Project Implementation Unit (PIU)
Khyber Pakhtunkhwa Rural Investment and Institutional Support Project (KP-RIISP)
Public Health Engineering Department (PHED)
Government of Khyber Pakhtunkhwa (GOKP)

PROCUREMENT OF SMALL WORKS

REHABILITATION OF EXISTING DRINKING WATER SUPPLY SCHEME, TEHSIL NAWAGAI, DISTRICT BAJAUR (RFB No. BJ-CW-R-05)

TECHNICAL SPECIFICATIONS

MARCH 2026

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PART-A. GENERAL

1.1. THE PROJECT

Design Review and Construction Supervision for Water Supply, Sewerage, Drainage and Waste Water Treatment Project in Newly Merged Districts of Khyber Pakhtunkhwa under Khyber Pakhtunkhwa Rural Investment and Institutional Support Project

1.2. PURPOSE AND LOCATION OF THE WORKS

The purpose of the proposed project is to expand access to and coverage of citizen-centric public services, to invest in the provision of critical public services in priority sectors, with a focus on poor and vulnerable households. The targeted project area will cover eight (8) newly merged districts (NMD) and six (6) Tribal Sub-Divisions (TSDs).

1.3. DESCRIPTION OF THE WORKS

This project relates to (a) Design review and construction supervision of the drinking water supply schemes as per the mode of source and power i.e. Gravity, Solar and Electric based. (b) Design review and construction supervision of sanitation schemes including Urban and Rural areas having components of drainage, sewerage and wastewater treatment. (c) rehabilitation of existing schemes including its designing and subsequently its construction supervision.

1.4. STANDARD SPECIFICATIONS

Plant, materials and workmanship shall comply with the requirements of relevant National and International Standards and Codes of Practice current at the time of bid.

The Contractor shall supply two copies of each ASTM, AASHTO, ACI, BS, EN and BSCP and other approved national or international standards which refer the specifications and other standards which apply to materials which are being supplied and workmanship which is being executed on the Works. One copy shall be available to the Engineer and other copy shall be kept by the Contractor on the site.

All materials and workmanship not covered by a ASTM, AASHTO, BS or BSCP or other approved standards shall be used in first class work and suitable for the climate in the area where the works are to be executed, for which Engineer's decision is a binding.

1.5. DRAWINGS

Drawings which form part of the Contract are attached in Volume III.

1.6. RECORD DRAWINGS

Within twenty-eight days of the issue of Certificate of Completion, the CONTRACTOR shall provide 6 copies and one reproducible of all drawings amended to comply with the works as built. These drawings shall include:

- General arrangement drawing of the structures, pipelines and Permanent Works

- Longitudinal sections of water lines and chambers shall be as shown on the Issued Drawings or as agreed by the consultant.

1.7. MATERIALS AND SUPPLIERS OF MATERIALS

Before ordering materials of any description intended for the Permanent Works, the contractor shall submit for the approval of the consultant the names of the makers or suppliers proposed, a specification of the materials and details of their place of manufacture. The contractor may be required to supply to the consultant for his retention, a copy of each order placed.

1.8. PROGRAMME

Before commencing the Works the contractor shall submit to the consultant for his approval a programme showing the order in which he proposes to carry out the Works. The programme shall be in the form of a bar chart, or any other form as may be agreed by the consultant, and shall clearly indicate the following:

a. the sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity or percentage of work expected to be achieved on each activity by the end of each month;

b. the time allocated for work by others, including those of the client and by utility undertakings;

The programme shall also include details of the following:

a. A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the Works.

b. A list and type details of major Constructional Plan (including vehicles) which the contractor proposes to employ on the Works.

c. Details of the contractor's methods of working for all operations.

d. A statement giving the proposals for location or locations and sizes of base camps, accommodation, offices, workshops and stores.

e. Details of the programme for the Works from the date of receipt of the consultant order to commence the Works including a complete resources allocation showing the number of units and allotted times for each unit of Constructional Plan, materials and labour allocated to each part of the works.

1.9. NOTICE OF OPERATIONS

The contractor shall give full and complete written notice of all important operations to the consultant sufficiently in advance to enable the consultant to make such arrangements as he may consider necessary for inspection or for any other purpose. The contractor shall not commence any important operation without the written approval of the consultant.

The consultant's Site supervision staff shall be working 8 hours per day, Monday to Saturday. Expense incurred due to operations beyond above stated time frame which requires consultant's staff supervision, shall be borne by the contractor.

1.10. TEMPORARY WORKS

Not less than fourteen days before commencing any portion of the Works, the contractor shall, if ordered, submit to the consultant for his approval complete drawings and calculations for all Temporary Works the contractor may be proposing for the construction of that part of the Works.

Notwithstanding approval by the consultant of any design for the Temporary Works, the contractor shall be entirely responsible for their efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

1.11. WATER AND ELECTRICITY SUPPLY

The contractor shall at his own cost make arrangements for the supply of water and electricity for the purposes of the Works.

1.12. DISPOSAL OF WATER

Water and wastewater derived from the construction, testing and completion of the Works shall be disposed of clear of the Site to the satisfaction of the consultant so as to cause no damage or complaint.

1.13. CONTRACTOR'S FACILITIES

The contractor shall provide all site facilities including offices with telephone, workshops, stores, accommodation, washing, latrines etc. necessary for use by his own staff.

The contractor shall be responsible for making all arrangements for drainage from his site facilities and shall be responsible for payment of all charges in connection therewith. Arrangements for the supply of electricity, water and gas shall be the responsibility of the contractor.

Works Areas for the Contract in addition to those defined as Site of the Works shall be agreed with the consultant.

1.14. LATRINES

Throughout the period of construction of the Works the contractor shall provide, maintain and cleanse suitable and sufficient latrines for use by his employees; he shall ensure that his employees do not foul the Site but make proper use of the latrines. Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable the contractor shall provide an adequately sized septic tank and soak away.

1.15. MEETINGS AND REPORTS

Representatives of the contractor, approved by the consultant, shall attend monthly progress meetings on Site or at the offices of the Client/Consultant at any other place.

In addition, approved representatives of the contractor shall attend further meetings in cases of emergencies or for other reasons when called upon by the Client/Consultant.

The contractor shall submit to the consultant each month a report on his progress on the performance of the Contract. The report shall include a copy of the approved programme with the current progress for each activity shown. No separate payment shall be made for this item.

1.16. CONTRACT SIGNBOARD

The contractor shall supply and erect one or more contract signboards at locations agreed by the consultant. The signboards shall be of substantial construction to the approval of the consultant and the lettering, in both English and Urdu shall be black on a yellow fluorescent background.

The layout and dimensions of the signboard shall be with the approval of the consultant's Representative.

1.17. LEVEL DATUM

All levels stated shall be related to bench-marks locations with its elevation datum at mean sea level.

1.18. MAINTENANCE OF EXISTING ACCESS TRACK DURING THE WORKS

On commencement of the Contract, the contractor shall be solely responsible for the maintenance of the existing access roads within the Site. This responsibility shall continue until the contract completion date, or until such earlier date as the consultant may advise the contractor in writing. In preparing his rate for maintenance of these access roads, the contractor shall take into account that the access roads under his maintenance control will also be used by the CLIENT's and his staffs vehicles and also those of other contractor. Such maintenance work shall include general up keeping, and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc (whether caused by the contractor’s activities or not) to a standard no worse than the original condition. During the carrying out of such maintenance work, the contractor shall make arrangements to maintain through passage for the CLIENT's and his, staff’s vehicles and also those of other contractor over these access roads, which may comprise temporary diversions all to the approval and satisfaction of the consultant.

The contractor shall not run tracked or unsprung vehicles on surfaced roads without the express approval of the consultant who may require that planking or some other protective material be used to protect the road surface.

1.19. EXISTING INSTALLATIONS

The contractor shall execute the Works in such a manner as to avoid interruption and interference with the operation of the existing water and sewerage conveyance system, treatment works, pumping stations and distribution systems and to minimize

disturbance to the existing staff quarters and mosque adjacent to the Site. Access to the existing facilities shall be maintained, to the satisfaction of the consultant, at all times.

The contractor shall apply to the consultant in writing at least 28 days before starting any work which involves interference with existing structures, equipment, etc., or otherwise interfere with or interrupt the CLIENT's normal operation of the existing conveyance system, pumping and treatment works, and distribution system. The contractor shall not execute such work until he has received permission to proceed, in writing from the consultant.

The contractor shall ensure that no earth, debris or rock is deposited on existing conduits, structures, public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

The contractor shall be responsible for the safety and security of existing services encountered during the course of execution of works and any damage to existing installation and services due to contractor’s operations shall be made good at his risk and cost. The contractor shall gather the information of all services require protection and relocations, falls within the area of works, from SSGC, PESCO, PTCL, TMA and any other agencies. The contractor shall strictly comply with the safety and precautions requirements as deemed necessary by the owner of the services.

1.20. UNITS OF MEASUREMENT

All designs, drainage, specifications and manuals shall use either FPS, MKS or SI (kg m s) units, but any unit system used shall be consistent for the project and all measurements, dimensions and performance data shall be quoted in those units.

1.21. LANGUAGES

All drawings, instructions, signs, notices, name-plates etc. for use in the operation and maintenance of the completed works shall be in English.

Warning signs shall be in Urdu and English.

1.22. ADVERTISING

The contractor shall not use any part of the Site for any form of advertising without the prior written approval of the ENGINEER.

1.23. SITE INVESTIGATION RECORDS

The site investigation if deemed necessary by the consultant, during the execution of the work shall be carried out by the contractor at his own cost.

Before commencement of work at site the contractor shall carry out the trial pits up to the required formation level to locate any existing underground services and utility lines.

1.24. SAFETY AND ENVIRONMENTAL REGULATIONS ON SITE

The contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the client and consultant and members of the public and protection of Environment, as a result of his operations. He shall obtain copies of all the relevant regulations, and shall make them available for inspection by the consultant.

1.25. OTHER WORKS AND SERVICES

For all other works and services specified in the Specifications or shown on Drawings and for which there is no separate item in the Bill of Quantities, no payment shall be made directly and the cost thereof shall be deemed to be included in the unit rates of other items of BOQ, except as decided by the Engineer.

1.26. COSTS

The costs for complying with this section of specification shall not be paid separately and shall be included in the contractor's rates and prices of the Bill of Quantities.

2. THE SITE

2.1. LOCATIONS

The extent of the site is defined in Bidding Documents. The contractor shall not use the site for any purpose not required by the Contract.

2.2. AREAS OUTSIDE THE SITE

For the contractor making use of any special or temporary way leave or additional accommodation acquired by him or any tip for the disposal of surplus materials, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record agreed by the owner, occupier or authority as aforesaid of the condition of the surface of that land before entering thereon.

The contractor shall permit the Client and the consultant and any person authorized by the Client or the consultant access for the purposes of the Contract to any such special or temporary way leave or additional accommodation.

In the event of the contractor making use of any special or temporary wayleave or additional accommodation made available to him by the Client for the purpose of the Contract, the land in which such way leave or accommodation is situated shall be deemed to be part of the Site as defined in Clause 2.1 hereof.

For the purposes of this Clause, 'accommodation' shall be deemed to include housing, offices, workshops, warehouses, storage areas and disposal areas.

2.3. ACCESS TO SITE

The contractor shall where necessary, provide access to and through the site to adjacent properties as well as to other agencies/contractor who might be executing any development work for PHED or for any other agencies and coordinate his work with these agencies / contractors.

Before the commencement of any part of the Works, the contractor shall make temporary access tracks including temporary diversions, approach roads, temporary roads in side river for movement of vehicles, transporting Pipe lines and other Construction material during execution of the work with approval of the consultant. The Contractor shall maintain such access tracks in a condition suitable for the safe and easy passage of plant, vehicles and pedestrians required for the purpose of the Contract.

The Contractor shall make a record to be agreed by the consultant of the condition of the surfaces of any private lands or of any public cultivated or maintained lands over which access to the Site lies before any work is commenced to make them suitable for access and he shall keep such surfaces in a reasonable state of cleanliness and repair during the execution of the Works. On the termination of The Contractor's use

of such access he shall restore the surfaces to a condition at least equal to that existing before his first entry on them.

2.4. CLEARANCE AND REINSTATEMENT OF SITE

The Contractor shall clear the Site of all vegetation, trees, hutments, obstructions etc. to the extent required by the consultant for checking the setting out. The Contractor shall also ensure that the parts of the Site to be occupied by the Permanent Works are clear and maintain the remainder of the Site as may be required for access and Temporary Works areas.

The Contractor shall remove the material arising from such clearance and dispose off it in a manner and at a location, away from the site and inhabitant areas, no obstruction shall be caused to the existing traffic and adjacent properties and no excavated material shall be dumped or stock pile at site but removed directly to disposal areas identified by the Contractor, to the approval of the Consultant.

No heavy equipment/ plant whether mobile or stationery shall be allowed to come nearer than 1.5 m of the existing water and sewage conveyance structures. For this purpose, such structures and pipelines shall be protected by erecting warning fence or barricades.

The Contractor shall fill and make good with appropriate materials those cavities and losses of soil which result from clearing the parts of the Site not subsequently to be occupied by the Permanent Works.

The Contractor shall not clear the Site of any structure without the prior written permission of the consultant.

Before start of concreting work the contractor will carry out sub soil investigations to establish soil characteristics and record ground water levels. Results of the test shall be timely reported to the Engineer before execution of the project.

2.5. CONDITION OF SITE

The Contractor shall maintain the Site in a neat, tidy and healthy condition for the whole of such time as he is responsible for the care of the Works.

2.6. LAYOUT

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

2.7. SITE RECORDS

The Contractor shall make records of the position and extent in the excavations of every type of service, stratum and obstruction encountered during the construction of the Works.

2.8. PERMITS

The Contractor shall be fully responsible for obtaining necessary permits and permissions, except those normally obtained by the PHED or consultant, prior to commencement of the Works.

2.9. PROTECTION OF WORKS AGAINST FLOODING

The Contractor shall ensure the protection of all temporary and permanent works including plants, materials and equipment against flooding caused by sewage flow in river / nala as well as recurrent rains or any other reasons, during the course of execution of works. Before the commencement of works the Contractor will submit its detail work methodology, for Consultant's approval, showing manners to divert the existing flows in the river/nala away from the work area to be acquired in orderly state. The Contractor shall maintain such flow diversions in part or as a whole till the works have been completed or covered in accordance with drawing, specifications or as directed by the consultant. The cost of complying with this section is deemed to be included in other items of BOQ, unless expressly specified otherwise.

2.10. SUBSOIL INVESTIGATIONS

Before start of Contract Works, the contractor will carry out sub soil investigations to establish soil characteristics and record ground water levels. Results of the test shall be timely reported to the Engineer before execution of the project.

2.11. COSTS

The costs for complying with this section of specification shall not be paid separately and shall be deemed to be included in the Contractor's rates and prices of the Bill of Quantities.

2.12. SURVEY EQUIPMENT

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

Table 1 - List of Survey Equipment

Sr. No.	Equipment	Quantity
1.	Total Station complete with Standard Accessories model SOKKIA SET 2010 or Equivalent	1-No.
2.	Single Tilting Range Pole Prism Complete Set Model SOKKIA KPS 11 PT or Equivalent	1-Set

Sr. No.	Equipment	Quantity
3.	Single Tilting Prism W / Coaxial Target Complete Model SOKKIA KPS 12 or Equivalent Model B20	1-Set
4.	Automatic Levels, with Standard Aluminium Tripod	2-Nos.
5.	Steel Measuring Tapes 50m and 20m long	2-Each
6.	Steel Measuring Tapes 3m long	6-Nos.
7.	Leveling Staff (4m)	2-Nos.
8.	Ranging Rods	as required
9.	All Miscellaneous Tools, Equipment and Materials required in Surveying	as required

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

2.13. PLANT, EQUIPMENT AND TOOLS

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

2.14. STORAGE & HANDLING FACILITIES

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

2.15. TEST LABORATORY TESTING AND TESTING REPORT

Testing, except as otherwise specified herein, shall be performed by testing agency approved by the Engineer and at no extra cost to the Client. The Contractor shall bear the Cost of such Testing. The Engineer may require all or part testing to be carried out under his supervision only. The quality control testing shall be performed by the Contractor's competent personnel in accordance with a site testing and quality control program to be established by the Contractor and approved by the Engineer. The Contractor shall keep a complete record of all quality tests performed on site.

All quality control and tests shall be carried out in accordance with applicable standards and codes.

2.16. PROTECTION OF THE WORKS

The Contractor shall whenever necessary cover up and protect the works from weather and damage by his own or other workmen performing subsequent operation

at no extra cost to the Client including all necessary dust sheets, barriers and guard rails and clear away the same on completion.

2.17. DEFINITIONS

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

2.18. ABBREVIATIONS

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

°C	Degree Centigrade
°F	Degree Fahrenheit
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
ACI	American Concrete Institute
ASIC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
BCP	Building Code of Pakistan
BS	British Standards
BSI	British Standard Institute
CBR	California Bearing Ratio
cm	Centimeter
DIN	Deutsches Institut für Normung
EN	European Norm
HDPE	High Density Polyethylene Pipe
HP	Horse Power
ISO	International Standards Organization
JMF	Job Mix Formula
Kg	Kilogram
km	Kilometre
lb	Pound

m	Meter
mm	Millimetre
PN	Pressure Nominal
WBM	Water Bound Macadam

3. MATERIALS AND WORKMANSHIP

3.1. STANDARD SPECIFICATIONS

Except where otherwise specified plant, materials and workmanship shall comply with the requirements of the relevant National Standards or American Society for Testing and Materials, British Standards and Codes of Practice (hereinafter referred to as ASTM, BS or CP current at the time of bid. Other equivalent National or International Standard Specifications may be substituted at the sole discretion of the ENGINEER or as may have been agreed in the Contract. All standards used will be the current version at the time of bidding.

The Contractor shall supply two copies of each ASTM, AASHTO, ACI, BS, EN and BSCP and other approved national or international standards which refer the specifications and other standards which apply to materials which are being supplied and workmanship which is being executed on the Works. These standards and reference works shall be supplied to the Consultant within 60 days of the Consultant's order to commence the Works. One copy shall be available to the Consultant and other copy shall be kept by the Contractor on the site.

All materials and workmanship not covered by a ASTM, AASHTO, BS or BSCP or other approved standards shall be used in first class work and suitable for the climate in the area where the works are to be executed, for which Engineer’s decision is a binding.

A list of standards and other publications referred to in the Specification is given in respective sections.

3.2. SUPPLIERS OF MATERIALS

Before ordering material of any description intended for the Permanent Works, the Contractor shall submit for the approval of the ENGINEER the names of the maker or supplier proposed, a specification of the material and details of the place of origin or manufacture. If it is found necessary test regarding its compatibility with specifications be carried out at external facility. If requested by the consultant the Contractor shall supply to the consultant for his retention, a copy of any such order placed.

All materials used in the Permanent Works must be new, unless the use of old or refurbished material is expressly permitted by the Specification or the consultant.

Materials used in the Works which are, or can be, in contact with the untreated or treated water shall not contain any matter which could impair taste, odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed. Approval by bodies mentioned in Clause 1.6 will generally be regarded as satisfactory evidence of suitability.

3.3. NATURAL MATERIALS

The Contractor shall make all arrangements for locating, selecting, and processing natural materials to comply with the Specification and shall submit to the consultant for approval full information regarding the proposed location well in advance of commencement of working of the material. Approval of a location shall not imply that all material in that location is approved.

3.4. SAMPLING

The Contractor shall provide the Consultant with samples of materials necessary for testing in accordance with the Contract. Unless expressly excused the Contractor shall also provide samples of all manufactured items required for the Permanent Works, or alternatively the Contractor shall submit trade literature where the provision of samples, in the first instance, is impracticable.

All samples rejected by the Consultant shall be removed from Site. All approved samples shall be stored on Site by the Contractor for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation to the Permanent Works shall be of a quality at least equal to the approved sample.

3.5. LABORATORY FACILITIES

The Contractor shall, for the duration of the Contract, supply maintain and operate a materials testing laboratory at site necessary for sampling, preparing and testing materials as specified. The Contractor may also use an off-site testing laboratory to perform certain of the specified tests. Both the laboratory and the tests shall be to the approval of the Consultant, such approval shall not be given if significant delays in obtaining results are likely, or if the results may be unreliable. The Contractor shall make all the necessary arrangements and provide all transport and labour for conveying the samples to the approved laboratory, and shall ensure that any results are conveyed to the Consultant 's Representative promptly. The Consultant's approval will be withdrawn if the service proves in any way unsatisfactory.

The Contractor shall provide trained and qualified Material Engineer, technicians and skilled labour to carryout specified tests to the satisfaction of the Consultant’s representative. The Material Engineer and technicians shall be approved by the Consultant. In case of unsatisfactory performance such approval will be withdrawn and the Contractor shall arrange for suitable replacements for approval by the Consultant’s representative.

The Consultant and his supervisory staff shall have access to the laboratory to supervise testing and to witness verification tests ordered by the Consultant or his staff.

The Contractor shall keep records of all tests he conducts in connection with compliance with, and as required by, the Specification, and shall supply copies of the results of such tests to the Consultant's Representative as soon as practicable after each test is made.

Notwithstanding the above the Contractor shall supply, maintain and operate all the necessary apparatus for certain tests which shall be carried out within the Permanent Works or elsewhere on the Site as directed by the Consultant; these tests are as follows:

3.5.1. Concrete Tests

(a)	Slump test	to ASTM C-143
(b)	Aggregate moisture test for determination of water/cement ratio	to ASTM C-566
(c)	Concrete Cylinder crushing strength test	to ASTM C-39
(d)	Elongation and flakiness of aggregate	to ASTM D-4791
(e)	Gradation of Aggregates	to ASTM C-136
(f)	Soundness of the aggregates to	ASTM C 88

The Contractor shall be responsible for making and curing test cylinders in accordance with ASTM C-31 and for measuring the temperature of atmosphere, formwork, concrete constituents and concrete itself as directed by the Consultant from time to time, and shall provide and maintain the equipment for so doing.

3.5.2. Soil Compaction Tests

(a)	Determination of the dry density/moisture Content relationship of soil	to AASHTO T-180
(b)	Determination of the dry Density of soil	to AASHTO T-191
(c)	Sand replacement test	to ASTM D 2974
(d)	Determination of organic matter Content in soil	to ASTM D 2974
(e)	Atterberg limit tests	to ASTM D 4318
(f)	Soil gradation analysis by mechanically vibrated sieves	to ASTM D 421
(g)	Soil gradation by Hydrometer (longstem type calibrated at 20^{o} C)	to ASTM D 422
(h)	Determination of sulphates content as SO_3	to ASTM D 2974
(i)	Testing of water samples for electrical conductivity, soluble Cations and Anions, PH and dissolved solids etc.	to ASTM C 1602

In addition, the following equipment will also be required:

- 1 No drying oven of a type approved by the Consultant and suitable for soil testing;
- 1 set Speedy Moisture Tester with balance and soil moisture absorbent, complete set in wooden case (for soil sample, 13 grammes);

- Spare Speedy Moisture absorbent, Calcium Carbide

3.6. COSTS

The costs for complying with this section of specification shall not be paid separately and shall be deemed to be included in the Contractor's rates and prices of the Bill of Quantities.

PART-B WATER DISTRIBUTION NETWORK

4. SECTION – 2 EARTH WORK FOR WATER LINES

4.1. SCOPE OF WORK

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

4.2. CLEARING AND GRUBBING

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

4.3. EXCAVATION

4.3.1. General

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

4.3.2. Trench Excavation

Unless otherwise directed or permitted by the Engineer not more than 150m of any trench in advance of the end of the pipeline already laid shall be opened at any time and unless otherwise directed permitted by the Engineer not more than 300 m of any one trench shall be worked on at a time. The banks of the pipe trench shall be as nearly vertical as practicable. Bell holes and depressions for joints shall be dug after the trench bottom has been prepared. The pipe, except for joints, shall rest on the prepared bottom for its length. Bell holes and depressions shall be only of such length, depth, and width as required for properly making the particular type of joints. Stones shall be removed to avoid point bearing. Whenever wet or otherwise unstable material that is incapable of properly supporting the pipe as determined by the Engineer is encountered in the bottom of the trench, such material shall be removed to the depth required and the trench backfilled to the proper grade with coarse sand, or other suitable approved granular material. Such replacement of unsuitable material will be paid for at the contract unit price for that item of work. Trenches shall be of a depth to

provide a maximum cover, over the top of the pipe, of 1 m. from the existing ground surface or finished grade whichever is closer except that trenches for pipe laid in lanes and alleys of narrow travelled way (average width of 8 feet or less between structures) shall be of a depth to provide a minimum cover, over the top of the pipe, of 18 in from the existing ground surface or finished grade whichever is closer.

4.3.3. Excavation for Appurtenances

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

4.3.4. Maintenance of Excavation

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

4.3.5. Removal of Water

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

4.3.6. Sheeting and Bracing

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

4.3.7. Protection of Facilities

Existing subsurface facilities likely to be encountered during the execution of work require special precaution for the protection, such as sewers, drain pipes, water main, conduits and electric cables and the foundations of adjacent structures. The

Contractor shall be liable for the damage of any such facility and shall repair the same at his expense whether or not this facility has been shown on the Drawings.

4.3.8. Surplus Materials

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

4.3.9. Cutting Pavement

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

4.4. BACKFILLING

a) The trenches shall not be completely backfilled until all required pressure tests are performed and until the water lines as installed conform to the requirements of specifications. Where in the opinion of the Engineer, damage is likely to result from withdrawing sheeting, shoring; the same shall be left in place and cut off at a level 12-inch below ground surface. Sheeting left in place at the direction of the Engineer will be paid for at the contract unit price/approved rate for that item of work. Trenches shall be backfilled to the ground surface with selected excavated material or other material that is suitable for proper compaction. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density. The surface shall be restored to its original or better condition. Pavement and base course disturbed by trenching operations shall be replaced.

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

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

4.5. BORROW

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

4.6. GRADING

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

4.7. TESTING DENSITY OF SOIL IN PLACE

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

4.8. MEASUREMENT AND PAYMENT

4.8.1. Measurement

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

4.9. PAYMENT

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

5. CONDUITS AND PIPES

5.1. SCOPE OF WORK

The work under this section consists of supplying, installing and commissioning of all material and services of the complete Conduits and Pipes as specified herein and/or shown on Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the consultant and co-ordinate at Site with other services for exact route, location and position of the conduits and pipes.

5.2. GENERAL

The extent of works shown in the drawing does not indicate the exact position of conduits and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer.

The quality and material for the accessories of conduits and pipes such as sockets, end cap, elbows, bushings, bends, inspection/pull boxes, round boxes, etc., necessary for the completion shall be similar to that of conduits or pipes. All the accessories shall be supplied by the Contractor without any extra cost and deemed to have been included in the price of conduits/pipes.

5.3. APPLICABLE STANDARDS/CODES

The latest edition of the following standards and codes shall be applicable for the materials specified within the scope of this section:

BS 31	-	Steel conduits and accessories
BS 4607	-	UPVC/PVC conduits and accessories
BS 3505	-	PVC Pipes and accessories
BS 1378	-	Galvanized Iron pipes & accessories

5.4. MATERIAL

5.4.1. UPVC/PVC Conduits and Accessories

The UPVC/PVC conduits and accessories for lighting, power and motor circuits shall be furnished by the Contractor as shown in the drawings or given in BOQ. The UPVC/PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will be allowed in special situations only, for which the consent of the Engineer shall be required. The use of sharp 90-degree bends and tees will not be allowed for concealed wiring.

The round UPVC/PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 63 mm diameter and depth. The junction boxes for wall light points shall have minimum dimensions of 63 mm diameter and 38 mm deep. Round junction boxes

shall be provided with one-piece UPVC/PVC cover plate fixed to the box by means of brass screws.

5.4.2. Inspection/Pull and Adaptable Boxes

Inspection/Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of inspection/pull boxes or adaptable boxes. However, these shall meet the following requirements: -

5.4.3. Inspection/Pull Boxes

The rectangular inspection/pull boxes shall be made of 16 SWG heavy gauge sheet steel of suitable design to receive conduits. The box shall be painted inside and outside with black enamel paint over a base coat of red oxide primer paint. The minimum length of the box shall not be less than four times the cable manufacturer recommended bending radius of the cable. All concealed type boxes shall have a white plastic sheet of appropriate size fixed to the box by means of galvanized screws.

If the spacing between the end points of conduit run with respect to bends exceeds the following, an inspection/pull box of suitable size according to the number and size of cables and as approved by the Engineer shall be provided:

Straight run without bend	:	Max. spacing 30 meters
Run with one 90^{o} bend	:	Max. spacing 20 meters
Run with two 90^{o} bends	:	Max. spacing 15 meters

5.4.4. Adaptable Boxes

Adaptable boxes shall also be made of 16 SWG sheet steel and painted and finished to the same quality as the lighting distribution boards. The adaptable box shall preferably be fixed adjacent to the DB and have suitable dimensions to match the installation with DB. However, in any case, the depth of adaptable box shall be according to the number & size of cables & conduits and shall not be less than the following:

Conduits up to 25 mm dia	:	Min. depth 50 mm
Conduits up to 38 mm dia.	:	Min. depth 65 mm
Conduits up to 50 mm dia.	:	Min. depth 90 mm
Conduits more than 50 mm dia.	:	Min. depth 2 x dia.

5.4.5. Galvanized Iron (G.I) Pipes and Accessories

The G.I pipes shall be made of mild steel, galvanized inside and outside by hot-dip galvanizing process. The pipes shall be free from stains, burrs or any other defect. The accessories for G.I pipes such as sockets, bends, etc. shall also be galvanized inside and outside and shall be of the same quality and specifications as the pipes.

These pipes shall be installed for crossing of cables above nallas and culverts wherever specified or as shown in drawing or given in BOQ. The pipes and

accessories shall be provided with one thick coat of bituminous paint on the outer surface prior to installation. All pipes shall be secured in position by means of galvanized clamps, supports, etc.

Galvanized Iron (G.I.) pipeline in trenches using G.I. pipes conforming to EN 10255:2004 Light Class or equivalent approved standard. All pipes and fittings shall be galvanized and suitable for potable water supply. Jointing shall be carried out with threaded socket joints using approved jointing material. The pipeline shall be laid to proper line and level, including provision of all necessary G.I. specials and fittings such as bends, tees, reducers, sockets, unions, and nipples as required. After installation, the pipeline shall be hydrostatically pressure tested in accordance with AWWA C600 standards (Installation of Ductile Iron Water Mains and Appurtenances) or equivalent applicable procedure, and the pipeline shall be flushed and disinfected in accordance with AWWA C651 standards for disinfection of water mains. The work shall include all labour, tools, equipment, jointing materials, testing, flushing and disinfection, complete in all respects as per drawings and specifications, excluding excavation and backfilling.

5.4.6. PVC Pipes and Accessories

The PVC pipe shall be rigid. All pipes shall be minimum Class 'B' (Working pressure - 6 bar), unless otherwise stated in drawings or Bill of Quantities. The buried PVC pipe should be able to withstand the external load acting upon it by continuous movement of heavy-duty vehicles such as trucks, cranes, forklift, etc., where pipe changes direction, manufactured smooth bends shall be used.

Fittings and accessories for use with PVC pipes shall be of the same class and manufacturer as the pipe and shall have the required shapes and dimensions of turned ends to fit the PVC pipes. PVC pipes and accessories shall be suitable for jointing with rubber rings or solvent.

Bending of pipes by heating or otherwise will not be allowed. The use of sharp 90-degree bends and tees will not be allowed. The bends shall conform to the same specifications as given for PVC conduits. For jointing of pipe all precautions and procedures recommended by manufacturer shall be followed.

Hard PVC or reinforced concrete pipe range spacers shall be used if there is more than one pipe running in parallel. The distance between range spacers shall be maximum 2 meters. Range spacers shall be prefabricated/pre-cast and decay resistant.

5.5. INSTALLATION

5.5.1. UPVC/PVC Conduits and Accessories

5.5.2. Concealed Conduits

Where concealed conduit system is stated in drawings, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid under floor only where

specifically stated. The entire conduit system shall be installed and checked before wiring is carried out. Any obstruction found shall be cleared before the installation of cable.

When concealed, the conduit shall have a minimum of 32 mm cover of concrete measured from the top of conduit to the finished surface. In the reinforced cement concrete (RCC) work the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories after pouring of concrete. The conduit shall be supported on top of bottom reinforcement of slab. All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed in cement concrete (CC) work after concreting or in block masonry, chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the cement concrete work or block masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from the Engineer before starting chasing and cutting.

The termination of conduits at or near the equipment/switchboard is shown in the drawings. The exact locations of the termination shall be coordinated with the equipment/switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all terminations of conduit, sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wires or cables during pulling through the conduits.

Under floor conduit shall be installed at a minimum depth of 2 inch from the finished floor level or as shown in the drawings. The conduits shall be installed empty, before finishing of floor or in RCC work, with an 18 SWG steel wire drawn through the conduit for pulling cable. No conduits shall be laid under floor in bathroom.

Wherever the conduit lengths cross the expansion joint either along the columns or slab, suitable arrangement shall be provided so that when the conduit lengths in the expansion joint are stressed, the conduit shall not crack or break.

5.5.3. Surface Conduits

The surface conduits shall be installed where shown in drawings only. The conduits shall be installed parallel or perpendicular to the surface of wall, structural members, ceiling, etc. by means of UPVC/PVC or steel saddles and clamps of approved design. The conduits shall be kept at least 150 mm away from parallel runs of flues, steam pipes and hot water pipes.

The saddles shall be installed on surface by means of nylon or wooden plugs and galvanized screws. Appropriate size of holes in structure shall be made by drilling. The thickness of saddles and clamps shall be of appropriate thickness and prime quality. The surface conduits shall be supported at a maximum of one meter spacing along horizontal and vertical runs. All accessories for complete installation of conduit system shall be provided by the Contractor. The pull boxes, etc. as stated for concealed conduits shall also be applicable for surface conduit system.

5.5.4. Galvanized Iron Pipes

The galvanized iron (G.I) pipes shall be installed at a minimum depth of 900 mm measured from the top of pipes to finished ground level. The pipe shall be laid and checked for soundness before completion of civil works. The G.I pipes shall be installed at locations as shown in the drawings.

At all joints, the pipes shall be firmly screwed and cotton yarn with waterproof compound shall be used to make the joint waterproof.

At each termination, the pipe end shall have threads and socket screwed on thread for installing soft metal bush. The soft metal bush shall be of approved quality and shall be male type.

The installation of pipes shall be complete in all respects including its fixing at terminations before the work is started. All sharp edges and burrs shall be removed by using reamer or any approved device.

The pipe shall be checked for any obstruction before installation of cable. If found, it shall be cleared without damaging the installation. All pipe ends shall be plugged to prevent entry of water, rodents etc.

5.5.5. PVC Pipes & Accessories

Rigid PVC pipes shall be installed under roads, paved areas, at crossing with other services and at cable entering building as shown in the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe:

Under roads/pavement : 900 mm below finished surface.
When crossing outer : 250/500 mm vertical/horizontal services clearances with concrete cover

The trench of required dimensions shall be excavated and the bottom of trench cleaned and levelled. A 100 mm bed of fine sand shall be provided over which the PVC pipes shall be installed after proper alignment. Where two or more pipes are installed in the same trench, the clearance between pipes shall not be less than 50 mm. This shall be done by the provision of pipe range spacer as per Engineer's approval. After laying of pipe the trench shall be backfilled with clean-screened sand at least 100 mm

above the top most pipes. The remaining portion & trench shall be backfilled with selected earth in layers and each layer shall be properly tamped and compacted.

After installation, the ends of the pipe shall be plugged with material impervious to water and chemicals. All joints shall be sealed adequately to prevent entry of foreign elements, but water tightness shall be ensured.

The installation of pipes shall be completed in all respects including its fixing at termination, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be through cleaned of dirt and dust from inside. The pipes shall be installed in proper co-ordination with other works.

The protective PVC pipe for cable entering building shall be installed so as to lead cable into the cable trench. The required number of pipes shall be fixed before completing the work in the plinth. If an opening is provided to the cable trench from outside, the required number of pipes shall be installed and part of the opening remained unutilized shall be properly packed and sealed using suitable packing material impervious to water and chemical to make it completely water-tight.

Spare pipes shall be provided with 5 mm dia. rope pulled from end to end and plugged with manufactured end cap.

Flexible pipes of compatible material and size shall be used wherever deemed essential.

5.6. MEASUREMENTS & PAYMENTS

5.6.1. MEASUREMENT

Measurement shall be made for the total running meter of each type and size of underground/surface/concealed class 'B' PVC/uPVC conduits or RCC pipes with all accessories including pull wire, excavation and backfilling etc. acceptably supplied and installed by the Contractor as a complete unit as per Tender drawings.

5.6.2. PAYMENT

Payment shall be made for the total running meter of each type and size of conduits and pipes measured as provided above at the contract unit price and shall constitute full compensation for supplying, installing and completion of the laying of the conduits and pipes including all accessories related to the items.

No separate payments shall be made for the under mentioned specified work related to the supply and installation of conduit and pipe. The cost thereof shall be deemed to have been included in the quoted rates of above work.

a. Excavation and backfilling.

b. Dewatering during excavation and backfilling.

c. Providing and filling of fine sand in trenches.

d. Providing pipe range spacers.

e. Providing flexible pipes and accessories, jointing material/compound, saddles, sockets, elbows, bend junction boxes reducers, 16 SWG G.I pull wire for empty conduit and 5mm rope for empty pipe, soft metal bush, making threads and plugging of pipe with manufactured end cap etc. whether used or left spare.

f. Compacted backfilling of trenches with specified material and disposal of surplus and rejected material.

g. Watertight sealing of any unutilized opening/ spare conduit, pipe to the buildings after installing the protective pipes entering the buildings.

6. SECTION – 3 HDPE PIPES & FITTINGS

6.1. SCOPE OF WORK

This work shall consist of providing, laying, testing and disinfection of High- Density Polyethylene (HDPE) pipes conforming to ISO 4427, DIN 8074/8075 & PS 3580 with PN-8, 10 & 12.5 (PE 100) and in trenches to correct alignment and grade, as indicated in the drawing and specifications including all other accessories and equipment.

6.2. DEFINITIONS

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

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

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

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

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

6.3. APPLICABLE STANDARDS AND CODES

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

ISO 4427	Polyethylene (PE) pipes for water supply - specifications
IS0161-1	Thermoplastic pipes for conveyance of fluids - nominal outside diameter and nominal pressure- part 1: Metric series
ISO 1167-1 to 4	Thermoplastic pipes, fittings and assemblies for the conveyance of fluids
IS0 3126	Plastic pipe - Measurement of dimensions
ISO 4065	Plastic pipe - Measurement of dimensions
ISO 6964	Polyolefin pipes and fittings - Determination of carbon black content by calcination and pyrolysis - Test method and basic specification.
ISO 9080	Thermoplastic pipes for the transport of fluids – Method of extrapolation of hydrostatic stress rupture data to determine the long-term hydrostatic strength of thermoplastic pipe materials.

ISO 11922-1	Thermoplastic pipes for the conveyance of fluids - Dimensions and tolerances Part: 1: Metric series.
IS012162	Thermoplastic materials for pipes and fittings for pressure applications - Classification and designation - overall service (design) coefficient.
ISO 13761	Plastic pipes and fittings - pressure reduction factors for polyethylene pipeline systems for use at temperatures above 200 C.
ISO 7005- 3	Metallic flanges - Part 3, Copper alloy and composite flanges
BS EN 12201	Plastic piping systems for water supply · polyethylene
ISO 974	Determination of the brittleness temperature by impact
ISO 2505	Thermoplastics pipes · Longitudinal reversion
ISO 6259	Determination of tensile properties
ISO 1133	Determination of the melt mass-flow rate (MFR) and the melt volume-flow
ISO 877	Methods of exposure to direct weathering

6.4. TECHNICAL REQUIREMENTS

6.4.1. Material

The Contractor shall identify the manufacturer of the resin, the resin type and classification. In addition, the Contractor shall provide evidence that the resin proposed is suitable for use at the design temperature and under the design pressures.

Any change in the material, the material specification, or the manufacturer's location shall be subject to prior approval of the Engineer.

Pipes and fittings shall be homogenous throughout and free from visible cracks, holes, foreign inclusions, blisters, dents or other damaging defects.

Material shall be uniform in opacity, density, interior smoothness, and other physical properties.

It shall have adequate resistance to weathering and other ageing from storage for a minimum of two years after manufacture.

The material of the polyethylene pipes and fittings which is in contact with or likely to come in contact with drinking water shall not constitute a toxic hazard, shall not support

microbial growth and shall not give rise to unpleasant taste or odour, cloudiness or discoloration of the water.

The concentration of substances, chemical and biological agents leached from materials in contact with drinking water, and measurement of the relevant organoleptic / physical parameters, shall not exceed the maximum values recommended by the World Health Organisation in its "Guidelines for Drinking Water Quality" or the EEC Council Directive on the "Quality of Water Intended for Human Consumption", whichever is more stringent in each case.

For the manufacturing of pipes & fittings new materials to be used only (Rework material is not acceptable.)

Pipe manufacturer shall confirm that all fittings to be provided for the pipe systems shall meet the same quality requirements as for the pipes to ensure the same performance for design life cycle.

The pipes and fittings shall be manufactured from polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacturing process to fulfil the requirements of the specification.

All pipes and fittings shall be suitable for butt fusion or electro fusion techniques.

Contractor shall provide HDPE manufacturers guideline for the applicability of the material used. If required HDPE manufacturers shall provide assistance and training.

6.4.2. Physical Properties

Pipe shall follow requirements of ISO 4427 PE 100. The material shall be produced by a member of the PE 100 + Association.

The material used for the manufacturer of pipes and fittings shall be in accordance with Table-1 and Table-2 of clause 4.4 of ISO 4427-1. The minimum required strength (MRS) of the material compound shall be 10 MPa at 20oC. The design stress shall be 8 MPa.

Lifecycle durability of 80 years is to be confirmed.

Pressure reducing coefficients, as included in Annexure-A of ISO 4427-1, are also applicable. The thermal stability of polyethylene material shall meet the requirements of ISO 4427.

6.4.3. Pipe Dimensions

The pipe dimensions for water systems shall be based on standard dimensions according to ISO 4427 and measured in accordance with ISO 3126.

Straight pipe shall be supplied in standard lengths measured at 239oC ± 29oC, unless otherwise specified; coil lengths shall not exceed 100 m (328 ft).

Coiled pipes shall be coiled such that localized deformation is voided and diameter of the coil shall not be less than 18 dn.

6.4.4. Pipe Appearance

When viewed without magnification the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects. The pipe ends shall be cut cleanly and square to the axis of the pipe.

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

The carbon black content in the compound shall be 2.25% ± 0.25% by mass when measured in accordance with ISO 6964. The dispersion of carbon black when determined in accordance with ISO 11420 shall be equal to or less than grade 3.

6.4.5. Fittings

The fittings shall be injection moulded and formed from material that is compatible to that of the pipe and shall be as resistant to the external and internal environments as the other demands of the pipe system.

At locations where HDPE pipe to metal connections is specified, Nylon-11 based polyamide coating system complying with the requirement of AWWA C224 or epoxy coated backing rings shall be used, or special restrained transition fittings subject to approval by the Engineer. The flanges shall be drilled to ISO 7005-2, as per the design requirements.

6.4.6. Fittings Appearance

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

6.4.7. Fittings Dimensions

The dimensions shall be measured in accordance with EN/ISO 3126.

6.4.8. Wall Thickness of Fittings

The wall thickness of the body of the fitting at any point shall be equal to or greater than the minimum wall thickness of the corresponding pipe.

6.4.9. Pipe Installation

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

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

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

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

c. The pipeline shall be within 1-inch of the specified line and the invert level shall be within 6mm of the specified value and shall be such that there is no back fall at any point on a gravity pipeline.

d. Install bedding, surround and backfill in accordance with the pipe manufacturer's requirements.

e. Install appurtenant facilities on the pipeline such as manholes, valve chambers as specified of the specification.

f. Lay pipes from downstream to upstream unless agreed otherwise with the Engineer.

g. HDPE pipelines can accommodate gradual changes of direction in the vertical and horizontal plane. However, the pipe should not normally be bent to a radius less than 25 times the outside diameter of the pipe.

h. When cut pipe is required, ensure that the cutting is done by a machine, leaving a smooth cut at right angles to the axis of the pipe.

i. Ensure that all pipes and fittings are sound and clean before laying. When pipe lying is not in progress, ensure that the pipe ends are at all times fitted with watertight plugs or caps. The plugs or caps shall only be removed for the purposes of making a connection of the pipe end or testing the pipeline. The plugs or cap shall be replaced immediately on completion of the test.

6.4.10. Backfilling

The selected fill material as shown on the Drawings shall be hand-compacted in layers not exceeding 150mm to complete the pipeline surround. Compaction shall be carried out equally on either side of the pipeline to prevent displacement. The backfill shall be hand-compacted up to 300 mm above the crown of the pipe. Any temporary support shall be gradually withdrawn during placing of the bedding and backfill materials to ensure that materials are placed against the trench side. The remaining portion of the trench shall be compacted in layers not exceeding 200 mm using approved mechanical rammers.

Where filter fabric is used to enclose granular pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with granular surround to the correct level the filter fabric will be closed by forming a lap equal to trench width. Care shall be taken that the membrane is not punctured or damaged in any way during these operations and backfilling. the trench.

Where concrete bedding or surround is specified, concreting shall be carried out as specified in SECTION- PLAIN & REINFORCED CONCRETE. The backfill other than first 150 mm of cover shall not be placed before the compressive strength of the

concrete has reached 15 MPa. The remaining portion of the trench shall be backfilled as specified.

6.4.11. Cutting Pipes

The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. No extra payment will be made for such adjustments or for any welding, couplings, fittings, or special lengths required to meet this requirement.

The cutting of ductile iron and HDPE pressure pipes for inserting specials, fittings or closure pieces shall be performed by the Contractor. Cutting shall be carried out in a neat and workman like manner with an approved cutting machine without damage to the pipe and so as to leave a smooth end at right angles to the axis of the pipe. The cut ends of pipes shall be chamfered. The Contractor shall take every precaution to ensure that both the measurements and the cutting of pipes are to the accuracy required and should any errors occur the Contractor shall remedy same at his own expense and as the Engineer directs.

6.4.12. Butt Fusion Jointing

Butt fusion jointing shall only be used to join pipes of the same PE material with compatible MFR and with the same nominal wall thickness and outside diameter. The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- The butt fusion machine should be sited within a shelter and the ends of the pipe being joined should be covered or plugged to prevent through drafts.
- Each component that is to be fused should be held in position in the purpose-built clamping. The lengths of pipe hanging outside the jig should be supported by means of roller cradles.
- The pipe ends should be faced so that the finished surfaces are perfectly smooth free of visible ridges, valleys or other surface imperfections.
- The outside diameters of the pipe ends should match closely without the offset exceeding 10%.
- The pipe ends should be heated to the pipe manufacturer's recommended temperature and interfacial pressure. The Contractor should use a pyrometer or other surface temperature measuring device to confirm and record the actual surface temperature for each weld. Temperature indicating crayons should not come into contact with the surface to be welded.
- After the pipe ends have been properly melted, the heater tool should be removed within the specified time. The molten pipe ends should be brought together and

allowed to cool without disturbance to form the permanent weld. The proper bead size and geometry specified for the pipe being welded should be formed.

6.4.13. Saddles/Sidewall Jointing

Saddle /sidewall fusion jointing shall be accomplished by using a mechanical saddle fusion machine that has been designed for this purpose to ensure proper alignment, temperature and force control. The following procedures shall serve as a general guide only. The Contractor shall obtain detailed jointing instructions from the manufacturer who shall have a technical representative available at the Engineer's request during the jointing process.

- Any dirt or coating that might interfere with the proper operation of the saddle fusion machine should be removed from the pipe and the surfaces of the pipe and saddle roughened to expose fresh material and any reside brushed away.
- Test fit the saddle fusion machine to ensure that alignment and contact are as they should be.
- Commence the fusion process and periodically verify the surface temperature using a pyrometer or other surface temperature measuring device. If temperature indicating crayons are used, they should not be used on a surface which comes into contact with the surfaces to be welded.
- After the heating period, remove the heater plate and check for the correct melt pattern on both the fitting and the pipe. Join the fitting to the pipe with the prescribed fusion force.
- Cool the joint without disturbance until the melt has formed a permanent weld. The joint should. not be subjected to any external stresses until the fusion joint has cooled.

6.4.14. Electro Fusion Jointing

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

- Ensure that the fitting is dimensionally appropriate for welding to the Pipe. Clean the pipe surface in the joint area. Cut the end of the pipe square. Mark on the pipe surface the proper position of the fitting to be installed. Scrape the surface of pipe area to be joined, removing all surface degradation and contamination. Avoid contamination of the scraped pipe surfaces.
- Place the pipe and fitting in the clamping fixture to prevent movement of the pipe or fitting.
- Connect the electro fusion control box to the fitting and to the power source. Apply electric current to the fitting as specified in the manufacturer's instructions. Turn off the current when the proper time has elapsed to heat the joint properly.
- Allow the joint to cool for the recommended time and remove the clamping fixtures. Do not remove prematurely from the clamps as any strain on a joint that has not fully cooled can be detrimental to joint performance.

6.4.15. Mechanical Joints and Fittings

Many types of mechanical connection styles and methods exist. The Contractor shall submit suitable mechanical joints. All such joints shall be recommended and acceptance tested by the manufacturer of the pipe. Where marked on the Drawings end-load resistant fittings of an approved type shall be used.

When tightening polyethylene flanges care shall be taken to produce an equal torque load to the limits given by the manufacturer. A torque wrench shall be used. Since polyethylene creeps under load, it is essential that the bolts are re-tightened several times prior to commissioning to minimize the risk of leakage.

All joint materials and gaskets shall be suitable for use in the prevailing climate, soil, ground water, and potable water and irrigation water conditions.

6.5. TOOLS

The Contractor shall supply all necessary tools for cutting, chamfering, jointing, and testing and for any other requirement for satisfactorily installing the HDPE pipelines.

6.6. CONTROL OF WATER

The Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep the excavation sufficiently free from water during construction of the work to permit proper laying and jointing.

6.7. INSPECTION AND TESTING

6.7.1. Certification and Documentation

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

6.7.2. Test Results and Frequencies

The Manufacturer shall establish and maintain a current record of test results according to the requirements of the applicable standards and this specification. The Manufacturer shall perform all the tests required by ISO 4427 to demonstrate the characteristics and quality of the resin material and the dimensional tolerances of the pipe. The Manufacturer shall document all the tests, with frequencies and results as indicated in ISO 4427. The records shall be kept for 10 years as a minimum.

