter to batteries, the DC cable can be single insulated, Single Core and suitable for minimum 300 VDC transmission.
5. DC circuit breakers (not 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.
6. 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.
7. AC / DC breakers should be marked with the manufacturer model number, rated voltage, ampere rating and batch/serial number.
8. DC / AC breakers rating should be approved from Engineer In-charge before installation at site.
9. 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).
10. DC Breaker, AC Breaker & Change overs should be placed in an enclosure. All Enclosures / Junction boxes should be made from Hot Dipped Galvanized Sheets of minimum 16 SWG.
11. Cables shall be clearly labelled with essential electrical parameters including manufacturer name, Voltage Range, standards etc.
12. All DC Wiring shall be aesthetically neat and clean, over all wiring/connection losses shall not exceed 1% of the total rated output power.
13. All connections/ socket outlet among array, controller, inverters, batteries, and pumping set etc. must be made in junction boxes of adequate protection level.
14. All wires/cables should be in standard flexible UV-Resistant conduits / HDPE of PN12, SDR 13.6, PE 100 for outdoor installation & (2-3 feet deep) for underground wiring / Cabling and PVC ducts for indoor installation.
15. The DC Combiner Junction Box should be properly earthed including earthing of door as well.
16. The DC Combiner should contain proper bus bars of adequate size each for

Positive, Negative and Earthing.

17. The Inverter Junction Box should be properly earthed as well as per vetted design of the Engineer in charge.
18. All wiring should be in proper conduit of capping casing. Wire should not be hanging loose.
19. All wires should be terminated properly by using lugs / thimble connectors / sleeves.
20. Distribution board must be installed with proper screws.
21. Electrical Hazards Safety Labels should be pasted on DC Combiner NFD Enclosure/ Charge Controller /Battery Enclosures.
22. Following lab tests are mandatory: Conductor resistance test, Insulation resistance test, Pressure test, Spark test.
23. DC Cable from PV Module to Junction Box / Inverter for each string should be minimum size 6 mm².
24. DC Cable sizing (For Pumping Schemes) from Junction Box to Inverter as per details below:

Sr.	Nos of Strings	Cable Size (mm ²)	Remarks
1	1	6	If Cable length is >200 ft. (One Sided) than cable size should also be increased accordingly.
2	2	10	
3	3	16	
4	4-5	25	
5	6-8	35	

8.1.3 PANEL MOUNTING & STRUCTURE

1. The panel mounting and structure should be made of hot dipped (80 microns Average) galvanized steel of minimum thickness of 12 SWG / 2.64 mm Channel / Pipe or 8 SWG/ 4.06 mm Angle (Profile of channel and Sketch Attached for Reference).
2. 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.
3. PV to ground clearance must not be less than 1.5 feet. The height of the upper edge of the structure should not exceed 10 feet above the ground and 6 Feet for Roof Top Installations.
4. 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.

5. The pit size for concrete works should be minimum 1.5x1.5x2 feet for each individual leg or 1.5x2.5x2 for double leg and the concrete should be extended at least 1 foot above the ground. The concrete ratio should be 1:2:4.
6. The Surface azimuth angle of PV Module 180° and the Tilt angle (slope) of PV Module should be 33°.
7. The PV modules will be mounted on metallic structures of adequate strength and appropriate design, which can withstand load of modules and high wind velocities up to 150 km per hour.
8. Due to land Non-availability or any other problem, Structure design can be modified as per site requirement. Pole Mounted or manual Tracker Structure can be provided with the approval of Engineer In-charge.
9. Array fasteners (nut/bolts/washers) between PV Module and Structure shall be stainless steel. Washers should be installed on both sides of Module frame.
10. The minimum space between two PV Modules should be 2.54 cm (1 inch), to avoid air push over PV Modules.
11. Mechanism / arrangement for cleaning of PV Panels should be provided. i.e. Space and ladder between panels or at the back side of structure, so that the operator can safely climb and clean the panels.
12. All other array fasteners Structure shall be stainless steel or galvanized steel that provides the required mechanical strength.
13. 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.

8.1.4 EARTHING / GROUNDING

1. The PV Panel frame and structure should be connected by the shortest practical route to an adequate earth contact (of Less than 5 Ohms Resistance) as per requirement of equipment manufacturer and site earth conditions, using an uninterrupted conductor. Grounding can reduce the risks of damage from lightning-induced surges.
2. The Sizing of Earthing conductor will be done as per NEC Table 250.122
3. The grounding conductor should be 99% 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.
4. Motor, inverter, Battery / Battery Box (if required), Main Distribution Board

should be connected to an adequate earth contact / Grounding.