6.7.3. Inspection and Audit Requirements

Pipe shall comply fully with ISO 4427, the requirements of the PE 100 + Association and all the additional requirements of this specification.

To verify compliance with this specification, the Engineer shall reserve the right to appoint an independent third-party inspector to witness the applicable qualification tests, review production records, and inspect general handling and shipping procedures. The third-party inspector shall have full access to the testing and production facilities and will be a fully authorized representative of the Engineer.

6.7.4. Acceptance Criteria

The order shall meet the following criteria:

a. A copy of the raw material Manufacturer's "Certificate of Quality Control Testing" covering each batch of raw material used for pipes purchased under this specification, shall be available for inspection by the Engineer on request.

b. Pipe wall thickness shall be controlled by continuous scanning using ultra-sound or other qualified devices. These devices shall be regularly calibrated for accuracy by certificated agency.

c. Successful test performance and acceptable results for the testing program outlined in this specification.

d. Acceptable results, when tested by the Engineer from samples collected from storage of pipes at the site of works, for tests included in ISO 4427 and summarised in Table 3.1.

Table 2 - Testing Requirements of HDPE Pipe

Sr. No.	Parameter to be Tested	Test Method
1	Mean Outside Diameter (Min. & Max.)	ISO 3126
2	Out-of-Roundness (Ovality)	ISO 3126
3	Wall Thickness (Min. & Max.)	ISO 3126
4	Minimum Required Strength	ISO 12162
5	Density	ISO 1183
6	Hydrostatic Strength at 20 ^{o}C	ISO 1167
7	Elongation at Break	ISO 6259
8	Tensile Strength at Yield	ISO 6259
9	Longitudinal Reversion	ISO 2505
10	Carbon Black Content	ISO 6964
11	Melt Mass Flow Rate	ISO 1133

6.7.5. Defects

When the rejected item is a length or coil of pipe, the lengths or coils manufactured immediately before and after the defective lengths or coils shall be carefully examined. If further defects are found, this is sufficient cause for rejecting the entire batch. This will not apply to local damage that did not occur during manufacture, such as gouges or cuts during handling or transit.

6.7.6. Quality Assurance/Quality Control

A copy of the Manufacturer's QA/QC plan shall be submitted to the Engineer with its quotation for review and concurrence prior to award. If Manufacturer's facility is ISO certified, QA audit requirements shall be waived in favour of ISO 9000 registrar audits, unless the Engineer's trend analysis program indicates areas of concern.

6.8. PIPELINE TESTING

6.8.1. General

The Contractor shall submit for the Engineer's approval details of his proposed methods and programme for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer. Unless otherwise directed by the Engineer, the Contractor shall ensure that no section of pipeline remains untested with pipe trenches and joints left exposed for more than 7 days after laying each pipeline section. The method of achieving this shall be entirely the Contractor's responsibility and no time extension or additional payments whatsoever shall be entertained on account of Contractor's failure to achieve this condition.

The Contractor shall provide all things necessary for carrying out testing and cleaning including potable water, pumps, gauges, pipes, connections, stop- ends and all other temporary works.

Pipelines shall be properly completed and supported before being put under test except as hereinafter detailed.

The Contractor shall provide for transmitting the unsupported end thrusts to solid ground at the ends or into the sides of the trenches.

Before testing any pipeline, the Contractor shall ensure that the anchorage of bends is complete and thrusts from all branch outlets are properly stayed.

No testing will be permitted until seven days after thrust blocks and other holding down works have been completed.

Open ends shall be stopped with plugs, caps, or blank flanges properly jointed and restrained from movement.

No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing of lengths of pipe work for testing, which shall be entirely at the Contractor's expense.

All water required for testing and cleaning the pipelines shall be potable water drawn off at locations approved by the Client and shall be provided by the Contractor at his cost.

In addition to any tests of individual joints or other interim tests which may be specified elsewhere, the Contractor shall submit all parts of the pipelines to a final acceptance test. Notwithstanding the foregoing the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and

workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve successful tests under the Contract.

The Engineer shall have power to require the Contractor to vary any test procedure or pressure as he (the Engineer) thinks fit at no extra cost to the Client.

The Contractor should note that neither the satisfactory testing of pipeline, section of a pipeline or any other pipe work, nor the acceptance of such testing by the Engineer or his representative shall in any way relieve the Contractor of any of his responsibilities and obligations under the Contract.

The Contractor shall notify the Engineer at least 24 hours before hand of his intention to test a section of pipeline having satisfied him in the first instance that the section of pipeline to be tested in the presence of the Engineer is satisfactory in all aspects.

Test gauges used for testing pressure pipelines shall be of conventional circular type of approved manufacturer, not less than 8-inch diameter, calibrated in bars or psi. Before any gauge is used, the Contractor shall arrange for it to be calibrated independently and a dated certificate of its accuracy shall be provided to the Engineer.

One additional gauge as above shall be handed over to the Engineer for purposes of verification during testing.

Calibration of pressure gauges shall be carried out by the Contractor at regular intervals as required by the Engineer.

The Contractor shall remain responsible for the care of the works during testing of the pipe work.

6.8.2. Interim Pipeline Testing

The interim test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth of at least 12-inch above the crown of the pipe but leaving the joints exposed. The sections to be tested shall be approved by the Engineer. The joints between each tested section shall then be left exposed until the pipeline has passed the Final Test on Completion

For purposes of interim testing, the pipeline shall be divided into sections and each section shall be separately tested to the Engineer's satisfaction for deflection and pressure when each section is completed and before the joints are covered in the case of buried pipes.

The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests for each section of pipeline shall indicate the location and capacity of the test pump, test pressure at the pump as well as that at the highest and lowest points procedures for venting the air from the pipeline and disposing the water after satisfactory testing.

Each pipeline or section thereof shall be filled with water and all air removed as far as possible. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled all cocks shall be closed and the test pressure applied. The line shall be filled slowly to prevent possible water hammer. The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the line to facilitate the release of air from the highest point.

The pressure in the pipeline shall then be raised steadily up to and maintained at rated pressure of the pipe (10-bars for PN10 HDPE pipe) for a period of not less than 12 hours to allow for absorption and achieve conditions as stable as possible for testing. The standing period will commence from the time at which the rated pressure (10-bars for PN10 HDPE pipe) was reached successfully, after which all exposed joints shall be carefully inspected for evidence of leakage.

If neither appreciable movement of the pipeline nor any leakage has been observed during the visual inspection the section shall be subjected to the proper pressure test.

Pumping shall then be resumed and the pressure slowly raised to the specified test pressure i.e., 15-bars for PN10 HDPE pipe (1.5-times rated pressure of pipe). The test pressure shall be continuously maintained by the use of the pump for a period of at least 3 hours and the amount of makeup water required to maintain the pressure shall be accurately measured (to the nearest 1/8 litre) regularly every 30 minutes throughout the test.

The pipeline shall be deemed to have passed the test if:

- No water is visible coming out of the pipe or joints at any point
- Leakage is equal to or less than the number of imperial gallons per hour as determined by the following formula:

$$Q = \frac{n \; x \; d \; x \sqrt{p}}{1850}$$

where,

Q = Leakage in imperial gallons per hour

n = Number of joints in test section

d = Nominal diameter of pipe in inches

P = Average test pressure during the test in psi

During all testing, the trench generally and the joint pockets in particular shall be kept clear of water and should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense. Should a test fail, the Contractor shall at his own expense replace defective pipes or

fittings or make good leaking joints or otherwise rectify defective work. Cleaning, inspection and testing shall then be repeated until the work is to the Engineer's satisfaction and at no extra cost to the Client.

The length of the section of pipeline to be tested shall not normally exceed 1,500 feet or as directed by the Engineer.

A simple stop end consists of a section of steel pipe about 1.5-3.0 feet long onto which a closing plate has been welded, containing the necessary opening for accommodating ingoing water and out-coming air. The stop end may also include an opening through which the test water may be pumped from the line, if necessary. The stop end may be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer. Thrust blocks or temporary anchorages shall be provided to

hold the stop end in place against the test pressure. The Contractor may also use propriety restrained joints in lieu of thrust blocks.

6.8.3. Final Acceptance Testing

The final acceptance test shall be carried out after all lengths have been joined together on completion of construction and interim tests have been carried out satisfactorily on the entire length of the pipeline.

Final pipeline acceptance procedures shall be as prescribed above for interim pipeline testing. The Contractor shall repair the pipeline if it fails to pass this test. The test shall be repeated and repairs affected until the pipe line passes the test.

6.8.4. Valves

Valves and all pipeline appurtenances shall be hydraulically tested together with the pipeline in which they are installed. Valves shall be tested for operation under working pressure and shall be adjusted so that they operate smoothly, seat properly and are installed to tolerances recommended by the manufacturer.

Before pressure testing is started the Contractor shall re-check pipes and valves for cleanliness and shall re-check the operation of all valves. The "open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges all anchor and thrust blocks shall have been completed and all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened.

6.9. PIPELINE DISINFECTION

6.9.1. General

Pipelines shall be disinfected after they have been thoroughly cleaned and at the time the pipeline final acceptance testing is satisfactorily completed.

6.9.2. Disinfection of Pipelines

All potable water pipe, fittings, valves, meters and appurtenances shall be disinfected by the Contractor as specified herein.

All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing will be performed at a laboratory approved by the Client the cost of which shall be borne by the Contractor.

The attention of the Contractor is directed to the requirements of these Specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipe work. The Contractor shall take extreme care to keep the interior of the pipe work free of dirt and other foreign material. If in the opinion of the Engineer, direct or other foreign material enters the pipe work, which will not be removed by flushing, then the Contractor shall clean and swab the interior of the pipe work with a five percent hypochlorite disinfecting solution to the satisfaction of the Engineer.

After testing and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:

- All mains shall be flushed out with clean water until there is no evidence of foreign matter or colour in the waste flushing water.
- A stock disinfecting solution shall be prepared by mixing for not less than 5 minutes, in a clean container, Sodium Hypochlorite solution (15 percent available chlorine) and distilled water in the proportion of 0.8 litres to 1000 litres of water by volume. After mixing, the solution shall stand for a further 5 minutes after which the clear supernatant liquid shall be decanted into another clean container. Stock solutions shall be made up fresh daily.
- The main to be disinfected shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing
  - 50-70 mg/l free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full.
  - Every main charged with disinfection solution shall stand for 24 hours.
  - A sample shall then be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 mg/l free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out and filled with potable water and allowed to stand for 1 hour.
  - Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 4 mg/l free chlorine the main shall be flushed out again. If the bacteriological

analysis is unsatisfactory, disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned.

- The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines.

6.9.3. Cleaning of Pipe work

All pipe work shall be cleaned by the Contractor after all pressure tests and disinfection operations have been performed and accepted by the Engineer. However, it is the responsibility of the Contractor to prevent all dirt and foreign mater from entering the pipe work and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute.

All potable water required for testing, flushing and disinfection of pipelines shall be provided by the Contractor at his own expense.

6.9.4. Disposal of Water Used for Testing, Disinfection and Cleaning

The Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities, structures or property. These means shall be subject to the approval of the Engineer and local authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfection, flushing and wastewater disposal operations.

6.10. PACKING, MARKING AND VENDOR DOCUMENTATION

6.10.1. Pipe Identification and Packing

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

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

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

The word "water" shall also be included if the pipe is intended for potable water. The maximum quantity of pipe to have the same coil/length number is one silo (coiled pipe) or one bundle (straight lengths). The maximum combined length of pipe in the silo or

bundle with the same coil/length number shall not exceed the maximum allowable coil length as specified,

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

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

6.10.2. Packaging and Transportation

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

a. Delivery

Delivery of the plastic pipes and fittings to site, shall be no later than six months after the stamped manufacture date.

b. Weathering

A certificate from the pipe/fitting manufacturers shall be provided, confirming that the products may be stored in the open for minimum of 2 years without any adverse effect.

c. Tie-downs

Tie-downs shall be at least 100 mm (4.0 inch) wide and be clean and free from sand, gravel and other such materials. For straight length pipe (up to 12 m (39 ft), a minimum of 6 tie-downs are required.

d. Pallets

The pallets shall be suitable for transporting the material from the place of manufacture to the designated receiving location without causing any damage to the pipe. The pallets shall not contain any broken planks or extremities that may damage the coiled pipe or straight lengths. They shall be durable enough to prevent loose pallet nails from gouging the bottom coil/straight length.

e. Overhang

Pipe shall not overhang at either end of the trailer.

f. Stacking

The Contractor/Manufacturer shall not ship small coils stacked inside silos of larger coils. Frames manufactured for the containment of straight lengths of polyethylene pipe during transport and storage shall not contain nails or other fastening devices that may damage the pipe.

g. Trucking

Where pipes are transported by vehicles, the vehicles should have a flat bed and be free from sharp edges or projections. During transport, polyethylene pipes shall be protected from diesel fumes and be continuously supported to prevent movement between the material and its support.

h. Silos

Silo packs of coiled pipes shall be squarely stacked and well supported on pallets. Coils shall not overhang the pallets and, shall not be stacked higher than 2.3 m (8.0 ft)

6.11. STORAGE OF PIPES AND APPURTENANCES

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

- Jointing materials and operational gear shall be stored under cover. Pipes may be stored in the open, but shall be placed on adequate timber bearers to prevent damage to sheathing or sockets. Pipes not delivered on manufacturers' pallets may be stacked one above the other up to three pipes high provided suitable protective packing is placed between them. If any pipes or fittings show signs of corrosions or deterioration during storage either they shall immediately be treated at no extra charge by the Contractor to arrest and prevent the corrosion or removed from site as the Engineer directs.
- The Contractor shall properly stack the pipes in his storage area and the stacks shall be laid out in a regular pattern and the limits of each stack marked so that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal of pipes is facilitated.
- The number of tiers of HDPE pressure pipe stacks shall be as per the Manufacturer's instructions and approval of the Engineer. Each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300mm. The pipes shall be stacked parallel to each other.
- The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.
- The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.
- Where the pipes are to be delivered and stacked by the Contractor on sites along the pipeline route, the areas where the pipes are to
- be stacked shall, if required, be graded flat by the Contractor at his own expense to provide a firm and even surface and shall be kept free from loose stones, rubble or waste liable to damage the pipes.
- Jointing materials, valves, fittings and specials, meters, gauges and polyethylene sheeting shall be stored in covered storage areas until required for installation.

- Pipe shall be removed from storage and directly distributed to their point of installation only in such quantities as can be installed in one week.

6.12. MEASUREMENT AND PAYMENT

6.12.1. Measurement

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

6.13. PAYMENT

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

7. PIPELINE APPURTENANCES

7.1. SCOPE OF WORK

The work included in this section consists of providing, laying, jointing, cleaning, disinfection, testing and commissioning of pipelines appurtenances for water supply. The Contractor shall provide all labour, materials and equipment necessary including removing from storage, transporting to sites, excavation, backfilling and compaction, laying, jointing and testing, disposal of excess excavated materials and removal of surplus pipes, fittings, valves and jointing materials. The responsibility for the safety and soundness of all material shall rest with the Contractor.

The Contractor is advised to carry out any tests at his cost needed to satisfy himself regarding the soundness of the valves, appurtenances and jointing materials including the pipeline installation before acceptance for testing by the Engineer.

7.2. Valves – General

7.2.1. General Requirements

Shop Drawings: The CONTRACTOR shall furnish shop drawings of all items and accessories in accordance with the General Requirements. Shop drawings shall include detailed design calculations stamped by a registered engineer, bill of materials listing all valve components, materials, tools, supplies, fittings, and appurtenances, etc., with manufacturer's name, trade and identification marks.

All manufactured items provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products; such manufacturers shall have had previous experience in such manufacture and shall, upon request of the ENGINEER, furnish the names of not less than 5 successful installations of its equipment of comparable nature to that offered under this contract.

All combinations of manufactured equipment which are provided under these Specifications shall be entirely compatible, and the CONTRACTOR and the listed manufacturer shall be responsible for the compatible and successful operation of the various components of the units con- forming to specified requirements. All necessary mountings and appurtenances shall be included.

All materials employed in the manufacture and installation of the valves shall be suitable for the intended application; material shall be high-grade, standard commercial quality, free from all defects and avoid imperfection that might affect the serviceability of the product.

Wetted parts of all valves shall be selected by the manufacturer to ensure optimum, corrosion-free, and erosion-free operation for the fluid involved.

Data Requirements: The drawings and data submitted shall include the following:

a. Name of manufacturer.
b. Dimensions of Valve.
c. Data sheet for pressure test.
d. Equipment weights.
e. All materials of construction listed and applied coating.

Sufficient valves must be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500 foot intervals in commercial districts and at not more than one block or 800 foot intervals in other districts.

Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile.

All valve and equipment shall be of the highest quality from an approved manufacturers and shall confirm in all respect to standard specifications referred to in this contract.

The technical and production capability of the manufacturer shall be provided with documentary evidence that the valves and sluice gates offered have been in production in for at least 20 years. The minimum numbers of these type of valves and sluice have been sold in South Asia , Especially in Pakistan.

Previous approvals of manufacturer from consultants and water authorities shall be provided.

No of units sold on water supply projects and have been in operation satisfactory for al least 10 years.

The manufacturer should have certified quality control produces in accordance with ISO 9000/9001/9002 and 1400, as appropriate and the contractor should submit evidence and get approval prior to placing of order to manufacturer of their distributor.

The valve parts shall be so designed that they may be easily replaced and shall be constructed of wear resistant materials.

Flanges on valves are to be full faced and drilled in accordance with B.S 4504 PN-10 and shall be compatible with flanges of meter, fittings and pipes provided for this contract.

Valves shall open by counter clockwise rotations of wheels.

All valves and equipment shall be pressure tested in accordance with the appropriate British Standard/ and test report provided.

All valves shall be fitted with opening wheels. All valves and other equipment shall be providing with required accessories and Jointing materials, including nuts, bolts gaskets etc, as per site requirement.

7.2.2. General Installation Requirements

General: Valves shall be installed in accordance with procedures submitted with the contractor approved shop drawings and as shown, unless otherwise acceptable to the ENGINEER.

Alignment: Equipment shall be field tested to verify proper alignment, operation as specified, and freedom from binding, scraping, or other defects. Equipment shall be secure in position and neat in appearance.

7.2.3. Testing and Commissioning

Each valve shall be test in presence of Engineer according to the manufacture pressure rating. Any kind of leakage from the valve is not acceptable. The valve shall be operate, by the Contractor, to demonstrate, to the satisfaction of the Engineer, that it is working, satisfactorily, in accordance with the specifications.

7.2.4. Measurement

Measurement for valve of specified type, materials, characteristics and dimensions will be made in the number of these items, acceptably installed, in accordance with the approved Drawings or directions of the Engineer

7.2.5. GATE VALVE

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

Specific clauses of BS 5150 are amplified as follows:

S. No.	Parameter	Details
1	Clause 3: Types of Valves	Solid wedge with non-rising stem
2	Clause 4: Nominal Sizes	All valves shall be of flanged end with sizes as specified on the Drawings
3	Clause 5: Nominal Pressure	PN 16 unless otherwise specified on the Drawings
4	Clause 9: Body Tapping	As specified to BS 21 (1S0 /R7) fitted with bronze or gunmetal plug
5	Clause14: Operation	Gate valves shall be provided with cast iron hand wheels or square heads for tee key operation as required. The direction of operation shall be clockwise to close the valve. Hand wheels shall require a force not greater than 20 kg on the outer rim to operate with a balanced pressure across the valve. Tee keys shall require a force not greater than 12 kg applied at the opposite ends of a standard key from the closed position.
6	Clause 19: Test Certificates	The Contractor shall provide a test certificate confirming that the valves have been tested in accordance with BS 5150

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

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

7.3. CHECK VALVE

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

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

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

Swing Check Closure is affected by gravity (Weight of disc) and reverse flow. The pivot point of the swing check is outside the periphery of the disc and the greater the head, the greater the possibility that the fluid will flow back through the valve before the disc can be shut off. To effect complete shut off, the disc of a swing check valve must travel through a 700 to 900 arc to the valve seat. Without resistance to slow the disc's downward thrust and reverse flow, the shut off can result in slamming and damaging water hammer.

7.4. AIR-RELEASE VALVE

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

a. Discharge air during charging of the pipeline.

b. Admit air during emptying of the pipeline or when the pipe in pressure falls below atmospheric pressure during a surge event.

c. Discharge air accumulated at local peaks along operating conditions the pipeline under normal Conditions ‘a’ and ‘b’ shall be met by the employment of a large orifice capable of handling large volumes of air at a high flow rate and condition ‘c’ by a small orifice capable of discharging small quantities of air as it accumulates. Valves with air intakes or exhaust facilities shall have approved screening arrangements to prevent the ingress of air borne sand.

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

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

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

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

7.5. VALVE CHAMBERS

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

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

7.6. VALVE BOX

Valve boxes shall be provided for all valves which are installed below ground level in conformance with the details shown in the Drawings. Valve boxes shall be of the heavy-duty type capable of withstanding a ten-ton load when located within carriageways. Ordinary valve boxes shall be used in other locations. All valve boxes shall be of the lockable type. They shall be installed on concrete bases as shown in the Drawings.

7.7. APPROVAL OF MATERIALS AND EQUIPMENT

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

7.8. TESTS AND ACCEPTANCE

All valves, fittings and accessories delivered to the job site shall be accompanied by test reports certifying that the valves, couplings and/or fittings and accessories conform to the relevant specifications.

The Contractor shall take the necessary measures to allow the Engineer to be present during the tests at the factory, if the Engineer finds it necessary to do so. Failure to present the aforementioned certificate, or to inform of the date and time of the factory tests, shall constitute grounds for rejection of the valves, fittings or couplings that do not comply with these conditions.

Acceptance of such material shall only be possible if the rejected batch of valves, fittings and joints is tested under the Engineer's supervision, at the Contractor's expense, and only those passing the tests shall be accepted.

In addition, the right shall be reserved for the Engineer to subject any consignment of valves, fittings and couplings to any or all of the tests, over and above the tests conducted by the manufacturer. The Contractor shall furnish all labour, material and equipment necessary to assist in performing the tests and inspecting the valves, fittings and couplings.

7.9. MEASUREMENT AND PAYMENT

7.9.1. Measurement

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

7.9.2. Payment

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

8. PIPE BEDDING

8.1. SCOPE OF WORK

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 bedding under water lines, drain pipes and other structures as a separate item of payment.

8.2. PURITY AND STACKING

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

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

8.3. PLACING OF BEDDING MATERIAL

The material for bedding shall be placed to the specified thickness and compacted by rammers of approved weight. The compaction level shall not be less than 95% of modified dry density as determined by AASHTO T-180.

8.4. MEASUREMENT AND PAYMENT

8.4.1. Measurement

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

8.4.2. Payment

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

9. WATER SUPPLY SERVICE CONNECTIONS

9.1. SCOPE OF WORK

Work under this section consists of furnishing all material, plant, machinery, labour and performing all functions and operations in connection with the execution of service connections for water supply, in strict accordance with the Drawings and applicable specifications and as directed by the Engineer.

9.2. MATERIAL REQUIREMENTS

The earth work shall be performed as per requirements of section-2 earth work for water lines

Service connection pipe shall be of HDPE of diameter as shown on the Drawings. Whereas, Clamp Saddle shall of Polypropylene with built-in rubber washer. Fittings and specials shall be as recommended by the manufacturer of the pipe and as approved by the Engineer. The plugging of the end will be part of the item.

9.3. CONSTRUCTION REQUIREMENTS

Service connection shall be executed as per Drawings or as indicated by the Engineer. Connection arrangement shall be as per requirements/recommendations of the manufacturer of the pipe and as directed by the Engineer. Service pipe shall be connected with the pipe running either in front of the individual plot or from other side of the road. Service end of the pipe shall be duly plugged.

9.4. MEASUREMENT AND PAYMENT

9.4.1. Measurement

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

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

9.4.2. Payment

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

PART-C SEWER NETWORK

EARTH WORK FOR SEWERS

9.5. SCOPE OF WORK

The work shall consist of furnishing all materials, equipment and labour for excavation, trenching and backfilling for sewers, drainage facilities, structures and all other appurtenances of sewage collection system, in accordance with Drawings to proper line and grade and refilling the trenches and dressing them to proper surface.

9.6. CLEANING AND GRUBBING

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

9.7. EXCAVATION

9.7.1. General

The Contractor shall do all excavation of whatever substance encountered to the depth shown on the Drawings or as otherwise specified. Excavation shall include without classification the removal and disposal of all materials of whatever nature that would interfere with the proper construction and completion of the work and shall include the furnishing, placing and maintenance of supports for the sides of the excavations. The work shall also include all pumping, ditching, dewatering and other measures required for the removal and exclusion of water. During excavation, material suitable for backfilling shall be stock-piled in an orderly manner at a sufficient distance from the bank of the excavation to avoid over-loading and to prevent sides from caving. Top soil should be stock-piled separately for subsequent reuse as necessary. All excavated material unsuitable or not required for backfilling shall be removed and disposed of at a location approved by the Engineer.

For contract purposes hereunder, the earth excavation work has been classified into two categories, earth excavation in trenches, and earth excavation for structures.

9.7.2. Earth Excavation in Trenches

Except as otherwise provided herein, excavation for a sewer line shall be open cut trenches with vertical side and not more than 200 feet of any trench in advance of the end of the built sewer shall be opened at any time and unless written permission to the Contractor is given by the Engineer. The trench shall be excavated to its full depth for a distance permitted for the sewer to be laid. Trenches for sewer-lines and appurtenances shall be to the lines and grades shown on the drawing or as ordered in writing by the Engineer as necessary for the proper completion of the work. Bell holes and depressions for joints shall be dug after the trench bottom has been graded. The pipe except for joints shall rest on the prepared bottom for its full length. Bell holes and depressions shall be only of such length, depth and width as required for properly making the particular type of joint. Stones shall be removed to avoid point bearing.

Where the bottom of the excavation is in material which, in the judgment of the Engineer by reason of its hardness cannot be excavated to provide a uniform bearing for the pipe, said material shall be removed to minimum of

6" below the grade of the bottom of the pipe, and the trench backfilled to the required pipe sub grade with sand or other material acceptable to the required depth or with concrete Class-E, if so ordered. In no case material removed from such excavations shall be used as backfill material unless approved by the Engineer. All instructions shall be in writing by the Engineer.

9.7.3. Earth Excavation for Structures

All earth excavation under this Contract, which is not included under the classification of “Earth Excavation in Trenches " shall be classified and paid for as earth excavation for structures.

The Contractor shall provide adequate timbering or shoring for excavations. Should the sides and ends of any excavations give way the contractor shall, at no extra cost, remove all disturbed ground. Any excavation carried outside the limits shown on Drawings and specified herein as the payment limits, shall not be treated as excavation and shall not be paid for.

When foundation level is reached, the Engineer's Representative will inspect the exposed ground and give directions as to what further excavation, if any, he considers necessary. The excavation should be done in such a manner, as to ensure that the work rests on a solid and perfectly clean foundation. If the Contractor allows any portion of such foundations to deteriorate due to exposure, he shall make good the foundation to the satisfaction of the Engineer without extra cost.

9.8. ALIGNMENT AND GRADE

The sewers are to be laid to the alignment and gradient shown on the Drawings, but subject to such modifications as shall be ordered by the Engineer from time to time to meet the requirements of the work. No deviations from the lines, depths of cutting or gradients of the sewers shown on the Drawings and sections shall be permitted except by express directions in writing of the Engineer.

9.9. SETTING OUT SIGHT RAILS

The sewer shall be constructed and laid to a true grade and in straight lines between curves as shown on the plan. The sewer shall be laid andconstructed to their proper levels with the aid of suitable boning rods and sight rails which shall be fixed according to the requirements of the Engineer at intervals not exceeding 40 feet, and also by levelling along the invert with levelling instrument. The sight rails and boning rods shall be provided, fixed and maintained by the Contractor who shall also provide and maintain suitable levelling instruments and equipment and shall set the positions and levels of the sewers and other work according to the Drawings and any instructions which he may receive from the Engineer. All sight rails and posts shall be well seasoned deodar timber of ample size and strength. The rails and boning rods shall

be suitably and accurately planned and no warped or otherwise defective or damaged sight rails or boning rods shall be used. Sight rails shall be secured to the posts by strong steel clamps to the approval of the Engineer and in such a manner that they shall be fixed as immovable, in relation to the correct lines and levels. All boning rods and sight rails shall have the centre line accurately marked thereon, by a fine saw cut and shall be painted black and white to the requirements of the Engineer. All boning rods shall suitably be shooed with iron. At least four separate sight rails shall always be maintained in correct level and alignment along the line of sewer at every place where construction work is proceeding and the alignment and level of the sight rails shall be checked by the level and line at least twice every day to ensure that no disturbance or interference of the alignment and level have taken place. Whenever required the Contractor shall erect and maintain such additional sight rails as the Engineer shall direct. The Contractor shall, at all times, see that his workmen or other unauthorized persons are not allowed, accidentally or otherwise, to tamper or interfere with sight rails or other alignment or level marks.

All bends and curves shall be set out mathematically in a manner to be approved by the Engineer and the Contractor shall provide and maintain for the purpose such additional sight rail posts and other wrought and rough timber work, steel wire and other articles as the Engineer shall require from time to time.

9.10. SHEETING AND BRACING

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

9.11. DEWATERING OF TRENCHES

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

Necessary precautions against water flooding shall be taken.

9.12. MAINTENANCE OF EXCAVATIONS

All excavation made hereunder shall be properly maintained while these are open and exposed. The Contractor shall provide warning lights, signs and similar items sufficient suitable barricades. The Contractor shall be responsible for any personal injury or property damage due to his negligence.

9.13. PROTECTION OF EXISTING FACILITIES

The Contractor shall take special care of existing sub-surface facilities likely to be encountered during the excavation for their protection, such as sewers, drain pipes, water mains electric cables, communication cables and the foundations of adjacent structures. The Contractor shall be responsible for any damage to any such facility and shall repair the same at his expense whether or not the facility has been shown on the drawing.

9.14. DISPOSAL OF SURPLUS EXCAVATED MATERIAL

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

9.15. BACKFILLING

9.15.1. General

After the completion of sewer line, drainage facilities foundations, walls and other structures below the elevation of the final grade all voids shall be backfilled with suitable materials specified below.

9.15.2. Backfilling for Structures

Backfilling operations for structures shall be performed as part of the Contractor's work under the payment items for earth excavation and at no extra cost. Backfill material for foundations, walls and other structures shall consist of excavated soil, which is free from stones and hard clods not larger than 3 inch in any dimension, and also free from trash, lumber and other debris. Backfill material shall have enough moisture for proper compaction and shall be compacted in an approved manner to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesion less soils. Backfill shall not be placed against foundation walls earlier than 4 days after placing of concrete or brick masonry.

9.15.3. Backfilling for Trenches

After the sewers have been constructed and tested as specified and to the satisfaction of the Engineer, the trench shall be backfilled. Utmost care shall be taken in doing this so that no damage shall be caused to the sewer and other underground utilities. After this has been laid the trench and other excavation shall be backfilled carefully in

150mm layers with earth as approved by the Engineer, each layer being watered to assist in the compaction unless the Engineer shall otherwise direct.

9.16. MAXIMUM DENSITY DETERMINATION FOR COMPACTED SOIL

The maximum density of the soil shall be determined in accordance with the latest revision of “American Society for Testing Materials (ASTM) Standard D 1557 Density Relations of Soils, using 6.8 kg Rammer and 450mm Drop".

9.17. TESTING DENSITY OF SOIL

The Engineer will make tests using the calibrated sand cone method/core cutter method to determine the density of soil in place in accordance with ASTM Designation D 2558, latest revision. If soil in place fails to meet the specified degree of compaction the areas represented by the failing tests shall be re-excavated and compacted to the specified density in the manner directed by the Engineer at no extra cost.

9.18. TOP SOIL

Top soil, which has been stock-piled during excavation, shall be used for the top 150mm of backfill, in locations as ordered by the Engineer. Top soil shall be saturated with water and after it has dried, shall be spread to the required final grade and of required density. The work shall be performed at no extra cost.

9.19. PROXIMITY TO BUILDINGS

Where buildings in the opinion of the Engineer near excavation are likely to be affected, the Contractor shall provide shoring to protect such buildings in addition to timbering of trenches. The Contractor shall be required to leave timbering inside trenches if so required by the Engineer for protection of these buildings at no extra cost.

9.20. LENGTH OF TRENCHES IN ADVANCE OF CONSTRUCTION

Unless otherwise directed in writing by the Engineer of the work not more than 200 ft in advance of constructed or laid sewer shall be left open at any time.

9.21. DISPOSAL OF FILTH AND GARBAGE

No night-soil, filth and garbage met with during the excavation shall be allowed to be deposited on side of road/street so as to cause nuisance or obstruction to traffic. The same shall be disposed of by the Contractor to a place to the satisfaction of the Engineer.

9.22. DISPOSAL OF SURPLUS EARTH

The Contractor shall dispose of all surplus excavated materials not required to be used on the work. This shall include surplus earth after refilling and compaction.

9.22.1. TUNNELING

9.22.2. Formation of Soil

Tunnelling shall only be permitted in strong hard and homogenous, clay formations, which are not likely to collapse under normal working conditions. The work shall not

be permitted in running sand. In weaker formations such as mixture of clay and sand, which are liable to collapse when exposed to atmosphere, the roof shall be protected by adequate timbering and shoring. If the tunnel is subject to any sort of traffic, it shall be provided with adequate timbering and shoring for its roof and walls.

9.22.3. Length of Tunnel

Normally the length of tunnel without adequate support shall not exceed 3 feet. This length shall, however, be exceeded under the directions of the Engineer, where depth of tunnel below ground level is considerable to avoid any danger of collapse. The tunnel, however, shall be driven in longer length up to 150 feet, if drive casing is provided as the tunnel is being excavated.

9.22.4. Horizontal Boring Machines

When considered necessary by the Engineer, horizontal boring machines shall be employed for crossing sewers underneath highways and canals. Whenever such machinery is used, drive casing of steel pipes shall be driven to avoid any collapse of the tunnel.

9.22.5. Backfilling of Tunnels

Backfilling of tunnels shall be done with clean river sand through bore holes duly lined with casing pipes, to be provided in the roof of the tunnel at suitable locations as per directions of the Engineer. The backfilling shall be made after the construction inside has been duly completed as per directions of Engineer.

9.23. MEASUREMENT AND PAYMENT

9.23.1. Measurement

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

9.23.2. Payment

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

10. REINFORCED CEMENT CONCRETE PIPE SEWERS

10.1. SCOPE OF WORK

The work shall consist of furnishing all pipes, plant, labour, equipment, appliances and materials and in performing all operations required for installing and testing the sewer pipes of reinforced cement concrete in strict accordance with the specifications of this section and the applicable drawing and subject to the terms and conditions of the contract.

10.2. REINFORCED CEMENT CONCRETE PIPES

10.2.1. General

All reinforced concrete pipes furnished and installed under this contract shall conform to ASTM C76 “Reinforced Concrete Culvert, Storm Drain and Sewer Pipe “and as per provisions of these technical specifications, using structural steel reinforcement. Sulphate Resistance Cement shall be used for sewers.

10.2.2. 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 Drawings and designated in Bill of Quantities of the Bidding Documents.

The strength classes shall be identified as one or more of the following:

- Class-I
- Class-II
- Class-III
- Class-IV
- Class-V

The design requirements for these five classes of reinforced cement concrete pipe shall be as described in ASTM C76-2003, or its latest version, Tables I through V for the respective strength classes. Unless otherwise called for in other parts of these Bidding Documents or applicable variation order, 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 ASTM C76-2003, or its latest version.

10.2.3. Basis of Acceptance

RCC pipes shall be used conforming to ASTM C76-2003, or its latest version, Class III, Wall "B" and acceptance of same shall be determined on the basis of following test results:

a. Concrete Compressive strength

i) Compressive strength of concrete used for the fabrication of the RCC pipe shall be minimum 4000 psi;

ii) Compression test determining concrete compression strength may be made on concrete cylinder compacted and cured as pipe; and

iii) All type pertaining information for conducting the compressive test is given in the specification ASTM C76-2003, or its latest version, which should be followed.

b. Inspection

i) Whether the required quantity or steel reinforcement is provided and placed for the fabrication of RCC pipe as required by the Specification; and

ii) Manufactured pipe for visual defects and imperfection such as diameter, wall thickness, length of pipe and smoothness of the inner/outer surface of the pipe.

c. Three Edge Bearing Test

i) The three-edge bearing test shall be conducted as required by ASTM C76-2003, or its latest version; and

ii) Test load expressed in pounds-force per linear foot per foot of diameter to produce a 0.01-inch crack. The dead load to produce 0.01-inch crack as desired by the ASTM C76-2003, or its latest version shall be 1000 lbs force per linear foot per foot of diameter.

d. Crushing Load Test

i) The crushing load test on the manufactured pipe shall be conducted in compliance with ASTM C76-2003, or its latest version; and

ii) Test load as desired by the specification shall ne 1,500 lbs force per linear foot per foot of diameter.

e. Marking

The following information shall be marked on each pipe:

i) Pipe class and specification designation;

ii) Name or trade mark of the manufacturer; and

iii) Identification of plants.

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 manufacture of the pipes at the factory shall be watched and tested by the authorized representative of the Engineer

10.2.4. Materials

All materials used in the manufacture of reinforced cement concrete pipes for use under this contract shall conform to ASTM C76-2003, or its latest version, and also with the following specifications:

a. Cement

The 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 ASTM Designation C-150 latest revision.

b. Aggregate

The course/fine aggregate to be used in the manufacture of concrete pipes to be furnished and installed under this contract shall be generally in accordance with the provisions of section of these specifications.

c. Steel Reinforcement

The material will conform to the specifications contained in relevant Section of these specifications.

10.2.5. Mixing of Concrete

The proper types and amounts of Portland cement, mineral aggregates and water shall be thoroughly mixed in an approved type of mechanical batch mixer which shall be kept in first class condition. Admixtures in the concrete will not be permitted.

10.2.6. Pipe Dimensions

The internal diameters and wall thickness of reinforced concrete pipes under this contract shall be as set forth in ASTM C76-2003, or its latest version, in Tables I through V for “Wall B" pipe as required and shown on the Drawings.

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. 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.

10.2.7. 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.

10.3. CERTIFIED PLANS AND DATA SHEETS

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.

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 ASTM C76-2003, or its latest version, and C-14 have been met.

10.4. JOINTS FOR CONCRETE PIPE

10.5. SEWERS

10.5.1. General

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

10.6. Rubber Gasket Joints

Rubber gasket joints shall be used for either tongue and groove or bell & spigot pipes.

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.

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.

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 centre of the groove. 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.

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 9 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.

10.7. INSTALLATION OF CONCRETE PIPE SEWERS

10.7.1. Handling of Pipes

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. 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.

10.7.2. 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.

10.7.3. Trench Bedding

Wherever called for on the Drawings 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.

The concrete encasement shall be placed in accordance with the details and notations on the Drawings or as ordered in writing. Concrete work shall be as specified in 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 or as called for in applicable variation orders.

10.7.4. Laying of Sewers

Neither any sewer pipe nor the bedding shall be laid or placed till the alignment of the sewer and its levels nor have gradients been carefully checked and tested with the trench excavation and found correct.

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. 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. As shown on Drawings, the bottom of the trench must be shaped to fit the pipe barrel, with holes left for the bells. 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.

The concrete pipe joints shall be of the types designated above and shall be made in accordance with the aforesaid specifications.

When laying is not in progress, the open pipe shall be closed with a tapered wooden plug to keep out foreign matter.

10.7.5. Pavement Restoration

The contractor shall restore paved surfaces which have been cut under this contract, as part of the work under the excavation items and at no extra cost to the Owner.

10.8. TESTS FOR INFILTRATION OR EXFILTRATION

10.8.1. General

All pipes built under this contract shall be tested for infiltration or exfiltration as specified below. The Contractor shall furnish labour, materials and equipment required for making the tests with no extra compensation over and above the agreed contract price 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.

10.8.2. Infiltration Tests

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. The duration of the tests shall be only long enough to establish the true rate of infiltration. The amount of leakage over a 24 hours period will then be calculated from the result of the measured true rate of infiltration.

10.8.3. 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:

a. 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.

b. The duration of the exfiltration test shall be one hour after the filling with water has been completed.

c. Determination of the amount of exfiltration shall be made by measuring the total loss of volume of water in the manholes.

d. The amount of exfiltration over a 24 hours period will then be calculated from the measured loss of volume during the test observation period.

10.8.4. Allowable Infiltration or Exfiltration

The calculated amount of infiltration or exfiltration over a 24 hours period shall not exceed 75 litre 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 24 hours period.

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.

10.9. MEASUREMENT AND PAYMENT

10.9.1. Measurement

Measurement for reinforced cement concrete pipes shall be made for the actual quantity of the work done in linear metre or linear feet (whichever is included in Bill of Quantities) of different sizes and strength installed tested and approved as authorized for payment under the Contract. The measurement will be made along the centre line of the pipe and between the inside walls of manholes or junction chambers.

10.9.2. Payment

The unit rate quoted in the Bill of Quantities for supplying, laying and jointing cement concrete sewer pipes, will be considered full compensation for the cost of pipes, charges for their carriage to site and testing before and after laying, labour charges for laying, jointing, etc. and cost of all incidentals for completion of this item of work as per specifications laid down in this section. Payment for this item of work shall be made at the unit rate(s) quoted in the Bill of Quantities for various internal diameters of pipes.

11. CONSTRUCTION OF MANHOLES

11.1. SCOPE OF WORK

The work consists of constructing manholes (including connection chamber) for sewerage 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, complete in all respects.

11.2. MATERIALS

Brick masonry, Portland cement 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 BS 1247.

11.3. CONSTRUCTION REQUIREMENTS

Manholes shall be constructed with brick masonry of specified wall thickness laid in specified cement sand mortar, built on concrete slab. The cover shall be 1:2:4 reinforced cement concrete, fitted with Mild Steel angle frame which shall have reinforced cement concrete cover as shown in the Drawings. The outside of the walls shall be plastered with specified cement sand mortar, painted with two coats of bitumen. At the bottom of manholes for sewers, a proper channel as per Drawings, 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.

Malleable iron steps shall be installed inside the manhole, during the construction of the manhole walls. Cutting holes into the wall for the steps after construction will not be permitted. Top rung shall be 18" below the manhole cover and the lowest not more than 12" above the benching (floor).

11.4. MEASUREMENT AND PAYMENT

11.4.1. Measurement

Measurement shall be made for the actual number of manholes of the appropriate type constructed at site as per Drawings and specifications laid down in this section and to the approval of the Engineer. The depth / height of manhole for the purposes of measurement and payment shall be difference of level between the top of manhole (top of cover) and invert level of manhole.

11.4.2. Payment

The unit rate quoted in the Bill of Quantities for the construction of manhole shall be considered full compensation to cover the cost of all materials including form work for concrete, excavations, brick masonry, steps, frame and concrete cover, and connecting pipe with the manhole, and all labour including curing, plastering, benching and bitumen painting etc. and all incidentals to completely construct them at site as per Drawings and specifications laid down in this section.

Payment shall be made for the actual number of manholes constructed and counted as above, at the appropriate rate quoted in the Bill of Quantities.

12. PIPE BEDDING

12.1. SCOPE OF WORK

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 gravel/crushed stone bedding under sewer lines, drain pipes and other structures as a separate item of payment.

12.2. SOURCE OF BEDDING MATERIAL

Sand and gravel/crushed stone bedding material shall be from a source and of specifications approved by the Engineer.

12.3. PURITY AND STACKING

The sand and gravel/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 admixture of deleterious materials mentioned herein. The sand shall have clay/silt contents not more than 5%.

12.4. PLACING OF BEDDING MATERIAL

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

12.5. MEASUREMENT AND PAYMENT

12.5.1. Measurement

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

12.5.2. Payment

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

PART-D TUBE WELL

13. Construction of Tube-Wells

13.1. Scope

The work covered shall consist of well drilling, installation of components, shrouding, development and testing including all plant, labour, equipment & other miscellaneous works necessary for the satisfactory completion of the tube-well as specified and approved by The Engineer/ Engineer-in-Charge.

Before proceeding with the work, the Contractor shall submit a complete work plan for performing the work. This will include but not limited to manpower, Plant and equipment and schedule of performance for completion of work.

The Contractor shall employ at site a fulltime competent Supervision staff for overall supervision of the work.

13.2. DESCRIPTION

The tube well of indicated capacity is to be drilled by direct rotary or reverse rotary method. Total depth of borehole shall vary depending upon the material encountered. An accurate drilling log of the tube well is to be made, and samples of the materials encountered through which the tube well is drilled are to be preserved and handed over to the Engineer.

Upon completion of drilling, blind and slotted tube well casing sections, of specified material, diameter and length are to be placed in the tube well, mild steel pump housing casing of required diameter and length is then to be connected to the tube well casing by means of a tapered reducer and installed in the tube well.

After installation of the pump housing and tube well casing, the tube well is to be shrouded (packed and grouted) with selected gravel of specified quality, sizes and gradation and specified cement grout after which it is to be developed and tested until it will efficiently produce clear water at a pumping rate of 50% higher than the designed capacity. After the tube well has been satisfactorily developed and tested, pump house of the specified design is to be constructed. The tube well is to be equipped with a vertical turbine pump connected to a vertical hollow shaft, electric motor. All motor control and necessary electrical equipment are to be installed, placed in operating condition and tested to demonstrate that the entire installation meets the requirements of the contract documents. A chlorinator and other equipment are to be installed with the tube well as specified.

The connection of electrical equipment to the power main shall be by others, testing of the installed equipment is however, part of this contract. Construction of facilities to convey water from the discharge pipe flange point to water main is part of this Contract.

13.3. CONTRACT DRAWINGS

The Drawings covering tube well and appurtenant works show the scope of work to be performed by the Contract. The tender drawings shall not be used as a basis for placing preliminary orders for materials. The drawings issued for construction will be

drawings from which shop erection, concrete placing, formwork or other construction details shall be prepared by the Contractor.

The works shall be executed in conformity with the Drawings issued.

13.4. SIZE OF TUBEWELL

The tube well may vary in depth, therefore, minimum and maximum depth for the tube well shall not be guaranteed. The pump head, pump setting and length of housing of tube well shown on the Drawings are indicative only. The horsepower, rating of the pump motor and the motor controls are specified under applicable sections of specifications.

13.5. BILL OF QUANTITIES

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

13.6. STANDARDS

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

If the Contractor, at any time and for any reason wishes to deviate from the above standards, or desires to use material or equipment not covered by the said standards, he shall state the exact nature of the change, the reasons for making the change and shall submit the complete specifications of the materials and equipment for approval of the Engineer, whose decision shall be conclusive and binding on the Contract.

13.7. CONSTRUCTION EQUIPMENT AND MATERIAL

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

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

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

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

13.8. CLEAN UP

Upon completion of construction, equipment installation and operation, test of tube well, the Contractor shall tear down and remove all temporary structures provided and occupied by him, shall remove all plant and refuse, all waste materials; shall remove from the site of the work, or satisfactorily cover with earth.

14. DRLLING OF BOREHOLE

14.1. SCOPE OF WORK

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

14.2. DRILLING OPERATION

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

14.3. DRILLING

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

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

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

If unstable material is encountered in drilling, the Contractor shall stabilize the material in a manner approved by the Engineer. The use of drilling fluid additives or other suitable materials may be employed for stabilizing the borehole when such use is specifically approved by the Engineer. If necessary, temporary casing shall be furnished and installed by the Contractor to hold walls of the hole during drilling

operations and until the gravel shrouding has been placed. All temporary casing shall be removed by the Contractor in stages as gravel shrouding is placed. The temporary casing may be new or used and will remain the property of the Contractor.

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

14.4. DATA AND RECORDS

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

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

14.5. MEASUREMENT AND PAYMENT

14.5.1. Measurement

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

14.5.2. Payment

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

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

15. TUBEWELL CONSTRUCTION

15.1. SCOPE OF WORK

The work shall consist of furnishing all plant, labour, equipment, appliances, and materials and performing all operations in connection with tube well construction except drilling, in accordance with these specifications and in close conformity with the dimensions shown in the Drawings or as established by the Engineer.

15.2. CASINGS

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

15.3. Fibre Glass Strainer & Blind Pipe

Glass Fibre shall conform to the following specifications:

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

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

15.4. Fabrication

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

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

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

meter of the tube well and opposite non-water yielding formations as directed by the Engineer.

15.4.1. Installation

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

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

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

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

Straightness shall be determined by lowering a section of pipe 40 feet long or a dummy of the same length to the bottom of the pump housing casing. The minimum outer diameter of the pipe or dummy shall be 15 mm less than inside diameter of the pump housing casing. If a dummy is used, it shall consist of a rigid spindle with three cylindrical rings, each ring having a height of at least 300 mm. The rings shall be true cylinders and shall be located at each end and in the centre of the dummy. The central shaft of the dummy shall be rigid so that it will maintain the alignment of the axis of the cylindrical rings. The pump housing casing shall be sufficiently straight so that the pipe or dummy can be passed freely throughout the entire length of the pump housing casing.

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

15.5. GROUTING

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

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

15.5.1. GRAVEL SHROUDING

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

15.5.2. Material

All gravel used for shrouding shall be clean, hard, well-rounded, washed, carbonate free and water-worn, without thin, flat particles and with the gradation as included in Table 3.

Table 3 - Gradation Requirements for Shrouding Material

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

15.5.3. Installation

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

15.6. DEVELOPMENT AND TESTING

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

15.6.1. Method

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

15.6.2. Equipment Required

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

a. Vertical turbine pump with variable speed and reversal in direction of rotation. Capable of discharge twice the rated capacity for the design discharge of the tubewell.

b. Prime Mover (Electric or diesel) closely coupled with V.T.P. and capable to give a variable/ adjustable speed to the pumping unit.

c. Discharge Measuring Device, Electronic flow meter, sluice valve for regulation of discharge.

d. Electronic measuring device to measure water level in tube-well during operation of pumping unit.

e. Imhoff Cone (Sand Cone)

15.6.3. Back Wash

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

15.6.4. Duration

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

a. Development (1st Stage)

Initial development shall be done step wise as included in Table 4

Table 4 Duration of Development for Tube Well

S. No.	Discharge	Period of Development
1	0.75 times the designed discharge of tube well	1 hour
2	1.00 times the designed discharge of tube well	1 hour
3	1.25 times the designed discharge of tube well	1 hour
4	1.50 times the designed discharge of tube well	3 hours

5	2.00 times the designed discharge of tube well	3 hours
	Total	9 hours

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

b. Recovery (1st Stage)

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

Table 5 Frequency of Measurement during Recovery Period for Tube Well

Sr. No.	Period (from pump closure)	Measurement Frequency
1	1st 5 minutes	Every minute
2	Up to15 minutes	Every 2-minutes
3	Up to 30 minutes	Every 5-minutes
4	Up to 1 hour	Every 10-minutes
5	Up to 3 hours	Every 20-minutes
	Total	**3-hours**

c. Testing for Development (2nd Stage)

The well shall be pumped in steps as included in Table 4.

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

d. Recovery (2nd Stage)

The well shall again be allowed to recover and the measurements of water table shall be carried out in the same way as in the first stage of recovery; Table 10.3.

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

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

The tube-well shall be re-developed for another 9 hours in steps as included in Table 10.2.

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

f. Recovery (3rd Stage)

Well shall again be allowed to recover for 3 hours and measurements of water table shall be done as in 1st and 2nd stage; Table 10.3. There shall be no difference at the recovery of water table between 2nd stage and 3rd stage. If it is observed that there is an appreciable difference of recovery, well shall be redeveloped for 6 hours with back wash and recovery should again be allowed for 3 hours to match it with 3rd stage recovery. The process shall be repeated till the preceding recovery is matched.

g. Stop Pumping

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

h. Final Pump Test

The tube-well shall be pumped finally for 4 hours at the rated discharge and final draw down shall be noted to find out the specific capacity of the tube-well. Hence the summary of development and testing of tube-well is included in Table 10.4.

Sr. No	Development Step	Time Period
1.	**Development**	
	Development, 1st Stage	9 hours
	Recovery, 1st Stage	3 hours
2.	**Testing**	
	Development, 2nd Stage	9 hours
	Recovery, 2nd Stage	3 hours
	Development, 3rd Stage	9 hours
	Recovery, 3rd Stage	3 hours
	Step Pumping	4 hours
	Final Pump Test	4 hours
	Total	**44 hours**

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

15.6.5. Performa for Records

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

15.6.6. Operation of Pump & Motor

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

15.6.7. Disinfection

After development and testing of the tube well has been satisfactorily completed, and when approved by the Engineer, the Contractor shall disinfect the tube well by

dispersing chlorine solution throughout the entire depth of the well to obtain a minimum chlorine content of 50 mg/l. The procedure and equipment used to introduce and disperse the chlorine in the tube well shall be subject to approval of the Engineer.

15.7. SEALING

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

15.8. MEASUREMENT AND PAYMENT

15.8.1. Measurement

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

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

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

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

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

15.8.2. Payment

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

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

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

16. Hypo-chlorinator

16.1. Description

Automatic Mechanical Diaphragm Dozing Pump as Hypo-chlorinator will be installed. The major components in hypo-chlorinator system are:

- Automatic Mechanical Diaphragm Dozing Pump/ Hypo-chlorinator
- Dozing Tank

Based on above components hypo-chlorination at each location will be carried out as follow:

- All the components will be installed in a pump room at each location.

- In each room, Automatic mechanical diaphragm dozing pump/ hypo-chlorinator will be installed on a separate concrete pad having two pipes. One pipe will be for dozing/ injecting hypo-chlorite in the water main to be treated whereas, other pipe will be for taking hypochlorite feed from a dozing tank.

- Hypochlorite will be stored in liquid form in a dozing tank inside chlorinator room. As the shelf life of hypochlorite solution is fifteen days therefore dozing tank will be replaced bimonthly at least which will be a laborious task. In order to avoid this hassle, transfer pump is proposed.

16.2. Automatic Mechanical Diaphragm Dozing Pump (Hypo-Chlorinator)

General

This specification sets the minimum acceptable requirements for designing, manufacturing, installing, testing and commissioning at Site of Automatic Mechanical Diaphragm Dozing Pump (Hypo-Chlorinator). In case of difference between this specification and the listed international standards then the most stringent requirements shall prevail.

It will be the backbone of Hypo chlorination system because it will inject hypochlorite inside the water main. For this purpose, mechanical diaphragm dozing pump has been approved. Working principle is described below:

- The diaphragm type dozing pump uses a diaphragm to replace the piston. The reciprocating motion under the action of the driving mechanism completes the pump for the suction and discharge process. It is a hydraulically or mechanically actuated positive displacement pump that uses a combination of reciprocating action and either a flapper valve or a ball valve to transfer liquids.

- Diaphragm pumps are self-priming. Diaphragm pumps use the up-and-down movement of a cupped, elastic surface to generate liquid flow. This surface, found within the pump, is typically made from polytetrafluoroethylene (PTFE), Teflon, synthetic rubber or a similar material. When the surface is pushed into the liquid, it adds pressure and displaces a certain amount of fluid. When it is pulled back from the liquid, it draws in more fluid. The diaphragm pump uses check-valves to prevent

the backflow of fluid through the entry valve. The diaphragm design means there is no tubing to fatigue or break due to wear or corrosion.

Applicable Standards

Automatic Mechanical Diaphragm Dozing Pumps shall comply with the latest revision of the following standards and other relevant standards noted elsewhere in this specification:

Table 13.1: Applicable Standards for Mechanical Diaphragm Dozing Pump

Standard	Description
ASME B73.3	Specification for Seal less Horizontal End Suction Centrifugal Pumps for Chemical Process
NEMA MG-1	Motors and Generators
NSF/ANSI 61	Drinking Water System Components
AWWA M20	Chlorination/Chloramination Practices and Principles

Materials

The minimum acceptable key parameters Automatic Mechanical Diaphragm Dozing Pumps shall be in accordance with **Table 13.2** of this specification.

Table 13.2: General Specifications for Automatic Mechanical Diaphragm Dozing Pump

Sr. No.	Parameter	Least Required Value/Standard
1	Casing	Aluminium with epoxy / acid proof coating
2	Flow Rate	0.5 – 50 L/hr
3	Pressure	12 bar max.
4	Diaphragm Material	Composite PTFE
5	Pump Head Material	PTFE
6	Check Valve	PTFE
7	Valve Ball	Ceramic
8	Suction Lift	1.5 meters minimum
9	Power Supply	230 V AC. ± 10 %, 50 Hz, single phase
10	Inverter Controls	Yes
11	Insulation Protection	IP 65 / NEMA 4X
12	Duty Cycle	Continuous
13	Operating Temperature	60^{o}C maximum

14	Accuracy	± 2 % of set point
15	Control Panel Protection	Adhesive polyester film, weather proof and resisting UV ray.
16	Foundation	On Ground with enough space around the pump to facilitate pump maintenance and adjustment. Titanium Anchor Bolts. Canopy will be required if installed outdoors
17	Warranty	All equipment to be furnished shall be warranted for a period of five (05) years after overall completion and trial/stability test run of at least fifteen (15) days.

Major Features

Given below are the general major features however, the Contractor/ manufacturer/ supplier can propose any advance feature with in the quoted amount for the successful operation:

- Capable of integration into process control systems.
- Flow rate can be changed in order to meet the international standards requirement of the sodium hypochlorite solution used in disinfection of water intended for human consumption.
- Flow rate can be varied using electrical or pneumatic stroke adjustment, or alternatively, by motor speed (frequency converter).
- Easy to read Back Lit LCD Display.
- Display percentage of motor speed & flow rate.
- Built-in Diaphragm Failure Detection System with Alarm.
- Priming / degassing valve.

16.3. Dozing Tank

General

This specification sets the minimum acceptable requirements for manufacturing, installing, testing and commissioning at Site of Dozing Tank. In case of difference between this specification and the listed international standards then the most stringent requirements shall prevail.

Applicable Standards

Dozing Tank shall comply with the latest revision of the following standards and other relevant standards noted elsewhere in this specification:

Table 13.3: Applicable Standards Dozing Tank

Standard	Description
ASTM D 1998	Standard Specification for Polyethylene Upright Storage Tanks

Materials

The minimum acceptable key parameters of dozing tank shall be in accordance with **Table 13.4** of this specification.

Table 13.4: General Specifications for Dozing Tank

Sr. No.	Parameter	Least Required Value/Standard
1	Material	Cross-linked Poly Ethylene (XLPE)
2	Capacity	At least 500 Liters
3	Wall Thickness	The minimum wall thickness shall be in accordance with ASTM D 1998
4	Fittings	PVC. Do not use stainless steel or Alloy C-276 due to nickel content reaction
5	Plumbing	Flexible, Hypo-resistant connections to allow for lateral and vertical tank contraction and expansion and to reduce vibration stress. Connections shall be on lower third of side wall of the tank.
6	Colour	Black, white, blue or grey colour or insulation with mastic coating required in outdoor applications to minimize bleach degradation and maximize chemical half-life.
7	Foundation	Smooth concrete, asphalt or steel foundation
8	Storage Temperature	Product should not exceed 100°F at delivery or during storage to reduce decomposition of the chemical and maintain ASTM D 1998 Parameters. Ideal Temperature is 60°F (15°C).
9	Manway	Fume-tight manway cover
10	Precautions	All cut edges (i.e., manway) shall be trimmed to have smooth edges.

16.4. Sodium Hypochlorite

General

This specification sets the minimum acceptable requirements, sampling and test methods for sodium hypochlorite solution used in disinfection of water intended for

human consumption. This specification sets forth a set of minimum physical and chemical properties that must be met. In case of difference between this specification and the listed international standards then the most stringent requirements shall prevail.

Applicable Standards

Liquid Sodium Hypochlorite shall comply with the latest revision of the following standards and other relevant standards noted elsewhere in this specification:

Table 13.5: Applicable Standards for Transfer Pump

Standard	Description
ANSI /AWWA B 300	Standard for hypochlorite, published by the American National Standards Institute/American Water Works Association
BS EN 901	Chemicals used for treatment of water intended for human consumption – Sodium hypochlorite, published by European Community
NSF/ANSI 61	Drinking Water System Components

Materials

The hypochlorite solution shall be a pale, yellowish green, clear liquid and shall not produce any sludge or turbidity when mixed with water. The material shall comply with the minimum available chlorine content for not less than 30 days from the date of packing. After the period of more than 30 days, the minimum available chlorine shall be as approved by the Project Manager.

NOTE - As a guide the following table provides a general guidance on the stability of the material:

Available Chlorine Trade	Chlorine	Half Life
(Percent)	(g/l)	(Days, 25°C)
3	30	1700
6	60	700
9	90	250
12	120	180
15	150	100

The material, when tested according to the methods prescribed in ANSI /AWWA B 300, shall comply with the requirements given in Table 13.6.

Table 13.6: Specific requirements for Sodium hypochlorite

Sr. No.	Parameter	Least Required Value/Standard
1	Available chlorine content, % wt /volume	0.5 to 1.0
2	Total free alkali (as NaOH), % weight by volume	1.2 max
3	Insoluble matter, %	0.15 max
4	Iron (as Fe), ppm	0.4 max
5	Neat pH range	9 - 12

Packing, Marking and Storing

Sodium hypochlorite shall be packed in a suitable airtight container that prevents it from deterioration of its quality during storage, transportation and handling.

Each package shall bear legibly and indelibly the following information:

a) name and formula of product, 'SODIUM HYPOCHLORITE'(NaOCl).
b) name and address of the manufacturer.
c) the net volume of the contents.
d) the batch or code number.
e) the nominal available chlorine content.
f) dates of manufacture and best before.
g) the instruction for use and handling.
h) first aid instructions.
i) the words 'STORE IN A COOL DRY PLACE AWAY FROM DIRECT SUNLIGHT '.
j) hazard warning in symbol or words.

The material shall be stored in a cool and dark place. While shipping, the material shall be stored away from boilers or any other source emanating heat and light.

17. WATER TESTING

17.1. SCOPE OF WORK

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

17.2. COLLECTION OF WATER SAMPLES

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

17.2.1. Collection for Bacteriological examination

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

17.2.2. Collection for Physio-Chemical Examination

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

17.3. TRANSPORTATION AND STORAGE OF SAMPLES

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

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

17.4. LABORATORY EXAMINATION

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

17.4.1. Turbidity

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

17.4.2. Colour

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

17.4.3. Total Dissolved Solids

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

17.4.4. Chlorides

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

17.4.5. Total Coliform and Faecal Coliform

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

17.5. RECORD & DATA

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

17.6. MEASUREMENT AND PAYMENT

17.6.1. Measurement

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

17.6.2. Payment

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

18. CONSTRUCTION OF PUMP HOUSE

18.1. SCOPE OF WORK

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

18.2. MATERIALS AND CONSTRUCTION REQUIREMENTS

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

18.3. MEASUREMENT AND PAYMENT

18.3.1. Measurement

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

18.3.2. Payment

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

19. ELECTRICAL & MISC. WORKS

19.1. SCOPE OF WORK

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

19.2. ELECTRICAL WORKS

19.2.1. Regulation

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

19.2.2. Coordination

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

19.2.3. Standard Products

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

19.2.4. Material and Equipment Schedules

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

19.2.5. Workmanship

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

19.2.6. Grounding

All electrical equipment, including motors, meters, lighting and distribution panels, switchgear and similar items shall be grounded. All exposed non- current carrying metallic parts of electrical equipment, raceway systems and neutral conductor of the wiring system shall be grounded. Earth plates for the grounding system shall consist of copper plates of the minimum size of 609.6mm square and 3.175mm thick. The top earth plate shall be 2.44m below the ground level with critical watering arrangement or at the natural water level whichever is easy to install. A minimum 152.4mm layer of charcoal and rock salt shall be provided underneath each earth plate and a minimum 457.2mm layer of charcoal and rock salt shall be provided above each earth plate. The ground connection from the earth plate shall be securely bolted by a copper nut and bolt and additionally soldered to the plate. The ground connection including earth plate shall be kept clear of the structure foundation. The earth plate shall be located not nearer than 1.83m from the outer face of the building wall. Ground connections indicated as 3.18x25.4mm copper tape may be made with number 4/0 AWG or SWG cable. Ground connections indicated as 3.18mm by 12.7mm copper tape may be made with number 2/0 AWG or SWG cable. All ground connections shall run vertically and horizontally exposed on the surface of the wall and shall run concealed in the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. Ground connection from the building to the earth plate shall be run at a depth not less two feet below ground level.

19.2.7. Conduit

Unless otherwise indicated, electrical wiring shall be run in galvanized steel (G.I.) conduit or PVC Pipe according to the specification PVC pipe shall not be used as conduit for buried or embedded run. Minimum size of raceways for branch circuit wiring shall be 19.1mm. Conduit pipes shall be exposed on walls and ceilings but shall run concealed in floors. Conduit shall be continuous when passing through wall or floor. Conduits installed on the surface of walls shall be supported and secured at intervals of not more than 0.91m and shall be installed parallel or perpendicular to walls, structural members or inter sections of vertical planes and ceilings. Field made bends and offsets shall in general be avoided, but if so required these shall be made with an approved method or by conduit bending machine. Changes in direction of runs shall be made with symmetrical bends or cast-iron fittings. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be taken to prevent the lodgement of plaster, dirt or trash in raceways boxes, fittings, and equipment during the course of construction. Clogged raceways shall be entirely free of obstructions or shall be replaced. Raceways crossing expansion joints in concrete slabs shall be provided with suitable expansion fittings or other suitable means to compensate for expansion contraction. Raceways installed underground or under slabs shall be coated with an approved type of protective coating.

a. Galvanized Iron (GI) Conduits

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

b. PVC Pipe

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

c. Additional Requirements for Exterior Conduit

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

19.2.8. Conductors

a. General

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

b. Conductor Sizes

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

c. Conductor Insulation

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

rubber insulation type RH or RH RW or thermoplastic insulation, type T or TW.

19.2.9. Boxes and Supports

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

19.2.10. Lamp Fixture and Accessories

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

19.2.11. Electrical Supply Points (Outlet Connections)

Electrical supply points shall be provided where indicated on the Drawings. Electrical supply points shall have the types of receptacles suitable for the plugs of the equipment to be connected to these points. Where receptacles are not available to match the plugs of equipment, standard receptacles shall be used and plugs on equipment supply leads shall be replaced by the contractor with plugs to match standard receptacles. Each electrical supply point shall be complete with a switch. Exterior electrical supply points shall be provided where indicated. Exterior electrical supply points shall be weather proof, complete with switch and of the type suitable for the plugs of the equipment to be connected to these points.

19.2.12. Flexible Connections

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

19.2.13. Fuse Circuits and Fuse Boxes

The Contractor shall provide proper fuse boxes for each circuit. The fuse boxes and the switches shall be metal clad and suitable for the load for which the circuit is

designed. All fuse boxes shall be complete with proper size fuse strips fitted to fuse bridges.

19.2.14. Power Switchgear Assemblies

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

19.2.15. Exterior Switches

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

19.2.16. Testing

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

a. Insulation Resistance

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

b. Operating Test

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

c. Earth Plate Resistance

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

19.2.17. Repair

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

19.3. POWER TRANSFORMER

19.3.1. General

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

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

19.3.2. Construction

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

The transformer shall be fully tropicalized for temperature rise, humidity, altitude etc. The local conditions shall be taken into account while following the above standards. The transformer shall be complete with oil filling, all accessories and attachments detailed in these specifications or otherwise required and the contractor shall provide all details, drawings, data and complete test results for final approval before installation. The tank and radiating tubes shall be designed to withstand, without developing any deformation, pressure at least 25% greater than the maximum operating pressure. The steel plate cover shall be bolted to the tank, using gasket for perfect oil seal. Two earth terminals shall be provided at the base of the tank.

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

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

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

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

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

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

The transformer shall be provided with the following accessories.

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

19.3.3. Drawings and Data

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

19.3.4. Transformer Technical Data

The technical data for Power Transformer shall be as included in Table 13.1.

Table 6 - Technical Data for Power Transformer

Sr. No.	Parameter	Data
1	KVA rating	As shown on Drawings
2	No load ratio	11kv/415 V
3	H.V. Winding	
	Line to line volts	11000
	Connections	Delta
4	L.V. Winding	
	Line to line volts	415
	Connections	Star
5	Vector Group	DY 11
6	Tapping on H.V side	-7.5%, ±5%, ±2.5%
7	H.V Termination	Bushing
8	L.V cable size	7x300 mm2

9	L.V Termination	Bushing
10	Impedance voltage	4.5% to 6%
11	Losses in watts	
	Iron at no load	to be furnished by Bidder
	Copper at full load	to be furnished by Bidder
12	Cooling	On
13	Temperature rise over 50°C ambient	
	Oil	40°C
	Winding	50°C

19.4. MEASUREMENT AND PAYMENT

19.4.1. Measurement

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

19.4.2. Payment

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

PART-E CIVIL WORKS

20. DISMANTLING (DEMOLITION)

20.1. SCOPE

The work shall comprise dismantling/demolishing whole or part of work including all relevant items consisting of but not limited to stone work, brick work, concrete, floorings, roofing and metal work structural steel roofs, trusses as specified and or shown on the drawings. Only such work or part of works which are designated on the Drawings or by the Engineer to be removed shall be included in the work to be done under these specifications. When approved by the Engineer, the contractor shall remove the dismantled/demolished works required to be removed and clear the site, as specified or directed by the Engineer.

20.2. DISCONTINUITY AND DIVERSION OF UTILITY SERVICES

Before the commencement of dismantling works, the Contractor shall be responsible to ensure that all the utility services including water supply, electric supply, gas supply, telephone connection and sewerage have been cutoff / discontinued. Wherever, directed by Engineer-in-Charge the Contractor shall also divert these services and install the same as per written instruction of the Engineer-in-Charge.

20.3. SERVICEABLE AND UNSERVICEABLE MATERIALS

Upon written instructions of Engineer-in-Charge, the Contractor shall make a list of all such items which in opinion of Engineer-in-Charge can be re-used. The Contractor shall take such measures to protect these materials / items from damage during dismantling process. The Contractor shall provide labour and other arrangements to properly stack / store such items safely until handed over to the Engineer-in-Charge. All unserviceable materials, rubbish etc. shall be disposed off as directed by the Engineer in-Charge.

20.4. PRECAUTIONS

Before commencement of dismantling/demolition, the Contractor shall prepare and submit his proposals and program for proceeding with the work for approval of the Engineer-in-Charge. Generally, the Contractor will be permitted to demolish the structures only through approved means, Blasting can be permitted only where specified by written approval of the Engineer-in-charge provided the necessary precautions are taken to protect the Works, public and private property and all persons in the vicinity of the Works. The work should generally be performed in reverse order of the one in which the structure was constructed. Necessary propping, shoring and or under pinning shall be provided to ensure the safety of the workers, adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Temporary enclosures or partitions and necessary scaffolding wherever specified shall also beprovided, as directed by the Engineer-in-Charge. Necessary steps/ precautions should be taken to keep noise and dust nuisance to a minimum. If specified or directed

by the Engineer-in-Charge, the Contractor shall provide, erect and remove screens of canvas or other suitable material to minimize the nuisance from dust and shall provide for watering as the work of demolition proceeds. The Contractor shall ensure provision of all human safety items and its use at site including helmets, goggle, safety belts etc. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall

Demolition be carefully removed first and lowered using appropriate methods. Chisels and cutters may be used carefully as directed. The dismantled articles should be removed manually or lowered to the ground and then properly stacked as directed by the Engineer-in-Charge. No demolition work should be carried out at night especially when the building or structure to be demolished is in an inhabited area. Screens shall be placed where necessary to prevent injuries due to falling pieces. Water may be used to reduce dust while tearing down plaster from brick work. Safety belts shall be used by labourers while working at higher level to prevent falling from the structure. First-aid equipment shall be got available at all demolition works of any magnitude.

21. EXCAVATION, BACKFILLING & DISPOSAL

21.1. SCOPE OF WORK

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

21.2. AUTHORIZED OUTLINES

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

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

21.3. CONSTRUCTION REQUIREMENTS

21.3.1. Excavation

a. General

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

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

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

b. Timbering or Sheeting

The Contractor shall provide adequate timbering or sheeting for excavation where necessary, as part of the excavation work, to hold up the sides and ends of all excavations. Should the sides and ends of any excavation give

away, the Contractor shall, at no extra cost to the Client reinstate all disturbed ground.

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

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

c. Inspection of Foundations

When excavation up to foundation level is reached, as per Drawings, it is inspected by the Engineer and approved before start of any permanent construction. If safe foundation could not be obtained at the depth shown on the Drawings or at maximum depth of five feet below the ground level, the work shall be carried out as directed by the Engineer. Additional cost, if any approved by the Engineer, shall be paid in accordance with the provisions of the Conditions of Contract.

d. Disposal of Unsuitable/Surplus Materials

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

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

e. Excavation to be kept Free of Water

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

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

f. Safety Measures

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

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

g. Excess Excavation

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

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

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

h. Classification of Material

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

i. Transportation of Materials

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

j. Termite Control

The approved foundation trenches shall be treated with the termite control solution.

21.3.2. Compacted Backfill

a. Excavated Earth for Backfilling

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

Backfilling operations for structure shall be performed as part of Contractor's work under the payment items for earth excavation, and at no extra cost to the Client. It comprises returning, transportation and filling the selected excavated material around foundations, and at back of walls etc., up to finished levels shown on the Drawings or as required in layers not exceeding 6 inches carefully rammed and consolidated (with addition of water if required) so as to achieve a maximum density of 90%. The backfilling earth shall be free from stones and hard clods, larger than 3 inches in any dimension and also free from trash, lumber and other debris.

No backfilling shall be made until the concrete foundations and footings etc. have been inspected and approved. Earth to be used for filling must be free of all the organic impurities, debris or any other foreign matter. Earth which contains more than 1% of salts, particularly sulphates, will not be used in filling.

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

b. Borrow Earth for Backfilling

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

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

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

c. Sand Backfill

Special sand backfill is to be provided when specifically required by the Drawings or when ordered in writing by the Engineer. This work shall consist of removal of the excavated material to waste and provision in lieu of graded clean and fill, free of all foreign matter, such that 100% passes a ¾” screen with not more than 5% passing a No.4 sieve. This shall be compacted to 95% of the maximum density as determined by AASHTO T 180, Method D.

21.4. FILLING UNDER FLOORS

21.4.1. Earth Filling

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

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

21.4.2. Sand Filling

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

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

The required in situ density with respect to maximum density to optimum moisture content shall be in compliance with test 12 of B.S. 1377-1967.

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

21.5. MEASUREMENT AND PAYMENT

21.5.1. Measurement

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

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

21.5.2. Payment

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

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

22. TERMITE CONTROL

22.1. SCOPE OF WORK

The work for anti-termite treatment includes injection of insecticide in sides and bottom of foundations or elsewhere as directed by the Engineer. The scope also covers treatment of all woodworks if any, with insecticides before installation in position. The contractor shall furnish all materials, labour and equipment to carry-out the termite treatment complete in all respects.

22.2. APPLICABLE STANDARDS

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

22.3. SUBMITTALS

Contractor shall prepare and submit, for the approval of Engineer, the following:

a. Qualification data of manufacturer;

b. Product data for termiticide to be used;

c. Detailed method statement describing the methodology maintained in applying termite control treatment;

d. After application of termiticide is completed, submit report for Client's record and information, with minimum following information:

- Date and time of application.
- Moisture content of soil before application.
- Brand name and manufacturer of termiticide.
- Quantity of undiluted termiticide used.
- Dilutions, methods, volumes, and rates of application used.
- Areas of application.
- Water source for application.

6. Special warranty specified in this Section that will be submitted by manufacturer at date of Substantial Completion.

22.4. MATERIAL

An emulsible concentrate insecticide specially formulated to prevent infestation by termites shall be used. Fuel oil will be permitted as a diluent. A working solution of one of the following chemicals with clean potable water with ratio specified by the manufacturer shall be used.

- Imidacloprid 5.0%, Chloronicotinyl, Formulation SL/SC with clean water in maximum ratio of 1:120.

- Fipronil 2.5%, Formulation EC (Emulsified Concentrate) with clean water in maximum ratio of 1:250.

Insecticide shall be obtained from the Sole distributor, in sealed drums in quantity necessary for the requirement of works.

All mixing shall be done at site and mixing proportion of insecticide with water shall be verified by the Engineer.

Pure turpentine shall be used for dilution of insecticide, in approved proportion for application to woodwork where such application is required

22.5. QUALITY ASSURANCE

22.5.1. Manufacturer's Instructions

In addition to the requirements of these specifications, the manufacturer's instructions and recommendations for the work, including preparation of sub-strata and application shall be complied with.

22.5.2. Application

A professional operator shall be engaged who shall have license in accordance with regulation of governing authority for application of soil treatment solution.

22.5.3. Guarantee

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

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

22.6. METHOD OF APPLICATION

a. All mixing will be done at site and mixing proportion of insecticide with water shall be verified by the Engineer.

b. Insecticide solution shall be applied with approved spraying equipment maintaining a pressure of 150 psi to all applications to, on or in earth.

c. Soil treatment shall begin after all work of preparation of earth prior to laying of concrete. After application, no additional earth moving or work upon subgrade shall be done. No covering of earth of concrete shall be applied over soil treatment until at least 24 hours after treatment.

d. Insecticide solution shall not be applied during wet weather, or when the earth surface is excessively wet. Application shall be made to all areas/beneath concrete slab-on-grade, including sidewalks and paving abutting building for the distance of at least 6.5 ft beyond

building line. Solution shall be applied on amounts of not less than 0.5 litres per sq.ft. of area. If applied over gravel or sand fill, application shall not less than 0.7 litre per sq.ft. of areas. Insecticide shall penetrate to a depth of 1-inch minimum in porous earth at bottom and 2 inches to 3 inches at side of excavations.

e. Sides of foundation excavations and similar areas shall be treated with solution at a minimum rate of 0.5 litres per sq.ft. upon inner sides of such excavation and at all locations where concrete slabs for platforms and similar work about the building.

f. In the area of application sign shall be fixed to show that soil treatment has been applied. Such sign shall be removed when area is covered by other construction.

g. Care shall be exercised to ensure that no marks or damage occurs to the finished structure as a result of the work under this section.

h. All woodwork for the entire project is to be insecticide treated (before application of solignum) in the case of material to receive before treatments, insecticide shall be sprayed on all surfaces of all the wooden work viz, door frames, blocking, furring, planks, boards etc. before installation. Spraying shall be necessary after field sawing, jointing or installation of such material.

22.7. MEASUREMENT AND PAYMENT

22.7.1. Measurement

Measurement of acceptably completed works of termite control treatment will be made on basis of number of square feet or square meter (whichever is included in Bill of Quantities) area to be termite proofed as per instructions of the Engineer.

22.7.2. Payment

The payment will be made on the basis of measurement made as above and at the unit rate quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

No separate measurement and payment shall be made for termite control treatment on wood works and turpentine/water required for mixing insecticide solution.

23. PLAIN & REINFORCED CONCRETE

23.1. SCOPE OF WORK

The work under this section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in connection with the supply, manufacturers, transporting, placing, consolidating and curing of plain & reinforced concrete and its constituents.

23.2. APPLICABLE STANDARDS

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

23.2.1. Pakistan Standards

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

23.2.2. ASTM (American Society for Testing and Materials)

- ASTM C 33, Concrete Aggregates
- ASTM C 39, Test Method for Compressive Strength of Cylindrical

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

- ASTM E 96, Water vapour transmission of materials in sheet form
- ASTM E 154, Materials for use as vapour barrier under concrete slabs
- ASTM E 337, Relative humidity by wet and dry bulk psychrometer

23.2.3. ACI (American Concrete Institute)

- ACI 211, Recommended practice for selecting proportions for normal and heavy weight concrete
- ACI 214, Quality control charts
- ACI 301, Specifications for structural concrete for building
- ACI 304, Recommended practice for measuring, mixing, transporting and placing concrete
- ACI 305, Hot weather concreting
- ACI 308, Recommended practice for curing concrete
- ACI 309, Recommended practice for consolidation of concrete
- ACI 315, Manual of standard practice of detailing reinforcement concrete structure
- ACI 318, Building code requirement of reinforced concrete
- ACI 347, Recommended practice for concrete formwork
- ACI 350, Building code requirement of environmental engineering concrete structures

23.2.4. British Standards

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

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

23.3. SUBMITTALS

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

b. For special concrete finish and for special methods of construction, formwork shop drawings shall be designed and prepared by the Contractor, at his own cost. Approval of shop drawings as well as that of actual samples of concrete finish shall be obtained before work is commenced.

c. The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate standard in respect of the samples of cement from the work-site. These tests shall be carried out in a laboratory approved by the Engineer.

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

e. Where doubt exists as to the suitability of the water, it shall be tested in accordance with BS 3148.

f. The Contractor shall provide Mix design by weight for each class of concrete. Manufacture 12 test cylinder for each 3 mix design batches (6 Dia. x 12 high) inches in accordance with the Mix design batching by weight and test 3 cylinders each at 3-, 7,14- & 28-days intervals in the presence of Engineers Representative and submit all relevant data and results of tests for approval of the Engineer. The Contractor shall obtain approval from the Engineer in writing for each Mix design before producing the actual concrete for the Works.

g. 'Workability' of Concrete shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given ASTM C 143.

h. The slump or compaction factor for each class of concrete shall be determined during the preliminary Test mixes and the value obtained shall not be modified without the written consent of the Engineer.

i. Manufacturer’s recommendations and instructions along with the sample of material shall be submitted to the Engineer for his approval.

j. The Contractor shall, at his own cost, make optimum mix design and testing for approval of the composition of non-shrinking grout and non-shrink second stage Concrete Grout, prior to Commencement of the work.

k. The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer: all pre-cast units shall strictly conform to the approved sample. The proposal for transporting and erecting pre-cast units in position shall also be submitted by the Contractor for the approval of the Engineer.

l. All submittals shall be made as per the requirements of relevant section.

23.4. MATERIAL REQUIREMENTS

23.4.1. Aggregates

a. The sources of supply of all fine and coarse aggregates shall be as specified or approved by the Engineer.

b. All fine and coarse aggregates shall be clean and free from clay, loam, silt and other deleterious matter. If required, the Engineer reserves the right to have them washed by the Contractor at no additional expense. Coarse and fine aggregates shall be delivered and stored separately at site. Aggregates shall not be stored on muddy ground or where they are likely be become dirty or contaminated. They shall be placed on sloped hard strata to ensure well drained at all times.

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

d. Coarse aggregate shall be crush stone of hard, durable material free from laminated structure and conforming to PS 243 and/or BS 882 and/or ASTM C-33, graded as included in Table 20.1, for use in mass concrete as in foundations.

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

e. Coarse aggregate for all cast-in-place concrete other than mass concrete, as for foundations, shall be graded with the limits as included in Table 20.2.

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

f. Wherever feasible, the nominal maximum size of aggregate for cast-in place reinforced concrete slabs and other members shall be 3/4-

inch. If there are difficulties in placing such a concrete the maximum size may be restricted to 1/2-inch. Provided the requirements for strength are satisfied, as approved by the Engineer.

g. Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4-inch maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day). The grading of the coarse and fine aggregates shall be tested at least once for every 100 tons supplied, to ensure that the grading is uniform and same as that of the samples used in the preliminary tests.

23.4.2. Cement

a. The cement shall be fresh and of approved origin and manufacture. It shall be one of the following as may be specified by the Engineer.

b. Ordinary or Rapid Hardening Portland cement complying with the requirements of PS 232 or BS 12 or ASTM C-150.

c. Sulphate Resisting Portland/Cement complying with the requirements of P.S.612 or BS 4027 or ASTM C-150.

d. Unless otherwise specified. Ordinary Portland cement complying with the requirements of BS 12 shall be used.

e. For all fair faced concrete, it will be necessary to use approved cement with a view to obtain a light shade concrete as approved by the Engineer.

f. The Contractor shall supply to the Engineer at fortnightly intervals, test certificates with the appropriate standard in respect of the samples of cement from the work site. These tests shall be carried out in a laboratory approved by the Engineer.

g. Only one brand of each type of cement shall be used for concrete in any individual member of the structure. Cement shall be used in the sequence of receipt of shipment, unless otherwise directed.

h. There shall be sufficient cement at site to ensure that each section of work is completed without interruption. If the cement is supplied by the Client, the Contractor should inform the Client, of his requirements sufficiently in advance of its use in construction.

i. Cement reclaimed from cleaning of bags or from leaky containers shall not be used.

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

k. The cement shall be used as soon as possible after delivery and cement which the Engineer considers has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise "shall be rejected and removed immediately from the site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or permitting access of the atmosphere prior to opening of the container at the time of concrete mixing shall be rejected and removed immediately from the site at the Contractor's expense.

l. The mixing together of different types of cement will not be permitted.

23.4.3. Water

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

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

23.4.4. Additive

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

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

23.4.5. PVC Water Stop

PVC Water Stop shall follow the requirements as included in SECTION-26.

23.4.6. Non-Shrink Grout

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

- Non-shrink grout of less than 1-inch thickness shall consist of one-part Portland cement and one part of clean sharp sand conforming to the requirements of these specifications and 1:22,000 to 1:15000 part of grained aluminum powder containing non-polishing agent.
- Non-shrink grout of 1-inch or more in thickness shall be proportioned as above except that 1-1/2 parts of 3/8-inch to ¼--inch pea gravel shall be added.
- The above-specified composition may be varied if required by the Engineer.
- Proportioning shall be done by weight.
- Mixing water shall be proportioned so as to provide a flow able mixture without segregation or bleeding. Dry packing will not be permitted.

23.4.7. Non-Shrink Second Stage Concrete Grout

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

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

23.4.8. Non-Shrink Concrete Grout for Stair Railing Column Post

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

23.5. NOMINAL CONCRETE MIXES

23.5.1. Proportions of Mix

a. Cement and aggregates

The cement, fine aggregate and the coarse aggregate shall be weighed separately. The proportions of cement to fine aggregate and coarse aggregate shall be adjusted so as to provide the concrete of the required crushing strength when tested as set out in Table 20.3.

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

c. Water Cement Ratio

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

d. Workability

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

Workability shall be determined by either the slump or compaction factor tests as directed by the Engineer and these shall be performed in accordance with the methods given in PS 422 and PS 177 or ASTM C-143. The slump or compaction factor for each class of concrete shall be determined during the preliminary test mixes and the value obtained shall not be modified without the written consent of the Engineer. Unless otherwise permitted or specified, the concrete shall be proportioned and produced to have a slump of 3-inch or less if consolidation is to be by vibration. A tolerance of up to 1-

inch above the indicated maximum shall be allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.

23.5.2. Strength requirements for concrete

a. Concrete made with Portland cement shall comply with the strength requirements as included in Table 20.3.

Table 7 - Strength Requirements for Portland Cement Concrete

Sr. No.	Concrete Class	Nominal Ratio*	Concrete
1	A	1:1:2	450
2	B (or A3)	1:1.5:3	400
3	C (or A1)	1:2:4	300
4	D	1:3:6	220
5	E (Lean Concrete)	1:4:8	140

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

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

b. The strengths given in Table 20.3 are based on the assumption that average temperature is 20 degree C. Where accurate records of temperature are kept, allowance may be made for change of temperature or the cylinders may be tested at the equivalent maturity.

c. All structural concrete shall conform to BS 5328.

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

Manufacture 12 test cylinders (6-inch diameter x 12-inch height) in accordance with the mix design, batching by weight, and test 3 cubes each at 3, 7, 14 & 28 days intervals in the presence of Engineer's Representative and submit all relevant data and results of tests for approval of the Engineer. The Contractor shall obtain approval from the Engineer in writing for each Mix design before producing the actual concrete for the works.

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

23.6. DELIVERY, STORAGE AND HANDLING

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the

period of the work, the grading of the aggregates shall be controlled by obtaining the 3/4" maximum nominal size, the different sizes being stocked in separate stock piles and recombined in the correct proportion for each batch at the batching plant. The materials shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as site and other conditions permit, preferably for at least a day).

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

23.7. CAST-IN-SITU CONCRETE

23.7.1. Batching

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

b. Aggregates shall be batched by weight, due allowance being made for moisture content. The apparatus for weigh-batching may be an integral part of the mixer or a separate unit of a type approved by the Engineer. It shall be accurate within 2% and shall be checked for accuracy at least once a month.

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

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

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

23.7.2. Mixing

a. The concrete shall be mixed in an approved batch mixer conforming to the requirements of BS 305. It shall be fitted with the manufacturer’s plate stating the rates, capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device.

b. Mixing shall continue for the period recommended by the mixer manufacturer or until there is apparently a uniform distribution of the materials and the mass is uniform in colour, whichever period is longer. If it is desired to use a mixing period of less than 1½ minute, the Engineer’s approval shall be obtained in writing.

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

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

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

23.7.3. Transporting

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

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

23.7.4. Placing

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

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

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

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

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

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

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

h. The concrete shall be deposited as nearly as possible in its final position to avoid re-handling. In no circumstances may concrete be railed or made to flow along the forms by the use of vibrators. Concreting shall be carried on as a continuous operation using methods which shall prevent segregation or loss of ingredients.

i. The free fall of concrete shall not be allowed to exceed 5 ft. (1.5 m) and where it is necessary for the concrete to be lowered more than this depth, it is not to be dropped into its final position, but shall be placed through pipes fed by a hopper. When a pipe is used for placing concrete the lower end shall be kept inside, or close to the freshly deposited concrete. The size of the pipe shall be not less than9-inch (225mm) diameter.

j. The workmen carrying concrete to the site, and all other workmen moving about on the reinforcement before the concrete is placed, shall move only along runways or planks placed for the purpose and no person shall be allowed to walk on the reinforcement itself.

k. Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by the Engineer, the surface will be brought to a true, hard, smooth, level surface using cement sand mortar in the ratio of 1-part of cement to 3-parts of sand. Two layers of building paper will then be laid flat to separate the concrete from the surface on which it is to be laid.

23.7.5. Construction Joints

a. Concreting shall be carried out continuously up to construction joints, the arrangement of which shall be predetermined by the Engineer.

b. Joints not shown on the Drawings shall be so made and located as to least impair the strength of the structure and shall need prior approval of the Engineer. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset a distance equal to twice the width of the secondary beam. Joints in walls and columns shall not be at the underside of floor slabs

or beams, and at the top of footings or floor slabs. Beams, brackets, columns, capital haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

c. All reinforcing steel shall be continued across joints. Key and inclined dowels shall be provided as directed by the Engineer. Longitudinal keys at least 1½-inch (40 mm) deep shall be provided in all joints in walls and between walls and slabs or footings.

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

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

f. The hardened concrete of joints in exposed work, joints in the middle of beams and slabs; and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout similar in proportions to the mortar in the concrete. The grout shall be as thick as possible on vertical surfaces and at least 150 mm thick on horizontal surfaces. The fresh concrete shall be placed before the grout has attained initial set.

g. Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristles and brushed, care being taken to avoid dislodgment of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 6-inch (150 mm) in thickness, and shall be well rammed against old work, particular attention being paid to corners and closed spots.

23.7.6. Expansion Joints

Expansion joints shall be provided wherever indicated on the Drawings. In no case shall the reinforcement, corner protection angles, or other embedded items be run continuous or through an expansion joint. All expansion joints shall be carefully placed so as not to be displaced during concreting. The method of placing the expansion joints shall be strictly in accordance with the Drawings and as approved by the Engineer. All materials for use in the expansion joints shall have, prior approval of the Engineer before placing order for supply.

23.7.7. Embedded Items

a. The material, design and location of water stops in joints shall be as indicated in the Contract Documents. Each piece of re-moulded water

stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum

b. Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water-tightness fully equal to that of the continuous water stop material, shall permanently develop not less than 50 percent of the mechanical strength of the parent section, and shall permanently retain their flexibility

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

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

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

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

23.7.8. Mass Concrete

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

23.7.9. Consolidation

a. All concrete shall be consolidated by vibration, spading, Roding or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items and into comers of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a minimum

frequency of 8000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. They shall be operated by competent workmen. Use of vibrators to transport within forms shall not be allowed. Vibrators shall be inserted and withdrawn at points approximately 18-inch apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not excessive so as to cause segregation, generally from 5 to 15 sec. A spare Vibrator shall be kept on the job site during all concrete placing operations.

Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process, supplemented, if necessary, by spading to work the coarse aggregate back from the formed surface.

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

c. Vibrator shall not be allowed to contact the formwork for exposed concrete surfaces.

d. Mechanical vibrators shall be of a type suited in the opinion of the

e. Engineer to the particular conditions.

f. Over-vibration or vibration of very wet mixes is harmful and should be avoided.

23.7.10. Curing and Protection

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

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

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

The compound shall be applied in accordance with the recommendations of the manufacturer immediately after- any water sheen, which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be

bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from areas to receive bonded applications.

c. Moisture loss from surfaces placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping the forms wet until they can be safely removed. After form removal the concrete shall be cured until the end of the time prescribed for curing.

d. Curing in accordance with sub-clause 'a' & 'b' above shall be continued for at least 10 days in the case of all concrete except concrete with rapid-hardening Portland Cement for which the period shall be at least 3 days. Alternatively, if tests are made of cylinders kept adjacent to the structure and cured by the same methods, moisture retention measures may be terminated when the average compressive strength has reached 70 percent of the minimum specified works cylinder strength.

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

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

   When necessary, arrangements for heating, covering insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury due to concentration of heat. Combustion heaters shall not be used during the first 24 hours unless precautions are taken to prevent exposure of the concrete to exhaust gasses, which contain carbon dioxide.

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

g. Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 3 deg. C (37 deg. F) in any one hour or 14 degree C (50 deg. F) in any 24-hour period.

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

23.7.11. Application of Non-Shrink Grout

Concrete surfaces to receive non-shrinking grout shall be roughened, cleaned and dampened.

Form shall be provided to retain the grout until sufficiently hard to support itself.

Grout shall he poured in place and thoroughly rodded or washed to prevent the formation of voids.

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

23.7.12. Placing of Vapour Barrier

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

23.8. WORKS IN EXTREME WEATHER

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

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

b. When the temperature of the surrounding air is expected to be below 5^{o}C during placing or within 24 hours thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 13^{o}C for sections less than 12-inch in any dimension nor 10^{o}C for any other sections.

   When necessary, concrete material should be heated before mixing and carefully protected after placing, in general, heating or mixing water alone to about 60^{o}C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials, containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content, of the mix should not exceed 5.5 gallon/bag of cement.

   If water or aggregate is heated above 38^{o}C the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water & aggregate having a temperature greater than 38^{o}C.

c. During hot weather, the temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or

cold joints and should not exceed 32°C. For massive concrete, this temperature should not exceed 21°C. When the temperature of the concrete exceeds 32°C, precautionary measures approved by the Engineer shall be put into effect. When the temperature of the steel is greater than 50°C, steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or flaked ice or well crushed ice of a size that will melt completely during mixing may be substituted for all part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.

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

23.9. PRECAST CONCRETE

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

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

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

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

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

23.9.1. Erecting Precast Units

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

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

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

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

23.10. CEMENT CONCRETE PAVEMENTS

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

23.10.1. Side Forms and Construction

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

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

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

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

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

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

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

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

23.10.2. Protection and Curing

a. General Requirements

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

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

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

b. Curing Periods

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

c. Removal of Forms

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

23.10.3. Finishing

All unformed surfaces shall be finished with a wood float except as otherwise specified. Visible vertical surfaces shall have all projections and irregularities removed. The entire surface shall be rubbed if required by the Engineer, with

a No. 16 carborundum brick, or other abrasive until even, smooth and of uniform appearance, and shall be washed clean. Plastering of surface, application of cement or other coating will not be permitted.

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

23.10.4. Spreading, Finishing and floating of concrete in pavements

a. General Requirements

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

b. Mechanical Methods

The concrete shall be spread uniformly between the forms, immediately after it is placed, by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine onto the finishing machine. Vibrators shall not rest on new pavements or side forms or in contact with any dowel bars, and the arrangement of power supply to the vibrators shall be such that when the motion of machine is stopped, vibration shall cease. The rate of vibration shall be not less than 8000 vibrations per minute. The concrete shall be spread to full width before being struck off and compacted so that the surface will conform to the finished grade and cross-section as shown on the Drawings and at the same time leave sufficient material for the floating operation. The spreading & finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer to ensure thorough compaction.

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

The Contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre line and

passing gradually from one side of the pavement to the other. Movements ahead, along the centre line of the road, shall be in successive advances of not more than half the length of the float.

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

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

c. Manual Methods

When striking-off and compacting by manual methods is permitted, the concrete shall be levelled and then struck-off to such an elevation that, when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither ends is raised from the side forms during the process. While striking off, a slight excess of concrete shall be kept in front of the cutting edge at all times. Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated a manner that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by 1 foot or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed with properly trussed roads to stiffen it and prevent sag and shall be shod with a heavy strip or metal for a tamping surface. The tamper shall be moved with a combined tamping and longitudinal motion, raising it form side form and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus material I is com acted and rammed into front of the tamper or vibrating unit and taming or vibrating shall continue until the true cross-section is obtained reed and the mortar flushes slightly to the surface.

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

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

d. Longitudinal Floating

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

e. First Straight Edge Testing

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

f. Burlap, (Coarse Canvas) Dragging

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

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

g. Second Straight Edge Testing

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

23.10.5. Expansion and Contraction Joints

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

preformed chase as shown on the Drawings. The lie preformed chase shall be thoroughly cleaned of all dust, debris, stone or other hard material prior to its sealing. The riser of all joints shall be rounded to a radius as shown on the Drawings before the concrete hardens.

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

c. Contraction joints shall be provided as shown on the Drawings.

d. The assembly and method of constructing the expansion joints/contraction joints shall be subject to the approval of the Engineer.

e. In general, all PVC water stops/hydrofoil shall be placed in the centre of the structural member. Each piece of the water stop-hydrofoil shall be of maximum practicable length. An ordinary sharp knife saw or any other sharp tool can be used to cut the water stop. Joints at inter sections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water tightness fully equal to that of the continuous water stop material and shall permanently retain their flexibility. For straight line connection melting method of connection can be used by passing two water stops intended for connection against a heated iron or copper sheet. When they are melted, the two are combined.

f. After joining, the water stop should be allowed to cool.

g. For all other connections such as T-type or L-type, the welding method of joining should be used. Welding rod of same material as the water stop shall be used. The welding rod & the water stop shall be heated & melt at the same time, by means of heated air jetting from the hot jet gun.

23.11. TEST OF CONCRETE QUALITY

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

concrete. All test specimens shall be made at site and tests carried out under his direct supervision.

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

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

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

made in the materials or in the proportions of materials to be used, or as required by the Engineer. The strengths shall comply with the standard of quality specified in accordance with Table 20.3 in accordance with ASTM C 39. The cost of such testing shall be borne by the Contractor.

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

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

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

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

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

23.12. FINISHING OF FORMED SURFACES

23.12.1. General

a. After removal of forms, the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Contract Documents.

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

c. Allowable deviations from plumb or level and from the alignment, profile grades, and dimensions are specified in clause 9. Tolerances for concrete construction are defined as tolerances to be distinguished from irregularities in finish as described herein. The finish requirements for concrete surfaces shall be as generally specified in this clause and as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skilled in concrete finishes. The Contractor shall keep the Engineer advised as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer. Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the limits herein after specified, surface irregularities are classified as abrupt or gradual. Offsets caused by displaced or misplaced form sheeting or lining or section, or otherwise defective form lumber will be considered as abrupt irregularities, and will be tested by direct measurements. All other irregularities will be considered as gradual irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template 2 meter for testing of formed surfaces and 3 meter for testing of unformed surfaces.

23.12.2. As-cast Finishes

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

a. Rough form finish

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

b. Fair face finish

Fair face finish applies to concrete formed surfaces, the appearance of which is considered by the Engineer to be of special importance, such as surfaces of structures prominently exposed to public inspection. Surfaces of concrete structures requiring fair face finish as shown in the Drawings. Surface irregularities, measured as described in section, ‘Rough form finish’, shall not exceed 4 mm for gradual irregularities and 6mm for abrupt irregularities, except that abrupt irregularities will not be permitted at construction joints.

Abrupt irregularities at construction joints and elsewhere in excess of 6 mm and gradual irregularities in excess of 1/8 inch. (3mm) shall be reduced by grinding so as to conform to the specified limits. Abrupt irregularities at construction joints shall be ground on level of 1 to 20 ratio of height to length.

Unless otherwise approved, repair of imperfections in formed concrete shall be completed within 24 hours after removal of forms. The form facing material shall produce a smooth, hard, uniform texture on the concrete. It may be plywood, temperated concrete form grade hardboard metal, plastic paper, or other approved material capable of producing the desired fair face finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used. The holes and defects shall be patched. All fins shall be completely removed

c. Architectural Finish Concrete

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

i. Sample approvals of precast & in-situ concrete

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

ii. Forms

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

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

Edges, surfaces and corners of forms shall be sealed to prevent loss of any matrix or unequal absorption of water. Corners of wood forms

shall be filled with suitable compound and all contact surfaces sealed with a polyurethane varnish.