5. Ground enhancement material (GEM) shall be used below and above the Earthing plate for proper grounding. Gravel or coarse sand shall be pour along with soil in the pit.
6. Grounding / Earthing plate should be made of Copper plate of 4mm thickness & Size minimum 1.0 x 1.0 Ft.
7. Grounding / Earthing conductor should be connected to the plate / Rode / GI Pipe by proper connector of minimum depth of 6 feet.
8. Alternatively Earthing Rod of suitable size and length can be installed. (Instead of Plate). If given / mentioned in the BOQ/Design and Engineer In-Charge Approval.
9. All nut / bolt and Earthing clamp shall be stainless steel or galvanized steel.

8.1.5 BATTERIES

1. The battery should be Deep Cycle, GEL, OPzV/OPzS, Lithium LiFePO4, Lead Carbon Type or equivalent. (Note: Battery type shall be specified in the bidding documents.)
2. The battery must ensure safe and reliable operation in the whole range of ambient temperatures from -5°C to + 50°C.
3. The maximum permissible self-discharge rate should not be more than 5 percent of rated capacity per month at 25°C.
4. The battery shall have a certificate of compliances, issued by a recognized laboratory.
5. The Batteries should have three years Comprehensive replacement warranty.
6. 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 cycle life should be provided.
7. The Battery must support parallel connection to increase capacity in case of future expansion. Each Battery should have following minimum information printed on battery:
 1. Model Number, Serial Number and Type of battery.
 2. Rated Voltage and Capacity (AH) at discharge rate of 10 Hours.
 3. Origin of made.
 4. Manufacturer Name with distinct logo.
8. The following information must be provided in the data sheet while submitting

technical bid.

1. Certification/Test Standard(s) of the battery.
2. Information regarding cycles & self-discharge rate.
9. In case of rechargeable battery bank (having more than one battery), the interconnection shall be made using lead plated copper bus bars or properly insulated flexible copper conductors.
10. Battery disconnect switch / breaker of suitable size should be installed between batteries and inverter / charge controller.
11. The Battery must have Low self-discharge rate, No memory effect and No gassing.

8.1.6 GEL BATTERIES

- a) Cycle life of the GEL battery (12V) before 80% capacity of Initial capacity must be minimum 1000 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours
- b) Cycle life of the GEL battery (2V Cell) before 80% capacity of Initial capacity must be minimum 1300 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours

8.1.7 LEAD CARBON

- a) Cycle life of the Lead Carbon battery (12V) before 80% capacity of Initial capacity must be minimum 2000 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours.
- b) Cycle life of the Lead Carbon battery (2V) before 80% capacity of Initial Capacity must be minimum 2500 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours.

8.1.8 OPZV / OPZS BATTERIES

- a) Cycle life of the OPzV / OPzS battery (12V) before 80% capacity of Initial capacity must be minimum 2000 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours
- b) Cycle life of the OPzV / OPzS battery (2V Cell) before 80% capacity of Initial capacity must be minimum 2500 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours

8.1.9 LITHIUM BATTERIES (LIFEPO4)

1. Cycle life of the Lithium LiFePO₄ battery before 80% capacity of Initial capacity must be minimum 5750 cycles @ 50% depth of discharge (DOD) at discharge rate of 10 Hours.
2. The battery must have Integrated Battery Management System (BMS) to

ensure battery safety and reliability.

3. The BMS of the battery must have the following specifications:
 1. Temperature protection
 2. Over charge protection
 3. Low voltage disconnect
 4. High Voltage Disconnect
 5. Short circuit alarm function
 6. Self-balancing function
4. The LiFePO₄ Battery must have LED status and alarm indication.
5. The charge and discharge rate of the battery must be designed at 0.2C minimum but capable of handling 0.5C charge and discharge currents.

Note: Product brochure, catalogue and certificates must be attached with the Technical Bid.