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

iii. Curing

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

iv. Finishing procedures:

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

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

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

On the day after the repair work, the concrete surfaces should again be wiped off clean with dry burlap to remove any inadvertent dust leave no built-up surfaces on the parent surfaces. Employ, if possible, a used piece of burlap containing old hardened mortar to act as a mild

abrasive. Use of find abrasive stone if needed to remove any remaining built-up film without breaking through the surface film of the original concrete. Such scrubbing should be light and sufficient only to remove excess material without working up a lather of mortar or changing the texture of concrete. Following the final bagging or stoning operation, provide a thorough wash down with stiff bristle brushes to remove all extraneous materials and spray the concrete surface

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

v. Rust Stains

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

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

vi. Repairing of Formed Surfaces:

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

vii. Finishes of Unformed Surfaces

Where monolithic concrete floor finish is shown on the Drawings, placing shall proceed continu6usly for the full thickness of the course or RCC slab without change in concrete mix. Mixing water shall be the minimum required for proper area shall be kept damp for 7 days. Metal tools shall not be used in finishing a patch in a formed wail, which will be exposed.

Where as-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast surfaces shall not exceed 2 sq ft. in each 1000 sq.ft. of as-cast surface. This is in addition to form tie patches, if the project design permits ties to fall within as-cast areas.

Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good colour match with the concrete when both patch and concrete are cured and dry. After initial set, surfaces of patches shall be dressed manually to obtain the same texture as surrounding surfaces.

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

viii. Tie and Bolt Holes

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

ix. Proprietary Materials

If permitted or required by the Engineer, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations with prior approval of the Engineer.

23.13. TOLERANCES

Where tolerances are not stated in the Drawings for any Individual structure or feature thereof maximum permissible deviations from established lines, grades and dimensions shall conform to the following. The Contractor is expected to set and maintain concrete limits. These allowable tolerances shall not relieve the Contractor of the responsibility for correct fitting of indicated materials. Those tolerances are not cumulative.

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

i. In the lines and surfaces of columns, piers, and walls and in arises. In any 10 ft. (3 meter) of length or height: 1/4" (6 mm)

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

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

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

b. Variation from the level or from the grades indicated on the Drawings.

i. In floors, ceilings, beams soffits and in arises.

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

In any bay or 20 ft. (6 meter) maximum: 3/8" (10 mm) Maximum for the entire length: 3/4" (20 mm)

ii. For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines.

In any bay or 20 ft. (6 meter) maximum: 1/4" (6 mm) Maximum for the entire length: 3/8" (10 mm)

c. Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

In any bay or 10 ft. (3 meter) maximum1/2" (13 mm) Maximum for the entire length: 1" (25 mm)

d. Variation in the sizes and locations of sleeves, Floor openings and wall openings. ± 1/4" (± 6mm)

e. Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls.

Minus: 1/4" (6mm); Plus: 1/2" (13mm)

f. Footings

i. Variation in dimensions in plan Minus

Minus: 1/2" (13 mm)

Plus (plus variation applied to concrete only, not to reinforcing bars or dowels). 2" (50mm)

ii. Misplacement or eccentricity

2 percent of the footing width in the direction of misplacement but not more than (applies to Concrete only, not to reinforcing bars or dowels).2" (15 mm)

iii. Thickness

Decrease in specified thickness: 5%

Increase in specified thickness: No limit

g. Variation in Steps

i. In a flight of stairs

Rise 1/8" (3 mm) Tread: 1/4" (6 mm)

ii. In consecutive steps:

Rise: 1/16" (1.5 mm)

Tread: 1/8” (3 mm)

h. Tolerances for Pre-Cast Concrete Constructions

Forms must be true to size and dimensions of concrete members shown on the Drawings and be so constructed that the dimensions of the finished products will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on structural-architectural Drawings:

i. Overall dimensions of members 1/16” per 10 feet ii Cross-sectional dimensions

Sections less than 3-inch: 1/16” (1.5 mm); Sections over 3-inch and less than 18-inch: 1/8” (3 mm);

Sections over 18-inch : 1/4” (6 mm)

iii. Deviations from straight line in long sections

Not more than: 1/8” per 10 feet

iv. Deviation from specified camber: 1/16” per 10 feet

v. Maximum differential between adjacent units in erected position 1/4” (6 mm)

23.14. ACCEPTANCE OF STRUCTURE

23.14.1. General

a. Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the Contract Documents.

b. Completed concrete work which fails to meet one or more of the requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the Contract Documents.

c. Completed concrete work which fails to meet one or more of the requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the Contract Documents. In this event, modifications may be required to assure that remaining work complies with the requirements.

23.14.2. Dimensional Tolerances

a. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances Section in Technical Specifications shall be considered potentially deficient in strength.

b. Formed surfaces resulting in concrete outlines larger than permitted by the tolerance Section in Technical Specifications may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to be removed in accordance with this clause.

c. Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely affected or if misplaced items interfere with other construction.

d. Inaccurately formed concrete surfaces exceeding the limits of Technical Specifications and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.

23.14.3. Appearance

a. Architectural concrete with surface defects exceeding the limitations of SECTION CONCRETE FORMWORK & ACCESSORIES shall be removed and replaced.

b. Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only

c. Concrete not exposed to view is not subject to rejection for defective appearance.

23.14.4. Strength of Structure

a. The strength of the structure in place will be considered potentially deficient if it fails to comply with any requirements which control the strength of the structure, including but not necessarily limited to the following conditions:

- Concrete strength requirements not considered to be satisfied in accordance with SECTION-20.5.2.
- Reinforcing steel size, quantity, strength, position or arrangement at variance with the requirements as listed under specification of
- ‘Reinforcement’ or in the contract documents.
- Concrete which differs, from the required dimensions or location in such a manner as to reduce the strength.
- Curing less than that specified.
- Inadequate protection of concrete from extremes of temperature during early stages of hardening and strength development.
- Mechanical injury, construction fires, accidents of premature removal of formwork likely to result in deficient strength.
- Poor workmanship likely to result in deficient strength.

b. Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.

c. Core tests may be required when the strength of the concrete in place is considered potentially deficient.

d. If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their result evaluated in accordance with British Standard, CP 110 or ACI 318 and ACI 350.

e. Concrete work judged inadequate by structural analysis or by results of a load test shall be reinforced with additional construction if so directed by the Engineer or shall be replaced, at the Contractor's expense.

f. The Contractor shall pay all costs incurred in providing the additional testing and/or analysis required by this section.

g. All costs of additional testing and/or analysis which is made at the Client request and which is not required by these Specifications, or by the Contract Documents shall also be borne by the Contractor.

23.15. MEASUREMENT AND PAYMENT

23.15.1. Measurement

Concrete will be measured for the number of cubic foot or cubic meter (whichever is included in Bill of Quantities) acceptably placed complete in all respects as per Drawings and in strict accordance with this section of specification.

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

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under this specification in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account:

- Providing, fixing, striking, etc. of formwork.
- Providing, placing and fixing of anchor bolts or any other embedded parts.
- Providing and installing all type of joints in concrete structure, including expansion joints.
- Providing and fixing water stoppers.

23.15.2. Payment

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the specifications and shall constitute full compensation for furnishing all materials, shuttering, equipment and labour and for performing all operation necessary to complete the work.

Concrete shall be measured as executed but no deductions shall be made for the following:

- Volume of any steel embedded in the concrete;

- Volume occupied by water pipes, conduits etc. not exceeding 10 square inches each in cross-sectional area; and
- Voids not exceeding 4 square inch in work given in square feet. If any void exceeds 4 square inch, total void shall be deducted.

Voids, which are not to be deducted as specified above refer only to openings or vents which are wholly within the boundaries of measured areas.

Openings or vents which are at the boundaries of measured areas shall always be subject to deductions irrespective of size.

Concrete work shall be classified and measured separately as listed under items of Bills of Quantities.

Junction between straight and curved works shall in all cases be deemed to be included with the work in which they occur.

24. REINFORCEMENT

24.1. SCOPE OF WORK

The work under this section of specifications consists of furnishing, cutting, fabricating, bending and placing steel reinforcement as shown on the Drawings or as directed by the Engineer. The scope of this section of specification is covered with detailed specifications as laid down herein.

24.2. APPLICABLE STANDARDS

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

24.2.1. Pakistan Standard

- PS 241, Tensile testing of steel
- PS 244, Bend test for steel
- PS 580, Rolled deformed steel bars (intermediate grade) for concrete reinforcement
- PS 605, Rolled deformed steel bars (hard grade) for concrete reinforcement
- PS 606, Rolled deformed steel bars (structural grade) for concrete reinforcement
- PS 607, General technical delivery requirement for steel

24.2.2. British Standard

- BS 693, General requirements for oxy-acetylene welding of mild steel
- BS 785, Hot rolled bars and hard drawn wire for the reinforcement of concrete
- BS 1856, General requirement for the metal arc welding of mild steel
- BS 4449, hot rolled steel bars for reinforcement of concrete
- BS 4461, Cold worked steel bars for reinforcement of concrete
- BS 4466, Bending dimensions and scheduling of bars for the reinforcement of concrete

24.2.3. ASTM Standard

- ASTM A 305, Minimum requirement for the deformations of deformed steel bars for concrete reinforcement
- ASTM A 615, Deformed billet steel bars for concrete reinforcement

24.2.4. ACI Standard

- ACI 315, Manual of standard practice for detailing reinforced concrete structure
- ACI 318, Building code requirements for reinforced concrete

- ACI 350, Building code requirement of environmental engineering concrete structures

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

24.3. SUBMITTALS

The Contractor shall submit the following to the Engineer for approval before commencement of work:

- Bar bending schedule prepared by Contractor on the basis of approved Drawings for the approval of the Engineer.
- Results of all tests performed upon steel reinforcement bars obtained from the site of work as per directions of the Engineer.

24.4. MATERIAL REQUIREMENTS

Reinforcement for concrete shall conform to the respective Pakistan, British, ASTM, or other Standards as specified in the Drawings and in the Contract Documents or as may be specified by the Engineer.

Unless otherwise specified, all plain reinforcing bars shall comply with the requirements of BS 4449 for plain mild steel bars and shall have a minimum characteristic strength of 40,000 psi.

Unless otherwise specified, all deformed reinforcing bars shall comply with the requirements of BS 4461 for deformed cold worked new stock billet steel bars and shall have a minimum characteristic yield strength of 60,000 psi.

Steel wire mesh reinforcement shall conform to requirements of ASTM Designation A-185-64 or BS 4483. Standard Specifications for Welded Steel Wire Fabric for concrete reinforcement. It shall be used where shown on the Drawings.

Reinforcement shall be free from all loose or flaky rust and mill scale, or coating, including ice, and any other substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not be used.

24.5. DELIVERY & STORAGE

24.5.1. Delivery

Steel reinforcement bars shall be kept in bundles firmly secured and tagged.

24.5.2. Storage

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

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

24.6. BAR BENDING SCHEDULES

The Contractor shall prepare bar bending schedules of all the reinforcing steel bars and these bar bending schedules shall be submitted to the Engineer for approval. The Contractor shall obtain approval of the bar bending schedules before starting actual bar bending works.

24.7. FABRICATING, BENDING & PLACING

All metal for reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.

Reinforcement is to be accurately placed as shown in the Drawings, and secured against displacement by using 16-gauge G.I wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover, they shall be made of mortar not leaner than 1 part of cement to 2 parts of sand.

Where the concrete surface will be exposed to the weather in the finished structure, the portions of all accessories in contact with the form work shall be galvanized or shall be made of plastic.

Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the bar bending schedule approved by the Engineer. The cutting tolerance for all bars shall be ± 1 inch. (± 25 mm).

Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as included in Table 21.1.

Table 8 - Bending Tolerances for Reinforcement Bars

Sr. No.	Dimension of Bent Bars		Tolerance	
	Over Feet	Up to & Including	Plus Inch	Minus
1	-	3	1/5	1/5
2	3	6	1/5	1/5
3	6	-	1/5	1

Bars shall be placed to the tolerances as included in Table 21.2.

Sr. No.	Location of Bars	Tolerance
1	Concrete cover to formed surfaces	± 1/4" (± 6mm)
2	Minimum spacing between bars	± 1/4" (± 6mm)

3	Top bars in slabs and beams	
	Members 8 inch deep or less	$\pm$ 1/4" ($\pm$ 6mm)
	Members more than 8 inch but not over 24 inch deep	$\pm 3/8"$ ($\pm$ 10mm)
	Members more than 24 inch deep	$\pm$ 1" ($\pm$ 25mm)
4	Crosswise members spaced evenly within	$\pm$ 2" ($\pm$ 50mm)
5	Lengthwise members	$\pm$ 2" ($\pm$ 50mm)

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

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

Reinforcement shall not be bent or straightened in a manner that will injure the material.

No bars shall be bent twice in the same place, nor shall they be straightened after bending.

Unless permitted, by Engineer reinforcement shall not be bent after being partially embedded in hardened concrete.

No splice of reinforcement shall be made except as shown on the working Drawings.

Welding shall be permitted for, bars only under suitable conditions and with suitable safeguards in accordance with BS 693, PS 1856, or AWS D12.1, provided the type of reinforcement bar has the required welding properties. Tack welding may be used to fix in position bars that cross each other, only with prior approval of the Engineer.

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

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

Welding shall be done as in section ‘Structural Steel Works’. All detailing shall be done as per ACI standards ACI-315, AC1-318 and ACI-350.

Concrete clear cover for reinforcing steel shall be as provided in Drawings. All reinforcing steel shall be held firmly in place before and during the placing of concrete by means of wires and supports adequate to prevent displacement during the course of construction.

24.8. MEASUREMENT & PAYMENT

24.8.1. Measurement

The measurement for acceptably completed works of reinforcement according to bar bending schedules approved by the Engineer shall be made by weight computed on the bases of Table below.

The Contractor shall not claim for the difference in the actual weights of bars and their standard weights given in Table below.

Table 9 - Standards Weights of Reinforcement Bars

Sr. No.	Nominal Bar Diameter, Inch	Bar No.	Weight, lb/ft
1	3/8	#3	0.376
2	1/2	#4	0.668
3	5/8	#5	1.043
4	3/4	#6	1.502
5	7/8	#7	2.044
6	1	#8	2.670
7	1-1/8	#9	3.400
8	1-1/4	#10	4.303

The rates quoted by the Contractor in the Bill of Quantities shall include work to be executed under these specifications in any floor and at any height except where otherwise specifically stated in the relevant item of Bill of Quantities and the Contractor shall not be entitled to any claim or claim any compensation on this account.

Providing and installing cover blocks, chairs, supports, hooks, spacers, binding wires, and laps not shown on Drawings including wastage and rolling margin and as such are not payable. Laps shown on Drawings shall be payable.

24.8.2. Payment

Payment will be made for acceptable measured quantity of reinforcement on the basis of unit rate per metric ton or kg (whichever is included in Bill of Quantities and shall constitute full compensation for all the works related to the item.

The rate quoted include all lead/lift required for steel fabrication & placement at/in any floor or at any height as per Drawings.

25. SULPHATE RESISTANT CEMENT CONCRETE

25.1. SCOPE OF WORK

This work shall consist of providing sulphate resistant cement in place of Portland cement to all classes of concrete subject to the contact with soil having sulphate content more than 0.1% and with ground water having sulphate content more than 1500 ppm or as mentioned in the drawing or directed by the Engineer. Maximum Chloride Ion Concentration (as a percentage of weight of cement) arising from all sources including aggregates should not exceed 0.1 for pre-stressed concrete, 0.2 for any concrete using sulphate resistance cement and 0.35 for all other cement containing matter. All requirements of concrete with sulphate resistant cement are same as mentioned in SECTION, PLAIN & REINFORCED CONCRETE except amended in this section

25.2. MATERIAL REQUIREMENTS

Sulphate resistant cement where required shall be sulphate resistant cement type 'A' fully conforming to Pakistan standard specification PS 612:1967 and satisfying to requirements for fineness, chemical composition, strength, setting time and soundness etc. The average compressive strength of three mortar cubes prepared with 1:3 cement and standard silica sand mortar shall not be less than 20.0 N/mm sq. at seven days. The initial setting time shall not be less than 45 minutes and final setting time not more than 10 hours.

25.3. MEASUREMENT AND PAYMENT

25.3.1. Measurement

The quantity of concrete with sulphate resistant cement shall be measured exactly in same way as mentioned in SECTION- PLAIN & REINFORCED CONCRETE and subsequently paid as elaborated below. Payment

The accepted quantity measured as provided above shall be paid only for the difference of cost for providing sulphate resistant cement in place of ordinary Portland cement at the contract unit price for particular pay item(s) as provided in the Bill of Quantities, which price and payment shall be full compensation for all the costs involved in the proper completion of the works.

26. CONCRETE FORMWORK & ACCESSORIES

26.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and in performing all operations in any floor and at any height in connection with the supply and installation of formwork for the purpose of shuttering in concreting work, complete in strict accordance with this section of the specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

26.2. APPLICABLE STANDARDS

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

American Concrete Institute

- ACI 301, Specifications for Structural Concrete for Buildings
- ACI 318, Building Code Requirements for Reinforced Concrete
- ACI 347, Recommended Practice for Concrete Formwork
- ACI 350, Building code requirement of environmental engineering concrete structures

26.3. American Plywood Association:

- APA, High Density Overlaid Concrete Form, Class 1
- APA, Structural 1, Exterior Quality, Class 1
- APA, Plastic Overlaid Plywood Forms

26.4. American National Standard Institute

- A199.1, Construction and Industrial Plywood.

26.5. SUBMITTALS

a. Product's Data: Submit manufacturer's specifications and installation instructions for proprietary materials and items as required, including form coatings, manufactured form systems, ties and accessories.

b. b. Detail Shop Drawings: Submit data on sequence of the concrete placement, location of construction joints, camber details, bearing values of the soils supporting false-work under wet and dry conditions, the anticipated settlements as well as false-work release sequence.

26.6. MATERIAL REQUIREMENTS

26.6.1. Concrete Formwork

Unless otherwise specified construct formwork of plywood, metal, metal framed plywood faced or other panel type materials acceptable to Engineer to provide continuous, straight, smooth surfaces. Provide formwork in the largest practice sizes to minimize number of joints and to conform to joint system indicated on Drawings. Provide form material with sufficient thickness

to withstand pressure of newly placed concrete without bow or deflection. Provide wood forms of minimum thickness of 16 mm.

26.6.2. Forms of Unexposed Finish Concrete

Provide forms of plywood, lumber, metal or glass fibre reinforced plastic or other acceptable material.

26.6.3. Form Ties

Provide factory fabricated, adjustable length, removable or snap off metal form ties, designed to prevent form deflection and to prevent spalling concrete surfaces upon removal. Use Plastic cone type, with threaded steel rod. For water tanks or other water retaining structures use watertight form ties as recommended by the manufacturer.

Unless otherwise indicated, provide ties so that portion remaining within concrete after removal of exterior parts is at least 38 mm from the outer concrete surface. Provide form ties which will not leave a hole larger than 25 mm diameter in the concrete surface.

Form ties fabricated on Project Site and wire ties are not acceptable.

26.6.4. Form Release

Non staining, non-reactive, rust preventive guaranteed not to affect bond of subsequent surface applications to concrete.

26.7. DESIGN OF FORMWORK

Design, erect, support, brace and maintain formwork to safely support vertical and lateral loads applied, until such loads can be supported by the concrete structure. Carry vertical and lateral loads to ground by formwork system and in-place construction that has attained adequate strength for the purpose. Design and construct formwork of concrete members and structures to correct size, shape, alignment, elevation and position.

Design form and false-work to include assumed value of live load, dead load, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability and other factors pertinent to safety of structure during construction.

Design formwork to be readily removable without impact, shock or damage to cast in place concrete surfaces and adjacent materials.

Provide formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide back-up material at joints as required to prevent leakage and fins.

Design forms according to ACI 318 and ACI 350 Parts 1, 2, and 3 requirements as well as ACI 347 requirements for loads, lateral pressure, and allowable stresses; in addition to other design parameters.

26.8. DELIVERY AND STORAGE

26.8.1. Delivery

The delivery of formwork materials shall be done in such a manner that damage can be prevented.

26.8.2. Storage

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

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

26.9. QUALITY ASSURANCE

Design, construct, erect, support, brace, maintain and remove forms according to ACI 318 and ACI 350, Parts 1, 2, and 3 requirements as well as ACI 347 requirements for loads, lateral pressure and allowable stresses; in addition to other design parameters such as wind loads.

Construct formwork so that cast concrete surfaces will conform to the requirements of ACI 301, Chapter 4, Paragraph 4.3 Tolerances.

Maximum allowable deflection of forming surfaces from concrete pressure will be length/360 between supports.

Provide surveys as required to check the lines and levels of the completed formwork for exposed concrete before concrete is placed. Make the required corrections or adjustments to formwork to correct deviations which exceed the specified tolerances.

Check formwork during concrete placement to ensure forms, shores, false- work, ties and other features have not been unduly disturbed by concrete placement methods or equipment. Report in writing to the Engineer deviations from the allowable tolerances

26.10. EXECUTION

26.10.1. Inspection

Examine substrate and conditions under which concrete formwork is to be performed. Correct any unsatisfactory conditions. Proceed with the work after unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

26.10.2. Form Construction

a. General

Construct forms complying with ACI 347, to sizes, shapes, lines and dimensions indicated and required to obtain accurate alignment, location, grades, level and plumb work in the finished structures. Provide for openings, offsets, sinkages, keyways, recesses, mouldings, rustication, reglets, chamfers, blocking, screed, bulkheads, anchorages, inserts, and other features required. Use selected materials to obtain the required finishes.

Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where the slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and assure ease of removal.

Provide temporary openings where interior area of formwork is inaccessible for cleanout, inspection before concrete placement and placement of concrete. Securely brace temporary closures and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

Form intersecting planes to provide true, clean out corners, with edge grain of plywood not exposed as form for concrete.

b. False-work

Erect false-work and support, brace and maintain it to safely support vertical, lateral and asymmetrical loads applied until such loads can be supported by in-place concrete structures. Construct false-work so that adjustments can be made for take up and settlement.

Provide wedges, jacks or camber strips to facilitate vertical adjustment. Inspect false-work and formwork during and after concrete placement operations to determine abnormal deflection or signs of failure and make necessary adjustments to produce work of required dimensions.

Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Provide trussed supports when adequate foundations for shores cannot be secured.

Support form facing materials by structural members spaced sufficiently close to prevent deflection. Fit forms placed in successive units for continuous surfaces to an accurate alignment, free from irregularities and within allowable tolerances. Provide camber in formwork as required for anticipated deflections due to weight and pressures of fresh concrete and construction loads for long span members without intermediate supports.

Provide temporary openings in wall forms and at other locations necessary to permit inspection and clean out.

c. Forms for Exposed Concrete

Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Do not splinter forms by driving ties through improperly prepared holes.

Do not use metal cover plates for patching holes or defect in forms.

Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back joints with extra studs or girts to maintain true, square intersections.

Use extra studs and bracing as required to prevent bowing of forms between studs and to avoid bowed appearance in concrete. Do not use narrow strips of form material which will produce bow.

Assemble forms in a way to be readily removed without damage to exposed concrete surfaces.

Form mouldings shapes, recesses and projections with smooth finish materials and install in forms with sealed joints to prevent displacement.

d. Corner Treatment

Form exposed corners to produce square, smooth, solid, unbroken lines, except as otherwise indicated.

Provide chambers for surfaces where indicated on Drawings.

Unless otherwise indicated, form chamfers using wood strips 19 x 19 mm; accurately formed and surfaced to produce uniformly straight lines and tight edge joints. Extend terminal edges to required limit and miter chamfer strips at changes in direction.

e. Provisions for other Trades

Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses and chases required for such work. Accurately place and securely support built-in items into forms.

f. Cleaning and Tightening

Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete placement. Re-tighten forms immediately after concrete placement as required to eliminate mortar leaks.

26.10.3. Form Coatings

Coat form contacts surface with form coating compound before placing the reinforcement. Provide form coating compounds that will not bond with, stain, nor adversely affect concrete surfaces and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. Do not allow excess form coating material to accumulate in the forms or to come into contact with surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.

Coat steel forms with a non-staining, rust preventive form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

26.10.4. Installation of Embedded Items

a. General

Set and build into the work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast in place concrete. Use setting drawings, diagrams, instructions and directions provided by the suppliers of these items to be attached thereto.

b. Edge Forms and Screed Strips for Slabs

Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in the finished slab surface. Provide and secure units to support types of screed required.

c. Metal Inserts

Provide metal inserts for anchorage of materials or equipment to concrete construction, as required for the work.

Provide adjustable wedge inserts of malleable cast iron, complete with bolts, nuts and washers; 19 mm bolt size unless otherwise indicated.

Provide threaded inserts of malleable cast iron, furnish complete with full depth bolts; 19 mm bolt size, unless otherwise indicated.

Provide box out sections in concrete work as required for installation of equipment or other work.

Coordinate location of all required embedded weld plates and other items for attachment of precast concrete to cast in place concrete.

26.10.5. Shores and Supports

Shore floor directly under slab being placed so that loads from construction above will safely transfer directly to these shores. Space out shoring below this level in such a manner that no member will be excessively loaded or will

induce tensile stress in concrete members where no reinforcing steel is provided. Extend shores beyond minimum if required to ensure the proper distribution of loads and the safety of all concrete members.

Remove shores and reshore in a planned sequence to avoid damage to partially cured concrete, and to assure that the structure supported is not subjected to impact or loading eccentricities. Locate and provide adequate reshoring to safely support the work.

26.10.6. Removal of Forms

Formwork not supporting concrete, such as sides of beams, columns, walls, and similar parts of the work (vertical faces) may be removed not less than

24 hours after placing concrete provided that concrete is sufficiently hard and will not be damaged by form removal operations, and provided that curing and protection operations are maintained.

Formwork supporting weight of concrete, such as slabs and other structural elements must remain in place for the time period shown in ACI 347 (assuming design live load is less than dead load) and until concrete has attained design minimum 28-day compressive strength determined by field-cured specimens as defined below. Do not remove forms until the approval has been obtained from the Engineer.

Form facing material may be removed not less than 4 days after placement, provided shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports and provided that concrete has achieved adequate compressive strength to safely support the load.

Use necessary means and precautions to protect workmen, passer-by, the installed work and material of other trades and complete safety of structure.

Cut nails as well as form ties off flush leaving surfaces smooth and clean.

Remove metal spreader ties on exposed concrete by removing or snapping off inside the wall surfaces and pointing up and rubbing the resulting pockets to match surrounding surfaces.

Flush holes resulting from spreader rods and sleeve nuts, using water, and solidly pack throughout the wall thickness with cement grout applied under pressure by means of grouting gun; grout shall be one part cement to 2-1/2 parts sand; apply grout immediately after removing forms.

26.10.7. Re Use of Forms

Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated or otherwise damage form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

When forms are extended for successive concrete placement thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces

26.11. MEASUREMENT AND PAYMENT

26.11.1. Measurement

No separate measurement shall be made for the works involved within the scope of this section of the specifications unless otherwise specifically stated in the Bills of Quantities.

26.11.2. Payment

No separate payment, unless otherwise included in the Bills of Quantities, shall be made. The cost thereof shall be deemed to have been included in quoted unit rates of relevant items of the Bills of Quantities.

27. STRUCTURAL STEEL WORKS

27.1. SCOPE OF WORK

The work covered by this section, consists of supply of all material, labour, plant, equipment and appliances including welding, bolts, nuts, washers, anchor bolts, embedded parts etc., fabrication, erection and painting in accordance with the specifications, as per Drawings and as directed by the Engineer.

27.2. SUBMITTALS

a. Product Data: Submit manufacturer's product information, specifications and installation instructions for all structural steel components and accessories.

b. Shop Drawings: Submit complete shop drawings, including details and schedules for fabrication, assembly and erection of structural steel members, procedures, and diagrams. Include details of cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols and show size, length, and type of each weld. Provide setting drawings showing all anchor bolt locations on plan with column grids. Show projection of each bolt above foundation concrete, length of threaded portion of each bolt and orientation of shear lugs.

c. Design Analysis and Calculations: Provide design analysis and calculations for structural steel members of which sizes are not shown, and connections for beams, girders and other steel member intersections.

d. Test Reports: Provide reports for tests conducted on shop- and field-bolted and welded connections. Include data on type(s) of tests conducted and test results.

27.3. MATERIAL REQUIREMENTS

Except otherwise stated in the Drawings, the material specifications shall conform to the following:

a. Structural steel shapes, plates and bars shall conform to the requirements of ASTM A36.

b. Cold-Formed Steel Tubing: Comply with requirements of ASTM A500, Grade B.

c. Hot-Formed Steel Tubing: Comply with requirements of ASTM A501. d.

d. Steel Pipe: Comply with requirements of ASTM A53, Type E or S, Grade B; or ASTM A501.

e. Build-up Members Fabricated from Plate or Bar stock: Comply with requirements of ASTM A529, A570 or A572; minimum 50,000 psi yield strength.

f. Members Fabricated by Cold Forming: Comply with requirements of ASTM A607, Grade 50.

g. Galvanized Cold-Formed Members: Comply with requirements of

ASTM A446, Grade D, galvanized to ASTM A525, Class G90.

h. Steel forging shall conform to the requirements of ASTM A235.

i. Steel casting shall conform to the requirements of ASTM A27, Grade 65-35, medium-strength carbon steel.

j. Galvanized Steel Sheet: Comply with requirements of ASTM A446, Grade C, galvanized to ASTM A525, Class G90.

k. Welding Electrodes for manual shielded metal arc welding shall conform to AWS A 5.1 latest edition or the A 5.5 latest edition. Equivalent locally manufactured electrodes may be used subject to the approval of the Engineer.

l. Common Bolts, Anchor Bolts, Nuts and Washers Bolts and Nuts shall conform to the requirements of ASTM A307.

m. High strength carbon steel bolts including nuts and washers shall conform to the requirements of ASTM A325 latest editions and of AISI B18.2

n. Cut Washers shall be of structural grade steel and shall conform to the dimension of the manufacturer's regular standard for plain washers for the size of bolts used.

o. Cast iron Shall conform to the requirements of latest edition of ASTM A 48.

p. Structural Steel Primer Paint: SSPC - Paint 2, red lead-iron oxide, oil alkyd.

27.4. TRANSPORTATION, HANDLING AND STORAGE

Stack materials out of mud and dirt and provide for proper drainage. Exercise care to avoid abrasions and other damage to shop primer paint. Protect from damage or soiling by adjacent construction operations. Keep steel members off ground by using pallets, platforms, or other supports. Protect material against corrosion and deterioration.

27.5. FABRICATION

27.5.1. Straightening of Material

Rolled material, before being worked upon must be straightened within tolerances, by ASTM specifications A6 Straightening, necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 1100oF for A514 steel or 1200oF for other steels.

27.5.2. Cutting

As far as possible cutting must be done by shearing. Oxygen cutting shall be done where shear cutting is not possible and shall preferably be done by Machine. All edges shall be free from gauges, notches or burs. If necessary, the same shall be removed by grinding.

27.5.3. Holes Punching Drilling

Holes shall be punched where thickness of the material is not greater than the diameter of bolt +3 mm. Where the thickness of the material is greater the holes shall either be drilled or sub-punched and reamed to size. The die for all sub-punched holes and the drill to all sub-drilled holes shall be at least 1.58 mm smaller than the nominal diameter of the rivet or bolt. Holes for A514 steel plates over 13 mm thick shall be drilled.

27.5.4. Welding

a. General

The execution and inspection of welding will be done in accordance with the provisions of the American welding society code for welding in Building construction, D1.0. No welding for piping/electrical supports shall be made transversely to any tension flanges of trusses, beams or columns.

b. Automatic submerged Arc Welding

For all built-up members, i.e., sections fabricated from plates and flat bars or compound rolled sections, plate and box girders, where long continuous, welding is to be done, should be executed by Automatic submerged Arc Welding process in accordance with relevant AWS specifications.

Maximum and minimum size and lengths of fillet welds shall be in accordance with AISC specifications.

Surface to be welded shall be free from loose scale, slag, rust, grease, paint or any other foreign matter except mill scale which withstands vigorous wire brushing.

27.5.5. Tolerances

A variation of I mm is permissible in the overall length of members with both ends finished for Contact bearing. The bearing surfaces prepared to a common plane by mining.

Members without end finished for contact bearing which are to be framed to other steel parts of the structure shall have a variation from detailed length not greater than 3 mm.

27.6. SURFACE PREPARATION & PAINTING

27.6.1. Surface Preparation

All structural steel material i.e., rolled steel sections, plates, pipes, flat bars, chequered plates shall be cleaned free from loose scale, rust, burrs slag, etc. by means of sand blasting.

27.6.2. Painting

a. Immediately after surface preparation all material shall be given one prime coat of rust preventive paint.

b. After fabrication one shop coat of prime paint and then one coat of enamel paint shall be applied.

c. One final coat of enamel paint shall be applied after erection of all components.

d. The type of primer and enamel paints to be applied shall be as specified on the Drawings.

e. All other requirements for the specified paint system shall be in accordance with the paint manufacturer's specification recommendations.

f. The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.

g. Steel work/Surfaces not to be painted

- Steel work to be encased/embedded in concrete or surface in coated with contact with concrete or grout shall not be painted, but shall be given a cement wash after sand blasting.
- Machined finished surfaces shall not be painted but shall be coated with rust preventive compound, (approved by the Engineer) immediately after finishing. Such surfaces shall also be protected with wooden pads or other suitable means for transportation. Unassembled pins, keys, and bolt thread shall be greased and wrapped with moisture resistant paper.

27.7. INSPECTION AND TESTS

Manufacturer's Work Test Certificate for all material used shall be furnished by the contractor for Engineer's scrutiny and approval.

Rolling tolerance of all shapes and profile according to AISC shall be in accordance with the provisions of the American Society for Testing and Materials Designation A.6. These shall be checked by the Contractor before being worked upon and shall be rejected if found not within limits.

The Contractor shall arrange for analysis and test of all material rolled locally at a testing laboratory selected by the Engineer.

a. Inspection of Welding

The inspection of welding shall be performed in accordance with the American Welding Society specifications, as directed by the Engineer.

b. Rejection

Materials or workmanship not in reasonable conformance with the provisions of these specifications shall be rejected at any time during the progress of the work or the completion and erection at site.

27.8. MEASUREMENT AND PAYMENT

27.8.1. Measurement

Measurement for miscellaneous items shall be made as per the units included in the Bill of Quantities.

27.8.2. Payment

Payment shall be made for the number of units of items as provided the Bill of Quantities, measured as above, and at the Contract unit price to furnish, construct and shaping the item and shall constitute full compensation for all work related to that item.

28. BRICK MASONRY

28.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances, scaffoldings and materials and performing all operations in connection with furnishing and installing brick masonry in position including Portland cement and sand for mortar & masonry, complete in strict accordance with this section of the specifications and applicable Drawings and subject to the terms and conditions of the Contract.

28.2. APPLICABLE STANDARDS

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

- ACI 530, Building code requirements for masonry structures
- ACI 530.1, Specifications for masonry structures
- PS 208, Classification, strength and properties of bricks
- ASTM C67, Standard method for sampling and testing brick and structural clay tile
- ASTM C144, Standard specifications of aggregates for masonry mortar
- ASTM C150, Specifications for Portland cement

28.3. SUBMITTALS

The Contractor shall submit the following to the Engineer for approval before commencement of work:

- Methodology and sequence of work
- Specimen samples of bricks, aggregates for mortar or grout and
- Portland cement.
- Results of all tests performed upon the materials and masonry units obtained from the site of work as per directions of the Engineer.

28.4. MATERIAL REQUIREMENTS

28.4.1. Cement

Portland cement for mortar shall conform to the applicable requirements specified in the SECTION-20, PLAIN & REINFORCED CONCRETE.

28.4.2. Sand

Sand for mortar used in brickwork shall be furnished by the Contractor, and shall meet the requirements set forth in ASTM C144. The Fineness Modules of the sand shall range between 1.9 & 2.8 and the grading shall be within the limits

Sand shall be stored at the site in such a manner that it is not mixed with foreign matter. Methods employed by the Contractor for unloading, loading, handling and storage shall be subject to the approval of the Engineer. Sufficient quantity shall be maintained at the Site at all times to assure continuous work

28.4.3. Water

Water used in the manufacture of bricks and in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, alkali, salts and other impurities, and shall conform to the applicable requirements as specified in the SECTION, PLAIN & REINFORCED CONCRETE.

28.4.4. Mortar

Mortar for all brickwork shall, except as otherwise specified in Drawings or directed by the Engineer, shall consist of one part Portland Cement to four parts of sand by volume for 4-1/2-inch thick walls, one part of cement to six parts of sand for 9-inch and over thick walls for building works and one part of cement to 5 parts of sand for other works. Where directed by the Engineer for increased workability, hydrated lime putty, approved by the Engineer, shall be added to the mortar but shall not exceed 25 percent, by volume of the dry cement.

Methods and equipment used for mixing mortar be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of water to the mix shall be rejected. Re-tempering of mortar shall not be allowed. The mixers shall be thoroughly cleaned and washed at the end of each day's work.

28.4.5. Bricks

All bricks, except otherwise specified, shall be of first-class quality made from good brick earth, free from saline deposit and shall be hand moulded. They shall be thoroughly burnt without being vitrified, shall be regular, uniform in shape and size with sharp and square edges, parallel faces and of deep red or copper colour. First class bricks shall be homogeneous in texture and shall emit a clear ringing sound when struck, and shall be free from flaws, cracks, chips, stones and modules of lime. First class brick in an oven dried condition shall not absorb more than 1/5 of its weight of water when immersed one hour in water at 21 to 27 degrees centigrade and shall show no signs of efflorescence on subsequent drying. The average compressive strength of

five representative first class bricks shall be not less than 2000 psi and not less than 1500 psi for any individual brick.

All bricks shall be manufactured by the Trench Kiln Method or other standard methods approved by the Engineer. The earth used in manufacturing bricks shall be carefully selected and shall be free from objectionable quantities of lime, gravel coarse sand, roots, or other organic matter. Salts shall not exceed 0.3 percent and calcium carbonate shall not exceed 2.0 percent.

The moulds used in the manufacture of bricks shall be thoroughly sanded before each use and shall be sufficiently larger than the size of the bricks being manufactured to allow for shrinkage in drying and burning. Over-size, irregular and worn moulds shall be destroyed. Each finished brick for brick masonry shall be 9 inch by 4-1/2 inch by 3 inch in size and shall weigh between 3.2 to 4.2 kilograms. All bricks shall have a “frog” 1/4-inch-deep on one face.

Bricks of approved samples shall only be used in the works. If at any time during the progress of the work, use of sub-standard material is found by the Engineer, such work shall be rejected and the Contractor shall replace the rejected work at his cost

28.5. PLACING

The methods and equipment used for transporting the brick and mortar shall be such as will not damage the brick not delay the use of mixed mortar Brick shall not be placed during rains sufficiently heavy or prolonged to wash the mortar from the brick. Mortar already spread which becomes diluted by rain shall be removed and replaced before continuing with the work. All brick to be used in brick masonry shall be moistened with water for three to four hours before they are used by a method which will ensure that each brick is thoroughly and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brick masonry.

Bricks shall be laid “frog” upward with mortar joints and in English and Flemish bond as shown on the Drawings or as directed by the Engineer. Both bed and vertical joints shall be 1/4 inch in thickness completely filled with cement mortar as specified herein, and each brick shall be bedded by firmly tapping with the handle of the trowel. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. Excess mortar at the outer edges shall be removed and joints drawn straight with the edge of a trowel and a straight edge. All anchors and similar work required to be embedded in the brick masonry shall be installed as the work progresses. At the completion of the work all holes or defective mortar joints shall be cut out and repointed.

Where shown on the drawing the exterior faces of the walls shall be finished by striking the joints as the work proceeds. The joints shall be struck by raking the green mortar

after the brick work has been laid and finishing the joint with a pointing tool. Horizontal joints shall be struck to form a weathered joint and vertical joint shall be struck with a V notch. Care shall be taken that the striking tools do not develop a cutting edge as the object of striking the joint is to compress the mortar into the joints.

The exposed faces of all brick masonry shall be thoroughly cleaned and left bear with struck joints as specified above.

28.6. CURING

All brick masonry shall be water cured and shall be kept wet for at least seven days by an approved method which will keep all surfaces to be cured continuously wet. Method to be utilised by the Contractor for curing of brick masonry shall be subject to the approval of the Engineer. Water used for curing shall meet the requirements of the Specifications for water used in the manufacture of bricks.

28.7. REPAIR

If, after the completion of any brick masonry work, the brick is not in alignment or level, or does not conform to the lines and levels shown on the Drawings, or shows a defective surface, it shall be moved and replaced by the Contractor at his expense unless the Engineer grants permission, in writing, to patch or replace the defective area.

At the completion of the work, all holes and defective mortar joints shall be cut and repointed. Exposed masonry shall be protected against staining or other damages and excess mortar shall be cleared off the surfaces as the work progresses. All exposed masonry shall be clean, smooth, plumb and shall be of acceptable finish. In the event ordinary cleaning is not adequate, special methods such as sand blasting or otherwise as approved by the Engineer, shall be used to clean the surfaces

28.8. SCAFFOLDING

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding which is unsafe in the opinion of the Engineer shall not be used until it has been strengthened and made safe for use of workmen. Cost of scaffolding etc., shall be included by the Contractor in the unit rate for masonry items.

Damage to masonry from scaffolding or from any other cause shall be repaired by the Contractor at his own cost.

28.9. TOLERANCES

The nominal/standard dimensions of brick are 9-inch (length) x 4-1/2-inch (width) x 3-inch (thickness). No dimension of brick (width, height and length) shall differ from the specified standard dimension by more than 1/8 inch.

Moreover, all brick work shall be erected plumb and true to line and level having maximum variation in plumb in height up to 1/16 inch for 3-feet height and limited to 1 inch for the entire height.

28.10. MEASUREMENT AND PAYMENT

28.10.1. Measurement

The measurement for brick work shall be made in cubic feet or cubic meter (whichever is included in Bill of Quantities) of brick work provided within the limits as shown on the Drawings or as directed by the Engineer.

28.10.2. Payment

Payment for brickwork shall be made at the contract unit price per cubic feet or cubic meter (whichever is included in Bill of Quantities). Payment shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work.

29. DAMP PROOF COURSE

29.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment and materials and performing all operations in connection with furnishing damp proof course (DPC) in position complete in strict accordance with this section of the specifications, applicable Drawings and as specified in the Bill of Quantities.

29.2. MATERIAL REQUIREMENTS

All materials i.e., cement, sand, aggregate, water polythene sheet and bitumen shall conform to the specifications given in respective sections.

29.3. HORIZONTAL DPC

29.3.1. In Walls

Unless specified in the Drawings, the horizontal DPC. shall consist of 2-inch thick, Class-C cement concrete mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications two floats of hot bitumen 10/20 penetration grade and intervening layer of polythene sheet.

29.4. Under Floors

Same as in walls except bitumen layers to be laid on 1/2" - 3/4" blinding screed (1:6) to even out surface of Class-E hard core.

29.5. VERTICAL DPC

Unless specified in the Drawings, the vertical DPC shall consists of ½" thick cement sand plaster in 1:3, mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be applied at required levels as per Drawings and instructions by the Engineer, including two float of hot bitumen 10/20 penetration grade.

29.6. CONSTRUCTION REQUIREMENTS

The Contractor shall lay the DPC only when the level, quality of masonry work, etc. is approved.

The concrete work of DPC shall conform to the applicable requirements specified in SECTION, PLAIN & REINFORCED CONCRETE.

Horizontal DPC shall extend to the full width of the wall i.e., up to the external faces. No portion of doors opening, etc. shall be left while laying DPC. The period of curing of concrete shall be not less than 72 hours. Every care should be taken that concrete is not left dry during this period. The work of laying DPC shall be carried out as follows unless otherwise described in Bill of Quantities:

- Placing 2-inch-thick layer of Class-C cement concrete.

- Laying 2 coats of hot bitumen 10/20 penetration grade @ 20 lbs. per sq.ft. (each coat) over entire width and lengths of concrete after the concrete has been properly cured for at least 72 hours, and sand blinding where specified.
- Laying of polythene sheet 500 gauge over entire width and length of concrete after the concrete has been treated with 2 coats of hot bitumen.

The application of bitumen coating in case of vertical DPC shall be same as mentioned above.

29.7. MEASUREMENT AND PAYMENT

29.7.1. Measurement

Measurement shall be made in square feet or square meter (whichever is included in Bill of Quantities) of superficial area or surface damp proofed as per this section of specification and accepted by the Engineer.

29.7.2. Payment

Payment will be made for the number of square feet or square meter (whichever is included in Bill of Quantities) of superficial area damp proofed at the contract unit price and will include full compensation for furnishing and placing all materials and for all labour, equipment, tools and incidentals necessary to complete the work prescribed in the Bill of Quantities.

30. CEMENT PLASTER

30.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances, and materials and in performing all operations in connection with providing and installation of cement plaster, and specified external rendering complete in strict accordance with this section of the specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

30.2. APPLICABLE STANDARDS

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

30.2.1. Pakistan Standard

- PS 232, Ordinary Portland Cement

30.2.2. ISO (International Organization for Standardization)

- R 597, Definitions and terminology of cement.
- R 679, Method of testing strength of cements, compressive and flexural strength of plastic mortar (Rilem - (embureau method).
- P 680, Chemical analysis of cement & main constituents of Portland Cement.
- R 68, Chemical analysis of cements-mixer Constituents of Portland cement.
- R 682, Chemical analysis of cements - determination of sulphur as sulphide.

30.2.3. ASTM (American Society for Testing and Material)

- ASTM C144, Aggregate for Masonry mortar
- ASTM C631, Bonding Compounds for interior plastering

30.2.4. BSI (British Standards Institution)

- BS 812, Methods for sampling and testing of mineral aggregates, sands and fillers.
- BS 1199, Sands for external renderings Internal plastering with lime and Portland cement and floor screeds.
- BS 1369, Metal lathing (steel) for plastering.
- BS 5262, External rendered finishes.
- BS 5492, Internal plastering.

30.3. SUBMITTALS

Sample of materials shall be submitted to the Engineer for his approval prior to use in the works.

30.4. MATERIAL REQUIREMENTS

Portland cement for mortar shall conform to the applicable requirements specified in the SECTION, PLAIN & REINFORCED CONCRETE.

Sand for plaster shall comply with the requirements of BS 1199, BS 1200 or the `Pakistan Standard “Sand for Plaster” as directed by the Engineer.

Water for plaster shall conform to the applicable requirements specified in the SECTION-20, PLAIN & REINFORCED CONCRETE.

All materials and workmanship for plaster not explained in these specifications, shall comply with the requirements of relevant BS CP 211 and CP 221 or as directed by the Engineer.

30.5. PROPORTIONING AND MIXING

Except as may be otherwise shown on surfaces specified, all plaster work, both internal and external shall be Ordinary Portland Cement plaster of the required thickness and cement/sand ratio as shown on the Drawings.

Measurement of materials by volume shall be by containers of known capacity to maintain consistent proportions. No lumpy or caked material shall be used. Mixing equipment boxes and tools shall be clean. Materials shall be proportioned as specified on the Drawings or as directed by the Engineer. Mixing shall be continuous until all ingredients are evenly distributed and thoroughly mixed.

Only limited water shall be added for proper workability and such quantity of mortar shall be prepared which can be consumed in thirty minutes after preparation. Preparation of mortar in bulk quantity for use during the entire day or for any other time more than that stipulated above is expressly prohibited. Re-tempering shall not be permitted and all mortar which has begun to stiffen shall be discarded.

Plaster ingredients shall be thoroughly mixed either by hand on a clean cement concrete platform or by a mechanical mixer, as directed by the Engineer.

Additives for controlling the setting and working characteristics of plaster or for imparting anticorrosion, fungicidal or water proofing properties, shall be added to the plaster strictly in accordance with the particular manufacturer's written instructions. Good quality hair or manila fiber in reasonably well distributed proportion may be to the plaster to assist application and reduce droppings. No additives shall be used except as specified in the Contract Documents

30.6. PREPARATION OF SURFACE TO BE PLASTERED

Plastering shall not commence until all electric conduits, drainage and sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are fixed in position. It shall be the responsibility of the Contractor to make sure that all such work is carried out by other contractors before starting of plaster work. Chiselling and repairing of cement plaster shall not be permitted without the approval of the Engineer.

Concrete surface to be plastered shall be cleaned to remove all grease, form oil and other surface impurities which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface of all concrete ceilings, beams and columns shall be lightly hacked by approved means to give the required key for plastering.

All masonry surface to be plastered shall be cleaned to remove all matter which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface shall be washed with clean water and kept damp for 24 hours before further treatment, the surface thus prepared shall be treated uniformly with cement and sand slurry. The slurry to be used shall be one-part cement to one-part sand by volume with water added to make a stiff. Spatter dash of slurry shall be applied on surface to receive plaster and be left to cure for three days.

30.7. APPLICATION OF PLASTER

The plaster of a thickness less than the specified thickness shall be rejected. If the plaster is to be more than ½-inch thick, it shall be done in two coats. The surface of first coat shall be made rough before the second coat is applied. Plaster shall not have wavy surface and shall be perfectly in plumb. The edges and corners shall represent a straight line. The plaster shall be kept wet continuously for at least ten days. No extra payment shall be allowed for jambs, junctions, corners, edges, round surfaces or plaster required due to any unevenness in the work done by the Contractor. The plaster work is to cover all conduits, pipes etc. fixed in the walls and ceiling. Wherever specified, metal lath shall be nailed firmly before plastering is commenced. The plaster surface shall be tested frequently with a 10-feet straight edge and plumb bob.

Plaster containing cracks, blisters, pits, discolouration or any defects shall not be acceptable. Any plaster giving hollow sound or loose plaster shall be removed and replaced with plaster in conformity with these specifications and as additionally directed by the Engineer. Contractor shall cut out and patch all defective work at his own cost. All damaged plaster shall be patched as directed by the Engineer. Patching plaster shall match appearance of and shall be finished level with adjoining plaster.

30.8. METAL LATH

Before plastering, wherever brick masonry meets with reinforced concrete members, 6-inch wide continuous strip of expanded metal lath shall be nailed to the masonry and the reinforced concrete member covering the point completely to prevent cracking of the joint Metal lathing shall be fabricated from sheet steel, and shall be of uniform quality and tree from flaws broken strands, cracks and corrosive pitting, shall he rectangular and true to shape and shall comply with BS-1369.

All lathing shall be galvanized. Where plastering material depends entirely on the lathing for its key, these shall be not less than two complete mesh openings per 1.12-inch in one direction and the width of the aperture shall not be less than 0.2-inch.

Sheet shall be not less than 1.60 kg/m2 when fabricated, using 0.7mm thick steel sheet. Where used on smooth surfaces to form a key, it shall be not less than 1.20

kg/m^2 when fabricated, using 0.5mm thick steel sheet. Typing wire shall be 1.2mm diameter galvanized annealed iron wire.

30.9. BEADS & PROFILES

Angle beads, corner beads, stop beads, architrave beads, depth gauge beads, edging profiles, plaster dividing profiles, interior angle profiles, plaster borders and the like shall all be manufactured from sheet steel and galvanized after fabrication, all beads & profiles shall be perforated at edges to ensure good adhesion of the plaster work. Thickness and dimensions shall suit particular locations and plaster work thickness.

Nails for fixing lathing shall be galvanized and have either clout heads or small flat heads to suit particular locations.

All angle beads, stop beads, architrave beads, depth gauge beads, and the like are to be fixed in accordance with the manufacturer's instructions.

30.10. CLEANING AND PROTECTION

Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Engineer. As each room or space is completed all rubbish, debris, scaffolding and tools should be removed to leave the room clean.

Prior to plastering, all doors/windows, finished metals etc. should be covered by sheet of plastic or tarpaulin to protect them from damage.

Protect finished, plaster from injury by any source. Contractor shall also protect walls, floors and work of other trades from plaster materials.

30.11. TOLERANCES

Surfaces of plaster work shall be finished with a true plane to correct line and level unless otherwise specified and with walls reveals plumb and square.

Maximum permitted tolerances shall not exceed 1/8-inch in 6-feet variation from plumb or level in any exposed line or surface and 1/16-inch variation between planes of abutting edges or ends.

30.12. POINTING WORK

Joints of masonry work to be pointed shall be properly raked to 1/2-inch depth, cleaned and wetted.

For struck pointing the mortar shall be filled in the joints flush with masonry with a pointing trowel and then pressed with proper pointing tools to form weathered and struck horizontal and triangular or V-notched vertical joints.

For flush pointing after pressing mortar in the joints these shall be tilled up with mortar and finished level with edges.

After pointing the face of the work shall be cleared of all surplus mortar. No washing shall be done till the pointing has set. All defects shall he treated at Contractor's expense. All work shall be kept wet for 10 days and protected from extreme temperatures and weather.

30.13. MEASUREMENT

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

- Metal lath over reinforced concrete and masonry joint.
- Joints, junctions, corners, drip course, edges and rounding.
- More than one layer due to any unevenness in the finished works.
- Cutting & patching of all defective works.
- Surface preparation, cleaning and protection as specified.
- Water proofing agent for water proof plaster.
- Angles beads, corner beads, stop beads, architrave beads, depth gauge edging profiles, plaster dividing profiles, interior angle profiles and plaster borders used in. plaster works as shown on Drawings.

Measurement shall be made of cement plastering for the actual area in square feet or square meter (whichever is included in Bill of Quantities) in accordance with this section of specification or as directed by the Engineer.

30.14. PAYMENT

Payment shall be made for the number of square feet or square meter (whichever is included in Bill of Quantities) of surface area cement plastered at the contract unit price and shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work in strict accordance with this section of specification.

31. POLYVINYLECHLORIDE WATERSTOP

31.1. SCOPE OF WORK

The work comprises of providing all labour, tools, equipment, to install, place and fabricate in position and locations rubber water stops together with all jointing and sealing materials as per recommendations, specifications of the Manufacturer and instructions. All embodiment in concrete, lapping, turning, sealing shall ensure absolute water tightness subjected to any pressures. The workmanship and operation shall be perfect and guarantee leak proof at places wherever used in the structure.

31.2. MATERIAL REQUIREMENTS

Polyvinyl chloride water-stop shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride (PVC). The compound shall contain such additional resins, plasticizers, stabilizers or other materials needed to ensure that when the material is compounded and extruded to the shapes and dimensions shown, it will have physical characteristics as included in Table 28.1.

Sr. No.	Parameter	Test Method	Criteria
1	Tensile Strength	ASTM C 638	Min. 1750 psi
2	Ultimate Elongation	ASTM C 638	Min. 350%
3	Low Temperature Brittleness	ASTM D 746	No Failure @ -37°C
4	Stiffness in Flexure	ASTM D 747	Min. 400 psi
5	Specific Gravity	ASTM D 792	Max. 1.37
6	Hardness, Shore A	ASTM D 2240	70-80

31.3. CONSTRUCTION REQUIREMENTS

Splices in the continuity or at the intersections of runs of PVC waters-stops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations or as directed. A thermostatically controlled electric source of heat shall be used to make all splices. The correct temperature at which splices should be made will differ with the material used but should be sufficient to melt but not char the plastic. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the water-stop shall be used to reform the ribs at the splice. The continuity of the characteristic components of the cross-section of the water-stop design (ribs, tabular centre axis, protrusions, and the like) shall be maintained across the splice.

The expansion joints wherever indicated on Drawings shall have centre bulb rubber water stops or its equivalent as indicated on Drawings to be cast integrally with the in-situ-concrete of retaining walls, beams, columns, slabs or at any locations marked on the Drawings incorporating junction places or as straight lengths with separate

intersection pieces to be jointed at Site as per Manufacturer's recommendations and Specifications. The water stops shall be installed so as to hold them securely in their correct position during the placement of concrete. The concrete shall be fully and properly compacted around the water stops to ensure that no voids or porous areas remain. Where reinforcement is present adequate clearance shall be left between water stops and the reinforcement to permit proper compaction of concrete. No holes shall be made through any water stops. Hot or cold vulcanizing for jointing places of water-stops at site shall be done with the prior Approval in accordance with the Manufacturer's recommendations and specifications.

31.4. MEASUREMENT AND PAYMENT

31.4.1. Measurement

Polyvinylchloride water stop of the size and gauge as shown on the Drawings will be measured for the number of linear feet or linear meter (whichever is included in Bill of Quantities) acceptably placed in the work. In computing the quantities, no allowance will be made for laps.

31.4.2. Payment

Payment will be made in accordance with the unit prices in the Bill of Quantities for the item as measured above in accordance with the specifications and shall constitute full compensation for furnishing all materials, shuttering, equipment and labour and for performing all operation necessary to complete the work.

32. ALUMINIUM WORKS

32.1. SCOPE OF WORK

The work under this section of specification includes furnishing all labour, equipment, appliances and materials and performing all operations in carrying out the work of anodized aluminium doors, windows (other than curtain wall type doors and windows) ventilators, louver and fly screen. All related items such as sealants, rubber gasket for glazing, netting, rollers, latches, fastenings, glazing, anchor bolts and all items supplied by other trades and customarily built in and/or installed in strict accordance with this section of the specifications and the applicable Drawings and subject to the terms and conditions of the Contract.

32.2. APPLICABLE STANDARDS

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

32.2.1. ISO (International Organization for Standardization)

- ISO 1804, Doors Terminology
- ISO 6442, Door leaves, Measurement of defects of general flatness.
- ISO 6443, Door leaves, Measurement of dimensions and defects of squareness.
- ISO 6444, Door Leaves, Test of behaviour under humidity variations (successive uniform climates)
- ISO 6612, Windows & Doors, Wind resistance tests.
- ISO 6613, Windows & Doors, Air permeability test.

32.2.2. BSI (British Standard Institution)

- BS 1227, Hinges
- BS 4873, Aluminium alloy windows.

32.3. GENERAL

Aluminium doors and windows shall be of profile, pattern and design shown on Drawings and manufactured by reputable manufacturer approved by the Engineer. The contractor shall provide manufacture literature completely describing the product, instructions for installation and maintenance.

All the sections used for doors, windows, ventilators & fly screens shall be of best quality aluminium products such as equal and unequal angles, channels, tubes, corrugated strips, mouldings etc., in accordance with International standards conforming to ASTM B 308 & B 221. All doors, windows & ventilators shall be of type and size indicated on Drawings and shall conform to the requirements shown and specified herein.

Contractor shall arrange tests and analysis if directed by the Engineer of scaled models of each window type at the maker's works or any laboratory specified by the

Engineer for the material supplied by him to be tested in the presence of the Engineer's Inspector, to whom test certificates, proof sheets, etc. shall be furnished. The models shall be submitted to the Engineer for approval prior to testing. Nevertheless, neither the fact that the materials have been tested in the presence of the inspector nor that the Engineer may have been furnished with test certificates in lieu of sending an inspector to the works shall affect the liberty of the Engineer to reject, after delivery of materials found not in accordance with these specifications.

The contractor shall submit shop drawings which shall show full construction details, quantities. and locations, fastenings and attachment to adjacent construction and materials. Shop drawings shall be submitted at the proper time to allow for checking, revisions, agreement and permit manufacturer's product delivery and start of site work to suit the building programme. The Contractor shall submit representative samples of finished windows, anchoring mechanism, embedded parts, fastenings, glass panes, accessories and other materials for the Engineering approval.

After approval of shop drawings and tests etc., the contractor shall submit at his own cost one mock-up sample of each type of aluminium works complete with glazing, all components assembly method and required fittings and accessories prior to be actual fabrication of the bulk. The samples shall be returned to the contractor for incorporation in the works after installation of at least 80% of the works.

Fabricate and assemble all work in the shop of the approved manufacturer to reduce field fabrication to a minimum unless otherwise directed by the Engineer.

The glass shall conform to specification laid down under section 'Glazing' and shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to size as shown on Drawings, so as to fit the grooves in door and window members. All the glass shall be best quality of approved manufacture.

The structural shape of the Aluminium members shall be of uniform quality, colour and temper, clean, round, commercially straight and free from injurious defects.

All doors, windows and ventilators shall be fabricated as a complete unit, fully airtight and watertight, including rubber gasket for glazing, rollers, latch, anodized in specified colour, inclusive of glass sheet, necessary holes for fixing, door locks, door closures and window locking requirements, all as approved by the Engineer.

Contractor shall, on request, get certificate signed by the manufacturer stating that each lot has been sampled, tested and inspected and has met the requirements in accordance with these specifications, and the same shall be furnished to the Engineer.

32.4. MATERIAL REQUIREMENTS

The frames/shutters of anodized aluminium doors, windows, ventilator and louvers shall be formed from rolled, strip or extruded aluminium and be as per Drawings. Fastenings bolts and screws shall be made from hardened aluminium.

Fasteners shall be stainless steel of a type selected to prevent galvanic action with the components fastened.

Gaskets shall be vinyl glazing channel gasket to commercial standard CS-230-60.

Hardware shall be manufacturer's standard hardware flush to match door and windows finish Joint sealant shall be approved elastomer.

The finish shall be in approved colour in accordance with the standards of Aluminium Association.

Minimum coating should not be less than 23-25 micron.

32.5. WORKMANSHIP

The Contractor shall be responsible for the protection and installation of all items furnished. All items shall be installed plumb and square and shall be solidly anchored in a good workman like manner in accordance with the manufacturer's instruction and as specified herein. The Contractor shall be responsible for the protection of installed items from damage by other trades. All items shall be left in operating, neat and clean condition, free from dirt, finger marks, etc. The Contractor shall be responsible for final cleaning before the final acceptance.

The glass panes shall firmly be secured in the rebates with the rubber gasket. Ensure that the beads and grooves are clean, dry and unobstructed at the time of glazing. The complete unit shall be airtight and watertight on completion. No doors windows ventilator louvers shall be considered complete until and unless the finger prints and other stains and marks have been removed from the surface of glass and aluminium.

32.6. PRODUCT DELIVERY AND STORAGE

Deliver doors, windows, ventilator and louvers in a manner preventing damage to units. Store materials off the ground under cover in a manner preventing deterioration or damage.

All embedded parts and anchor bolts shall be delivered to the site carefully and keeping the fabricated shape and configuration. All these parts shall be suitably marked for identification.

32.7. ERECTION

Rawl plugs and anchoring bolts shall he embedded into the concrete or block masonry for holding the doors, windows, ventilators and louvers in their correct positions.

Care shall be taken to install the doors and windows, ventilators and louvers in line and plumb & solidly anchored in a workman like manner in accordance with the Drawings. Should any scale or scratch appear on the surface of doors, windows, ventilators and louvers the contractor shall at his own expense and at the Engineer's direction have all exposed surfaces cleaned to bare bright specified

All works shall be installed in strict accordance with the manufacturer's instructions.

32.8. PROTECTION AND CLEANING

Temporary protection shall be achieved by applying water soluble protective coating capable of withstanding the action of lime mortar.

Apply coating in the manufacturer's plant to the exposed surfaces of all components.

Before application of coating, remove all fabrication compounds, moisture and dirt accumulations.

32.9. DEFECTIVE WORK

In the event of non-conformance to specifications and Drawings the aluminium work shall be rejected by the Engineer and the Contractor shall remove and replace the rejected works by new work of same specifications.

32.10. GUARANTEE

The manufacturer shall furnish his standard written guarantee against leakage of rain, excessive infiltration of dust and air and all defects in materials and workmanship covering all work under this section.

Such guarantee shall be in addition to and not in lieu of all other liabilities which manufacturers and the Contractor may have by law or by other provisions of the Contract Documents.

32.11. MEASUREMENT AND PAYMENT

32.11.1. Measurement

Measurement and payment for doors, windows, and ventilators shall be in square feet or square meter (whichever is included in Bill of Quantities) of net openings in the walls where aluminium doors, windows and ventilators have been acceptably fixed complete including glazing, in all respects as per relevant Drawings or as directed by the Engineer.

32.11.2. Payment

Payment shall be made on the basis of measurement as measured above at the contract unit price for all supply of items and means of fixing, cutting, shaping, glazing, and all other operations required for the complete erection and commissioning to the full satisfaction of the Engineer.

33. GLAZING

33.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all labour, equipment, tools, appliances, scaffoldings and providing glass gaskets, sealants, compound and other materials required for performing all operations in connection with the installation and setting of all types of glass, glazing and glass blocks complete in every respect in accordance with the Drawings or as directed by the Engineer.

33.2. APPLICABLE STANDARDS

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

- BS-952, Glass for glazing
- BS-5051, Security glazing Part I & II
- CP-152, Glazing

33.3. SUBMITTALS

Contractor shall submit samples for each type of glass, minimum 12-inch x 12- inch in size with protective edges. Samples of glazing sealant minimum 0.1 litre specified types shall be submitted. Samples of minimum of three glass blocks shall also be submitted.

Contractor shall submit 12-inch long sample each type of glazing gasket. Contractor shall also submit printed materials manufacturers installation instructions for specified glazing gaskets, compounds sealants and accessories including description of required equipment and procedures and precautions to be observed.

33.4. MATERIAL REQUIREMENTS

33.4.1. General

Glass shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to fit the rebates so as to have a uniform clearance of 1.6 mm round the panes between the edges of glass and the rebates. All glass shall be of best quality manufacture as approved by the Engineer.

Each type of glass shall have the manufacturer's label on each pane, and the labels shall remain on the glass until final cleaning.

Spacer shims (distance pieces) shall he plasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on Drawings between glass and rebates, bead or cleat. Depth shall give not less than ¼ inch cover of glazing sealant.

33.4.2. Glass

Glass for windows and ventilators and louvers shall be of thickness and size as shown on the Drawings of approved quality.

a. Plain / Tinted Glass.

Glass for doors and windows shall be Local Float Glass where the sheet glass is to be used and for double glazing imported order made double layer vacuum glass of appropriate thickness tinted as selected and as approved by the Project Manager.

b. PSG Heat-strengthened glass or PSG Tempered glass

It is manufactured by heating up flat glass to a temperature of around 700^{o}C and then blowing air on to its surface, quenching it down swiftly and uniformly. It can be divided into two types depending on the degree of heat treatment, heat-strengthened glass or tempered glass. PSG heat-strengthened glass in manufactured by controlling the tensile stress caused by heat treatment process with in a certain range of temperature. PSG tempered glass has an impact strength which is 5 times higher than that of the annealed flat glass of the same thickness, as well as 3 to 4 times higher resistance to weight.

33.4.3. Rubber Acrylic Glazing Sealant

Contractor shall provide material coloured to match frame in which glass is installed. Provide only compounds known to be fully compatible with surfaces which they will contact as follows:

- Two component polysulfide glazing sealant.
- One component acrylic glazing sealant.
- Acrylic-latex glazing sealant consisting of modified latex rubber and acrylic emulsion, non-hardening, non-staining and non-bleeding.
- Cleaners, Primers and sealer as recommended by the sealant manufacturer.

33.4.4. Accessories

a. Vinyl Glazing Bead

It shall be for external windows and entry doors and shall be in accordance with glass manufacturer's recommendation.

b. Glazing Sealant

It shall be tape or ribbon of polymerized butyl or mixture of butyl and polyisobutylene compounded with inert fillers and pigments, solvent based,95 percent solids thread or fabric reinforced, paintable, non-staining.

c. Setting Blocks

It shall be chloroprene (Neoprene) 70 to 90 durometer hardness, compatible with sealant used, channel shaped and of the necessary height for proper perimeter clearance.

d. Channels. Gaskets and Spacer’s

It shall be chloroprene (Neoprene), 40 to 50 durometer hardness compatible with sealant used.

33.5. DELIVERY, STORAGE AND HANDLING

Contractor shall deliver materials in manufacturers original, unopened containers clearly labelled with manufacturer's name and address, material, brand, type, class and rating as applicable. Contractor shall store the materials in original unopened containers with labels intact/protected from ground contact and from elements which may damage glass. Contractor shall handle the materials in a manner to prevent breakage of glass and damage to surfaces.

33.6. INSTALLATION OF GLAZING

Glazing shall comply with the recommendations of glass and glazing materials manufacturers.

Examine each piece of glass and discard and replace glass with edge damage or face imperfection. All glazing shall be wind tight and fully water tight on completion.

Clean glazing channels and other framing members indicated to receive glass. Remove coatings which are not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever electrometric sealants are to be used. Apply primer and sealer to joint surfaces wherever recommended by the sealant manufacturer and as shown on the Drawings.

Trim and clean excess glazing materials from surrounding surfaces immediately after installation and eliminate stains and discolorations.

Cure glazing sealants and compounds in compliance with manufacturer's instructions to obtain high early bond strength internal cohesive strength and surface durability.

While glazing operation is in progress care shall be taken to avoid breakage or damage to the glass and adjoining glazing. The Contractor shall make good at his own cost, all glass broken by his workmen while cleaning or carrying out other operations. On the completion of the glazing work, all glass that has been set by the Contractor shall, if it becomes loose, within the maintenance period, be re-fixed at Contractor's expense.

No glazing shall be considered complete until and unless paint and other stains have been removed from the surface of the glass and checked by the Engineer for water tightness.

33.7. PROTECTION AND CLEANING OF GLAZING

Remove all smears, labels and excess glazing sealant, leave clean inside and outside tree from scratches. The Contractor shall be responsible for the protection of installed glass. Before final acceptance, damaged or broken glass shall be removed and replaced with new glass at no additional expense to the Client. All glass surfaces shall be washed clean both inside and outside within two weeks prior to final acceptance by the Client.

33.8. MEASUREMENT AND PAYMENT

33.8.1. Measurement

No separate measurement shall be made of glazing of doors/windows, ventilators.

33.8.2. Payment

No separate payment, unless otherwise included in the bill of quantities, shall be made for doors, windows, and ventilators.

34. PAINTING

34.1. SCOPE OF WORK

The work under this section of the specifications consists of furnishing all materials, plant, labour, equipment, appliances and performing all operations in connection with surface preparation, mixing, painting concrete works, plaster works, gates, frames, walls, ceilings and all such surfaces as shown on the Drawings and/or as directed by the Engineer.

34.2. APPLICABLE STANDARDS

Latest editions of following British Standards are relevant to these specifications, wherever applicable:

- BS 245, Specification for mineral solvents (white spirits and related hydrocarbon solvents) for paints and other purposes
- BS 2521, Lead-based priming paint for woodwork
- BS 2523, Lead based priming paint for iron and steel
- BS 2569, Sprayed metal coatings
- BS 4800, Paint colours for building purposes
- CP 231, Painting of building
- CP 3012, Cleaning and preparation of metal surfaces

34.3. GENERAL

Except as otherwise specified, all painting shall be applied in conformity with BS CP 231 “Painting of Building” as applicable to the work.

The Contractor shall repair at his own expense all damaged or defective areas of shop-painted metal works and structural steelwork. Metal surfaces against which concrete to be placed will be furnished shop-painted and shall cleaned prior to being embedded in concrete.

Except as otherwise specified, all concrete and plastered surfaces are to be painted.

The Engineer will furnish a schedule of colours for each area and surface. All colours shall be mixed in accordance with the manufacturer’s instructions.

Colours of priming coat and body coat where specified, shall be lighter than those of finish coat. The Engineer shall have unlimited choice of colours.

Samples of all colours, and finishes shall be prepared in advance of requirement so as not to delay work and shall be submitted to the Engineer for approval before any work is commenced. Any work done without such approval shall be redone to the Engineer’s satisfaction, without additional expense to the Client. Samples of each type of paint shall be on separate 1-ft. x 1-ft. x 1/8-inch tempered hard board panels. Manufacturer’s colour chart shall be submitted for colour specifications and selection.

34.4. MATERIAL REQUIREMENTS

All materials shall be acceptable, proven, first grade products and shall meet or exceed the minimum standards of approved manufacturers.

Colours shall be pure, non-fading pigments, mildew-proof sun-proof, finely ground in approved medium. Colours used on plaster and concrete surfaces shall be lime-proof. All materials shall be subject to the Engineer's approval.

The plastic emulsion/weather shield paint or similar as approved by the Engineer shall be used where specified on the drawing as directed by the Engineer.

The synthetic enamel paints and primers for structural steel or metal works shall be the best available for its type and shall be approved by the Engineer prior to its procurement.

All material shall be delivered to site in their original unbroken containers or packages and beef the manufacturer's name, label, brand and formula and will be mixed and applied in accordance with his directions.

34.5. DELIVERY STORAGE AND CONTAINER SIZES

Paints shall be delivered to the site in sealed containers which plainly show the type of paint, colour (formula or specifications number) batch number, quantity, and date of manufacture, name of manufacturer and instructions for use. Pigmented paints shall be supplied in containers not larger than 20 litres. All materials shall be stored under cover in a clean storage space which should be accessible at all times to the Engineer. If storage is allowed inside the building, floors shall be kept clean and free from paint spillage.

34.6. SURFACE PREPARATION

All oil, grease, dirt, dust, loose mill scale and any other foreign substance shall be removed from the surface to be painted, polished and white washed by the use of a solvent and clean wiping material. Following the solvent cleaning, the surfaces shall be cleaned by scrapping, chipping. blasting, wire brushing or other effective means as approved by the Engineer.

In the event the surfaces become otherwise contaminated in the interval between cleaning and painting, recleaning will be done by the Contractor at no additional cost.

All the surfaces to be painted shall be free from dust, dirt, fungus, lichen, algae etc. Oil paint, varnish and lime wash should always be removed by scraping and washing.

No work in this section shall be allowed until all surfaces or conditions have been inspected and approved by the Engineer.

34.7. APPLICATION

All paint and coating materials shall be in a thoroughly mixed condition at the time of application. All work shall be done in a workman like manner, leaving the finished surface free from drips, ridges, waves, laps, and brush marks. All paints shall be applied under dry and dust free condition unless approved by the Engineer. Paint shall

not be applied when the temperature of the metal or of the surrounding air is below 7 degrees centigrade. Surfaces shall be free from moisture at the time of painting.

All primary paint shall be applied by brushing. The first coat of paint shall be applied immediately after cleaning. When paint is applied by spraying, suitable measures shall be taken to prevent segregation of the paint in the container during painting operation.

Effective means shall be adopted for removing all free oil and moisture from the air supply lines of the spraying equipment.

Each coat of paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Surfaces to be painted that will be inaccessible after installation shall be completely painted prior to installation.

Only as much material should be mixed as can be used up in one hour. Over- thinning will not be permitted. After the first coat the surfaces will be soaked evenly four or five times and the second coat shall be applied after leaving for at least overnight.

Where shown on Drawings all exterior finishes shall be painted with weather resistant paint in approved colours as per manufacturer's specifications.

Plastic emulsion paint of the approved make and shade shall be applied to surfaces as shown on Drawings or as specified by the Engineer.

Polyvinyl Distemper of the approved make and shade shall be applied to surfaces as specified.

34.8. FINISHES

The finished coating film shall show uniform coverage throughout and shall be reasonably free from brush marks, runs, sags or noticeable colour variations. Edges, where coating ends, change colour or change thickness shall be clean and straight.

The completed coating shall be compared with sample areas. The completed coating shall be at least as smooth (free from orange feel effect, overspray, embedded or partially embedded particles, craters, pinholes, holes etc.) as the approved sample areas.

The thickness of the coating shall be checked by the Engineer at random locations by cutting out sections on concrete or plaster surfaces. The cut-out sections shall be patched by the contractor, using the same material and thickness used originally. Porosities shall be marked and patched with the basic primer material or with a mixture of basic primer material and finely divided filler or with a proprietary patching compound compatible with coating. Any moisture on the surface of the coating shall be allowed to dry thoroughly before patching. In addition, all porosities and imperfections which become evident after applying subsequent coats shall be repaired. This repairing shall be done with basic coating material or with a proprietary patching compound compatible with specific coating, except for the top coat, where only basic coating material shall be used. The completed coating shall be free of porosity visible to the naked eye.

34.9. JOB CONDITIONS

Observe manufacturer's recommended minimum and maximum temperature but do not apply paint or finish to any surface unless ambient temperature is 10°C or above and less than 43°C. Non painting shall be done above 90% relative humidity. Adequately protect all finished work.

Remove and replace all items of finish hardware, device plates, accessories, lighting fixtures or other removable items.

In no case shall any finish hardware or other finished item that is already fitted into place be painted, unless otherwise specified.

34.10. QUALITY ASSURANCE

All paint for any one surface shall be top quality, of one manufacturer of the specified. Deep tone accent colours shall be used and the unavailability of final coat colours may be the basis for rejecting materials for any one surface.

34.11. MEASUREMENT AND PAYMENT

34.11.1. Measurement

Measurement for painting shall be made in square feet or square meter (whichever is included in Bill of Quantities) of painted area acceptably completed in all respects as per Drawings and in strict accordance with this section of specification or as directed by the Engineer.

34.11.2. Payment

Payment will be made for the number of square feet or square meter (whichever is included in Bill of Quantities) of painted area measured as above at the Contract unit price and shall constitute full compensation for all work and all other incidentals to complete the work.

35. CERAMIC TILE WORK

35.1. SCOPE OF WORK

The work covered under this section comprises of providing and laying best quality local made glazed/matt ceramic tiles of approved size and pattern wherever required or shown on the Drawings or mentioned in the Bill of Quantities.

35.2. MATERIAL REQUIREMENTS

35.2.1. General

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

- BS 1281, Glazed ceramic tiles and tile fittings for internal wall
- BS CP 212, Fixing methods and workmanship.

35.2.2. Joint Filling

Joint Filler shall be white Portland cement grout which shall bond to dry tile, shall be non-shrinking, stain resistant, permanent in colour, and shall not inhabit fungus and bacterial growth. It shall be odourless and non-toxic, of smooth consistency for easy preparation and neat, rapid installation, and shall contain non-metallic material. Grout shall be water resistant and shall not wash out under water.

35.2.3. Adhesives

Adhesives for ceramic tiling as specified in the British Code of Practice CP 212 or Dry Bond Floor and wall thin set mortar as manufactured by Shabbir Tile and Ceramics Limited or equivalent approved.

35.2.4. Samples and Tests

The samples shall be furnished in sizes and colours and adequate in number for testing in an approved laboratory.

35.3. WORKING DRAWINGS

The Contractor shall prepare working Drawings on the basis of working Drawings for all the ceramic tile work to be carried out. These Drawings will show clearly the sizes, method of fixing, jointing and the anchorage to be used in the process and the Contractor shall get approval in writing well in time before the actual start of the work.

35.4. CONSTRUCTION REQUIREMENTS

35.4.1. In Cement Sand Mortar

Surfaces to receive the ceramic tiling shall be clean and free of dirt, dust, oil, grease or other objectionable matter. Setting beds and tile shall be installed

with their respective surfaces to true planes, level or pitched to off-sets as required by the Drawings, so that the surface of the completed tiling work will be at the elevations and grades shown. Re-tempering of mortar will not be permitted. Tiles shall be laid out from the centre lines of each space outward

and adjustments made along walls, partitions and borders, if any, so as to symmetries the pattern with a minimum of cut tiles.

Joint between tiles shall be of uniform width and the same as the tile installed. Fractional changes in dimensions without varying the uniformity of joint widths shall be permitted. Tile shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut-tile misfits shall be laid to the straight edges. Straight edges shall be accurately set to the lines established and reset at suitable intervals to keep the joints parallel over the entire area.

Over the existing bed a topping of 1-1/2" thick PCC 1:2:4 shall be laid. Scratch coats for application as foundation coats shall be not less than 5/8" thick and shall be composed by volume of 1-part Grey Portland Cement to 3 parts dry sand, mixed with the minimum amount of water necessary to produce a workable mass. Mortar for scratch coats shall be used within one hour after mixing and re-tempering will not be permitted. Scratch coats shall be applied in sufficient quantity and with sufficient pressure to cover the entire area and to form good keys, shall be deeply scoured or scratched and cross- scratched, shall be protected and kept moist during the curing period. Scratch coats shall be thoroughly damp-cured, and an interval of not less than 24 nor more than 48 hours shall be permitted between application of scratch coats and application of float coats.

Float coats shall be composed by volume of 1-part Grey Portland cement to 2 parts dry sand, mixed with a minimum amount of water necessary to produce a workable mass. Float coats shall be applied in sufficient quantity to entire area and to form a good key, shall be brought out flush with the temporary screeds or guide strips so placed as to give a true even surface at the proper distance from the finish suitable for reception of tiles.

Joints shall be straight, level perpendicular and of even width throughout. Vertical joints shall be maintained plumb for the entire height of the tile work. Each tile shall be brought to true level and plane by uniformly applied pressure under a straight edge or rubber faced block. Tiles that are out of true plane or misplaced shall be removed and reset. Damaged or defective tile shall be replaced. The tile shall be installed as follows:

- Wall tile shall be set by trowelling a skim coat of neat Portland cement on the float coat or by applying a skim coat to the back of each tile unit and immediately floating the tile into place. After tile has set remove mortar using a minimum of water. Replace damage tiles.
- After the tiles have been thoroughly set, joints shall be grouted full

with a plastic mix of neat, white cement immediately after a suitable area of tile has been set. The joints shall be struck flush and excess mortar shall be cut off and wiped from the mortar joints after grout has been cleaned from the surface shall be roughened at once and filled flush with the tile edge,

before the mortar begins to harden. Tile skirting and coves shall be solidly backed with mortar.

35.4.2. In Thin Set Mortar

Tiles laid in Thin Set Mortar shall be applied as per details shown on Drawings and shall consist of a P.C.C. base of specified thickness. Tiles shall be set by trowelling a skin coat of Dry Bond Mortar on the base coat and combed with a notched edge of trowel. Back butter each tile unit to ensure 100% mortar coverage and float the tile into place, tapping the tile to ensure maximum bond strength. All other installation requirements shall be as per specifications mentioned above.

MEASUREMENT AND PAYMENT

Measurement

Measurement shall be made in square feet or square meter (whichever is included in Bill of Quantities) of ceramic tile work acceptably placed complete in all respects as per Drawings and in strict accordance with this section of specification or as directed by the Engineer.

35.4.3. Payment

Payment will be made for the number of square feet or square meter (whichever is included in Bill of Quantities) of ceramic tile work as above at the contract unit price and shall constitute full compensation for all work including material, labour, plant, equipment, and all other incidentals to complete the work.

36. TERRAZZO WORK

36.1. SCOPE OF WORK

The work covered by this section of the specifications, consist of furnishing all plant, labour, equipment, appliances and materials and in performing all operations complete in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the contract. The work under the section include precast terrazzo tiles flooring and in situ terrazzo flooring, dada or skiting.

36.2. APPLICABLE STANDARDS

Unless otherwise specified, terrazzo work shall be in conformity with British standard Code of Practice C.P. 204 In Situ Flooring Part 1, 'General' and Part 3 "Terrazzo Flooring" as applicable to the work shown on the Drawings and specified in the Bill of Quantifies.

36.3. SUBMITTALS

All materials used for terrazzo work shall be submitted to the Engineer for obtained approval. Same materials should also be tested and this shall be got done by the Contractor at its own expense from a laboratory approved by the Engineer.

36.4. MATERIAL REQUIREMENTS

Cement, Sand, Aggregate and Water for Concrete shall conform to specification as included in SECTION - PLAIN & REINFORCED CONCRETE.

Marble Chips shall be crushed marble and shall be best quality white or coloured sound and hard local marble chips approved by the Engineer and of the as mentioned in the Bill of Quantities or as required by the Engineer.

Dividing Strips shall be glass, brass or marble strips 4-5 mm thick and 1-1/2" wide or as specified in the Bill of Quantities.

Angle Clips for precast toilet partitions shall be chromium plated steel or stainless steel clips as shown on drawings.

Bolts of precast toilet partitions shall be 5/16" inch bars bolts chrome-plated, with acorn heads, fitted to wall anchors.

Terrazzo Tiles Terrazzo tiles shall be first grade, mechanically compressed type conforming to PS-531. Tiles shall be 12"x12"x0.88" / 30.0x30.0x2.2cm with a toping of 0.4" or 10.00mm thickness composed of 1:2 cement & marble chips. The base being 1:3 cement mortar. The colour, quality and size of chips shall be as per Project Manager's approval.

The Compound used for all cleaning of terrazzo shall be an approved neutral chemical cleaner free from acid and alkali or any other material that will affect the colour or otherwise damage the terrazzo and shall not affect the conductivity of terrazzo floors.

36.5. EXECUTION

36.5.1. In Situ Terrazzo Flooring

The floor shall consist of a wearing surface to consistency and net thickness as specified in Bill of Quantities, laid over 1:2:4 under bedding concrete of the specified thickness. The net uniform thickness specified for wearing surface shall be that obtained after grinding and polishing. The 1:2:4 concrete shall be mixed and laid in the manner specified for cement concrete floor using a minimum quantity of water.

The concrete shall be levelled with a trowel and straight edge consolidated and finished with steel trowels to an even but rough surfaces. The top layer of cement and marble chips mixed in the proportion of 1:2 (1 cement and 2 marble chips) shall be laid over it within 12 hours. The cement and marble chips must be mixed dry in such quantities that are sufficient for a unit area of one specified shade. Water shall be added to only such quantities that can be mixed thoroughly and consumed in less than 30 minutes, the quantity of water being the minimum for workability.

Mixing must to be done on water tight platform and any mix not used within 30 minutes shall be discarded and removed from the Site. A layer of cement and marble chipping mixture should be well trowelled into the surface of the base concrete before filling to the top level of the screeds. The layer should be well compacted and all voids shall be filled in. A layer of neat cement, of the specified colour shall then be well-trowelled into a plain smooth surface. Floors shall be laid in panels of sizes as shown on drawings and in Bill of Quantities or as directed by the Project Manager. Dividing strips, as specified shall be provided and fixed to exact levels making an allowance for grinding.

Three days after laying, the top layer must be evenly and smoothly machine ground with Carborundum blocks of coarse, medium and fine grades so as to ensure that all marble chipping are evenly exposed all over the surface.

If marble chips are not evenly exposed the Contractor shall pull down the sin face and relay it at his own cost. The surface after grinding shall be left undisturbed and cured for 2 to 3 weeks after which it shall be cleaned of dirt and dust gently by rubbing with pumise stone or washing soda in sufficient water. Three days after the surface has been cleaned, it shall be rubbed hard with 1:10 solution of oxalic acid using fell. The surface shall then be cleaned and washed with plenty of water. After the surface has dried a final gloss shall be given by polishing surface to the satisfaction of the Project Manager.

36.5.2. Terrazzo Dado & Skirting

marble chips and cement shall conform to specifications for floor. Mixing shall be done in the same manner and proportion. The plastered surface over which the dado/skirting is to be applied shall be well roughened and watered, cement mortal of specified ratio shall then be plastered over this well roughened surface to indicated thickness. Before the base course had set, the layer of terrazzo mixture of the specifications for flooring shall be well

trowelled into the surface of the base to a thickness which after, grinding shall result in the finished thickness as per Bill of Quantities. A layer of neat cement of the specified colour shall then he well trowelled into the surface leaving a plain smooth surface. After 24 hours the Contractor shall start finishing as for floors specified above, Terrazzo skirting shall be provided around all terrazzo floors unless otherwise shown. Skirting and dado shall be straight, level and in plumb. Intersections at floors shall be straight and flush. They shall be with 1/4 radius coved at floor unless otherwise shown.

36.5.3. Terrazzo on Stairs

The stair risers and treads shall be finished according to exact sizes including the terrazzo making allowance for grinding of terrazzo.

36.5.4. Terrazzo Finished Precast Partitions of Urinals

Partitions walls of urinals shall be precast R.C.C. slabs finished will) l/'l" thick polished terrazzo on both faces. The finished thickness of these walls shall be 3" or as shown on drawings and BOQ R.C.C. slab shall conform to the specification for "Concrete" and terrazzo as per this section. Fixing of these partitions of floor walls. etc. shall be as directed by the Project Manager and as shown on Drawings.

36.5.5. Terrazzo Tile Works

The terrazzo tiles will be laid to the required levels and grades over a bedding of cement mortar comprising of 1 part of cement and 3 parts of sand by volume. I thickness of cement sand bedding screed shall be as per Bill of Quantities.

The curing period of the bedding shall be as directed by the Project Manager. As large an area of bedding shall be spread at one time as can be covered with tiles before the mortar has set. Surplus mortar shall be removed. The thickness of bedding in any space shall not be less than 1/2" /12.5mm.

Floor and wall surfaces to receive the tiles shall be thoroughly cleaned of all dirt, dust, oil and other objectionable matters. Tiles shall be laid out from the Centre line of each space in an outward direction and the pattern should be made symmetrical with a minimum number of cut tiles. Joints between the tiles shall be of uniform width. Tiles shall be cut with a suitable cutting tool and rough edges shall be nibbed smooth. Tiles shall be laid to the straight edges.

After seven days the terrazzo tile floors shall be machine ground to a true

even surface using various grades of abrasive stones as required and directed by the Project Manager. After the first grinding the floor shall be grouted with the same colour composition as used for its manufacture. The grout shall be of the consistency of thick cream and shall be brushed over the floor to fill in the joints and after 72 hours the grouting coat shall be

removed by grinding till a smooth and even surface is obtained. Area and portion of the floor inaccessible for the grinding machine shall be ground and rubbed by hand. The final gloss shall be given by polishing the surface to the satisfaction of the Project Manager.

The tiled floor shall be kept wet for at least 72 hours and no one should be allowed to walk on the tiles during that period.

36.6. MEASUREMENTS & PAYMENTS

36.6.1. Measurement

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

- Grinding, washing polishing and finishing of Terrazzo work.
- Under bedding and screening.
- Preparation of concrete surface for Terrazzo works.
- Cement concrete base.

Measurement shall be made of cement plastering for the actual area in square feet or square meter (whichever is included in Bill of Quantities) in accordance with this section of specification or as directed by the Engineer.

36.6.2. Payment

Payment shall be made for the number of square feet or square meter (whichever is included in Bill of Quantities) of acceptable measured quantify of Terrazzo Work at the contract unit price quoted in the Bill of Quantities and shall constitute full compensation for furnishing all materials, equipment and labour including all incidentals necessary to complete the work in strict accordance with this section of specification.

37. ELECTRICAL WORKS AND DG SETS

37.1. SCOPE OF WORK:

1.1 The scope of services covers the design, detailed engineering, preparation of construction drawing, manufacture, acceptance testing at manufacturer's works or at any accredited agency, supply, packing, forwarding and delivery from manufacturer's works/ place of storage to erection site including transit insurance, unloading, storage at site, moving from place of storage to place of installation, assembly, erection, testing, commissioning & performance demonstration and handing over along with all necessary spares of original ratings & specifications on Design, Build & Operate basis. Inland and overseas transit insurance, transport, testing at site shall be Contractor scope. Tender Bill of Quantities (BOQ) and Drawings are for reference purpose only which is the minimum requirements for the water supply system including raw water Intake, various Headwork/ Sub-Headwork with/ without water treatment facility as applicable; Contractor to ensure that design & equipments are as per specification requirements.

1.2 The Contractor shall prepare design calculations based on parameters/ design criteria indicated in the specifications. The Contractor shall prepare detailed engineering and construction purpose drawings to make his/ her own estimate of ratings & quantities (minimum requirements as per price schedule, technical data sheets, reference drawings & other relevant details) for entire electrical systems including all items, systems such as equipments, cables/ cabling system, lighting, ventilation, earthing, lightning protection, main & auxiliary power distribution, instruments, civil works required for completion of Works.

1.3 Contractor shall take due care of the site Seismic conditions while design of all equipments/ components used in entire electrical systems covered in this specification. Contractor shall furnish list of additional design parameters considered in design to fulfill above requirement.

1.4 Design and detailed engineering of the materials procured by Contractor is included in scope. Contractor shall submit design drawings/ calculations of each system which is included in scope to Purchaser/ Purchaser's representative for final review/ approval. All design documents/ calculations prepared by Contractor shall be as per ISO documentation i.e., with duly singed by qualified authorities and

stamped. Design documents/ calculations prepared by Sub- Contractors shall be approved by Contractor and stamped copy of approval along with no-deviation sheet from Sub-Contractor shall be submitted by the Contractor to Purchaser/ Purchaser's representative for final review/ approval.

1.5 Expert or manufacturer supervision for SUB-Contractor supplied material shall be provided by Contractor and included in offer.

1.6 Contractor shall be solely responsible for any shortages or damages in transit for his supply scope, handling and/ or in storage of any materials and erection of the equipment, supply of erection tools at site. Contractor shall ensure that it will not affect any activity or project schedule. Any demurrage, other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

1.7 Contractor shall identify activities and mile stones of the work forecasted for next month with optimistic and pessimistic dates of work completion. Contractor shall prepare program evaluation and review techniques to identify critical path of project and activity sequences. The project schedule shall be prepared and updated fortnightly in MS Project.

1.8 Nothing in this specification shall be constructed to relieve the Contractor of his/ her responsibilities towards following best engineering practices established in the country.

1.9 Obtaining approval including load sanction/ release LESCO (Lahore Electric Supply Company), No Objection Certificates from LESCO relevant government agencies, statutory authority, as applicable is included in Contractor's scope.

1.10 All necessary legal fees required for various applications to LESCO, relevant government agencies, statutory authorities shall be paid by the Purchaser. The LESCO deposit required to be paid for load sanction/ release shall also be borne by the Purchaser.

1.11 The Contractor's scope shall include measurement of soil resistivity at site by Wenner's four electrode method as per ISO: 3043-1987 (Reaffirmed in 2006) at minimum four locations at site. The earthing shall be designed for the actual mean soil resistivity value obtained.

1.12 Even if all components of a system included in this specification are not explicitly identified and/ or listed herein, these shall be supplied under this contract to ensure completeness of the system and facilitate proper operation and easy maintenance of the plant. Any and all other works not indicated above but necessary/ required to complete the system in all aspects, are included in the Contractor's scope.

1.13 The Contractor shall include start up spares, essential spares, recommended spares and a set of special tools necessary for operation, routine maintenance of equipment supplied for a period as specified in this contract.

1.14 Whether specifically called for or not, all accessories required for normal and satisfactory operation (as deemed by the Purchaser) of the

equipment shall be considered to be a part of the Contractor's basic scope of supply and/ or work and no claims whatsoever, for extra payment on these grounds, will be accepted.

1.15 Contractor should visit site and get him/ her ascertained regarding the scope of work for the complete Electrical works before submission of quote/ offer for the pumping stations for 24 x 7 Water Supply.

1.16. Contractor's scope shall include design, engineering, manufacture, supply, testing, commissioning and handover of following electrical equipment/ systems as per tender specifications, BOQ, reference drawings and other relevant details for the following pumping stations for 24 x 7 Water Supply for WASA.

1.16.1 Tariff metering equipment as applicable (as per LESCO) & electric supply connection including necessary liaison works (Tariff metering equipment & electric supply connection shall be provided by LESCO for which necessary liaison shall be done by the Contractor).

1.16.2. 415 V Metal Enclosed Switchgears including Power & Motor Control Centre (PMCC) including Starter Panels, PDBs, Sub DBs, Lighting DBs, Receptacles for utilities. Local Start/ Stop Push Button Stations shall be provided near those motors which are not controlled from a Local Console/ Panel.

1.16.3 LV Capacitor Banks with control panel consisting of automatic power factor correction (APFC) relay to improve the plant power factor up to 0.99. APFC panels shall be provided on both bus sections of the PCC/ MCC.

1.16.4. Cabling system shall consists of various HV/ LV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power, control cables, GI ladder/ perforated type Cable Trays & associated accessories including support structures.

1.16.5 Provision for continuous monitoring of electrical Power & Energy parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-Hours etc.

1.16.6 Earthing for HV/ LV equipments and lightning protection system for all buildings in the plant premises. The general design shall be on the basis of following codes and standards (their latest amendments) in line with design criteria & specification requirements.

a. ISO 3043 Code of practice for Safety Earthing

b. ISO/ IEC 62305 Code of Practice for the protection of buildings and allied structures against lightning.

c) CEA guidelines 2010 Measures related to safety & electric supply.

c. 1.16.7. Lighting system for all indoor & outdoor areas of plant(s). The lighting system will be controlled by lighting panels installed in respective plant/ station areas, which will be fed from the main lighting DB.

37.2. DC SYSTEM:

a. 24/ 30V or 110V DC in built DC power pack unit shall be provided wherever applicable.

b. 24/ 30V or 110V DC Battery & Battery Charger (with inbuilt DCDB) shall also be provided wherever applicable.

37.3. DIESEL GENERATORS WITH AMF & SYNCHRONISING PANEL.

All necessary and supplementary items & equipment required for completeness, safe & efficient operation of the system, even though these may not have been mentioned in this specification. Spares & consumables for successful commissioning, establishment of performance guarantee and five years of trouble-free & safe operation of the plant.

1.17 Submission of drawings & documentation as specified under ‘’General Technical & Particular Requirement’’ section for Electrical equipment/ systems.

1.18 Contractor’s scope shall also include all civil works required for electrical equipment/ structure such as equipment foundations, indoor & outdoor trenches, equipment support structures, two pole structures, flow meter chamber, control rooms, all excavation works including those for earthing, cabling etc, de-tanking area, soak pits, burnt oil pits, chamber etc.

1.19 It is not the intent to completely specify all details of design and construction herein.

Nevertheless, the Electrical system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.

1.20 Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

37.4. PROJECT INFORMATION:

37.4.1. Site / Environmental Conditions

- Ambient temperature : 45ºC (site specific)
- Relative Humidity : 5 - 95%
- Area Classification : Non Hazardous / Hazardous
- Seismic Data: As per ISO 1893 (latest Issue)

37.4.2. Nominal System Voltage

Incoming AC power supply voltage to the plant premises is derived based on Load Demand as per GERC norms as follows:

Contract Demand	Supply Voltage
Not exceeding 100 KVA up to 1 MVA	415V
Exceeding 1 MVA KVA & up to 4 MVA	415V and 11 KV,
Exceeding 4 MVA	11 KV & above

37.4.3. Plant Power/ Control Supply Distribution Voltage:

Plant Power Distribution Voltage:	415V, 3 Phase, 4 Wire, 50 Hz, AC
General Lighting & Space Heating:	240V, 1 Ph, 2 Wire, 50Hz, AC
Control, Protection & Emergency Lighting:	24/ 30 or 110V, 2 Wire DC (as applicable)
Voltage Transformer Secondary:	110 V, 3 Ph, 50 Hz, AC
Voltage Variation:	10%,
Frequency Variation:	5% and
Combined Voltage & Frequency Variation:	10%

37.4.4. System Earthing

132 kV, 3 Ph AC system:	Neutral Grounding Resister
11 kV, 3 Ph AC system:	Neutral Solidly Earthed
415 V, 3 ph, AC system:	Neutral Solidly Earthed
240 V, 1 ph, AC system:	Neutral Solidly Earthed

37.5. DESIGN CRITERIA FOR ELECTRICAL EQUIPMENT / SYSTEM

37.5.1. General

The design criteria, given below has to be followed by the Contractor for designing/ sizing of electrical equipments covered under Contractor's battery limits; However it is to be noted by the Contractor that, following this design criteria does not relieve the Contractor from adherence to the standards, regulatory requirements & best engineering practices.

ESTIMATION OF LOAD/ MAX DEMAND: The following considerations are to be followed to arrive at the maximum electrical demand.

a. Load Factor

a)	Main motors	0.9
b)	Auxiliary load (valve actuators, Crane/ Hoist, etc.)	0.4
c)	Lighting load	1.0

b. Diversity Factor

a)	Main motors	1.0
b)	Auxiliary load (valve actuators, Crane/ Hoist, etc.)	1.1
c)	Lighting load	1.1

Power factor of Motors : As per the Manufacture's Data sheets Efficiency of Motors : As per the Manufacturer's Data sheets.

37.6. INCOMER SIZING/ SELECTION:

The capacity of the incomer(s) will be calculated based on the total simultaneous maximum demand (calculated based on the load factors and diversity given above, PF, efficiency).

Additional 20% contingency shall be considered for deriving incomer sizing.% voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running); the % voltage dip during starting at motor terminal shall not exceed 15%.

a. The Voltage dip and fault level calculations needs to be calculated based on following actual data collected from nearest Substation and Grid.
   i. The fault level of HV bus from which power supply will be taken to the plant.
   ii. Impedance of HV Overhead Line Conductor/ HV Cable interconnecting the HV bus of Substation and HV switchboards of the Plant

b. For the per unit calculation purpose, minimum starting current for various types of starter applications shall be considered as following:
   i. DOL Starter – 6 times the rated current.
   ii. Star- Delta Starter – 3 times the rated current.
   iii. Auto Transformer Starter (ATS) – 3 times the rated current.
   iv. Soft Starter – 3 times the rated current.

37.7. SWITCHGEAR SIZING/ SELECTION:

Switchgear shall be sized/ selected considering the following:

a. Rating suitable for carrying full load current of the equipment.

b. Suitability for Short Circuit Rating for 1 sec duration.

c. Switchgear for motors shall be suitable for motor duty application.