8.1.10 BOX / STAND FOR BATTERIES, SHS-INVERTER & CHARGE CONTROLLER

1. 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.
2. A mechanism to prevent opening and entry of the battery should be provided.
3. This compartment should be manufactured of mild steel of at least 18 SWG.
4. The compartment should be powder coated paint.
5. 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. Battery Box /stand should be installed at a place in accordance with user's preference

8.1.11 PVC CHANNEL DUCTS & PIPES

1. A product of good quality standard material standardized by the provincial standardization committee with suitable size to be provided / used, as per direction/approval of Engineer In-charge.
2. Ducting must be done with proper steel nails and clips.
3. All ducting (wiring) must be align.

8.1.12 FLEXIBLE PVC PIPE

The flexible PVC pipe should be of good quality material standardized by the provincial standardization committee with suitable size to be provided / used, as per direction/approval of Engineer In-charge.

8.1.13 CIVIL WORK

1. The following Civil Works should be carried out for ground installation of SPV Modules/mounting structures.
2. Minor Cutting and clearing of trees/plantation to avoid shadows.
3. Civil work for earthing system as per the statutory requirements.

8.1.14 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, Resists surface fungal growth.

8.1.15 WARRANTY / AFTER SALE SERVICE

Three years Comprehensive Free Replacement, Repair and maintenance Warranty at site (Free of Cost) should be provided for all the components of Solar System. (if not mentioned separately otherwise).

8.2 SPECIFICATIONS FOR SOLAR PUMPING SYSTEMS

8.2.1 PUMP (SUBMERSIBLE)

Pump should be supplied having standard 150-9906 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 150-9906 standard. The pump should be suitable for installation and operation in tube wells/dug wells/open well 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 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

Sr.	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 / 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).
9	Pressure Gauge	As per British standard specifications (BSS), having PSI or Bar scale (4 Inch Size), Liquid Filled, minimum 350 PSI Range, Looped Siphon tube Pipe, Stainless Steel / polypropylene Casing.
10	Clamps	Steel - Pressed
11	Pump Efficiency	Minimum efficiency of the pump (For discharge of 3000 GPH and more) should be 70% ensured at duty point. (Duty Point of the Pump be preferably selected at the peak efficiency point or (Within $\pm 10\%$ of discharge) of Pump Peak efficiency Point)

8.2.2 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. 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 Volts at 50 Hz. The motor should be capable of operating with variable speed through V/F control. Winding of the motor shall of rewind able type with class - IC40 insulation and IP68 protection. The synchronous speed should be 2850-2950 RPM. Motor shall be capable of operating in well water with temperature normally start from 40°C. Motor should be designed for continuous operation. Motor must be filled with water without any 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 down load 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. Motor shall be capable of maximum of 20 starts in an hour. Motor efficiency of motors 7.5 HP and above should not be less than 75% at Full Load and Motor Rated Voltage.

Technical specification of rewind-able wet stators, three phase squirrel cage water filled submersible motor

Sr.	Components	Specifications
1	Winding	Made of pure electrolyte copper and the winding insulation should be suitable for > 1000 Volts and must full fill resistant tests range.
2	Stator	Energy efficient low-losses electrical magnetic sheet 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 fixed with high grade copper bars. M800 or M600 magnetic sheets are preferable to use.

4	Spline Shaft	AISI 420 stainless steel, flange dimension according to NEMA standard, over size design to ensure stiffness in severs condition.
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 20000N axial load
7	Mechanical Seal (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 (130°C) NEMA Insulation Class F (155°C) 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	20

Submersible Elate 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%. 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.

8.2.3 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" dial 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 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, PE 100, 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 BSEN 10255 & ASTM 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 straightening process to remove bendiness.

8.2.4 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)

For Cleaning of solar Panels, Plastic pressure pipe should be provided of suitable length to reach the furthest / last Solar Panel.

8.2.5 SOLAR PUMP INVERTER / CONTROLLER

1. 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 atleast equivalent.
2. The make and origin of the inverter/controller should be clearly mentioned in the catalogue and submitted in the technical proposal.