Switchgear for all the motor feeders shall be as per Type-2 co-ordination. Motor starter selection shall be done as follows:

a. Direct On Line (DOL) Starter – For motors rated up to 5.5 kW

b. Star- Delta Starter - For motors rated above 5.5 kW to 15 kW

c. Auto Transformer Starter (ATS) - For motors rated above 15 kW to 75 kW

d. Soft Starter – For all low/ medium voltage motors above 75 kW rating. e) In-panel de-ration of minimum 20% or as provided in Manufacturer's

catalogue, whichever is higher shall be considered.

a. Bus Bar Sizing:

a. The Contractor shall furnish calculations after award of contract, establishing the adequacy of the bus bar sizes to meet the continuous and short time current ratings as calculated.

b. The bus-bars shall be sized considering the following criteria:

i. Sleeving made of insulating material on all bus bars.

ii. Design ambient temperature 50^0C.

iii. Final temperature of the bus-bars complying with requirements of ISO 8623 & IEC 60947. Reduced temperature rise limit by 5K (for indoor panels) & 10K (for outdoor panels) to that of mentioned in ISO 8623 & IEC 60947 shall be considered to satisfy the final temperature.

iv. Bus bars being inside the panel; De- ration for enclosure and ventilation.

v. Bus bar suitability for carrying rated current continuously

vi. Configuration of bus bars and Proximity effect

vii. Bus bars shall withstand the short time rating of the panel for 1 sec duration.

37.8. POWER FACTOR IMPROVEMENT:

APFC Panel shall be sized considering following design criteria:

Minimum 8 steps in an APFC relay shall be considered. Capacitor shall be All Poly Propylene (APP), double layer type.

Fixed type capacitor bank, with manual & auto switching and components as indicated in reference electrical Single Line Diagram(s) shall be provided in each mains incomer (LV) panel for transformer no load compensation.

For each bus section of the Main LV PCC/ MCC panel, separate APFC panel-based on above design criteria to be provided. Other requirements of APFC panel & its components shall be as per requirement provided in this specification.

Total capacity & capacitor bank sizes shall be as given in Table below:

Capacity	5 kVAr	10 kVAr	15 kVAr	25 kVAr	50 kVAr	100 kVAr
* kVAr	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.

(*) = Contractor has to calculate the capacitor rating based on the system power factor (0.85 or actual, whichever is lesser - to be corrected for 0.99. Rating of APFC panel shall be based on 50% of running load on each bus section & not on the connected load basis. Number of stages/ steps in a particular APFC panel shall be decided by the Contractor such that minimum 8 steps & maximum 16 steps shall be provided in a particular panel. CT changeover scheme when only one transformer is running to be considered.

CABLE SIZING: The Contractor shall ensure that cable and wires associated with the power distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.

The following main aspects shall also be considered while deciding the final size of the cables-

a. Supply voltage and frequency

b. All cables shall be selected to carry the corresponding full load current under site conditions.

c. Route length and disposition of cables

d. Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).

e. Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.

f. For Cables emerging from ACB outgoing, fault clearing time shall be considered as 0.16 second (for Tie feeders if any it shall be 0.5 second)

g. For Cables emerging from MCCB outgoing, fault clearing time shall be considered as 0.01 second

h. Cable from metering kiosk to PCC incomer, fault clearing time shall be 1sec

i. Contractor to note that, the above fault clearing times are minimum to be considered & fault clearing time shall be considered as per actual relay co-ordination study.

j. Appropriate de-rating factors as per cable manufacturer ' s catalogue and enlisted below shall be considered for sizing the cable:

   i. Ambient Air Temperature (minimum 50^0C).

   ii. Ambient ground temperature (minimum 40^0C to be considered)

iii. Laid in Air/ ducts/ directly in ground etc.

iv. Depth of cable burial (minimum 750 mm for LT and 900 mm 11kV HV)

v. Thermal Resistivity of Soil (minimum 150^0C Cm/ W to be considered)

vi. No. of cables in a group-touching each other or separated by a distance vii. No. of cable trays in tier

vii. Any other de-ration factors as applicable & as per

viii. Manufacturer's catalog.

k. % voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running) The Voltage dip calculations, minimum starting current for various types of starter applications shall be considered as following:

i. DOL Starter – 6 times the rated current.

ii. Star- Delta Starter – 3 times the rated current.

iii. Auto Transformer Starter (ATS) – 3 times the rated current.

iv. Soft Starter – 3 times the rated current.

l. In running condition, cumulative voltage drop (at 100% rated load) shall not exceed 5% (measured at load end) for the LV loads.

m. LV cables shall be 1.1 kV grade, multi-stranded Copper/ Al conductor, XLPE insulated, colour coded, inner and outer extruded PVC sheathed, galvanized steel round wire/ flat strip armoured cables.

n. Cables up to & including 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.

o. Single core cable shall have non magnetic material armouring.

p. Control cables shall be Cu multi-stranded conductor with galvanized steel round wire/ flat strip armoured. For cables above 7 cores, minimum two spare cores shall be considered.

37.9. ILLUMINATION SYSTEM:

Illumination for various indoor & outdoor areas shall be conforming to the requirements mentioned below:

All lighting fixtures for indoor and outdoor shall be of LED only.

The illumination levels to be considered for the design of lighting system for various areas shall be as following. These are the illumination levels achieved at Work plane. Work plane height shall be considered as 0.76 m from FGL.

Area	Illumination Level (Lux) -Average values
Office rooms	300
Switchgear rooms	250
Control rooms	300
Chemical and general stores	150
All other indoor areas	150
Outdoor platforms and walk ways	50
Outdoor plant areas	20
Switchyard & Transformer Area General - On Equipment	10 30
Road	15

Critical lighting shall be designed such that at all junctions, exit passages & strategic locations the Lux level shall be maintained above 10 Lux. Installite fixtures with built in battery backup shall be considered.

Lighting design shall be performed using DiaLux Software Version 4.5 or its latest version/ Original Equipment Manufacturer (OEM) validated software. The Validation Report along with software and data files shall be acceptable to Purchaser/ Purchaser's representative.

Various design factors shall be considered as following:

a. Maintenance Factor:

i. Outdoor area: 0.6 (0.7 for LED)

ii. Indoor areas: 0.7 (0.8 for LED)

b. Reflectance Factors:

i. Wall 30%

ii. Ceiling 10%

iii. Floor 30%

c. Uniformity (Min. / Avg.)

50% Minimum for indoor and 30% for outdoor

37.10. EARTHING & LIGHTNING PROTECTION SYSTEM:

a. ISO 3043 -1987 (Reaffirmed in 2006): Code of practice for Safety Earthing.

b. IEEE 80 - 2000.

c. ISO/ IEC 62305 - 2013: Code of Practice for the protection of buildings and allied structures against lightning.

d. CEA guidelines - 2010: Measures related to safety & electric supply.

The fault levels considered shall be as follows:

System Voltage	Fault level in kA (*)
11	18.4 kA for 1 sec
415	50 kA for 1

(*) Contractor to design on the basis of actual impedance and adequacy calculations for sufficiency of earth conductor size shall be provided.

Following factors shall be considered for sizing the earthing conductor:

a. Design Ambient Temperature 50C
b. Allowable temperature rise for steel welded joints 500C
c. Fault clearing time 1 Second
d. Overall earthing resistance to be achieved as per ≤ transmission Ohm for

IEEE std 80 – 2000 substation. ≤ 5 Ohm for distribution substation.

Measurement of soil resistivity shall be done using Wenner ' s four (4) electrode method as described in ISO 3043 -1987(Reaffirmed in 2006) including its latest amendment.

The soil resistivity of the plant area has not yet been measured; the same should be carried out during detailed engineering by successful Contractor.

After soil resistivity measurement; length of conductor, number of earth electrodes and no. of test pits shall be finalized based on these design criteria & the requirements specified in earthing requirements.

37.10.1. DRAWINGS / DOCUMENTS FOR REFERENCE

The electrical Single Line Diagram(s)/ PLC system architecture for water supply project including raw water intake & various headwork/ sub-headwork with/ or without water treatment facility (as applicable) form part of this specification and should be used for reference purpose only.

The equipment/ switchgear component ratings & requirements shown in the reference electrical Single Line Diagram(s) are minimum requirements & after award of contract, Contractor has to get approval for the equipment selection with the approval for sufficiency calculations.

The fault levels considered shall be as follows:

System Voltage	Fault level in kA (*)
11	18.4 kA for 1 sec
415	50 kA for 1 sec

(*) Contractor to design on the basis of actual impedance and adequacy calculations for sufficiency of earth conductor size shall be provided.

Following factors shall be considered for sizing the earthing conductor:

a)	Design Ambient Temperature	50C
b)	Allowable temperature rise for steel welded joints	500 C
c)	Fault clearing time	1 Second
d)	Overall earthing resistance to be achieved as per IEEE std 80 – 2000	≤ 1 Ohm for transmission substation.
		≤ 5 Ohm for distribution substation.

Measurement of soil resistivity shall be done using Wenner ' s four (4) electrode method as described in ISO 3043 -1987(Reaffirmed in 2006) including its latest amendment.

The soil resistivity of the plant area has not yet been measured; the same should be carried out during detailed engineering by successful Contractor.

After soil resistivity measurement; length of conductor, number of earth electrodes and no. of test pits shall be finalized based on these design criteria & the requirements specified in earthing requirements.

37.10.2. Drawings/Document for Reference

The electrical Single Line Diagram(s)/ PLC system architecture for water supply project including raw water intake & various headwork/ sub-headwork with/ or without water treatment facility (as applicable) form part of this specification and should be used for reference purpose only.

The equipment/ switchgear component ratings & requirements shown in the reference electrical Single Line Diagram(s) are minimum requirements & after award of contract, Contractor has to get approval for the equipment

selection with the approval for sufficiency calculations.

38. GENERAL TECHNICAL & PARTICULAR REQUIREMENTS FOR ELECTRICAL EQUIPMENT/ SYSTEMS:

38.1. 415V METAL ENCLOSED SWITCH BOARDS:

38.1.1. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear- General requirements

Factory Built Assemblies of SWGR and control gear for Voltages up to and including 1000V AC & 1200VAC ISO: 3427

ISO: 8623 / BS: 5486 / IEC: 439

Air Break Switches ISO: 13947-P3 / BSEN6049 / IEC: 947-3

Miniature Circuit BreakersISO: 8828 / BSEN: 60898

Low Voltage FusesISO: 13703 / BS: 1362 / IEC: 269-1

Contactors ISO: 13947/ BSEN: 60947 4 / IEC: 947-1

Starters: ISO: 13947/ BSEN60947-4/ IEC: 292-1 to 4

Control Switches & Push buttons ISO: 6857 / BSEN: 60947

Current Transformer: ISO: 2705 / BS: 7626

Voltage Transformer: ISO: 3156 / BS: 7625 / IEC: 44, 186

Indicating instruments: ISO: 1248 / BS: 89 / IEC: 51

Marking and Identification of Conductors and Apparatus Terminals:

ISO: 11353 / BS: 159

A.C. Electricity Meters: ISO: 722, 8530 / BS: 5685 / IEC 145,211

Degree of Protection: ISO: 13947 / IEC: 947-P1

Selection installation and maintenance of switchgear and control gear

Code of practice for phosphating iron and steel

Specification for copper rods and bars for electrical purposes

Control transformers for switchgear and control gear voltage not exceeding.

1000V AC

ISO: 10118

ISO: 6005 / BS: 3189

ISO: 613

ISO: 12021

38.1.2. Constructional Features:

The switchgear shall be metal enclosed, modular type suitable for indoor/ outdoor installation, dust & burning proof, self standing floor/ plinth mounting with a height not exceeding 2300 mm and shall have following features:

a. Panels shall be complying to Form-4 as per ISO 8623: 1993, Part I/ IEC 439-1

b. Breaker up to 1250A shall be installed in two tiers and above 1250A, it shall be mounted in single tier.

c. Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm at any location & shall be complying with the BIL for the panel.

d. Switchgear shall be divided into distinct vertical sections each comprising :

   i. A completely enclosed bus bar compartment running horizontally.

   ii. Enclosed vertical bus bars serving all modules in vertical section.

   iii. A separate horizontal enclosure for all auxiliary power and control buses.

   iv. Vertical cable alley of minimum 250 mm wide covering entire height e) Operating devices shall be incorporated only in the front of switchgear.

e. Each shipping section shall have metal sheets at both ends

f. Cable alley shall be provided with suitable hinged doors

g. All doors shall be with concealed type hinges and captive screws

h. Each vertical section shall be equipped with a space heater controlled by thermostat

i. Each switchgear cubicle shall be provided with interior lighting with 11W CFL luminaries inclusive of lamp with door limit - on/ off switch.

j. A power socket (240 V AC, 5/ 15 A) shall be provided in the interior of each cubicle with On-Off switch.

k. All identical equipment and corresponding parts be fully interchangeable without any modifications

l. Main and Auxiliary Buses:

   i. Switchgear bus bars shall be of uniform cross section throughout the length and made of Electric grade Aluminium (91 E- 63401)

   ii. All bus bars shall be covered with heat shrinkable black PVC sleeves. Coloured polyester tapes for phase identification shall be provided at suitable locations.

   iii. Bus bar shall be adequately supported to withstand stresses developed due to short circuits.

iv. Bus bar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts, washers and nuts

v. The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.

vi. Vertical bus bars shall have Short Circuit rating same as main bus bar and shall be suitable for all connected load of vertical section.

vii. Neutral bus bar size shall be 50% of phase bus bar.

viii. Termination on bus bars at ACB, MCCBs shall be as per IEC60947-2. For terminations on MCCBs, where phase- phase and phase to earth clearance are not possible, Cu spreaders of suitable size shall be used along with the use of separators.

ix. Bus bar supports shall only be WASA irrespective of bus bar size. The span between the two insulators shall be adequate. Joint positions and insulators shall be properly adjusted so that they don't interfere.

x. For the Main PMCC, Contractor shall ensure that incoming feeders from transformer shall be suitably designed for terminating bus duct. Contractor shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the bus-duct. Phase transposition, if required, will be done in the Main PMCC.

xi. Wherever Cu bus bars are provided, it shall be tinned copper & not bare Cu.

m. All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor.

n. All the indoor switchgear panels shall be suitable for IP-54 degree of ingress protection for the enclosure. Outdoor panels shall be with minimum IP-55, degree of protection

o. All panels shall be made up of CRCA sheet steel of following thickness .

p. Load bearing members: 2.5 mm.

q. Doors and partitions: Doors - 2.0 mm, Partition - 1.5 mm. iii. Mounting plate: 2.0 mm.

r. Gland plate: 3.0 mm for both incomer and outgoing. For single core cable these plates shall be non magnetic.

s. All the panel wiring shall be done with PVC FRLS, multi-stranded copper wires

t. Feeder shall have hinged open-able (more than 105˚) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.

u. Suitable barriers of FRP material shall be provided between two terminals connected to different voltage supplies.

v. All doors and detachable components shall be earthed with flexible green coloured (with Yellow coloured band) PVC sheathed 2.5/ 4.0 sqmm. multi-stranded Copper cable.

w. The equipment shall be given tropical and fungicidal treatment.

x. Each compartment & component shall be provided with name plates (with white letters on Black background) at front, inside & rear side.

y. Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.

z. Metallic Shrouding shall be provided for the isolation of main and vertical bus; as well as to avoid accidental contacts with live parts.

aa. Drawing pocket shall be provided on the inside of incomer feeder door.

bb. Provision for Top/ Bottom cable entry shall be made to suit the site condition.

cc. Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type.

dd. All the panels shall be provided with 20% extra power & control terminals.

ee. All unused contacts of the circuit breaker, protection, auxiliary, control relays shall be wired up to the terminal block.

ff. All terminals of different control voltages shall be separate from each other.

gg. Stud type terminals and ring type lugs shall be used for control cables. ff) All the control/ power wiring shall be dressed neatly & the wire running through troughs shall be provided with covers

hh. Switchgear shall be easily extensible on both sides by the addition of vertical sections after removing the end covers. It shall be provided with a metal sill frame made of structural steel channel section properly drilled for mounting the switchgear along with necessary mounting hardware. Hardware shall be zinc plated or passivated. It shall be provided with labels on the front and rear indicating the switchgear designation.

ii. Any operating handle of switchgear shall not be more than 1800 m and not lower than 300 mm from base of the panel.

jj. For individual feeder modules arranged in multi tier formation, it is essential that the modules are integral multiples of the unit size to provide for flexibility in changes if any at site. For safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power slab contacts to engage with vertical Bus bars. A vertical cable alley shall be sufficiently wide for motor control modules and for circuit breaker control modules.

kk. A horizontal separate enclosure for all auxiliary power and control buses, as required shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap off connections from these buses shall be arranged separately for each vertical section.

ll. All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section.

mm. For draw out type modules, only the handles of control and selector switches, push buttons, knobs & cut outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door.

nn. On circuit breaker controlled circuits, protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawal chassis. All cut outs shall be provided with gaskets for the purpose of dust proofing.

oo. Current transformers shall not be directly mounted on the buses. Current transformer on circuit breaker controlled circuits shall be mounted on the fixed portion of the compartment.

pp. In breaker compartments, external cable connections shall be carried out in separate cable compartments for power and control cables.

qq. After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the Bus bars and adjacent circuit live.

rr. The withdrawals chassis shall move on suitable guides and on suitably plated steel or stainless steel rollers or balls to facilitate easy withdrawal.

ss. Cable alleys shall be provided with suitable hinged doors. It shall be possible to safely carryout maintenance work on cable connections to any one circuit with the Bus bars and adjustment circuits live. Adequate number of slotted cable support arms shall be provided for cleating the cables.

tt. Rear of single front switchgear shall be provided with removable panels. It shall be possible for one person to remove and fix the removable panel.

uu. All doors shall be provided with concealed type hinges and captive screws.

vv. The draw out contacts shall be only between copper/copper alloy/ aluminum fuses, which are silver or tinplated. The contact design shall be such that there should be no arcing/ deformation under the associated peak short circuit current.

ww. Switchgear shall be designed in such a way that all components equipment and Bus bars operate satisfactorily without exceeding their respective maximum permissible rise in temperature under ambient temperature conditions prevailing within the switchgear cubical, with reference to ambient temperature outside the switchgear cubical.

xx. Provision of ventilating louvers shall be provided with fine-screened brass or GI meshes to prevent entry of vermin and dust.

yy. The various types of modules indicating the control requirements of each type together with the list of component equipment required for each type shall be as follows:

i. Incoming circuit - Draw Out type air circuit breaker for above 630A/ Fixed type MCCB for 630A & below

ii. Outgoing feeder - ACB/ MCCB/ MPCB

iii. Auxiliary services - Starters, capacitors, Distribution Boards and other auxiliary load

iv. Physical size of compartment for each type of control and current rating shall be so chosen that all the basic and additional equipment can be housed in the compartment. No equipment associated with any particular circuit shall be permitted to be mounted in any other circuit module.

4.1.3. Power Distribution Board (PDB) configuration shall be two no. *A TPN MCCB I/Cs and six no.

*A TPN MCCB O/G feeders. The O/G feeders shall be supplying to Sub DBs. The configuration of Sub Distribution Board (SDB) shall be *A FP MCCB I/C and 2 nos. 63A TPN

MCB & 12 nos. 20A SP MCBs as outgoing feeders. (*A) shall be decided during detailed engineering.

4.1.4. Separate instrument's compartment for indicators of flow meter (s), energy meter, level & pressure controller (if any) shall be provided as per actual requirement of suitable size.

38.1.3. Control Voltages:

Following control voltages shall be used in LV panels

a. All ACBs tripping/ Closing shall be suitable for 110/ 240V AC (24/ 110VDC) as applicable. The trip coil and closing coils of ACBs shall operate satisfactorily under the following conditions of supply voltage:

i. Closing coils- 85 % to 110 % of rated voltage

ii. Trip coils- 70 % to 110 % of rated voltage.

b. Indications/ Annunciator for LV Main PCC/ MCC- 110/ 240V AC (24/ 110VDC)

c. Indications for auxiliary DBs - 240V AC

d. Space heater, 5/ 15A socket, panel illumination lamp etc- 240V AC derived from AC bus.

e. 240V AC, 110V AC and other voltages shall be segregated to avoid mix-up of voltages.

f. Control transformers suitably rated of voltage ratio 415/ 240/ 110 V on the Incomer/ Bus shall be provided. For the control transformers, fuses shall be provided on the 415 V side and MCBs on the 240/ 110V side. The control transformer shall be cast resin type only.

38.1.4. Painting:

a. All sheet steel work shall be paint through 7 tank electrostatic powder coating process in accordance with the required procedure and with the applicable standards. The switchgear enclosure shall be powder coated with shade as per RAL-7032.

b. The final finished thickness of paint film on sheet steel enclosure shall not be less than

80 microns. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

38.1.5. Interchangeability:

All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable without having to carryout modifications. For trouble free interchangeability, the draw out arrangements shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.

38.1.6. Drawings & Documents:

Prior to fabrication of the switchgear, the Contractor shall submit following for Purchaser Representative's approval - the dimensional drawing and design calculations indicating bus bar size, short circuit rating of all the electrical component used, internal wiring, components mounting details etc. The Contractor shall submit manufacturers catalogues of the electrical components installed in the switchgear.

38.1.7. Inspection:

At all reasonable times during production and prior to dispatch of the switchgear to site, the Contractor shall arrange and provide all the facilities at their plant for inspection & testing of switchgear.

38.1.8. Earthing:

a. Al/ GI earth bus bars of adequate size shall be provided for the entire length of the panel.

The framework of the enclosure shall be connected to this earth bus. Provisions shall be made for connection form this earth bus to the main earthing bus bar coming from the earth pit on both side of the switchgear.

b. The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bus bar. The armour of cables shall be properly connected with earthing clamp and the clamp shall be ultimately bonded with the earth bus bar.

38.1.9. Labels & Name Plate:

a. Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

b. A nameplate with the switchgear designation in bold letters shall be fixed at top of the central panel. A separate nameplate giving feeder details shall be provided for each feeder module door.

c. Inside the feeder compartments the electrical components, equipments, accessories like switchgear shall be provided with stickers shall suitably identify control gear, lamps, relays etc.

d. Engraved nameplates shall preferably be of 3-ply (Red-White-Red or Black-White-Black) lamicoid sheet however black engraved perplex sheet nameplates shall also be acceptable. Engraving shall be done with square grove cutters.

e. Nameplate shall be fastened by counter sunk screws and not by adhesives.

38.1.10. Danger Notice Plates:

a. The danger notice plate shall be affixed in a permanent manner on operating side of the switchgear.

b. The danger notice plate shall indicate danger notice in Gujarati, Hindi and English.

c. The danger notice plate, in general shall meet to requirements of local inspecting authorities.

d. Caution name plate, “Caution Live Terminal” shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.

e. The danger notice plate shall be made from minimum 1.6 mm thick steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.

f. The letters, figures, the conventional skull and bones shall be positioned on the plate as per recommendations of latest edition of ISO 2551-1982.

g. The said letters, the figures and the sign skull and bonds shall be painted in signal Red color as per latest edition of ISO 5 - 1978.

h. The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit the design of the switchgear enclosure.

38.1.11. Cable Entry:

a. The panel shall have provisions of cable entry from top/ bottom. The removable cable gland plate shall be provided to make entry dust and vermin proof.

b. The panel shall have provisions for fixing the multi-core cable glands.

c. The cable glands support plates shall be 3 mm thick.

d. Cable entries to the panel shall be from the bottom unless otherwise specified. Cable gland shall be double compression screwed type and made of brass.

38.1.12. Mountings:

a. All equipment in front of panel shall be of flush mounting type.

b. All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services of others.

c. All equipment inside the panel shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.

d. The centreline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.

It is important to note that when pumping station is idle and transformer is required to be kept energized under no load/ part (miniscule) load condition, the necessary LV fixed capacitor bank (approx. 5% of transformer rating) shall be provided in PMCC (transformer LV incomer) panel and shall be manually/ automatically switched on to maintain power factor more than 0.95 but less than 0.99 (near unity). All the components for fixed type Capacitor bank (to be mounted in Main LV PMCC) panel shall be as indicated in typical electrical Single Line Diagram attached with the specifications. This is a complete responsibility of the Contractor to maintain the power factor under idle condition of pumping station. Any power factor adjustment charges levied by power utility shall be recovered from the Contractor along with 5 % lump sum administrative charge by the Owner.

38.1.13. Air Circuit Breaker (ACB):

a. All the incomers & bus coupler ACBs shall be 4P EDO type. All other ACBs shall be TPN EDO type.

b. All the ACBs shall have Ics=Icu=Icw=100%

c. Up to and including 630 A, Fixed Type FP/ TPN MCCB shall be considered, while above 630A FP/ TPN, fully draw out type ACB shall be considered in line with the electrical Single Line Diagram requirements.

d. All ACBs shall be provided with additional 6 NO + 6 NC contacts, exclusively for Purchaser's use.

e. All the ACBs (except for APFC panel) shall be provided with microprocessor based O/L+ S/C + inbuilt E/F protections.

f. ACBs/ MCCBs for APFC panel shall be provided with thermal magnetic based O/L+ S/C + E/F protections.

g. Each ACB shall be provided with – On, Off, Trip, Spring Charged, Trip Coil Healthy, Service & Test Position indication lamps.

h. For incomer feeders R, Y & B Phase indication lamps shall be provided.

i. All ACBs shall be Schneider make 'Masterpact NW'/ Siemens '3WL'/ L&T 'C Power' OR Equivalent from the approved make list.

j. Circuit breaker shall be horizontal withdrawal type, comprising three/four identical poles operated through a common shaft.

k. It shall be suitable for switching duty of transformer and motors and other devices.

l. It shall be possible to push in and withdraw the breaker easily and without much effort.

Insulating plugs and sockets for power as well as for control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced, insulated with PVC or other insulating material.

m. The breaker shall have three distinct positions namely services, test and fully withdrawn positions. In test position, it shall be possible to operate the circuit breaker without energizing the power circuits. Separate limit switches each having a minimum of four (4) contacts shall be provided for both service and test position of the circuit breaker. These contactors shall be rated for 10 Amp, 240 volts AC.

38.1.14. Operating Mechanism:

a. The EDO type ACB shall be power operated by a motor charged spring operated mechanism & MDO type shall be manual type spring operated mechanism.

b. The operating mechanism shall have anti-pumping features under every method of closing. The operating mechanism shall normally be operated by Local/ Remote electrical control, when the breaker is in service position. Shunt trip coils shall perform electrical tripping.

c. The main poles of the breaker shall operate simultaneously. Also there shall not be any objectionable rebound of the moving contact in the fixed contacts.

d. The mechanism shall be such that any failure of auxiliary spring shall not prevent tripping. When the breaker is in closed position, failure of any auxiliary spring shall not cause damage to the CB or danger the operation.

e. A mechanical indicator shall be provided on the breaker operating

mechanism to indicate open and closed position of the breaker. This shall be visible to a man standing in front of the cubical with the door closed.

f. It shall be possible to operate the breaker mechanically. This shall be possible only after opening the cubical door. Provision shall be made for local electrical control also when the breaker is in the test position by a control switch on the cubical doors.

g. All working parts of the mechanism shall be of corrosion resistance material. All split pins; bolts, nuts and other parts shall be properly pinned and locked to prevent loosening with repeated operation of the breakers.

h. Auxiliary switch containing 6 NO +6 NC potential free contacts rated for 10 Amp 240 V AC (Inductive breaking).

38.1.15. Spring Charged Mechanism:

a. Spring operated mechanism shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.

b. The breaker operation shall be independent of the motor, which shall be used only for tensioning/ compressing of the spring.

c. The closing operation shall automatically charge the tripping spring.

The closing, opening shall get charged immediately after a closing operation is performed.

d. Motor used shall be preferably universal type operated on AC supply. The Motor shall operate satisfactory at all values “between” 85% to 110% of rated voltage.

38.1.16. Mechanical/ Electrical Interlocking:

a. Mechanical interlock arrangement shall be provided between two incomer breakers.

Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.

b. Interlocking between two-incomer breakers shall be provided in such a way that in normal condition bus coupler shall be in “ OFF “ position so that both the transformer can be kept charged and the total load can be divided equally between two circuits.

c. During fault, maintenance or any other abnormal condition while one of the transformer is not in working mode, the bus coupler shall be in “ ON “position so that total load can be supplied by the remaining transformer circuit.

d. Interlock shall be Mechanical and Electrical type. In case if one of the interlock fails the other way can be used for interlocking purpose.

38.1.17. Moulded Case Circuit Breakers (MCCB)

a. The MCCBs shall conform to IEC 947 & the latest applicable standards.

b. All MCCBs shall be of fixed type unless otherwise specified in the specifications elsewhere.

c. MCCBs shall be of four pole/ triple pole with neutral construction arranged for simultaneous four/ three-pole manual closing and opening and for automatic instantaneous tripping on short circuit.

d. All the incomer & bus coupler MCCBs for Main LT PMCC panels shall be FP type with microprocessor based O/L+S/C+inbuilt E/F release & all outgoings MCCBs shall be TPN with thermal magnetic based O/L+S/C+ E/F releases.

e. All MCCB’s shall be Schneider make Compact NSX/ Siemens- Sentron 3VL OR equivalent from the approved make list.

f. For achieving the Earth Fault protection in thermal magnetic (TM) based MCCBs, external CBCT, Earth Fault relay & shunt trip provision shall be considered as part of complete TM based MCCB.

g. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated by using LED indications.

h. MCCBs shall be with Ics = Icu = 100%

i. MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stresses caused by the peak short circuit current of value associated with the switch gear rating.

j. All the MCCBs shall be of current limiting type and shall provide a cut off in 4-8 milli seconds for prospective currents during faults.

k. All the MCCBs shall be provided with rotary operating handle with door interlock.

l. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

m. All MCCBs shall be provided with additional 2 NO + 2 NC contacts, exclusively for Purchaser's use.

n. All the switchgear selection for motor feeders shall be Type-2 co-ordinated. Entire LV system shall be fuse less type & fuses shall be used only for VT/ Control

Transformer primary side. MCBs shall be provided on secondary of PT/ Control transformer

38.1.18. Miniature Circuit Breaker (MCB):

a. MCB shall be hand operated, air break, quick make, quick break type.

b. Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

c. Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the characteristics of the connected load. Where this is not specified, it shall be Type C.

d. The short circuit rating shall be not less than that of the system to which they are connected.

38.1.19. Direct-On-Line Starters:

Direct on line motor starter shall have following components/ features:

a. Direct-on-line starters shall be suitable for Class AC-3 utilization category as per ISO:

13947 (Part 4), unless otherwise mentioned in tender.

b. DOL starter shall have MCCB/ MPCB, Overload Relay with SPP, Contactor etc.

c. Type 2 Co-ordination shall be ensured.

38.1.20. Automatic Star-Delta Starters:

Automatic star-delta motor starters shall have following components/ features:

a. Three sets of contactors one for the line, one for the star point and one for the delta, and a timer to automatically change the connections from star to delta.

b. Star Delta Starters shall consist of MCCB/ MPCB, Overload Relay with SPP, Contactors, electronic timer etc.

c. Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized after time delay, timer contact de-energizing the star contactor, and delta contactor closing.

d. Star-delta starters shall be suitable for AC-3 utilization category as per ISO: 13947 (Part unless otherwise mentioned in tender. e) Type Coordination shall be ensured.

38.1.21. Reversing Starters:

Motor Reversing starter shall have following components/ features:

a. Forward and reverse contactors, electrically interlocked with each other.

b. Reversing starters shall be suitable for Class AC-4 duty as specified in applicable standards, unless otherwise mentioned in tender.

38.1.22. Auto Transformer Starter (ATS):

Auto Transformer starter shall have following components/features:

a. Auto transformer shall be air cooled type having three (3) tappings of 50%, 65% and 80%. The same should be wound with Copper wire. The size of the wire should be determined to suit the associated motor rating. The tapping requirement indicated is minimum required & Contractor to ensure proper tapping selection based on motor starting requirement.

b. Stamping of reputed make and winding wire with 'B' class insulation should be used.

This should also be suitable for minimum 6 starts per hour. Core shall be of CRGO material.

c. Maximum temperature rise should not be more than 115°C. Kordnoffer circuit (Closed Transition type) should be adopted in ATS panel. There shall be an acrylic/ Hylam sheet over & below the transformer. Also to absorb humming rubber sheet shall be provided below auto transformer.

d. Auto transformer shall be vacuum impregnated.

e. Testing of transformers should withstand full load starting current for six starts per hour, each kick of 15 seconds duration as per relevant ISO.

f. ATS shall be provided with thermal overheat protector in each coil of transformer from overheating. Thermal overheat protector rating shall be 900ºC with 10% tolerance.

g. ATS shall consist of MCCB/ MPCB, Overload Relay, and Contactors etc.

38.1.23. Soft Starters

Fully automatic microprocessor based soft starters with built-in bypass terminals for pump control application shall be considered for the motors above 75 kW. The features/ requirements of the starters shall be as per following but not limited to:

a. The soft starter shall be designed, built and tested according to the latest editions of applicable IEC standards/ IEC 947-4-UL, CE.

b. Input Voltage – 3Ph, 415V, ±10%

c. Input Frequency – 50 Hz, ±5%

d. Control Voltage – 100 - 240 V AC

e. Ambient Conditions:

   i. Temperature- 50 Deg C. (Operating range -5 to 70ºC)

   ii. Relative Humidity of 5 to 95%

f. Control Method - Torque Control/ Reduced Voltage/ Ramp

g. Motor Protection - Thermal overload protection

h. Starter Protection - S/C, Phase imbalance, Phase failure, Phase reversal, O/ V, U/ V, Locked rotor, excessive starts per hour for application, Phase loss input/ output, Motor output loss.

i. EMC standard – IEC 61000-4-2 level-3, IEC 61000-4-3 level-3 j)

j. Built-in communication port for RS 485.

k. Type 2 Co-ordination shall be ensured.

   i. The soft starter shall be complete with the following acceleration and deceleration settings & display requirements as a minimum-

   ii. Starting Torque: Initial torque shall be adjustable from 0- 100% of maximum locked rotor torque.

   iii. Ramp Time: The time between starting torque and maximum torque shall be adjustable between 1 to 60 seconds. The time between maximum torque & stop shall be adjustable between 2 to 120 seconds

   iv. The current limit feature shall have the following characteristics:

The maximum allowed current during start shall be adjustable from 150% to 500% of soft-starter maximum current rating.

Starting torque shall be fixed at 40% when utilizing the current limit function.

v. Voltage Ramp start & Full voltage DOL start shall be possible.

vi. For stop function – Linear torque control, Quadratic Torque

Control, Voltage ramp control, soft break etc. functions shall be provided.

vii. The soft-starter shall be provided with a functional ground to remove and/ or minimize electrical noise injected on the soft starter control board.

viii. Normally open output relays shall be provided for faults and status indications.

ix. Normally closed contacts for fault relays shall be provided as an option.

x. The soft-starter shall be provided with a 2-position dip switch to select between the normal in-line connection (3-lead motor) and inside the delta (6-lead or 12-lead delta wound motors).

xi. The soft-starter shall be controlled completely through solid state design algorithms. No moving electromechanical contacts shall be allowed.

xii. All adjustments shall be made from the front of the soft starter through keyboard (soft keys)

xiii. The Soft starter shall have in-built/ remote parameters. With following display display

- Three Phase Currents
- Three Phase Voltages
- Shaft Power in kW / HP (selectable)
- Motor thermal capacity
- Motor Energy consumption (kWh)
- Power factor
- Run time in hours

The Soft starter shall have following fault indications

- Line failure
- Phase imbalance
- Over temperature – Motor
- Over temperature – Soft Starter
- Shorted Thyristor
- Open Thyristior
- Locked Rotor
- Motor output loss
- Overload - Shaft Torque

- Underload - Shaft Torque
- Over voltage
- Under voltage
- Excessive Starts
- Phase reversal

xiv. Shaft Power measurement without the use of external electro mechanical sensors.

xv. Shaft overload and under load protection shall be available through the controller, even in a by-pass configuration.

xvi. When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

xvii. The standard feature pump control shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomenon commonly referred to as “water hammer”.

xviii. The soft-starter shall be designed for three-phase control with two anti parallel SCRs in each phase. SCR-Diode combination shall not be acceptable.

- The PCB shall provide digital microprocessor control and supervision of all controller operation, including SCR pulse firing control.
- The PCB power supply shall be self-tuning to accept control power input from 100 to 240 or 380 to 500 V AC, 50/ 60 Hz.
- The SCR firing circuitry shall incorporate an RC snubber network to prevent false SCR firing.
- When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

xix. SCRs shall have the following minimum repetitive peak inverse voltage ratings:

- 200 to 525V: 1600 V
- 200 to 690V: 1800V

l. Soft Starter shall be ABB make PSTB 840-600-70/ Schneider makeAlistart-48 or better from the approved make list.

38.1.24. Contactors:

The power contactors used in switchboard shall have following features:

a. The contactors shall confirm to ISO 13947 & the latest applicable standards

b. The power contactors shall be of, air break, single throw, triple pole, electromagnetic type.

c. The insulation class of contactor's coil should be B or higher.

d. Operating coils of all contactors shall be suitable for operation on 110/ 240 V, single phase, 50 Hz, AC supply.

e. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.

f. Contactors shall not drop out at voltages down to 70 % of coil rated voltage.

g. All the switchgear selection for motor feeders shall be Type- 2 coordinated.

h. Motor starters shall be complete with auxiliary relays, timers and necessary indications.

38.1.25. Relays:

a. Main protective relays shall be Numerical type. They shall be suitable for semi-flush mounting with only flanges projecting on the front with connections from the rear.

b. All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.

c. All protective relays shall be in draw out cases with built in test facilities.

d. Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage

e. Test block and switches shall be located just below each relay for testing unless otherwise specified. All auxiliary relay and timers shall be supplied in non-draw out cases.

f. All protective relays shall be provided with at least two pair of potential free output contacts, exclusively for Purchaser's use.

g. Relay cases shall have adequate number of terminals for making potential free connections, to the relay coils and spare contacts. Paralleling of contacts if any shall be done at the terminals on the casing of the relay.

h. Each relay shall have provision for easy isolation of trip circuit for the purpose of testing and maintenance.

i. All relays shall with stand out a test voltage of 2 KV, 50 Hz RMS voltages for one minute.

j. Auxiliary seal in units provided on the protective relay shall be shunt reinforcement type.

k. 250 kW & above rated motors shall be breaker controlled with motor protection relay Siemens '7SK 80' OR equivalent from approved make list.

38.1.26. Thermal Overload Relays

a. Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with

adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.

b. Thermal overload relays shall be hand reset type

c. 'Stop' push button of the starter and hand-reset device shall be separate from each other.

d. Overload relay hand reset push button shall be brought out on the front of the compartment door. Overload relay shall be provided with at least 1 'NO' and 1 'NC' or one changeover contact.

38.1.27. Timers

Thermal/ Electronics timer for change over in star-delta and ATS panel should be provided.

38.1.28. Switch And Contactor Ratings:

Switch and contactor rating for various motor starter modules shall be selected by the Contractor, based on the specifications. Contractor shall also select appropriate ratings & ranges for thermal overload relays. These details shall be subject to the Purchaser's approval.

38.1.29. Single Phasing Preventers:

a. Single phasing preventer relay shall be provided to protect motors against single phasing.

b. It should operate satisfactory from 320/ 480V. Timing range of delay start 0 - 45 seconds.

c. Toggle switch for Auto SPP by pass should be provided on front of unit.

d. The relay shall not operate for supply voltage unbalance of ± 5%.After sensing single phasing, the relay shall operate with a time delay of 2 to 3 secs.

e. The relay shall not operate for a 3- phase power supply failure. The relay shall be of the hand-reset type with a hand-reset push button. Resetting shall be instantaneous and independent of the adjusted time delay in the tripping of the unit. Visual indication for the operation of the relay shall be provided.

f. The relay shall be suitable for application to protect reversible and non reversible motors.

g. The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and RPM of the motor.

h. The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited.

38.1.30. Power & Control Wiring Connections:

a. Terminals for both incoming and outgoing cable connections shall be suitable for 1.1kV grade Al/ Cu conductor XLPE armoured cable and shall be suitable for connections of solder less sockets for the cable size.

b. Main PMCC incomer feeder shall be suitable for bus duct connections using Aluminum Bus bars

c. Both control and power wiring shall be suitable for Bus Duct/ Cable termination as per guidelines mentioned in transformer specifications.

d. Both control and power terminals shall be properly shrouded. Power terminals shall be of stud type.

e. 20% spare terminals shall be provided on each terminal block.Sufficient terminals shall be provided on each terminal block so that not more than one out going wire is connected to per terminal.

f. Suitable barriers of enclosures shall preferably separate terminals strips for power and control from each other.

g. Wiring inside the modules for power, control, protection and instruments etc shall be done with use of 1.1 kV grades, multistranded Cu, PVC FRLS wiring.

h. Power wiring inside the starter module shall be rated for full current rating of respective contactor but not less than 4.0 Sq. mm. 2.5 Sq. mm copper wire shall be used for current transformer circuits.

i. Other control wiring shall be done with 1.5 Sq. mm copper conductor wires.

j. Wires for connection to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.

k. There shall be control transformer for control power supply (110/ 240V AC) and separate control bus.

l. Particular care shall be taken to ensure that the layout of wirings is neat and orderly.

Identification ferrules shall be filled to all the wirings terminations for ease of identification and to facilitate checking and testing.

m. Washers shall be used for all Copper and Aluminum connections.

n. Final wiring diagram of power and control circuit with ferrules nos. shall be submitted along with the panel as one of the documents against the contract.

38.1.31. Terminals

a. The outgoing terminals and neutral shall be brought to a cable alley suitably located and accessible from the panel front.

b. The current transformer for instruments metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming or outgoing cables to internal components of the distribution board is permitted; only one conductor may be connected in one terminal.

38.1.32. Wire Ways:

a. The horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

38.1.33. Indicating Instruments:

a. All analogue indicating meters shall be 144 x 144 mm size taut band with 240^0 Scale. All indicating meters shall be provided as per enclosed electrical Single Line Diagram.

b. Ammeters for motor feeders shall have suppressed scale up to 6 times beyond full load.

c. Dials shall be parallax free and white with black numbers and letterings & pointer shall be of knife-edge type. Such instruments shall be provided with zero adjustor accessible from the front.

d. Instruments shall have an accuracy class 1.0 or better.

e. Instrument dials shall be white with black numbers and lettering.

f. Ammeter and current coils of wattmeter's and ammeters shall continuously withstand 120 % of rated current and 10 times the rated current for 0.5 second without loss of accuracy.

g. Voltmeters and potential coils of voltmeters shall withstand 120% rated voltage continuously and twice the rated voltage for 0.5 seconds without loss of accuracy.

38.1.34. Metering Instruments:

a. Multifunction meters shall be provided for incomers, main pump motor feeders and outgoing feeders of 250A & above. Size of the MFM shall be 96 x 96 sq. mm & provided with following metering features:

   i. Current, Voltage, Energy (kWh), MD (kW, kVA), PF & Hz etc.

   ii. MFM shall be L&T make 'Quasar'/ Siemens OR equivalent.

   iii. MFM shall be with accuracy class 1.0 or better & having RS 485 communication port.

b. Multifunction meters shall be suitable for operation from the secondary of CTs and VTs.

They shall be provided with a separate 3 phases, 4 wires type test terminal blocks for testing of meters without disturbing CT and VT secondary connections.

c. Current coils of meters shall have a continuous overload capacity of 120 % for both accuracy as well as thermal limits. Also the coil shall withstand at least 10 times rated current for 0.5 second without loss of accuracy.

38.1.35. Current Transformers:

a. Current transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.

b. Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second for breaker feeders.

c. Unless otherwise specified, the minimum performance requirement of current transformers is as follows:

   i. Measuring CTs -15 VA, accuracy class 1.0 or better.

   ii. Protective CTs - 15 VA, accuracy class 5P20.

d. The above mentioned burdens are minimum required & it will be Contractor's responsibility to coordinate the current transformer burden with the requirements of relays, instruments and leads associated with that particular current transformer. Contractor has to provide sufficiency calculations for the same.

e. Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block

f. CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current

g. Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests.

h. Identification labels giving type, ratio, output and serial numbers shall be provided.

38.1.36. Voltage Transformers:

a. Voltage transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.

b. Unless otherwise specified, the minimum performance requirements of Voltage transformers are as follows:

   i. Measuring VTs - 50 VA per phase and accuracy class 1.0

   ii. Protective VTs - 50 VA per phase and accuracy class 3P.

   iii. Dual purpose VTs - 100 VA and dual accuracy class 1.0/

   iv. 3P for metering and protection respectively. VA is per phase.

   v. The above mentioned burdens are minimum required & Contractor has to provide sufficiency calculations for the same.

c. All secondary windings of voltage transformers including open delta windings shall be rated for 110 V /√3, 110V/ 3 per phase.

d. Voltage transformer shall have a continuous over voltage factor of 1.2 and short time over voltage factor as follows:

   i. 1.5 for 30 seconds in case of effectively earthed system.

   ii. 1.9 for 8 hours in case of non-effectively earthed system.

e. Voltage transformers shall be complete with suitable rated primary, fuses. Primary fuses shall have a rupturing capacity equal to the

rupturing capacity rating of the associated switchgear. All the secondary circuits of the VT shall be protected by MCBs.

f. It shall be possible to replace voltage transformers without having to de-energize the main bus bars.

g. The terminals of VT secondary and tertiary windings, which are required to be connected to earth, shall be earthed by an isolating link without a fuse.

h. Identification labels giving type, ratio, output and serial numbers shall be provided.

38.1.37. Push Buttons:

a. Push buttons shall have two normally open and two normally closed contacts unless otherwise specified. The contacts shall be able to make and carry 5A at 110V DC and shall be capable of breaking 1A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.

b. Emergency stop' push buttons shall be of Mushroom type, lockable in the pushed position and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.

c. The Internal wiring and terminal blocks shall meet the relevant requirements.

38.1.38. Auxiliary Transformers:

Any auxiliary voltage required for any of the component inside the switchgear shall be derived from the main supply by providing adequately rated auxiliary transformer mounted inside.

38.1.39. Indicating Lamps: Indicating lamps shall be:

a. Clustered LED type and of low watt consumption.

b. Provided with series resistors.

c. Provided with translucent lamp covers of colors 'Red', 'Green' andAmber' etc. as required.

d. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 110 V AC or at the specified AC/ DC system voltage as applicable.

38.1.40. Control & Selector Switches: Control and selector switches shall be:

a. Rotary type with enclosed contacts.

b. Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 230V AC and 1A (inductive break) 220V DC.

c. Provided with escutcheon plates clearly marked to show the positions.

d. Control switches shall be spring return to normal type & provided with pistol grip type handles.

e. Selector switches shall be maintained contact stay put type.

Switches in ammeter circuits shall be of break type contact. Selector switches shall be provided with oval handles.

38.1.41. Space Heaters:

a. Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.

b. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.

c. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 C.

d. Space heater indicated in the breaker modules represents the space heater for each vertical section of the switchboard. Where breakers are mounted in two-tier formation, then only one space heater with associated MCB and thermostat is adequate for the vertical section

38.1.42. Cubicle Lighting/ Receptacle:

a. Each control cabinet, marshalling box, etc. shall be provided with interior lighting by means of 11 W CFL luminaries with door operated On/ Off switch.

b. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB.

Routine and Acceptance Tests to be conducted by the manufacturer at their own risk and cost in presence of Purchaser/ Purchaser's representative during inspection & testing at manufacturer's works:

a. Following Routine tests as per ISO: 13947 and IEC: 60947 standards & other specified relevant ISO standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's representative on LV Switchgear panel complete with the accessories.

i. Dielectric test on main circuit.

ii. Test on auxiliary and control circuit.

iii. Measurement of insulation resistance of the main circuit.

iv. Tightness of main circuit.

v. Design and visual check.

vi. Dimensional check and BOM verification.

vii. High Voltage test on power & control circuit.

viii. Functional & mechanical operation test of all components.

a. Measurement of thickness of sheet steel & paint.

b. Verification of wiring as per approved schematic.

b. Following Type Tests reports as per ISO: 13947 and IEC: 60947 to be submitted for the same rating & type of LV Switchgear panel conducted in past for review of Purchaser at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.

i. Dielectric test on main and auxiliary circuit.

ii. Temperature rise test.

iii. Making and Breaking test of switching elements.

iv. Degree of protection test.

v. Short circuit withstand test.

vi. Electromagnetic compatibility test.

c. Certified copies of all type and routine test certificates and Calibration Certificates of measurement instruments which are used during inspection shall be submitted for the Purchaser's review/ approval before dispatch of the switchgear.

d.

38.1.43. Test Certificates:

a. Testing of switchgear shall be carried out at factory or at site as per standard in presence of Purchaser/ Purchaser's representative.

b. The test results shall be recorded on prescribed forms. The certificates for the test carried out at factory or at site shall be submitted in duplicate to the Purchaser/ Purchaser's Representative for approval. Components and equipment that are not fully interchangeable are liable for rejection. Contractor shall replace all such non interchangeable equipment at his cost.

38.1.44. Drawings/ Documents:

After award of contract, Contactor has to submit drawings/ documents for Purchaser's approval as mentioned below but not limited to:

a. General arrangement diagram showing dimensions of enclosure, length, widths and depth of enclosure and bill of quantity indicating the rating, make of each components and quantity.

b. Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.

c. Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.

d. Schematic power and control wiring diagrams with bus bar rating with material, instrument & control transformers, switchgear rating, control interlocks, relays, instruments, space heaters details etc.

38.2. LOCAL PUSH BUTTON STATIONS

38.2.1. Constructional Features

The constructional features of the local push button stations shall be as follows:

a. Metal enclosed, weatherproof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminum or sheet metal of 2 mm thickness.

b. Dust and vermin proof.

c. Provide a degree of protection of not less than IP55.

d. Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light gray epoxy paint.

e. Provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.

f. Provided with two earthing terminals suitable for earthing wire /strip.

g. Provided with removable undrilled gland plate and cable glands for two nos. 5C x 2.5 mm² Copper conductor, XLPE insulated, armoured cable. The cable entry shall be from the bottom.

h. Earthing shall be provided by 8 SWG GI wire and connected to earthing system.

38.3. APFC PANEL WITH CAPACITOR BANKS

Scope of this specification covers design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, unloading, storage at site, assembly, erection, testing, installation, commissioning and performance demonstration of the following equipment with associated accessories.

38.3.1. Capacitor Banks:

a. The type of capacitors shall be All Polypropylene type double layer conforming to ISO 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V
Rated frequency	50 Hz.
Permissible over voltage	1.1 Vn
Permissible over current:	1.5 In
Temperature category:	50º C

b. The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.

c. The capacitors shall have Low Dielectric Loss of 0.5 W / kVAr. d) Each capacitor bank shall be provided with the 7% detuned filter.

d. * kVAr is net reactive compensation required to maintain 0.99 PF at 415 V Bus, i.e. excluding compensation required for detuned filters.

e. Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.

f. Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.

g. Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of harmonics.

h. Contactor for switching of capacitor banks shall have AC-6b utilization category according to IEC 60947-4-1 & sized accordingly.

i. All the components shall be suitable for capacitor duty application.

j. The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. Capacitor shall be designed to improve the power factor to 0.99 lagging

k. It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/ Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.

l. Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.99 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.

m. The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/removal of capacitor or other components and maintenance considerations. Contractor shall submit General Arrangement drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.

n. For control circuit 415/ 240/ 110V AC control transformer shall be considered. VA burden to be decided by the Contractor.

o. Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.

p. Bus bars shall be sleeved with coloured heat shrinkable sleeves. All the Bus bar supports shall be WASA type only.

q. Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL-7032 for exterior & interior with minimum thickness 80 micron.

r. All necessary auxiliary contactors are included in scope.

s. Contractor shall note that verification of double layer construction shall be done on any one of the capacitor bank during inspection by opening the capacitor bank at no extra cost.

t. The cubicle shall be fabricated out of 2.0 mm thick cold rolled sheet steel & shall comprise of :

i. Isolating ACB/ MCCB

ii. Contactors with overload element

iii. Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.

iv. Auto-manual selector switch

v. Microprocessor based Automatic Power Factor Correction (APFC) Relay minimum 10 stage relays.

vi. Push button for opening and closing the power circuit

vii. Red and Green lamps for capacitors ON/ OFF indication viii. Protective relays to protect the healthy capacitor units when one unit fails in a series connection

viii. Space heater and cubicle lighting & receptacles.

38.3.2. Principle of Operation:

On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.

38.3.3. APFC Relay:

APFC relay shall have following standard features:

a. The Automatic Power Factor Correction relay shall be of microprocessor based type and shall automatically switch ON/ OFF the capacitor banks to attain the value of “pf” close to the set value.

b. Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.

c. To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.

d. Following adjustment shall be available in APFC Relay

i. Power factor

ii. Dead band capacitive region with respect to set power factor (PF).

iii. Inductive region with respect to set PF

iv. Operating time for programmable switching steps.

v. Auto/ manual selector switch.

vi. Manual step control.

e. All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.

f. It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3…..13, 14.

g. Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out will only be reconnected by the pulse counter, after 60 sec. has elapsed so that it has safely discharged. This is a requirement for 415V capacitors

h. Loss of voltage element- This would prevent abnormal switching surges on loss of supply. Also it would control the switching On/ Off surges.

i. Dead band features- Relay response sensitivity adjustable using dead band so that hunting is prevented.

j. Auto/ Manual control- This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

38.3.4. Performance Tests:

a. Contractor shall carry out all routine tests as specified in relevant ISO/ IEC standards on all major components and furnish copies of test reports for Purchaser's approval.

Wherever required, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.

b. Contractor shall also carry out all routine and functional tests as specified in the relevant ISO on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.

c. During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.

d. Primary Injection Test for various currents & time settings shall be provided in routine test.

e. All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

38.3.5. Maintenance Requirements:

a. As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with the equipment.

b. Contractor shall furnish detailed inter-panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

38.3.6. Drawings/ Documents Required:

a. Dimensioned general arrangement drawings of capacitor and capacitor control panel.

b. Justification for number of steps for switching.

c. Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.

d. Complete schematic and wiring diagrams for capacitor control panel.

38.4. CABLES & CABLING SYSTEM

The scope shall be inclusive of supply, installation, testing & commissioning of power, control cables, cable terminations, cable accessories, stripping of cable insulation, supplying and fixing of Aluminium lugs for aluminium cables & tinned plated copper lugs for copper cables and crimping the same to the conductor, supply and fixing of double compression cable glands including all labour supply and consumable material required for jointing/ termination. The rate shall also include the laying of cable in ground/ in cable trays / cleating to structure etc.

38.5. APPLICABLE STANDARDS:

The cables shall confirm to the latest applicable standards specified below.

In case of conflict between standards and this specification, this specification shall govern.

PVC insulated cables (for voltage up to 1100 V)	ISO/BS: 694
HRPVC & PVC insulated cables heavy duty	ISO/BS: 1554
Cross linked polyethylene insulated PVC sheathed cables	ISO/BS: 7098
Low frequency cables and wires with PVC insulation and sheath	IEC: 189-1 & IEC-189-2
PVC insulation and sheath of electric cables	ISO/BS: 5831
Polyethylene insulation and sheath for electric cables	ISO/BS: 6474
Conductors for insulated electric cables	ISO/BS: 8130
Methods of test for cables	ISO/BS: 10810
Specification for drums of electric cables	ISO/BS: 10418
Specification for PVC insulated cables for electricity supply	BS: 6346
Specification for PVC insulation and sheath of electric cables	BS: 6746

38.5.1. Constructional Features

a. HV power cables shall conform to 11kV Earthed grade (E), three core, stranded, Aluminium conductor, screened by extruded semi-conducting compound, cross-linked poly ethylene (XLPE) insulated, cores screened with non-magnetic metallic tape laid up with inner and outer extruded PVC sheath compound Type-ST2 and galvanized steel strip armouring. The cables shall generally conform to ISO/BS 7098-1985 with relevant parts thereof.

b. Armouring shall confirm to latest version of ISO/BS: 3975.

c. LV Power cables shall be 1.1kV grade, 4/ 3.5/ 3 Core, multi-stranded, Al/ Cu conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanized wire (up to 6 sq mm)/ steel strip (>6 sq mm) armoured cables. All single phase, Lighting cables, UPS cables shall have 100% Neutral.

d. All the control cables shall be 1.1kV grade, no. of cores (as per requirement/ application with minimum 2 spare cores for 7C & above) multi-stranded, Copper conductor, XLPE insulated, extruded inner PVC & outer PVC FRLS sheath compound type ST2 and galvanized steel round wire armoured.

e. All control cables shall be with following specific requirements:

   i. Copper conductor stranded class 2.

   ii. XLPE Insulated

   iii. Provided with inner extruded PVC and outer PVC FRLS sheath of extruded black PVC compound.

   iv. Galvanized steel armouring in the form of GI round wire.

   v. Core identification shall be by printed numerals.

   vi. The insulation over the individual conductor core will be colour coded.

   vii. Minimum 2 spare cores for above 7C.

f. The DC power supply cable shall be two core, multistranded copper conductor, armoured cables with inner extruded PVC & outer PVC FRLS sheath. All control wiring shall be PVC FRLS insulated.

g. All the power, control cables used in the Hazardous area shall be flame proof type suitable for the intended application.

h. Earthing Cable shall be Single core multi-stranded Cu, 1.1 kV grade, XLPE insulated, un-armoured green coloured outer sheath with yellow strips/ band cable to be laid in trays, underground, trenches etc. as applicable.

i. Submersible Cables: Multi core flexible Cu conductor XLPE insulated & PVC sheathed heavy duty cable suitable for submersible application (in case of submerged pumps) shall be manufactured as per governing standards. High purity electrolytic grade, annealed Cu conductor shall be used. Cables shall be extruded inner & outer PVC

sheathed. PVC compound shall be dielectric grade & shall be impervious to water, oils & grease etc. Similarly double PVC sheathing shall also be done as per ISO/BS: 5831/ 1984. Flexible inner sheath & high abrasion resistant flexible outer sheath is required for these cables. Double PVC sheathing shall be done so as to withstand abrasion & prevent ingress of water along the interstices of the cable. Core identification shall be by printed numerals. Conductors shall be as per ISO/BS 8130. Cable shall be constructed as per relevant ISO/BS/ IEC standards.

38.5.2. Cable Colours:

a. All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

b. The colour coding should be as follows:

i. 3 phase Red, Yellow and Blue

ii. single phase or dc supply Red and Black

iii. earth Green/Green with Yellow coloured band

iv. control Gray (DC)

38.5.3. Cable Conductors;

a. Cables up to 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multistranded conductor with galvanized steel round wire/ flat strip armoured.

b. Single core cable shall have non magnetic material armouring.

c. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm2.

d. Small control cables shall be of a minimum cross-section of 1.5 mm2.

e. Internal wiring of control panels shall be of a minimum cross-sectionof 1.5 mm2 flexible and multistranded.

f. Control cabling shall be of a minimum cross-section 1.5 mm2 for external use and 1.0 mm2 for internal use.

g. Cable Sizing shall be done as per design criteria specified in specifications.

38.5.4. Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Necessary loop at both ends shall be provided for future use and cables of different categories shall be tagged with the following subscripts and three-digit number.

HV power	HV-P_ _ _

LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

38.5.5. Cable Terminations

a. Cable Lugs

i. Cable lugs shall be of tinned copper, solder less crimping type for Cu cables & AL lugs for the AL cables.

ii. The current rating of the lugs shall be same as that of the respective cable conductors.

iii. Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.

iv. Double holes extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.

v. Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs. This shall especially be ensured for Al cable terminations & bimetallic terminations shall be used wherever required.

vi. If termination is done with crimping tool employing crimping die then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned and special jelly applied over it to prevent further oxidation.

b. Cable Glands

i. Glands shall generally be of the double compression hexagonal type brass glands. Earth continuity of brass glands shall be assured.

ii. Double compression type cable glands shall be used.Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.

iii. For single core cables, gland shall be with brass ring.

iv. Glands for single core cables shall be constructed from non-magnetic materials.

v. Cable glands shall be with metric threads.

vi. Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

vii. For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.

viii. For dry indoor situations, standard industrial glands with shrouds are acceptable.

ix. For hazardous areas, glands conforming to IEEE standard shall be used with double seal and shroud.

c. Trefoil Clamps for Single Core Cables:

i. All the single core cables shall be laid in trefoil formation only.

ii. The grouping & sequencing of three single core cables arranged in trefoil formation shall be done in such a way to ensure balanced current distribution.

iii. Trefoil clamp of suitable size & having non magnetic material shall be used.

iv. The Trefoil groups shall be held in trefoil clamps at an interval not exceeding 3.0 meters.

v. In addition to trefoil clamps as mentioned above, the tre- foil groups of cables shall be additionally tied by means of 3.0 mm dia. nylon cord clamp at an interval not exceeding 750 mm.

d. Wherever applicable, supply & installation provision of bimetallic strip for connection between Al to Cu strip & GI to Cu strip shall be provided.

38.5.6. Cable Drums:

a. Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

b. Before winding the cables on drums, Contractor shall obtain Purchaser's approval for the drum lengths. Cable ends shall be sealed by non-hygroscopic sealing caps.

c. Contractor has to ensure reference of an arrow and suitable accompanying wording which shall be stenciled on the sides of the drums indicating which way it should be rolled. The number on each drum shall be either branded at the end of the drum or stamped on the metal attached to an end of the drum. The cable shall be placed on the drum in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. The drum shall be securely blocked in position

so that the cable will not be displaced during transit. Cable ends shall be sealed by non-hygroscopic sealing caps.

d. It shall be the Contractor's responsibility to prepare the drum cutting schedule so that cable wastage is minimum while cutting.

e. Contractor shall obtain Purchaser's approval for the drum lengths.

f. The following information shall be given on the drums as a minimum:

i. Drum identification number

ii. Voltage grade

iii. Type of cable.

iv. Number of cores and cross-sectional area

v. Cable quantity

vi. Purchaser's order number and item number

vii. Total weight of cable and drum

38.5.7. Tests Before and After Laying of Cables at Site

Following Routine & acceptance tests on each drums as per ISO/BS 10810, ISO/BS 7098 standard & other specified relevant standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's Representative.

a. For 1.1 kV Power & Control cables:

i. Dimensional & visual check

ii. Conductor resistance test

iii. Insulation Resistance Test

iv. High voltage test

b. For 11 kV power cables:

i. Design and visual check

ii. Conductor resistance test

iii. Very low frequency AC HV test (instead of DC test)

iv. Insulation resistance including P.I. at rated voltage

v. Capacitance and tan delta

vi. AC leakage current

vii. Partial discharge measurement

c. All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 6.0 in ISO/BS: 1255 (Code of practice for Installation & Maintenance of Power Cables up to and including 33kV).

d. Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the Megger for cables of different voltage grades shall be as indicated below.

Voltage Grade	Megger rating
1.1k	500
11kV	1000

e. Following tests in the presence of Purchaser/ Purchaser's representative shall be carried out at site before commissioning of cables.

i. Insulation Resistance test between phases and phase to Neutral and phase to earth.

ii. Continuity test of all the phases, neutral and earth continuity conductor.

iii. Sheathing continuity test.

iv. Earth resistance test of all the phases and neutral.

f. Cable Gland:

i. Cable glands required for glanding all cables at both ends shall be supplied by Contractor.

ii. A minimum of 20% of cable glands shall be supplied as spare.

iii. Cable glands shall be of SS 316 and double compression type suitable for armoured cables.

iv. All cable glands shall be weatherproof to IP-66.

v. Flameproof glands wherever required shall be supplied with Ex (d) certification suitable for Gas Groups IIA / IIB / IIC.

vi. All cable glands shall be with LSF shrouds.

vii. For all field items and junction box end, NPT threaded cable glands shall be used and for control room / control panel end, cable glands shall be ET threaded types.

g. Junction Boxes:

i. In order to make the most economic use of cable tray and trench capacity, multicore / multipair cabling shall be utilised in order to connect instrumentation groups by using suitably located junction boxes.

ii. The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit.

iii. They shall be readily accessible for maintenance and clearly labeled.

iv. Junction box shall be constructed of die cast aluminium and provide degree of protection IP 65.

38.5.8. Drawings/ Documents Required

a. Wires and terminals for the digital and analog signals shall be segregated within junction boxes.

i. General information

ii. Principal technical data

b. After award of contract it shall be the responsibility of Contractor to work out a detailed layout for the complete plant cabling system. The layout drawing shall be furnished for the approval of Purchase/ Purchaser's representative before commencement of installation including cable trays, cable racks/ trenches, accessories, tray supports, conduits etc.

c. Contractor to submit following drawings/ details after award of contract

i. Cable Sizing calculations

ii. Details of Installation of cables in trenches, on cable trays, directly buried etc at all locations inside the plant.

iii. Cable routing lay out inside and outside the plant with route marker provided at 30 meter interval.

iv. Bill of quantities of cables, lugs and glands.

v. HV Cable termination and mounting Kit Layout drawing.

d. Following Type Tests reports as per relevant standard to be submitted for the same rating & type of Cables conducted in past for review of Purchaser/ Purchaser's Representative by the Contractor at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.

i. Annealing test

ii. Tensile test

iii. Wrapping test

iv. Test for thickness of insulation & sheath

v. Physical test for insulation & sheath

vi. Tensile strength and elongation at break of insulation and sheath

vii. Loss of mass test

viii. Ageing in air oven

ix. Shrinkage test

x. Heat shock test

xi. Insulation resistance test xii.

xii. High voltage test

xiii. Flammability test

38.5.9. Cable Tray & Accessories:

a. Cable trays shall be of Galvanised Steel/ Fiber Reinforced Plastic and of ladder/ perforated/ solid type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings. All

hardware (i.e. bolts, nuts, screws, washers, etc) shall be hot dip galvanized.

b. Cable trays of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows etc., shall be fabricated from 14 gauge (2.0 mm thick) mild steel sheets. Cable tray covers shall be fabricated from 16 gauge perforated (1.60 mm thick) M.S. sheets.

c. The cable trays shall be supplied in standard lengths of 2500 mm and clear inside widths of trays shall be as follows:

   i. Perforated type trays: 150, 300, 450 and 600 mm.

   ii. Ladder type trays: 300, 450, 600 and 750 mm

d. Cable trays, accessories and covers shall be painted with one shop coat of red oxide zinc chromate primer and two site coats of aluminium alkyd paint for indoor use.

e. For outdoor use, cable trays, accessories and covers shall be either galvanized or made of aluminium as specifically mentioned in the layout drawings.

f. For use in corrosive atmospheres both indoors and outdoors, the cable trays, accessories and covers shall be as per serial no. (e) above.

g. The spacing of rungs for ladder type of trays shall be 250 mm unless otherwise noted.

h. All finished cable trays and accessories shall be free from sharp edges, corners, burrs and unevenness.

38.6. EARTHING & LIGHTNING PROTECTION SYSTEM

38.6.1. Scope

a. The scope includes collection of data, design of the system as per relevant National/International Standards preparation of layout drawing supply of earthing conductors, earth electrode, earthing strips installation and approval to the satisfaction of electrical inspector under this tender specification.

b. Earthing system shall be provided to ensure equipment safety, personnel safety and facilitate designed operation of protective switching during earth fault conditions in the associated system.

38.6.2. Applicable Standards

The earthing and lightning protection system shall conform to the CEA guidelines and the latest applicable standards indicated below:

a. Code of Practice for Earthing ISO/BS: 3043

b. Code of Practice for the Protection of ISO/BS: 2309

c. Building and allied structure against

38.6.3. Earthing & Lightning system:

a. The design basis for designing earthing conductor is indicated under design criteria for electrical system. Earthing system shall be provided for complete plant i.e. pumping stations, switchyard and all electrical equipments as per the latest edition including all official amendments and revisions of ISO/BS-3043 and CEA guidelines.

b. All materials and fittings used in the earthing installation shall conform to the relevant Pakistan Standards or shall be approved by the Engineer's representative.

c. Contractor has to carry out soil resistivity test at, at least 4 locations for which locations shall be provided by Purchaser's representative. Testing to be done at each site.

d. Soil resistivity shall be carried out by Wenner four electrode method as described in ISO/BS 3043. Contractor has to carry out the test in presence of Purchaser's representative & test shall be carried out keeping electrode spacing as 1, 2, 4, 6, 8, 10, 15, 25 M (each, along all 8 directions) as per normal practice and report has to be submitted. Polar curves shall be used for measurement of mean soil resistivity, which shall be used in finding earthing resistance at a particular location. Mean soil resistivity values shall be approved by Purchaser's representative.

e. The Contractor shall base his earthing calculations on actual measurement carried out by him in the presence of Purchaser/ Purchaser's Representative.

f. Galvanized Iron flat / wire shall be used as earthing conductor.

g. The conductor sizes & types shall be as per specified in the Technical schedules in Volume- II, Section A3. Contractor to note that, the sizes indicated are minimum required & earthing conductor sizes shall be approved by the Purchaser/ Purchaser's representative on the basis of adequacy calculations submitted by Contractor.

h. The underground joints in the system shall be properly welded or brazed and the bolted type connection shall be made with structures/ equipments. Petroleum jelly shall be applied to contact surface of the bolted joints, which will be covered with bituminous compounded and tapes.

i. Earthing conductor shall be protected against mechanical damages considering the installation conditions.

j. The earthing system shall comprise one or more earth electrodes, earthing grid or a combination of these in order to obtain the required earth electrode resistance of less than one (1) Ohms/ or as per IEEE Std 80 -2000.

k. For equipment earthing, two earthing leads will be used if rated voltage of the equipment is 250 volts & above and one earthing lead will be provided for equipment rated below 250 volts.

l. The earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm below FGL.

m. For each 11 KV DP/ FP Structure, minimum 2 nos. of CI plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit- 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block and CI Cover complete as per ISO/BS 3043 with necessary length of double GI earth flat 25x6 mm bolted with lug to the plate complete connected to the required point of DP with end socket as per direction and duly tested by earth tester conforming to ISO/BS as per drawing and specifications complete with 600 x 600 x 6.0 mm CI earth plate.

n. For each transformer neutral, minimum 2 nos. of Cu plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block CI Cover complete as per ISO/BS/IEEE 3043 with necessary length of double Copper earth flat 25x6 mm bolted with lug to the plate complete connected to the transformer neutral with end socket as per direction and duly tested by earth tester conforming to ISO/BS/IEEE as per drawing and specifications complete with 600 x 600 x 3.15 mm Copper earth plate.

o. For other equipment & area, Earth electrodes shall be of heavy duty galvanized mild steel of not less than 40 mm NB and minimum 3000 mm long. Where multiple rods are used they shall be separated by a distance of not less than the driven length.

p. Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing strips shall be connected. These connections shall each be housed in individual inspection chamber set which shall project 100 mm above the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked `Electrical Earth'.

q. All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Purchaser’s Representative.

r. All civil works, such as excavation, boring, provision of charcoal & salt in adequate quantity, backfilling for the installation of the earth electrodes and the earth pit/ inspection pit shall be in the scope of Contractor.

s. After the earth installation has been completed the Contractor shall demonstrate to the Purchaser/ Purchaser’s Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

t. Main Equi-potential Bonding Conductor: Main equi-potential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

u. Circuit Protective Conductors: An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

38.6.4. Important Instructions for Earthing:

a. Each pole of lightning arrestors shall be earthed with separate earth pit.

b. Two-earth conductor shall connect outdoor CT secondary winding to earth grid.

c. The switchyard fencing shall be earthed at every alternate block and the switchyard gate shall be earthed with flexible GI wire.

d. All the earthing material with laying etc. shall be included in the scope.

e. The entire plant will have an earth grid laid in trenches/ trays/ buried in the ground outside. The main earthing grid shall be embedded at a minimum depth of 600 mm below FGL which shall be connected to earth electrodes.

f. All interconnections of the earthing grid conductors will have welded type joints except at electrodes with disconnecting facility and at equipment with bolted connections. All indoor earthing grids will be suitably interconnected to the external earthing grid.

g. Each steel/ RCC column of the building will be interconnected to the floor-earthing grid.Steel columns, steel strips / conduits, cable trays etc. will not be used as earth continuity conductors.

h. Disconnecting type facility shall be provided between Earthing grid & each earth electrode.

i. All connection between the conductors shall be welded/ brazed type. Metallic pipe, conduit, structures shall be bonded to lightning protection conductors to prevent the side flashover. But no metallic pipe, conduit, structure shall be used as air termination conductor or down conductor.

j. The down conductors shall be fixed with embedded brass posts (on concrete columns) with nuts & bolts used for fixing the saddle/ clamp (direct drilling of down comer and fixing with screw shall not be acceptable).

k. Cleats for ‘earthing and lightning protection systems’ shall be of GI.

l. The lightning protective conductor shall not be connected with the earthing above ground however both the systems shall be interconnected below ground.

m. The earth pits may require boring & drilling in the soil & the same shall be considered in Contractor’s scope.

n. Earth electrode with disconnecting facility shall be provided so that the resistance of the independent earth electrode may be measured.

o. Internal earth Bus of each panel shall be connected to both ends to the earthing system by means of earthing conductor.

p. Metallic frames of all current carrying equipment, structures supporting and adjacent to current carrying conductors, lightning protection system conductors, metallic structures, metallic stairs, hand rails, fences shall be connected to a single earthing system. Neutral points of various systems shall be connected to the dedicated treated earth pits and these earth pits shall be interconnected to each other below ground.

q. All connections in the equipment earth conductors buried in ground (or otherwise) shall be cad welded/ brazed, whereas connection at equipment end shall be of bolted type. All connections shall be of low resistance. All bimetallic connection shall be treated with suitable compound to prevent moisture ingression. For Bimetallic bolted connection, bimetallic washers shall be used. All bolted joints shall have minimum two bolts to ensure proper surface contact. Termination of stranded conductors at earth inserts shall be with ring type/ lugs.

r. Galvanized conductors shall be touched up with zinc-rich paint where holes are drilled at site for bolting to equipment/structure.

s. Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductor. The minimum length of such risers inside the building shall be 200 mm and outdoor shall be 500 mm above ground level.

t. Metallic conduits and pipes shall be connected to the earthing system unless specified otherwise.

u. All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval of not more than 10 meters by 25 x 3 mm GS flat.

v. Earthing Pits:

   i. Adequate number of earthing pits shall be provided in conjunction with earthing grid for the earthing system. The minimum spacing between two adjacent earthing pits shall not be less than length of the electrode (minimum 3 m) and shall be kept 1500 mm away from footings of the structure.

   ii. Earthing pits shall be located in ground, which has a reasonable chance of remaining moist. Arrangement comprising of GI pipe with top funnel with wire mesh shall be made to facilitate pouring of water to keep earthing pit wet.

   iii. A galvanized iron strip of adequate size (as per calculations) shall be provided from plate electrode to about ground level to facilitate jointing with earth conductors. Each earth electrode ending at the pit shall be connected to suitable linking strips to connect and disconnect the earthing suitably.

   iv. Earthing chamber shall be of RCC/ brick chamber of 600 mm x 600 mm, with removable 6 mm thick MS chequered plates. The

covers shall have holes for handling. Earthing pits (chambers) shall be painted Green and the earth-pit number shall be marked on it.

v. Earthing cables crossing other metallic structures such as conduits pipelines etc shall be minimum 300 mm away from such structures.

vi. Earthing conductors shall be protected against mechanical damage.

vii. All earth lead connections shall be as short and direct as possible and shall be without kink.

viii. The main earth loop in plant area shall be generally routed along cables. When equipments are located away from main earth loops, suitable sub-loops shall be run up to them for deriving connections for individual equipment. The entire earthing system shall fully comply with the CEA guidelines and requirements.

ix. The Contractor shall have to carry out any changes as desired by the Electrical inspector or the Engineer in charge, in order to make installation conforming to the CEA guidelines 2010.

38.6.5. Lightning Protection

a. The lightning protection system need will be established by calculating the risk factor value of each building, structure etc. as per procedure given in ISO/BS/IEEE 2309-1989 and if found necessary the same shall be provided by the Contractor.

b. For Lightning protection of Civil Structures including RCC Buildings, fixing of 25x6 mm GI earth strip to roof as per ISO/BS/IEEE/ IEC std, saddle clamp, down comer connector etc. as required with all hardware shall be in Contractor's scope. Structural Columns (which are used as down comers for lightning protection system) bottom shall be connected to the earth pit with 25x6 mm bare GI strip.

38.6.6. Galvanizing

a. Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below.

i.	Thickness less than 2 mm, but not less than1.2 mm	340 gms/ sq.m
ii.	Thickness less than 5 mm, but not less than 2mm	460 gms/ sq.m
iii.	Thickness 5 mm and over	610 gm/ sq.m

b. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.

c. Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

38.6.7. Drawings/ Documents Required

The Contractor should prepare Layout drawings, after award of contract and before commencement of work for Purchaser's approval, showing the location of earthing grid, electrodes, interconnection grids and earthing leads to various equipment, down comers, isolating links etc. should be accompanied by design calculations.

38.7. LIGHTING & VENTILATION SYSTEM

38.7.1. Scope

a. The scope of the Contractor shall include design, supply and installation of all equipment necessary for a complete lighting and receptacle system. The lighting system includes Lighting fixtures (indoor/ outdoor), lamps, lighting panels (LP), switchboards, Receptacles, JBs, cables/ wires for lighting/ receptacles, conduits etc. The supply of street light/ flood light poles as per ISO/BS/IEEE 2713 or ISO/BS/IEEE 3713 is also included in the Contractor's scope.

b. The various types of lighting fixtures with lamps shall be installed based on the mounting arrangement shown in the typical drawings enclosed with the specification. Installation scope shall include all material to mount the fixtures in proposed manner.

c. The various types of lighting fixtures as per specified in this specifications shall be assembled, installed, tested & commissioned by the Contractor.

d. The type of lighting fixtures and receptacles, illumination level and approximate quantity required shall be generally as per design criteria.

e. Lighting system installation shall be as per the tender specifications

f. It shall be the responsibility of the Contractor to work out complete detailed requirement of lighting and receptacle system for the whole plant and staff quarters including area lighting as per specification and accordingly procure and install them.

38.7.2. General Requirements

The Lighting system includes following items.

a. Lighting fixtures complete with Lamps and accessories. Only LED fixtures shall be used for both indoor & outdoor applications (Except for High mast lighting).

b. Lighting system equipment

c. Light control switches, receptacle units with control switch units, lighting wires, conduits, earth wires and other similar items necessary to complete lighting system.

d. Lighting fixture supports, street lighting poles and flood light towers/poles.

e. Lighting main distribution board, lighting panels

f. Multi core cables for street, boundary and flood lighting

38.7.3. Lighting Layout

a. It shall be the responsibility of the Contractor to work out a detailed layout for the complete plant in order to provide the levels of illumination as indicated in the relevant standards

b. b) The types of fixtures to be used in various areas are also indicated in the above mentioned drawing. The Contractor shall be responsible for measuring the levels of illumination and uniformity after installation and establish compliance with the specification.

c. The lighting system will comprise the following:

i. Normal A.C Lighting: Normal lighting in all indoor and outdoor areas will be operated on 230V, 1Phase, 50 HZ A.C supply

ii. Emergency Lighting: Emergency Lighting shall be designed such that at all junctions, exit passages & strategic locations, Lux level shall be maintained above 10 Lux. Emergency light fitting shall be 240 V self contained 2 x 10 W LED fixtue with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house/area. Emergency fixtures shall come in service when AC supply fails. Pump room and Electrical room shall be considered for Emergency lighting.

38.7.4. Applicable Standards:

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

a. Lighting Fixtures & Accessories for General & High mast Electrical lighting fittings general and safety requirements : ISO/BS/IEEE: 1913/ BS: 4533 Code of practice for industrial lighting ISO/BS/IEEE: 6665

Code of Practice for Interior Illumination : ISO/BS/IEEE 3646

Code of Practice for Lighting of Public Thoroughfares : ISO/BS/IEEE 1944

Calculation of co-efficient of utilization : ISO/BS/IEEE: 3646

(Part - III) Testing procedure of photometric testing for LED luminaires LM 79

Testing procedure on the lifespan of LEDs LM 80

National Lighting Code SP72

Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources ISO/BS/IEEE:16105

Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products

ISO/BS/IEEE:16106
Limits of Harmonic Current Emissions ISO/BS/IEEE 14700-3-2
DC or AC supplied electronic control gear for LED modules performance requirements IEC 62384
Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules
Environmental Testing: Test Z- AD: composite IEC 61347-2-13 temperature/ humidity cyclic test
Electro Magnetic compatibility (EMC)- Limits for IEC 60068-2-38
Harmonic current emission-– (equipment input current ≤ 16 A per phase) IEC 61000-3-2 EMC Immunity requirement IEC 61547
LED modules for general Lighting-Safety requirements
IEC 62031Classification of degree of protections provided by IEC 60529 enclosures (IP Codes) Fixed general purpose luminaries IEC 60598-2-1 General Lighting - LEDs and LED modules – ISO/BS/IEEE:16101 / IEC TS Terms and Definitions 62504
LED Modules for General Lighting Part 1 Safety
Requirements LED Modules for General Lighting Part 2
Performance Requirements
Safety of Lamp Control Gear, Part 2 Particular
Requirements Section 13 D.C. or A.C. Supplied
Electronic Control gear for Led Modules
ISO/BS/IEEE:16103(Part1) ISO/BS/IEEE:16103(Part2)
ISO/BS/IEEE:15885(Part2/Sec13)
Industrial lighting fittings with metal : ISO/BS/IEEE: 1777
Reflectors
Decorative lighting fittings : ISO/BS/IEEE: 5077
Dust proof electric lighting fittings : ISO/BS/IEEE: 4012
Dust tight electric lighting fittings : ISO/BS/IEEE: 4013
Flood lights : ISO/BS/IEEE: 10322/BS: 4533
Luminaries for street lighting : ISO/BS/IEEE: 10322 Part 5
Water tight electric lighting fittings : ISO/BS/IEEE: 3553/ BS: 4533, 5225(I)
High pressure mercury vapour lamps : ISO/BS/IEEE: 9900/BS: 3677/ IEC: 188
Screw less terminal and electrical : ISO/BS/IEEE: 10322
connections for lighting fittings
High pressure sodium vapour lamps : ISO/BS/IEEE: 9974
Emergency lighting units : ISO/BS/IEEE: 9583
Ignition proof enclosures, dust-tight for : ISO/BS/IEEE: 11005 elect. equipment
Luminaries : ISO/BS/IEEE: 10322(Part I to V)
Lighting System Equipment:

Arrangement for busbars, main : ISO/BS/IEEE: 5578/ 11353/ BS: 159 connections and auxiliary wiring and marking
Enclosed distribution fuse boards and : ISO/BS/IEEE: 2675/BSEN 60439 cutouts for voltages not exceeding 1000V
General requirements for switchgear : ISO/BS/IEEE: 13947 and control gear for voltages not exceeding 1000 V
Code of practice - installation and : ISO/BS/IEEE: 10118/BS: 6423
Maintenance of switchgear BS 6626, BS 6867
Factory built assemblies of switchgear : ISO/BS/IEEE: 8623/BS-5486/ IEC: 439 and control gear for voltages up to and including 1000 V AC and 1200 V
DC Miniature air break circuit breakers for : ISO/BS/IEEE: 8828/BSEN 60898 AC circuits HRC cartridge fuse links up to 650 V : ISO/BS/IEEE: 9224/BS: 88/ IEC: 269 'D' Type fuses : ISO/BS/IEEE: 8187
Current transformers : ISO/BS/IEEE: 2705/BS: 7626/ IEC: 185
Voltage transformers : ISO/BS/IEEE: 3156/BS: 7625/ IEC: 186
Direct acting electrical indicating : ISO/BS/IEEE: 1248/BS: 89/IEC: 51Instruments
A.C. electricity meters : ISO/BS/IEEE: 722/BS 5685
Electrical relays for power system : ISO/BS/IEEE: 3231/BS: 142/
protection IEC: 255
Switches for domestic and similar : ISO/BS/IEEE: 3854/BS: 3676
Purposes
Three pin plugs and socket outlets : ISO/BS/IEEE: 1293/BS: 546
Boxes for enclosure of electrical : ISO/BS/IEEE: 5133(1) Accessories
Rigid steel conduits for electrical wiring : ISO/BS/IEEE: 9537/BS: 31
Accessories for rigid steel conduits for : ISO/BS/IEEE: 3837/BS-31 electrical wiring
Flexible steel conduits for electrical : ISO/BS/IEEE: 3480
Wiring
Rigid non-metallic conduits for electrical : ISO/BS/IEEE: 9537/BS: 4607(2) installations
Fittings for rigid non-metallic conduits : ISO/BS/IEEE: 3419/BS: 4607(2) PVC
insulated cables for working : ISO/BS/IEEE: 694 voltages up to and including 1100 V
Tubular steel poles : ISO/BS/IEEE: 2713
Specification for copper rods and bars : ISO/BS/IEEE: 613 for electrical purposes
Code of practice for phosphate iron : ISO/BS/IEEE: 6005/ BS: 3189 and steel
Fittings for rigid steel conduits for : ISO/BS/IEEE: 2667 electrical wiring
National Building Code of Pakistan (NBC) : NBC 2005

38.7.5. Other Design considerations for Lighting

a. Lighting panels shall be provided in various areas and circuit wiring to the lighting fixtures shall be made from lighting panels. Lighting panel shall comprise of Four pole MCB + RCCB (100 mA) for incomer and SP MCB's for each outgoing single phase circuits.

b. The wiring for lighting circuits in indoor areas will be done by wires run in GI conduits.For outdoor lighting, wiring will be done by using armoured cables.

c. Lighting cable from Main lighting DB (MLDB) to Lighting panels shall be Al conductor, XLPE insulated, 1.1KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam.

d. For lighting fixtures (Pump room) 1100V grade, 4C x 2.5 sq. mm. PVC insulated, multi stranded copper conductor armoured/ unarmoured cables shall be used.

e. For lighting fixtures (For Office, electrical room, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded Copper conductor wires of area not less than 1.5 sq mm laid in min. 20 mm dia GI conduit (above false ceiling) shall be used.

f. For 5/15A decorative sockets (For Office, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded copper conductor wires of area not less than 2.5/ 4.0 sq. mm. Cu laid in minimum 20 mm dia. GI conduit shall be used.

g. Wiring shall be concealed in wall below false ceiling with concealed switch board. Minor civil work like chasing wall, cut outs for conduit, switch board, Lighting Panel in wall, entries for tray, conduits etc. is in scope.

h. Lighting cable from MLDB to Lighting Panels and Lighting Panels to street light fixtures, shall be Al conductor, XLPE insulated, armoured, 1.1 KV grade, laid in cable trays otherwise cleated along the wall/column/ beam and buried in the ground.

i. The point wiring for lighting/ receptacle/ exhaust fan/ wall mounted fan/ ceiling fan shall include conduits, conduit accessories, FRLS PVC insulated multistranded Copper conductor wires and earthing wires,

pull boxes, ceiling rose, clamps, cleats, hardware, accessories, anchor fasteners etc. It shall include wiring from lighting panel to switchboard and receptacles & switchboard to lighting fixtures. Sheet metal switchboard embedded in wall shall be considered for receptacles and lighting switchboards on wall shall be considered for lighting.

j. For power sockets in wall/ furniture, PVC switch box of approved make with switch plate & accessories and 16 Amp piano modular switches and 5/15A sockets etc. as applicable shall be considered. For all types of point wiring the receptacles with switches shall be included in the point wiring rate.

k. Lighting switchboard consisting of (*) no. of 6A piano switch without indicator, 1 no. 6A piano switch with indicator, 1 no. white coloured cover plate for (*) module (4/ 6/ 8/ 12 module), 1no. 2/ 3 pin shuttered socket of 5/ 15A and metal flush box.

l. Decorative socket switchboard consisting of (*) no. of 16A piano switch with indicator, (*) no. 2/ 3 pin shuttered socket of 5/ 15A and metal flush box, 1 no. white coloured cover plate for (*) module (4/6/ 8/ 12 module).

m. Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring. Lighting Control Philosophy as per mentioned below shall be observed. From each switch –

n. Max. 2 (3 in case unavoidable) normal LED light fixture. ii. Max. 4 (5 in case unavoidable) for LED down lighters

o. All indoor, outdoor & street light fixtures shall be controlled directly from respective Lighting Panels, through MCB.

p. Each lighting panel/ Receptacle DB shall have minimum 2 spare circuits of 10/ 16A SPN outgoing feeders. A circuit consists of R, Y, and B Phase each.

q. Lighting for staircase shall be controlled with flushed modular switch. The conduit for main staircase shall be concealed. Lighting for all staircases shall be with 2 way switch

r. Contractor shall note that any chasing in walls or cutouts or openings such as fixing of LPs, DBs, switchboards, concealing conduit in wall etc. in walls required shall be made before plastering of brickwork wherever applicable and installation rates quoted shall be inclusive of chasing, cutting & making the plaster as per standard practice.

s. Lighting for street light fixtures/ flood light fixtures shall be carried out with cables. The supply of cables, junction boxes, street light poles & structural steel required for mounting fixtures/ LPs etc. are in the scope of Contractor. The cable wiring shall include supply & installation of cable required from LP to the junction box mounted on street lighting pole / near indoor fixture and also between junction box mounted inside pole/near indoor fixture to control gear box and same for flood lighting, supply and installation of all termination accessories such as lugs, cable glands etc. DBO Contractor's scope shall also include excavation, preparation of soil bedding, supply and installation of protection cover, back-filling, supply and installation of cable route markers etc.

t. Point Wiring for lighting/ raw power receptacle/ emergency lighting:

   i. Point wiring covers the wiring between a circuit of the lighting panel to switchboard and then from switchboard to lighting fixtures connected to that circuit of the lighting panel.

   ii. For receptacle circuits point wiring shall cover wiring between circuit of the lighting panel to receptacles connected to that circuit of the lighting panel.

iii. The scope of the Contractor shall include the supply, erection, testing and commissioning of the above LPs/ DB boards for supply of power to the various sockets required for computers, raw power points etc. The point wiring rate from these DBs shall include supply of wires, conduits, cleats/ clamps etc. as may be required and shall be in the scope of electrical Contractor.

iv. The conduit point wiring rate for exhaust fan shall include conduits/ casing capping, conduit/ casing capping accessories, Switch boards, PVC insulated wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, sheet metal switchboards fabricated out of 16 SWG. sheet steel housing 5 Amp piano switches. It shall include wiring from EXHAUST FAN DB/ RDB to switchboard & switchboard to exhaust fan as applicable. Neutral for individual circuit shall be run separate from DB to individual receptacles.

v. All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor under the scope of this contract.

vi. Required no. of 1-Ph & 3-Ph, industrial receptacles with respective 2P/ 4P ELCB (30mA) & 3/ 5 pin plug shall be provided for maintenance purpose.

vii. Receptacle & its ELCB shall be mounted in prefabricated CRCA box of 16 SWG, epoxy painted with shade 631of ISO/BS/IEEE-5. Earthing studs shall be provided for connecting external earthing with receptacle box.

viii. The Configuration of Industrial receptacle units shall be as per following – Combination 240V, 1-Ph, 50Hz, 3 pin, 15A Industrial receptacles with RCBO (30 mA). 415V, 3-Ph, 50Hz, 32/63A Industrial receptacles with respective RCBO (30 mA).

u. Lighting Fixtures and Accessories:

i. General

Normal supply voltage, phase and	**240 V, 1 ph, 2 wire, 50**
Variation in supply	
Voltage (AC & DC)	±10
Frequenc	±5
Combined voltage & frequency	±10
Design ambient air temperature	50^0C

ii. The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

iii. Connections between different components shall be made in such a way that they will not work loose by small vibration.

iv. For each type of Luminaires the Contractor shall furnish the utilization factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

v. All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage, frequency and combined voltage and frequency of 10%, 5% and 10% respectively.

vi. The Luminaires and accessories shall be designed to have low temperature rise.

The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.

vii. The Luminaires shall have a sturdy and corrosion resistant high pressure Die cast Aluminium housing with weatherproof gasket for lamp and control gear accessories. The Housing shall be Epoxy coated, without any cracks or thorough holes, made in a single piece of die-cast LM6 aluminium alloy. The luminaires shall be totally enclosed, dust tight and water proof.

viii. Heat sink used should be aluminium extrusion having high conductivity. The dimensions of luminaires shall be optimum and adequate to permit sufficient heat dissipation, through the body itself, so as to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.

ix. The Luminaire Housing shall be suitable for termination of Cable with Double Compression Cable Glands

x. The optical system shall consists of individual PC lenses on high power LEDs designed & tested to achieve typical street lighting distribution from the LED lantern. These lenses provided for individual LEDs are to be fixed on lens plate in order to have consistent light distribution from luminaires. Luminaires should conform to the photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in ISO/BS/IEEE 1944.

xi. Suitable number of LED lamps shall be used in the luminaires. The manufacturer shall submit the proof of procurement of LEDs from OEMs at the time of testing

xii. The Luminaires shall be provided with high tensile heat resistant toughened glass of minimum 0.8mm thickness or UV resistant polycarbonate cover fixed with stainless Steel screws.

xiii. An extruded silicon loop gasket shall be provided in the lantern body to ensure a weather proof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc.

Luminaire should conform to degree of protection of IP 65 or above. Felt gasket will not be accepted.

xiv. Year of Manufacture, Batch No., Serial Number or Identification No. Luminaire Manufacturer's Name / Logo, Wattage and Frequency should be embossed on the housing.

xv. LED luminaires, should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. Lumen maintenance report as per LM 80 guidelines shall be submitted for the LEDs used along with the BID.

xvi. Luminaires should conform to the ISO/BS/IEEE standards for Safety & Performance and test certificates as per ISO/BS/IEEE 16107 should be provided by the manufacturer. In case of luminaires are imported, the CONTRACTOR shall conform to test parameters as per UL or equivalent standards.

xvii. The electrical component of the LED and LED driver must be suitably enclosed in sealed unit to function in environment conditions mentioned earlier.

xviii. All the connecting wires inside the Luminaire shall be low smoke halogen free, fire retardant cable.

xix. Adequate protection against Overloading, Short Circuit, Over Voltage, over temperature, Under Voltage, String Open shall be provided within the Luminaires

xx. Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.

xxi. The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/ PAS 62612 depending on the type of luminaire.

xxii. All the material used in the luminaires shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.

xxiii. The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the Client for verification of the required parameters and tests. CONTRACTOR shall confirm the same in the BID.

xxiv. The control gear shall comply with the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384 as appropriate.

xxv. The LED lighting fixtures offered shall comply with the following requirements;

Sr. No.	Parameter	Design Requirement / Value
1.	Type	Dimmable LED Luminaires complete with all accessories for Street Lighting

Sr. No.	Parameter	Design Requirement / Value
2.	Rated Voltage	230 V
3.	Expected Frequency	50 Hz +/- 3%
4.	Operating Voltage Range	150 V to 270 V
5.	Power Factor	> 0.90
6.	Operating Temperature Range	0 Deg C to 50 Deg C
7.	Working Humidity	10% - 90% RH
8.	Driver Type	Constant Current based Electronic Driver
9.	Driver Efficiency	> 92%
10.	Driver Life	>20000 hrs.
11.	Protection required in Driver module	
a.	Short Circuit	To be provided by the contractor
b.	Over Voltage	To be provided by the contractor
c.	Over Temperature	To be provided by the contractor
d.	Under Voltage	To be provided by the contractor
e.	String Open Protection	To be provided by the contractor
12.	Luminaires IP Protection	Minimum IP 65 for Outdoor Fixtures
13.	Minimum Surge Protection	>4 KV
14.	THD	≤ 15%
15.	Power Factor	≥ 0.9
16.	Rated Minimum LED Life(L70)	50000 Burning Hours
17.	Rated Minimum Driver Life	20000 Burning Hours
18.	CRI	>70
19.	Junction temperature rise	< 85 Deg C
20.	Solder point temperature	< 70 Deg C
21.	Maximum temperature rise for Driver	<30 Deg C at 45 Deg C ambient
22.	Make of LED	Cree / Nichia/ Philips / Osram

Sr. No.	Parameter	Design Requirement / Value
23.	Make of Driver	Cree / Nichia/ Philips / Osram
24.	Operating Hours	Dusk to Dawn (max 12 Hrs.)
25.	Efficacy of Luminaires	>92lm/W
26.	Colour Temperature	5000K – 6000K
27.	Illumination Regulation	<5%
28.	Material used for following	
a.	Housing	Die cast aluminium/ extruded Aluminium body

xxvi. Each luminaires shall have a terminal block suitable for loop-in, loop-out and T-off connection by 230/ 415 V, 1 core, FRLS PVC insulated Copper conductor wires up to 4 sq. mm in size. In outdoor areas the termination at the luminaires shall be suitable for 1100 V, PVC insulated, Cu/ Al conductor, armoured cables of sizes up to 6/ 16 sq. mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of stranded Copper wire of minimum 1 sq. mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

xxvii. Mounting facility and conduit knock-outs for the luminaires shall be provided.

v. Earthing

i. Each luminary shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.

ii. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.

iii. All metal or metal enclosed parts of the luminaries/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

iv. Earthing of each pole shall be carried out with one dedicated earth electrode. The earth electrode can either be a GI coil type or GI pipe/ rod type electrode. The GI rod/ Pipe electrode shall be 2.5 m deep and can be hammered directly into the ground where ordinary soil is present. For Hard strata, preparation similar to that mentioned in latest version of ISO/BS/IEEE 3043 or the latest version of Rural Electrification Corporation (REC) manual can be carried out. For GI Coil earthing, preparation as per REC manual shall be followed. The earth electrode shall be connected with two 25X6 sq.mm GI strips to the two distinct earth boss on the pole.

w. Painting/ Finish:

i. All surfaces of the Luminaries/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

ii. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

iii. The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.

iv. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. Over 1/2" dia. mandrel.

v. The finish of the luminaries shall be such that no brigHV spots are produced either by direct light source or by reflection.

vi. External control gear box provided for housing accessories shall be painted or galvanised.

38.7.6. Outdoor/ Street Lighting Luminaries:

a. LED luminaires:

i. Street light LED luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

ii. The luminaires shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

iii. The luminaires shall be suitable up to 70/150/ 250 watts LED lamps and for mounting heights from 4 meters to 12 meters.

b. Metal Halide luminaires (For High Mast Only As Applicable):

i. Street light MH luminaries shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

ii. The luminaries shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

iii. The luminaries shall be suitable up to 150/ 250 watts MH lamps and for mounting heights from 4 meters to 12 meters.

c. Post Top Lantern:

i. Post top lantern luminaries shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

ii. The luminaries shall have cast aluminium spigot finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

38.7.7. External Light Poles-Street Light/ High Mast Flood Light (where applicable)

a. All the Poles shall be designed to withstand the maximum wind speed as per ISO/BS/IEEE 875. The top loading i.e., area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BSEN 40-3:2000, pr EN-40-3-3.

b. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied. One steel ladder shall be provided separately. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.

c. The supply of poles shall be complete with fixing bracket/ necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

d. The pole shaft may have Octagonal or Conical cross section and shall be continuously tapered with single longitudinal welding as applicable. There shall not be any circumferential welding.

e. All Octagonal or Conical pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations .i.e. from inside and outside.

f. The welding of Octagonal or Conical pole shaft shall be done by Submerged Arc Welding (SAW) or using high end MIG/ TIG Welding process. The welding shall be carried out conforming to approved procedures. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

g. The Octagonal or Conical poles shall have integrated Junction box with open able door of adequate size (approximate 600mm length) at the elevation of 750 mm from the base plate.

h. The door shall be hinged type with mechanical interlock, dust proof, weather proof and vandal resistance and shall ensure safety of inside connections and components. The door shall be flushed with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.

i. The door of the integral Junction Box shall permit clear access to the components inside viz., termination strips, connectors, MCBs, cables etc.

j. The Octagonal or Conical pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

k. Material for Octagonal or Conical Poles shall be HT Steel Conforming to grade S355JO; Base plate shall be FE 410 conforming to

ISO/BS/IEEE 226/ ISO/BS/IEEE 2062; and Foundation Bolts shall be of EN.8 grade.

l. Aesthetic appearance - All the grooves and carvings of the pole unit shall be free from any kind of distortion for a pleasing aesthetic appearance.

m. The Octagonal or Conical poles shall be hot dip galvanized as per is 2629/ ISO/BS/IEEE 2633/ ISO/BS/IEEE 4759 standard with average coating thickness of 70 micron. The galvanizing shall be done in single dipping.

n. The Octagonal Poles shall be bolted on a pre-cast foundation with a set of foundation bolts for greater rigidity.

o. Top Mountings -The galvanized mounting bracket shall be supplied along with the Poles for Installation of the luminaires.

p. The Octagonal or Conical pole manufacturing & galvanizing unit shall be ISO/BS/IEEEO 9001: 2000 & ISO/BS/IEEEO 14001 certified to ensure consistent quality & environmental protection.

q. Electrical connections - Four way connectors shall be provided along with Slide lock suitable for connecting 1.1 kV grade, 4 C x 16 sq.mm Al cable. It shall also in-house 1 no. 6 amps DP MCB, 2.5 sq.mm connectors for looping with 2.5 Sq.mm Copper wires for connecting to the luminaire through 1.1 kV grade, 3 core X 2.5 mm² PVC insulated copper conductor flexible un-armoured Cable from the terminal block to the fixture within the pole. All the cables laid through the pipe shall be without any joint.

r. Two nos. Earth Boss shall be provided at the bottom of the pole (diagonally opposite) suitable for connecting 25X6 mm GI/ CU earth strip for earthing of the poles. Similar Earth Boss suitable for connecting 4 sq.mm copper wires shall be provided on the control plate inside the Junction Box for earthing of the electrical components.

s. Two nos. 50 mm NB HDPE sleeves of suitable length shall be provided through the foundation up to the Junction Box for entry of power cable.

t. The Contractor shall carry out all the relevant tests and inspection in the presence of the Client or Third Party Agency, as may be selected by the Client, before the dispatch of the poles at no extra cost to the Client.

u. The CONTRACTOR shall inform the CLIENT at least Fifteen (15) days in advance, about the manufacturing schedule so that arrangement can be made for inspection. CLIENT reserves the right to waive the inspection at any stage.

v. All the material/ equipment/ accessories shall be supplied with manufacturer's test certificates.

w. CONTRACTOR shall submit the Proposed Product Catalogue, Detail Data sheet, spare parts list and drawing of Pole & Bracket along with the BID for each product quoted.

x. High mast shall be outdoor weather proof type for illumination of main roads and area lighting, wherever found necessary.

y. The high mast shall be continually tapered, polygon cross section, telescopically jointed steel fabricated construction. The mast shall be hot dip galvanised internally and externally. Weather proof door shall be provided near the base to permit access to winch, cables, plug, socket etc. The mast shall be designed for wind speeds depending upon wind pressure and direction as per relevant Pakistann Standards. Foundation bolts shall be included in the scope of supply.

z. The moving platform shall be of steel construction hot dip galvanised and designed to hold the number of flood light luminaires specified. The control gear boxes shall be cast aluminium weather proof type mounted on the moving platform. The moving platform shall be raised or lowered with the help of winch, pulley system and stainless steel wire ropes. The winch shall be suitable for hand operation or alternate by electric power.

aa. The mast shall be suitable for mounting numbers of luminaires as required. The standard mast heights are generally from 16 to 30 meters.

bb. CONTRACTOR shall arrange for all the tools and equipments including M20 concrete foundations shall be provided for all the poles. Approx dimension of the foundation for evaluation purpose is 600X600X1700 mm. However, CONTRACTORs shall design as per the stability requirement and Soil bearing Capacity of each location. The Poles shall be bolted on a pre-cast foundation with minimum four foundation bolts for greater rigidity.