3. The inverter offered should comply to or Equivalent standards:
 - CE/RoHS
 - Low Voltage Directive 2014/35/EU
 - EMC Directive 2014/30/EU
 - IEC 62109-1 (Safety of Power Converters for use in PV Systems)
4. The complete datasheet showing all the electrical parameters like input & output voltage ranges should be provided in the technical bid.
5. All the electrical parameters like input & output voltage ranges, and efficiency should be provided at the time of pre-supply testing and inspection.
6. Efficiency of inverter should be 96% and above at Rated Capacity.
7. Efficiency of MPPT should be 98% and above.
8. 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.
9. Inverter / Controller having the capability to run both on AC and DC Power would be given preference.
10. Inverter should have at least three (3) years product and performance warranty.
11. The Pump Controller / Inverter should have an ON/OFF Switch/Button to Start and Stop the Pump.
12. Inverter should have active RS232/485 etc. communication port available, the Data available, through this port can be used for Remote Monitoring.
13. Inverter circuit must include protection against:
 - Over or Low voltages and currents beyond critical level of the inverters circuits.
 - Protection against accidental short circuits & reverse polarity connections.
 - Protection against lightning induced transients.
 - Over load protection.
 - Low RPM Protection (i.e.: Frequency < 30 Hz or as per pump characteristic curve) Motor Should Stop.
 - Dry run protection. (PF / Current Based).

8.2.6 PRESSURE PUMPS (UP TO 5.5 HP)

1. Submersible pump confirming to ISO-9906 Standard.
2. Pump + AC Motor (3-Phase-220V /380V) or DC Motor and Pump with Display Unit.

3. Solar pump inverter/controller should be MPPT based and Minimum Ingress Protection of IP65.
4. In case, where the column pipe diameter is less than or equal to 1.5-inch (For discharge equal or less than 6000 LPH and/or for Motor 4 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 mm^2) 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)
5. Top set shall comprise of Suitable Galvanized stand (Design should be verified from Engineer In-Charge before start of work)
6. For Pressure Pumps ≤ 5.5 HP schemes, Solar Module efficiency requirement is minimum 16%. (Only for Cut Cells PV Modules or Cell Size of 5 Inches PV Modules).
7. Connection to overhead water storage tank. Top bend, S.S Fasteners & Erection clamps.
8. Civil work to protect borehole i/e foundation.
9. The pump should operate safely with Sand particles up to $(50) \text{ gram/m}^3$.

8.2.7 SOLAR AUTO TRACKER

1. 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. Individual Auto-Tracker should be $\geq 4 \text{ kW}$ each and Tracking Accuracy should be within $\pm 5^\circ$.
2. The auto Tracker should also have manual control mode to adjust the tracking angle manually. Structure Material Should be Hot Dipped Galvanized Steel (Minimum 80 Microns).
3. All nuts, bolts, washers and other fasteners for mounting structure shall be made of minimum A2 grade stainless steel.
4. Foundation and other details will be separately provided.
5. Three years Comprehensive free Replacement, Repair and maintenance Warranty (Free of Cost) should be provided for all the components of auto Tracker (including Batteries).

8.2.8 PV MOUNTING FRAME WITH MANUAL TRAKERING

Suitable for 2.5 or 3.5 KW PV Panels easily movable in multi directions having flanges with bearing balls $\frac{1}{2}$ " and having angle adjustment. Base steel cage $\frac{3}{4}$ ", MS rod 3.5 feet length with nut-bolts system for strong anchoring. Pillar pipe 6 mm with 5.5" dia, base plate 15"x15"x $\frac{1}{2}$ " size with 04 numbers of supports. Support for PV, 5 mm thickness 4" dia pipe and 24"x12"x $\frac{1}{4}$ " side plates. MS Angle side bracing 2"x 2" x $\frac{1}{4}$ ". MS Angle frame 2"x 2" x $\frac{1}{4}$ " for panel mounting. Steel structures/frames shall be powder coated. Galvanized nuts, bolts and washers for tracker fitting. Steel frame shall be properly designed and shall withstand wind speed/load of at least 130 km/hr and tough weather condition.

8.2.9 PRE-SUPPLY TESTING & INSPECTION

The firm applying for the tender 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 test prior to supply and installation, In order to ensure the quality and standard of the equipment contractor may be asked to provide test result conducted by third party for re-verification.

8.2.10 OPERATION AND MAINTENANCE MANUAL

An Operation and Maintenance Manual, in English and Urdu language, should be prepared and provided by the contractor with the solar PV pumping system. The Manual should have information about solar energy, photovoltaic, modules, DC/AC motor pump set, tracking system (if any), mounting structures, electronics and switches. It should also have clear instructions about mounting of PV module, DO's and DONT's and on regular maintenance and Trouble Shooting of the pumping system. Name and address of the person or Centre to be contacted in case of failure or complaint should also be provided.