38.7.8. Emergency Light Luminaries

a. Emergency light fitting shall be 240 V self contained 2 x 11 W fixture with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house / area.

b. Emergency fixtures shall come in service when AC supply fails.

c. Pump room and Electrical room shall be considered for Emergency lighting.

d. In addition to above emergency fixtures, every pump station shall be provided with two nos. of portable emergency luminary, which shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two meter length cord with plug, mounting

pads and other accessories required for satisfactory operation of the luminaries.

e. The luminaries shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal AC supply the luminary shall start automatically and on restoration of AC supply the luminary shall switch off automatically.

38.7.9. Accessories for Luminaries:

a. The Routine test on each of the offered Luminaire shall be carried out by the CONTRACTOR before dispatch. Following tests shall be carried out as Routine tests by the CONTRACTOR for the offered.

Luminaires;

i. Visual and Dimensional check
ii. Checking of documents of purchase of LED
iii. Insulation resistance test
iv. HV test
v. The Reverse polarity

b. Acceptance test shall be carried out by CLIENT or CLIENT's Representative on a sample of the lot offered for Acceptance. The Lot shall be different from the lot from which the Type test samples have been drawn. The cost of the testing shall be borne by the CONTRACTOR. Following tests shall be carried out as Acceptance tests by the CONTRACTOR for the offered Luminaires;

i. Visual and Dimensional check
ii. Checking of documents of purchase of LED
iii. Insulation resistance test
iv. HV test
v. Over voltage protection
vi. Surge protection
vii. Reverse polarity
viii. Lux measurement
ix. Test for IP 65 protection

c. Following Type tests reports shall be provided by the CONTRACTOR for the offered Luminaires along with the BID;

i. Resistance to humidity
ii. Insulation resistance test
iii. HV test
iv. Over voltage protection
v. Surge protection
vi. Reverse polarity

vii. Temperature rise Test

viii. Ra (Colour Rendering Index) measurement test

ix. Lux measurement

x. Fire retardant Test

xi. Test for IP 65 protection

xii. Endurance Test,

xiii. Life Test

xiv. Photometric Measurements Test Report (IES LM 79)

xv. LED Lumen Maintenance Test Report (IES LM 80)

xvi. Vibration test as per ANSI

38.7.10. Lighting System Equipment:

a. Main Distribution Boards and Lighting Panels:

i. Main Lighting distribution board (MLDB) shall have MCCB as incomer & outgoing feeder with thermal magnetic release for O/L+S/C+E/F protections.

ii. This MLDB shall feed to different Lighting Panels/ Lighting DBs for further distribution.

iii. Where ever MLDB is not applicable, lighting feeder of appropriate rating shall be derived from the local distribution board. This feeder will feed to local LP catering to lighting requirements of that particular area.

b. Constructional Features:

i. Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP-54 for indoor. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP-55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2.0 mm thick.

ii. The lighting panel for outdoor lighting shall have a programmable timer for automatic control of lighting along-with contactor, MCB, auto/ manual selector switch.

iii. All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets.

iv. A slotted metallic sheet shall be provided inside. Only the MCBs operating knobs shall project out of the metallic sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with Four pole MCB + RCCB.

v. All accessible live connections/metals shall be shrouded and it shall be possible to change individual MCBs from the front of the boards/ panels without danger of contact with live metal.

vi. For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

vii. Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/ bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

viii. Two earthing terminals shall be provided to suit the earthing conductor.

ix. All sheet steel parts shall undergo rust-proofing process which should include 7 tank processing. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final epoxy based finish paint of colour 63I as per ISO/BS/IEEE 5.

c. Busbars:

i. Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.

ii. Busbars shall be provided with at least the minimum clearances in air as per applicable standards.

iii. Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the bus bars, bus bar risers/droppers and contacts does not exceed 85 C under site reference temperature.

iv. The bus bars, bus bar connections and bus bar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the MCB's let through/cut- off current associated with the specified short-circuit level of the system.

v. Busbar supports shall be WASA type. Separate supports shall be provided for each phase of the bus bars.

vi. The neutral bus of the main 3 phase, 4 wire distribution board shall be 100% of the phase busbars.

d. Panels/ Boards' Component & Lighting Accessories:

i. MCB/ ELCB :

MCBs shall be C curve type for lighting panels.

For all the lighting panels RCCBs shall be with 100 mA sensitivity & for all receptacles RCBO sensitivity shall be 30 mA.

ii. MCCB :

MCCB requirements shall be as per specified in the LV switchgear requirements & as specified above.

iii. Indicating Instruments and Meters:

Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.

Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.

Potential fuses shall be provided at the tap-off point from the bus bars for the voltmeters.

iv. Instrument Transformers:

Current and voltage transformers shall be of cast resin type, with insulation class B, & accuracy class 1.0 unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.

Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short- circuiting and grounding the CTs at the terminal blocks.

Voltage transformers shall be provided with suitably rated primary and secondary fuses.

v. Indicating Lamps:

Indicating lamps shall be of the clustered LED type, low watt consumption.

vi. Internal Wiring

Panels/ boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1.1 kV grade, FRLS PVC insulated, multistranded Copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.

Cross Ferruling i.e., engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make of approved list, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current, the minimum rating shall be 20 A.

Terminals for circuits with voltage exceeding 125 V shall be shrouded.

Terminals shall be numbered and provided with identification strip for identification of the circuit.

Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

vii. Labels & Diagram Plate:

All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/ panel.

Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved acrylic

Inside the door of the 1 phase ways lighting panels a circuit diagram/ description shall be fixed for reference and identification.

viii. Conduits:

Rigid steel/ non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.

Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 meter.

Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

ix. Junction Boxes:

Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, three (3) phase receptacles etc.

The junction boxes shall be dust and vermin proof and shall be fabricated from 14 SWG sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.

The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/ conduit entry knock outs, terminal blocks, and HRC fuses as required.

The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of Copper alloy and shall be of box clamp type.

The boxes shall be painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.

x. Lighting Poles and Flood Light Pole Mounting:

Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.

Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless

otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. One steel ladder shall be provided separately. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.

The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.

The required sizes of poles and the junction box shall be as indicated in the attached drawings.

Outdoor JBs shall be minimum IP 55 protected.

Cable entry for street lighting junction boxes shall be from bottom.

Rain water canopy shall be provided at the top for the outdoor JBs. Terminal strip shall be provided for looping loop out of cables.

Street lighting JB shall consist of terminal strip (3 ways) for looping in & loop out of cables. The JB shall be provided with 6A MCB (C- Curve type) for isolation of lighting fixture, as well as sufficient arrangement (earthing studs) for termination of 2 nos. earthing connections.

xi. Ceiling Fans/ Wall Mounted Fans:

Ceiling/ Wall mounted fans shall be suitable for operation on 240 V, 1 phase,

50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc for ceiling fans and easy accessibility for wall mounted fans. The fans shall be supplied with appropriate speed regulators.

Exhaust fans, where ever required shall also be provided. The exhaust fan with all parts shall be according to ISO/BS/IEEE: 2312- 1967 & its latest amendment with IP-55 specification. The exhaust fan shall have epoxy powder coating with specially pretreated components for better resistance to corrosion and acid alkali flumes. The exhaust fan shall have totally enclosed highly efficient heavy-duty motor with pressure die cast aluminium rotor mounted on two ball bearings.

The fans shall generally conform to the applicable standards indicated in Tender. Details regarding blade sweep and suspension requirements shall be as per Project layout drawing/price schedule.

38.8. DC SYSTEM

38.8.1. Scope:

DC system (as applicable) shall include the following:

a. One set of 24/ 30 or 110 V DC, maintenance free rechargeable sealed lead acid batteries of adequate AH capacity shall be provided for control of electrical switchgears in the Plant.

b. Batteries shall be provided with battery charger cum DC distribution board. Battery charger shall include a float & float cum boost charger, indicating lamps and annunciations.

38.8.2. Sealed Maintenance Free Lead Acid Battery

a. Applicable Standards: The sealed maintenance free lead acid battery shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification this specification shall govern. Sealed lead acid: ISO/BS/IEEE: 1651, 1652 BS: 6290

b. The sealed batteries shall be a starved electrolyte type with electrolyte immobilized in a micro-porous material to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any watering and be maintenance free.

c. Positive Plates: Positive plates shall be either of cast solid in pure lead in one piece with plante formation and shall have adequate mechanical strength or of tubular plate which shall consist of a suitable bar with spines cast of suitably alloyed lead to give adequate mechanical strength or of pasted positive plates consisting of either pure lead, low anti- monial lead alloy or lead calcium positive grids; having double separation with a glass wool retainer mat or any other suitable material placed against the surface of the positive plates for good service life.

d. Negative Plates: The negative plates shall normally be of the box type. End negative plates, if of box type may be of the half pasted type. Pasted plates shall have adequate mechanical strength and shall be so designed that the active material is maintained in intimate contact with the grid under normal working conditions.

e. Containers: The containers shall be made of plastics, or fiber reinforced plastics (FRP). The container shall be spill proof, leak proof, explosion resistant and increased safety type enclosure.

f. Vent Plug: The vent plug shall be for safety pressure vent and of self-resealing type.

g. Separators: The plate separator shall consist of a micro-porous matrix which shall serve as the mobiliser for the electrolyte. The battery separator shall maintain the electrical insulation between the plates and shall allow the electrolyte to permeate freely.

h. Connectors and Terminal Posts: Inter-cell and inter-tier connectors and terminal posts shall be of Copper. Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for terminal connections. All the metal parts of the terminals shall be lead coated. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

i. Electrolyte: The electrolyte shall be battery grade sulphuric acid conforming to latest editions of relevant standards. The sealed battery shall be transported with the electrolyte immobilized, sealed and fully charged.

j. Accessories: The battery shall be complete with accessories and devices, including but not limited to the following:

   i. Battery racks

   ii. Set of inter cell, inter-tier and interbank connectors as required for the complete installation.

   iii. One Voltmeter with suitable range and leads for measuring cell voltage

   iv. Insulated wrencher.

k. One set of terminals and cable boxes with glands for connecting cable as required.

l. Battery Racks: Battery racks shall be constructed from good quality teak wood and painted with two coats of approve alkali resisting paint. The construction of the racks shall be suitable for fixing to a flat concrete floor. The racks shall be rigid, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form a continuous row. Insulators shall be provided below the legs of the stands.

m. Capacity: The standard ampere-hour capacity at ten hour rate of discharge of the battery has been based on the requirements of loads as applicable and the minimum ambient temperature specified. Contractor shall guarantee that the capacity of the battery offered by him is adequate for the duty specified (all loads being coincident from the instant of supply failure even at the minimum ambient temperature as specified) assuming that the battery is fully charged to

   i. 2.15 V at the start of the cycle

   ii. 1.75 V/ cell at the end of the cycle.

n. The Battery sizing basis shall be IEEE 485 & the Contractor to note that the Battery sizing shall be done considering design ambient temperature of 50^0C & following factors.

i. Design Factor- Min. 1.1

ii. Aging Factor- Min. 1.25

iii. Temperature Correction Factor- Min. 1.1

o. Cell Identification: Each cell shall be marked in a permanent manner to indicate the following information:

i. Cell number

ii. Type of positive plate

iii. Ah capacity at 10 hour rate

iv. Type of container

v. Manufacturer's name

vi. Month and year of manufacture.

p. Drawings/ Document: The complete battery layout drawing shall be furnished as part of the tender and also after award of contract for Purchaser's approval.

38.8.3. Battery Chargers:

a. The battery charger and DC Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern Basic climatic and mechanical durability tests for components for electronic and electrical equipment Environmental tests for electronic and electrical equipment Metal clad base material for printed circuits for use in electronic and telecommunication equipment Transformers and inductors (power, audio, pulse and switching) for electronic equipment ISO/ BS/ IEEE:9000

b. Requirements: The Battery Charger shall be microprocessor based & shall have two chargers mainly- i) Float Charger ii) Float cum Boost Charger.

c. The float & float-cum-boost type battery charger shall comprise silicon controlled rectifiers (SCRs) connected in a full wave bridge circuit. Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic. Microprocessor shall be MU 1000C or Equivalent makes from the approved makes.

d. The rectifier transformer shall be dry type and double wound with required number of taps. The DC output voltage during float charging shall be stabilized within ±1% of the set DC bus voltage for AC input voltage variation of ±10%, frequency variation of ± 5% and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The

ripple content shall be within ±1% of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of ±1%. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%.The setting of the output DC bus voltage shall be adjustable between ± 10% of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.

e. If the spare float charger supplying DC load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes. Two blocking diodes in series shall be provided to take care of short circuit of any one diode

f. For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilized within ±2% for AC input voltage and frequency variation of ±10% and ±5% respectively. There shall be provision for manual control if auto-mode fails. The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 30 to 100% of maximum boost charging current.

g. Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.

h. In the float charging mode, the charger shall be designed for supplying:

   i. The DC loads of control, indication and annunciation circuits that remain energized during normal operation and the momentary closing and trip coil loads of circuit breakers, vacuum contactors; and

   ii. The float charging current of the battery.

   iii. 25% margin over the above load.

i. Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 42. Sheet steel used for construction shall be 2 mm thick. The units shall be wired using 1100 V grade, FRLS PVC insulated, multi-stranded Copper conductor cables.

j. During boost charging the DC bus load shall be connected via two diodes in series connected to the tap cell of the battery. This is to take care in case of failure of standby charger supplying DC load.

k. All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily marked test pins.

l. All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.

m. All components and modules shall be clearly and unambiguously marked and all wiring colour coded and tagged

n. Each battery charger shall be provided with accessories that include, but not limited to the following:

i. Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance. The controller shall also be suitable for boost charging the battery in case of float-cum-boost charger.

ii. Boost charge current limiter with potentiometer to adjust the setting

iii. Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.

iv. 240 V AC compact fluorescent lamp fixture for internal lighting with MCB

v. Automatic voltage regulator unit with Manual/ Auto control switch

vi. Double wound, dry type, three phase suitably rated mains transformer with fuse protection and with one set of power factor correction capacitors to maintain a power factor of

vii. Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of

viii. ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.

ix. Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

x. Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit

xi. Coarse and fine control potentiometers for manual control xi. Selector switch for mode of charging i.e. float charging /

xii. boost charging

xiii. Off-load tap changing switch for changing the taps of the transformer

xiv. DC voltmeter with fuses and a three position selector switch

xv. DC ammeter with shunt

xvi. AC ammeter with selector switch for incoming AC power

xvii. AC voltmeter with selector switch for incoming AC power

xviii. MCB for incoming AC supply along with surge suppressers

xix. MCB on DC output side with kick fuses and alarm contacts

xx. Voltage dropping diodes in load circuit during boost charging mode

xxi. DC under voltage relay and earth fault relay

xxii. AC/ DC switching relays for alarm and indication circuits including buzzer

xxiii. Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat

xxiv. Each battery charger shall be provided with the following alarms / indications:

xxv. AC and DC supply 'ON' AC and DC supply fail Modes of charging Over voltage

xxvi. Under voltage on DC side

xxvii. Earth fault on DC side

xxviii. AC/ DC MCB trip

o. The DC circuit switching shall be through DC MCBs only.

p. Power Electronic Components:

i. Diode and thyristors shall be of mono-crystalline type silicon, capable of providing continuous output at specified voltages. It shall have high power efficiency.

ii. If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly.

iii. Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

iv. Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

v. The diodes or thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e resistor-capacitor combination and Metal oxide variator

38.8.4. DC Distribution Board:

a. The distribution board shall be of floor mounting design. Entry for incoming and outgoing cables shall be from the bottom. Bus bars shall be of Copper. Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs suitable for DC application.

b. Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.

c. An earth busbar of 25x3 mm copper flat shall be provided along the length of the DB at the bottom. Two nos. earthing terminals shall be provided on the external face of the board for connection to the earthing grid.

38.8.5. Tests

a. The batteries, chargers and distribution boards and their components shall be subjected to routine/ acceptance tests as per the applicable standards. For battery & battery charger, following tests are also to be carried out:

i. Visual checks for dimensions and general arrangement.

ii. Wiring checks.

iii. Functional checks.

iv. IR Test.

v. Capacity test.

vi. Test for voltage charging and discharging.

vii. Ampere-hour and watt-hour efficiency test.

viii. Hipot test, excluding electronic controller, at 2 kV AC for one minute.

b. Certificates of type tests carried out on similar equipment not older than 5 years shall be furnished by Contractor.

38.9. DRAWINGS/ DOCUMENTS REQUIRED:

After award of contract Contractor has to submit the below mentioned drawings/ documents for Purchaser's approval :

a. Dimensioned general arrangement drawings

b. Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details

c. Complete schematic and wiring diagrams.

d. Detailed BOM for the complete panel, with details of switchgear, controller, components etc.

39. SAFETY EQUIPMENTS/ REQUIREMENTS AND MISCELLANEOUS ITEMS:

Following safety procedure and practice should be provided by Contractor in switchgear room/ sub-station as per latest edition of GOP MRS SPECS 1967 VOL-1.5216.

900 mm wide antiskid insulating mat as per ISO/BS/IEEE 15652 and of reputed make to be spread in front of the 11kV, 415V switch gear panels & power DBs, DCDB etc.

First aid box with all the standard contents.

First aid chart made of cloth for electrical shock treatment printed in English, Hindi and Gujarati duly framed with front glasses.

Charts/ drawings duly framed with front glass.

HV and LV power supply single line diagrams in adequate sizes approved by Purchaser/ Purchaser's representative & in line with the local electrical inspector.

Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system etc.

Provision of portable type Class A, B, C, and D type fire extinguishers at various locations in line with the statutory requirements.

39.1. FIRE SAFETY

The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Tariff Committee, 10th edition 1988.

Water Sealing & Fire Barriers at appropriate locations as specified in this specifications & good engineering practices.

39.2. DEGREE OF PROTECTION

The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels etc. to be installed shall provide minimum degree of protection as detailed here under

a. Installed outdoor – IP 55
b. Installed indoor – IP 54

The degree of protection shall be in accordance with ISO/BS/IEEE 13947 (PartI)/ IEC 947 (Part I)/ ISO/BS/IEEE 2063/ IEC 529

39.3. ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS

The electrical equipments for hazardous areas shall be selected as per ISO/BS/IEEE 5572. Following factors shall be considered for proper selection of electrical equipments for use in Hazardous Area.

39.3.1. Area Classification (Zone):

Gas Classification (Group) – The characteristics of the gas or vapour involved in relation to the ignition or energy and safe gap data

Temperature Classification - The ignition temperature of the gas or vapour involved or lowest value of the ignition temperature, if more than one combustible material is present.

Environmental conditions – In which apparatus is to be installed. The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies water ingress, thermal and mechanical stresses as determined by the environmental condition.

40. INSTALLATION, TESTING & COMMISSIONING – ELECTRICAL EQUIPMENT:

40.1. GENERAL:

In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer In Charge the Contractor shall unload, erect, install, wire, test and place into commercial use of all electrical equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, and properly aligned and oriented.

The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.

Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.

The Contractor shall erect and commission the equipment as per the instructions of the Purchaser/ Engineer In Charge and shall extend all co-operations to him.

In case of any doubt/ misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.

The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.

Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between bus bars/ wires. The Contractor shall also carry out the adjustments/ alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.

The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/ mechanism employed for the safe transit of the instruments and relays shall be removed

after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer In charge.

Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.

Foundation work and grouting of fixing bolts or channels for all transformers, switchgear, motors, and control panels shall be carried out by the Contractor.

40.2. POWER/ DISTRIBUTION TRANSFORMERS

Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Pakistann Standards Code of Practice ISO/BS/IEEE: 10028. All commissioning tests as applicable, vide Appendix B of ISO/BS/IEEE: 10028 (Part II) shall be carried out. Fire Wall of 4 Hr fire rating shall be provided between two transformers.

40.3. HV/ LV SWITCHGEAR CONTROL PANELS

Switchgear control panels shall be installed in accordance with the latest Pakistan Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.

Following minimum clearances shall be observed while finalizing the HV/ LV panel layouts-

a. Minimum clearance of 1.0 meter shall be maintained from the rear of the panel to the nearest wall /structure.

b. Minimum clearance of 2.0 meter between panels facing opposite to each other.

c. Side clearance for LV panels shall be either ≤ 200mm or ≥ 800 mm.

d. For HV metal enclosed, indoor panels, Minimum 1 meter clearance from all sides & 1.5 meter in the front.

Emergency Exit doors shall be provided for electrical room, complying with the requirements of NBC 2005 latest edition.

After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/ panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on

equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary arrangements for proper functioning of the equipment.

40.4. EARTHING AND LIGHTNING PROTECTION SYSTEM

The Contractor shall install copper/ steel conductors, braids, etc., required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/ coating, drilling, brazing/ soldering/ welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Contractor's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti- corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

The quantities, sizes, material of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be shown in the earthing layout drawings, which are to be prepared by Contractor & approved by Purchaser's representative.

The work of embedment of earthing conductor in RCC floors/ walls along with provision of earth plate inserts/ pads/ earth risers shall be done by the Contractor when the floors are cast or during construction of walls. Contractor's scope of installation shall also include, laying the conductors in position with 60 mm concrete cover, making welded connections to inserts/pads/risers above the floor near the equipments. The embedded conductors shall be connected to reinforcing rods wherever necessary.

If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Contractor where required, together with associated civil work such as excavation/chasing, concreting and surfacing. The concrete cover over the conductor shall not be less than 60 mm.

Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth up to 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing/ welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch, and tampered utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.

Installation of earth connection leads to equipment and risers on steel structures/ walls shall include laying the conductors, welding/ cleating at

specified intervals, welding/ brazing to the main earth grids risers, bolting at equipment terminals and coating welded/ brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/ structure.

Electrodes shall be installed in constructed earth pits, and connected to main buried earth grid, The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe/ rod/ plate electrodes in test pits and connecting to main earth conductors.

Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening/ cleating/ welding of the down comers on the walls/ columns of the building and connection to the test links to be provided above ground level.

Installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.

Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.

Suitable earth risers shall be provided above finished floor/ ground level. If the equipment is not available at time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.

Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.

An earthing mat shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.

A separate earth electrode bed shall be provided adjacent to structure supporting lightning arrestors. Each connection shall be as short and as straight as practicable. For arrestors mounted near transformers, earth conductors shall be located clear off the tank and coolers.

Wherever earthing conductors passes through walls, galvanized iron/PVC sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound.

40.4.1. Earthing Connections:

a. All connections in the main earth conductors buried in earth/ concrete and connection between main earthing conductor and earth leads shall be of welded type.

b. Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.

c. All bimetallic connections shall be treated with suitable compound to prevent moisture ingression.

d. Metallic conduits and pipes shall be connected to the earthing system.

e. Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrester and transformer earthing leads which shall be directly connected to pipe electrode.

40.4.2. Earth Electrodes:

a. Electrodes shall as far as practicable, be embedded below permanent moisture level.

b. Test pits with concrete covers shall be provided for periodic testing of earth resistance.Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil work such as excavation and connection to main earth grid.

c. Earth pits shall be treated with salt and charcoal. In case found necessary, then with the approval of Purchaser's representative, Back fill compound of suitable composition may be used. Back fill material shall not be water soluble & shall retain moisture & enhance conduction around electrode. Back fill compound shall be low resistance & non corrosive earth enhancement compound which shall provide safe discharge path to fault current & lightening current.

d. Ohmic value shall be within safe limits & it shall be stable & not fluctuating.

e. Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

40.5. INSTALLATION OF CABLE RACKS AND CABLE TRAYS

40.5.1. General

a. Lines and grade for trays may be measured from building steel and finished floor elevations. Change in line or grade, or the

addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.

b. Where embedded steel inserts in concrete floors/ walls for welding the supports for cable racks/ trays are not available, Contractor shall provide suitable anchor fasteners at no extra cost.

c. Cable shall be clamped to the cable trays at every 750 mm distance.

d. Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

40.5.2. Cable Trays

All the cable tray shall be hot dipped galvanized with minimum galvanization thickness as per mentioned in this specifications.

a. Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.25 mm for trays up to 100 mm width, not less than 1.5 mm for trays from 100 mm to 150 mm width and not less than 2.0 mm for trays from 150 mm to 300 mm width.

b. All the cable trays above 300 mm width shall be of ladder type with minimum thickness of 2.5 mm.

c. Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.

d. All cable trays tees, intersection units, bends, turns and sets shall be prefabricated (made by the manufacturer) and shall be of a matching design to the main section of cable tray.

e. Tray shall only be joined by couplers supplied by the manufacturers.

f. The joint shall be secured in accordance with the manufacturer’s instructions.

g. Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.

h. Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends or damaged section of the tray shall

i. immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

j. All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weigh of 125 kgs.

k. Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray

l. The sizing of the cable tray shall provide a minimum of 20% spare capacity.

m. The tray shall be run at least 300 mm clear of plumbing and mechanical services.

n. Bends in the installation shall take account of the minimum bending radii of cables to be installed.

o. All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2 meter interval.

p. Other cable tray details & cabling system shall be as per typical drawings attached with the specifications.

40.5.3. Cable Trunking – Metal

a. Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.

b. Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

c. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

d. Cables shall be retained in the trunking when the cover is removed by means of straps.Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

e. Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

f. Trunking shall be supported at intervals not greater than 2 meter horizontally or 2.5 meter vertically.

g. Crossings over expansion joints shall be made in flexible conduit.

h. Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

i. Cable and conduit/ trunking runs shall be determined by the Contractor and agreed by the Purchaser's Representative before any work is started. The run shall be at least 300 mm clear of plumbing and mechanical services.

j. Conduit/trunking systems erected outside a building shall be weatherproof.

40.6. CABLE INSTALLATION

40.6.1. General:

a. Cable installation shall be in accordance with ISO/BS/IEEE 1255: 2001- latest edition

b. Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

c. Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

d. Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/Protection	Tele-communication
HV	N/A	300	600	600
LV	300	N/A	300	300
C&I/ Protection	600	300	N/A	200
Tele- communication	600	300	200	N/A

e. These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

f. A distance of minimum 300mm shall be maintained between the cables to be laid on trays/ conduits carrying low voltage AC and DC signals and a distance of minimum 600 mm shall be maintained between cables carrying HV and LT signals.

g. In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

h. In order to make the most economic use of cable tray and duct capacity, multicore cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled junction boxes shall be constructed of die cast Aluminium and provide degree of protection IP 65.

i. Where practical a separate cable support system shall be provided for power and non- power cables. Where this is not practical a separation as per indicated in above table shall be maintained between power and non-power cables when run on the same support system.

j. Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

40.6.2. Laying of Cables:

a. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box.

b. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.

c. Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.

d. All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end.

e. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables.

f. A loop of 1.0 meter shall be left near each field instrument before terminating the cable.

g. Cables shall be complete uncut lengths from one termination to the other.

h. Separate cables shall be used for digital and analog signals.

i. All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules.

j. Identification tags shall be securely fastened to the cables at both the ends.

k. Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.

l. The Contractor shall take the actual measurement of the cables and the associated accessories such as cable trays, conduits etc required at site, prior to the placement of order on the cables.

40.6.3. Cables Laid Direct in Ground

a. Buried cable up to 1.1 kV shall have a laid at a minimum depth of 750 mm measured from FGL to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

b. Cables of greater than 1.1kV shall be buried at a minimum depth of1 meter.

c. The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. For HV cables sand bedding shall be of 150 mm & cables shall be covered with half round Hume pipes of twice the diameter of cable.

d. Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked ‘Danger-Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

e. Warning tape shall be laid a minimum of 200 mm above the protective covers.

f. Cables are to be installed without tees or through joints unless otherwise approved by the Purchaser’s Representative. Single core cables shall be run in trefoil formation.

40.6.4. Cables Laid in Underground Ducts

a. Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 750 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1.0 meter deep and encased on all sides by 150 mm of concrete.

b. The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

c. Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous

compounds or by any other method approved by the Purchaser's Representative. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated. However, for two different trefoil formations, they shall be laid in separate ducts.

40.6.5. Cables installed in Conduit

a. Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with ISO/BS/IEEE 9537, Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.

b. A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

c. Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

d. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/ or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

e. Heavy hexagonal lock nuts shall be used at all positions where running joints are required and care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

f. Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Purchaser/ Purchaser's Representative.

g. Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.

h. Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

40.6.6. Surface Installation

a. Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips at every 500mm, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Purchaser's Representative before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Purchaser's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Purchaser/ Engineer in Charge before carrying out the work.

b. Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

40.6.7. Concealed Installation

a. Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

b. At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

c. Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

d. The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

40.6.8. Cable Installed in Flexible Conduit

a. Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment

or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

b. Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

40.6.9. Cable Clipped Direct

a. All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

40.6.10. Cable Installed in Internal Floor Trench

a. In shallow trenches (maximum depth 500 mm)

b. In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.

c. Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum separation distance of 300mm shall be maintained.

d. All other trenches including walk through service ducts

e. Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.

f. Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above `cold' wet services. Cables should not be run if at all possible above or in close proximity to `hot' services.

g. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

40.6.11. Cable Terminations and Joints

a. Power Cable Terminations

i. Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.

ii. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

iii. Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

iv. Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.

v. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

vi. Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

vii. Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

b. Power Cable Joints:

i. Through joints shall only be allowed with the approval of the Purchaser's Representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

c. Multi-core or Control Cable Terminations:

i. A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

ii. Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose- made solid links shall be incorporated in the design of the terminal blocks.

iii. Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.

iv. Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

40.6.12. Cable Fixings

a. Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.

b. Large single cables shall be secured with cable clamps or cable cleats.

40.6.13. Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

40.6.14. Marking Locations of Underground Cables

a. The location of all underground cables shall be engraved on brass or other non- corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

b. Cable route markers as per the attached drawing shall be installed at an interval not more than 30 meter & at bending/ road crossings the interval shall be at every 10 meter.

c. The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

40.6.15. Additional Requirements for Cable Installations

a. The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination or the cables.

b. All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.

c. Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.

d. After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non- ferrous material on single conductor power cable. Tags shall further be attached at 10 meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.

e. Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:

i.	11 kV, XLPE insulated, multicorearmoured cables	15 times the overall dia of the cable
ii.	1.1 kV, XLPE insulated, multicore armoured cables	12 times the overall dia of the cable
iii.	(If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)	

f. Power, control and instrumentation cables shall be laid in separate cable racks/ trays.

g. Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.

h. Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.

i. Cables laid in ground shall be laid on a 75 mm riddled earth bed.The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more

than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 75 mm in the centre and tapering towards the sides of the trench.

j. In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.

k. Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directory into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.

l. Cable splices will not be permitted except where permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturer's and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

m. Jointing of cables shall be in accordance with relevant Pakistan Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.

n. At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.

o. Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.

p. When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected

to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.

q. Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

r. After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.

s. Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

40.7. LIGHTING SYSTEM INSTALLATION

This covers the requirements of installation of the following:

a. Lighting fixtures complete with lamps and accessories

b. Main Lighting distribution board

c. Lighting panels

d. Receptacles and lighting control switches

e. Point wiring

f. Street lighting poles and flood light towers

g. Multi core cables for street and boundary lighting

h. Maintaining equipment/ materials during storage and being responsible for the equipment/ material until they are handed over to Purchaser.

i. Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

40.7.1. Applicable Standards for lighting system installation

Electrical wiring installations	**ISO/BS/IEEE: 732 (System voltage exceeding 650 V)**
Code for practice for interior illumination (Part-1)	ISO/BS/IEEE: 3646/ BS: 8206
Code of practice for street lighting installation	ISO/BS/IEEE: 1944
Code of practice for industrial lighting	ISO/BS/IEEE: 6666
Code of practice for fire safety of building	ISO/BS/IEEE: 1646

Boxes for enclosure of electrical accessories	ISO/BS/IEEE: 5133(Part-1)
Guide for safety procedures and practices in electrical work	ISO/BS/IEEE: 5216
Ceiling roses	ISO/BS/IEEE: 371

40.7.2. Lighting Fixtures

a. The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings. The rates quoted for installation shall include all materials required to mount the fixtures. Hooks in RC slabs for suspension of high bay fixtures shall be provided wherever not already provided. Cost of supply and installation of such hooks shall be included in the cost of installation of lighting fixtures. Rate for installation of lighting fixtures shall include cost of installation of control gear box wherever applicable.

b. Installation of receptacles and switches shall be carried out suitably. Switch shall be mounted in flush with the front cover plate. Cost of supply and installation of necessary hardware shall be included in the lump sum rates quoted for installation of receptacles/ switches.

c. Lighting distribution boards shall be installed at the suitable location. Installation shall include supply and installation of base channels, foundation bolts, etc.

d. Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 1000 mm (min.) above the grade level. Cost of construction of concrete plinth shall be included in Contractor's scope. No cement and steel will be supplied by Purchaser. Installation cost of lighting distribution board shall include cost of installation of earthing conductor from LDB to the nearest earthing grid.

40.7.3. Point Wiring:

a. Contractor has to prepare the detailed conduit layout drawing showing primary & secondary point wiring points. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches of receptacle units.

   i. Primary Point Wiring:

      Primary point wiring covers the wiring between a circuit of the lighting panel to the junction box of the first lighting fixture/receptacle unit and between junction boxes of the subsequent lighting fixture connected to that circuit of the lighting panel. In some cases where there are junction boxes, the primary point covers the wiring between junction box and the first lighting fixture/receptacle unit in that circuit.

   ii. Secondary Point Wiring:

Secondary point wiring covers the wiring of the remaining lighting fixtures/receptacle unit other than that covered under primary point of that circuit in the lighting panel. Secondary point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and control switches of receptacle units.

b. Supply and Installation of Conduit Point Wiring:

i. The point wiring shall include supply of necessary materials for the conduit wiring such as galvanized rigid steel conduit, galvanized M.S. fixing saddles with spacer plates, nylon/fiber fixing plugs, galvanized M.S. fixing screws, 12 SWG galvanized steel earthing wire, FRLS PVC insulated Copper conductor wires, control switches and pulling, termination of the earthing/ FRLS PVC insulated wires as required, installation of control switches, drilling holes in brick walls/ RCC roof slabs for taking the wiring conduits and refinishing and any other works/material necessary for making point wiring complete in all respects.

ii. Wires used for conduit point wiring of lighting fixtures/ceiling fans, 5A receptacles and receptacles above 15A shall be 1.1 kV grade, FRLS PVC insulated, single core, multi stranded Copper conductor wires of sizes not less than 1.5 sq. mm and 2.5 sq. mm respectively. Wires shall conform to ISO/BS/IEEE: 694 and shall bear the ISO/BS/IEEEI mark.

iii. Contractor shall take into consideration necessary galvanized MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

c. Supply & Installation of cabling for Street and Flood Lighting:

i. Work includes supply and installation of cables required between LDB and junction box mounted on street lighting pole/flood lighting tower and also between junction box mounted on flood light tower to metal enclosed control gear box located near flood light fixture, supply and installation of all the termination accessories such as crimping type cable lugs and double compression cable glands at each junction box and fixture, termination, testing and commissioning of cables. Contractor's scope of work also includes excavation, preparation of riddled soil bedding, supply and installation of protective covers over the cable, backfilling, ramming, supply and installation of route markers, supply and installation of HDPE / Hume pipes for road crossing, etc, supply and installation of necessary cleating arrangement for cabling on flood light tower, supply of labour, supervision, welding equipment, all tools and tackles and testing equipment as required.

ii. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary the same shall

be provided by the Contractor and a joint marker shall also be provided at no extra cost. Earthing of street light pole/flood light tower, lighting fixtures, etc. are included under Contractor scope.

d. Point wiring shall also include/ hold good for the following:

i. Supply and installation of lighting control switches and switchboxes complete with fixing accessories.

ii. Drilling holes in brick/ RCC wall and roof for taking cable or conduit, sealing and refinishing with cement plaster.

iii. Testing, commissioning and handing over the lighting system in commercial working condition.

iv. Marginal shifting of any fixture/accessory from the location indicated in the lighting layout drawings.

40.7.4. Outdoor Lighting (Street and Flood Lighting)

The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

a. Installation of multicore/ single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.

b. Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination, testing and commissioning of cables.

c. Contractor's scope shall also include excavation and preparation for buried cables.Supply and installation of route markers, supply and installation of HDPE/ Hume pipes for road crossing shall also be included in the scope of installation of point wiring.

d. Supply and installation of necessary cleating arrangement for cabling on flood light poles.

e. Contractor shall provide necessary foundation for erecting street light pole/ flood light tower and install the same. Contractor shall prepare foundation drawings with necessary details & Purchaser

f. Representative's approval shall be obtained.Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Contractor and joint marker shall also be provided at no extra cost.

g. Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation of point wiring. Contractor shall earth street light pole/flood light poles and junction box with 25x3 mm G.S. flat tap off from the 25x3 mm M.S. flat earthing grid along the street lighting included in scope. The Contractor shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate pole.

h. Installation of lighting Poles and Towers for Outdoor Lighting (Street and Flood Lighting)

i. Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.

ii. All street light poles and towers shall be painted with one shop coat of red oxide oil primer followed by two coats of aluminium alkyd paint.

Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 230 V, AC 1- Ph Distribution Boards.

Installation of above items shall include necessary foundation channels, bolts/ nuts, etc. for grouting lighting distribution boards, iron brackets/ grouting brackets, bolts/nuts for wall/ column mounted panels and associated civil works.

Details of work requirements are covered in lighting installation notes and details and typical drawings which form the part of specification. Any changes, if necessary due to site conditions/requirements shall be carried out after obtaining approval of Purchaser/ Purchaser's Representative. The changes carried out shall be marked clearly in the layout drawings by Contractor and 'AS BUILT DRAWING' shall be prepared by the 'Contractor' and this shall be forwarded to Purchaser's site / design office.

a. Wiring:

i. Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.

ii. Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.

iii. Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires the following colour wires shall be used.

R – Phase Red

Y – Phase Yellow

B – Phase Blue

N – Neutral Black

b. There shall be a circuit breaker on each live conductor of supply mains at the point of entry.

c. Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.

d. Receptacles and lighting fittings in general shall be fed from different Circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.

e. Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.

f. For long conduit wiring runs, inspection/ pull boxes shall be provided at intervals not exceeding 10 meter. Such facilities shall also be provided at conduit bends.

40.7.5. General Practices for lighting

a. All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.

b. Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.

c. All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

40.7.6. Earthing for lighting

Conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints.

a. Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.

b. For outdoor lighting poles & mast 8 SWG GI earth wire shall be run buried in ground at a depth of 600 mm along-with lighting cables and shall be terminated up to the junction box on the pole and 12 WG wire shall be taken up to the pole fitting. In case of lighting poles where the main earth grid is far away from the pole, local pits shall be provided for pole earthing.

41. PRE COMMISSONING-TESTS ON ELECTRICAL EQUIPMENT/ SYSTEMS TO BE CARRIED OUT AFTER INSTALLATION:

41.1. GENERAL:

Pre-commissioning tests in addition to mentioned in the specification requirements for various equipment but not limited to following shall be carried out by Contractor in presence of Purchaser/ Purchaser's representative. Commissioning shall be carried out only after obtaining satisfactory results, acceptable to Purchaser/ Purchaser's representative.

41.2. ELECTRICAL EQUIPMENT:

11 KV Equipment (Lightning Arrestors, AB Switch/ Isolators & Insulators etc):

a. Visual checks for cracks in insulators.

b. Earth secured continuity check

c. IR Test with 5KV Megger

41.2.1. POWER/ DISTRIBUTION TRANSFORMER

a. Insulation resistance test HV side, LV side and HV - LV.

b. Magnetizing current test.

c. Winding resistance test.

d. Voltage Ratio & Tap continuity test at all tap.

e. Vector group test.

f. Magnetic Balance Test.

g. Buchholz Relay Test (if any)

h. Neutral CT Test (if any)

i. Winding Temperature Indicator/ Oil Temperature Indicator Test

j. Polarization Index Test (For LV windings 3.3 KV and above)

k. Local/ Remote operations of OLTC (if any)

l. Operational tests of RTCC panel (if any) as per schematic drawing. m) No load test and performance observations

41.2.2. HV Metal Enclosed Switchgear:

a. IR values of power and control circuits

b. Local/ Remote operations in test as well as service position including all electrical interlocks

c. Control circuit and operational tests as per schematic drawing.

d. Tripping through relays and trip circuit health. e) Anti pumping device operation

e. Protection system operation stability and sensitivity by primary injection testing method including testing of metering circuits

f. HV Test on switchboard

g. Panel indication, annunciation, space heater circuits

h. Spare contact for customer use

i. Termination correctness & proper installation.

41.2.3. LT Metal Enclosed Switchgears

a. IR Values of power & control circuits.

b. Mechanical charging - closing - tripping of breaker.

c. Electrical charging - closing - tripping of breaker.

d. Trip circuit healthiness and tripping through relays.

e. Remote closing/ Tripping/ Interlocks circuits

f. Indication/ Annunciation/ Panel space heater circuit/ Spare contacts for customer use

g. Secondary injection testing of protective relays/ releases.

h. CT testing for polarity, ratio, IR values and magnetization for class PS characteristics

i. PT testing for ratio, IR values.

j. IR Values of breaker.

k. Testing of modules for DOL/ Star-Delta/ ATS/ Soft Starter starting or any other starting method as per the schematic drawings applicable.

41.2.4. Power and Control Cables

a. IR Values before Hi-pot

b. Hi-pot Test - Measurement of leakage current

c. IR Values after Hi-pot

41.2.5. Induction Motors:

a. IR Values

b. Polarization Index Test

c. Interlocks and simulation tests local / remote operations

d. No load test

41.2.6. Control Panels for Miscellaneous Equipment:

a. IR Values of all power circuits

b. Operational test and scheme - wiring testing as per control schematics

41.2.7. Lighting System:

a. Visual inspection for operating problems

b. b) System activation -burning in the lamps for 100 Hrs

c. Measuring light level & reflectance.

41.2.8. Earthing System:

a. Earthing resistance of each electrode.

b. Earthing resistance of grid. Technical Specification for Diesel Generator

41.3. DIESEL STANDBY GENERATOR:

41.3.1. Applicable Standards

The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes The Electrical Performance of Rotating Electrical Machinery : BS 5514 / ISO 3046 BS 5000

Rotating Electrical : Machines ISO/BS/IEEE 4722

Circuit breakers : ISO/BS/IEEE-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)Air break switches air break :

disconnectors, air break switch ISO/BS/IEEE-13947 (P-3), BS- EN60947, IEC-60947-3

disconnectors and fuse combination units for voltage not exceeding

1000 V AC or 1200 V DC Current transformer : ISO/BS/IEEE-2705/BS-7626, IEC-60185

Voltage transformer : ISO/BS/IEEE-3156/BS-7625/IEC 60186

Electrical Relays : ISO/BS/IEEE-3231, 3842/BS-142/IEC-60255

Contactors for voltage not : exceeding 1000 V ac or

1200 VDC ISO/BS/IEEE-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1

Control Switches : ISO/BS/IEEE-6875/BSEN-60947 / IEC-60947-4-1

High Voltage Fuse ISO/BS/IEEE-9385/BS-2692/ IEC-60282

Low Voltage Fuse : ISO/BS/IEEE-13703/BS-1362 IEC-269-1

Electrical direct acting :

indicating instruments ISO/BS/IEEE-1248/BS-89/IEC-6005

A.C. electricity meters of :

induction type voltage greater than1000 volts ISO/BS/IEEE722,

8530/BS-5685 / IEC-60145, 60211

Resistance wire, tapes and :

stripes for heating elements ISO/BS/IEEE-3725

41.3.2. General Requirements:

The diesel engine and generator shall be skid mounted and shall be located in a room near Treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for DG capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. In case more than one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement. At no point DG sets will be operating parallel with grid.

The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers. The storage tank shall be sized to store fuel for one (1) day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level meter shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

The fuel storage tank shall be located in a bund capable of holding not less than 125 % of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

The system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm.

The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

All alarms shall be conveyed to the central HMI through the PLC.

41.3.3. Diesel Generating Set Automatic Control

AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting

during mains power failure. Diesel generating set for use in auto mains failure mode shall have a three position automatic / off / manual selection and shall operate as follows:

a. Automatic mode

On occurrence of mains failure the following sequence shall be followed. Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

b. Manual mode:

The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

41.3.4. Alternator for Diesel Generating Set:

The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be 11kV for capacity more than 2MVA.

Alternator shall be 4 pole, 3 phase ,50 Hz, 0.8 P.F, salient pole, revolving field, brushless type, self-regulating continuously rated and manufactured in accordance with ISO/BS/IEEE 4722, BS 5000 : Part 99 or IEC 60034-1. They

shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23.The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for regreasing whilst in service.

The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in ISO/BS/IEEE 12075.

The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation heater. No individual harmonic shall exceed 1%

and the total harmonic shall not exceed 3%. The alternator, its neutral and control panel shall be earthed as per relevant standards.

The alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within ±2.5% for a power factor of

0.8 to unity, including hot to cold variations. The steady state frequency droop between no load and full load shall not exceed 5%.Transient voltage deviation following a step load of 60% of rated at a power factor of between

0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second. The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within ±5% of rated.

41.3.5. Diesel Engine for Generating Set:

Engine shall be four strokes, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10000 hours between major overhauls. The maximum operating speed shall be 1 500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical device which shall operate at 120% of the rated speed. Re- setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with ISO/BS/IEEE 1460 or BS 2869, Class A2.Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling

the engine oil. A thermostatic by- pass valve shall be incorporated. Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer. The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at

0C. An engine driven alternator and charging system shall be provided. An automatic mains energised battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfill the starting requirements. Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be

arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected. Twin heavy duty air intake filters in accordance with ISO/BS/IEEE 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbocharger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion.

Machined surfaces shall be incorporated for mountings and for leveling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for leveling purposes and shall be designed to resist horizontal movement of the diesel set.

The fuel System shall comprise an engine driven feed pump with duplex filters,990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe etc.

41.3.6. Diesel Generator Control Panel:

a. The control panel shall be separately mounted on anti vibration mountings and shall
b. Comprise the following:
c. Breaker incorporating short circuit and overload trip
d. Earth fault protection for the Alternator
e. Alternator Over & Under Voltage Protection
f. Voltage Controlled Over Current Relay
g. voltmeter and seven position selector switch
h. ammeter and 4 Position selector switch
i. frequency meter
j. Power Factor Meter
k. kWh Meter
l. engine temperature and oil pressure gauge
m. service hours run indicator
n. key switch start and stop control
o. operational status indicator
p. anti-condensation heater and thermostat
q. alternator anti-condensation heater controls

r. mains fed battery charger

s. Auto start on mains power supply failure facility

t. Fails to Start (Alarm)

u. Over / Under Voltage Alarm

v. Battery Charger Fault (Alarm)

w. Low fuel Oil Level (Alarm)

x. Over Load (Alarm)

y. Low Lube Oil Pressure (Trip)

z. High Water Temperature(Trip)

aa. High Lube Oil Temperature (Trip)

bb. Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting. Simple operating instructions shall be detailed on the fascia of the control panel.

41.3.7. Synchronizing Panel

Whenever two sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, relays, meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

41.3.8. Acoustic Enclosure

a. The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.

b. The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam /glass wool as acoustic material.

c. The sound level shall be restricted to 75 dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.

d. The acoustic enclosure shall be certified to meet the emission norms.

41.3.9. Bulk Fuel Storage Tanks

Tanks and fittings, etc shall conform to ISO/BS/IEEE 803 or BS 799: Part 5. The tank shall be constructed in mild steel and the fittings in materials other than:

- Yellow brass, including low grade alloys of copper and zinc.
- Lead and zinc.
- Galvanized metals.

- Natural rubber.

An ullage volume above maximum contents level of the tank shall not be less than 5% of the maximum volume of the fuel. The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment. The following fittings shall be included:

a. 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.

b. Dipstick, calibrated in litres with guide tube and striker plate.

c. c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.

d. Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.

e. Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.

f. Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.

g. Inlet fittings for overflow pipe from daily service tank or tanks (where specified).

h. Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted `U' bend and vermin screen.

i. External ladder for horizontal tanks more than 2 m diameter.

41.3.10. Drawings / Documents Required:

All Drawings, data, technical particulars, calculations, detailed literature, catalogues Test certificates etc shall be submitted along with the bid/ after award of contract.