Section VIII

Technical Specifications for the Construction of 156-bedded hostel at College of Natural Resources (CNR), Lobesa

Technical Specifications

The Technical Specifications contain the materials, equipment, workmanship and quality control to cover major items of work contained in the Bill of Quantities/Milestone package of the contract.

The "Specifications for Building and Road Works-2018" of the BSB, Ministry of Works and Human Settlement, Royal Government of Bhutan and other relevant international standards such as IS code of practice has been referred for preparation of this Technical Specifications, as appropriate.

This technical specification is prepared by Engineering Cell, Office of the Vice Chancellor, Thimphu for the construction of 156-bedded hostel at CNR, Lobesa.

Chapter : 1

GENERAL

01 GENERAL

The Technical Specifications and Bill of Quantities shall be read in conjunction with the other Contract Documents. All the documents and drawings are to be regarded as mutually explanatory. In the event of any discrepancy or assumed discrepancy being found between them, the Contractor shall immediately inform the Engineer of the matter in writing and the Engineer will issue his instructions in the matter in accordance with the Conditions of Contract including the Environmental Codes of Practice for Building and other Constructions.

The terminology Engineer in these Technical Specifications shall be read as Project Engineer/site Engineer according to the General and Particular Conditions of the Contract.

The Sections, Clauses and/or Sub-clauses mentioned in these Specifications deem to apply those of these Specifications only, if otherwise not specified. The Specifications or Technical Specifications shall denote the same meaning of the specifications.

02 PROGRAM OF WORKS

Right after the issuance of letter of acceptance and before signing of the Contract Agreement, the Contractor shall submit in triplicate the Program and particulars required under General Conditions of Contract. The Contractor shall provide all information needed for fulfillment of the Program and required in accordance with the Conditions of Contract including the sequence in which the Contractor intends to work including implementation of quality assurance plan. In the Program and particulars the Contractor shall provide details of how the Contractor proposes to carry out the Works including:

(1) The Program for the construction and completion of the works shall be established using CPM/PERT techniques or equivalent. The Program shall be detailed enough to give, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials, procurement/rental/leasing of equipment, progress milestones, fabrication of special products/equipments, if any, and their installation and testing, and for all activities of the Engineer that are likely to affect the progress of work. It shall be prepared so as to permit revisions, inclusion of additional detail and regular updates as the work progress. Such agreement shall not relieve the Contractor of his responsibility to obtain specific approval for each closure or series of closures. In all respects the Contractor shall pay particular attention to seasonal weather pattern including rainfall and snow conditions (if any), and the construction sequencing while preparing the Program and executing the Works in accordance with this. Any proposal for night working shall also be stated in the Program.

(2) A detailed Statement of Construction Management Procedures the Contractor proposes to adopt.

Once approved by the Engineer the Program and Statement of Construction Management Procedures shall be incorporated into the relevant Item of the Contract Agreement and shall be strictly adhered to unless any alterations are found to be necessary during the construction of the Works and are confirmed in writing by the Engineer. If the Contractor requests a change in the sequence and such change is approved by the Engineer, the Contractor shall have no claim as per the Conditions of Contract for delay arising from such revisions to the Program.

The Contractor shall update all activities in accordance with the Conditions of Contract on the basis of the decision taken at the periodic site review meetings or as directed by the Engineer.

The Contractor shall furnish, at least 14 days in advance, his site work program of commencement of item of work, the method of working he intends to adopt for various items of work. The Contractor shall provide information regarding the details of the method of working and equipment he proposes to employ and satisfy the Engineer about the adequacy and safety of the same. The sole responsibility for the safety and adequacy of the methods adopted by the Contractor will, however, rest on the Contractor, irrespective of any approval given by the Engineer.

03 SUBMITALS

1 General Requirements

The Contractor shall maintain an approved system of recording (daily Log record) and tracking submissions indicating dates, status (i.e. approved, not approved, approved subject to conditions), quantities, and other details as required.

Copies of all approved submissions will be retained securely and properly filed on site, available for reference by the Engineer at any time.

2 Contractor's Monthly Progress Report

The Contractor shall submit the daily report in the standard format provided by the site engineer and monthly progress report to the Engineer submitted in duplicate and showing actual work done.

The contractor shall submit monthly Laboratory/Field test report if any. If required, the Engineer shall ask the contractor to submit quarterly Fund Projection Statement.

3 Samples

(1) The Engineer may at his discretion request or take samples of any material or product intended for use in the Works. Where samples are requested in the Specifications they shall be submitted in the number requested or if not specified then as directed by the Engineer.

(2) Samples shall be of the type and size specified and fully representative of the materials proposed to be used.

(3) Samples shall be indelibly and clearly marked with the date of submission, material reference and any other data required to determine the source and kind of sample.

(4) One or more "accepted" samples will be retained by the Engineer for comparison with materials and workmanship supplied and will form the standard of acceptance.

(5) One or more "accepted" samples shall be retained at the Contractor's site office and be available for reference on request.

(6) The Engineer may reject any materials and goods which in his opinion are inferior to the samples thereof previously approved and the Contractor shall promptly remove such materials and goods from the Site.

04 Diversions and temporary works

(1) Scope

This Clause covers the construction and maintenance of the necessary detours and diversions, barricades and signs, and everything necessary for the safe and easy passage of all public traffic during the construction period and also the removal of diversions as they become redundant including bringing up the area under use into its original condition. The Contractor shall take

necessary safety procedures regarding traffic diversion or temporary road closures that are needed in execution of the works.

(2) General Requirements

The Contractor shall at all time carry out works for building and related construction in a manner creating least interference to the flow of pedestrians. The Contractor shall take prior approval of the Engineer regarding arrangements of passage during construction if any.

The Contractor may be allowed to stop passage temporarily. The period of such closure shall be as agreed by the Engineer. For this the Contractor shall submit the time and period of the closure to the Engineer at least 07 days in advance, to enable the Engineer to issue the relevant notices.

(a) Access to Properties

Access to properties which fall within or adjoining the area over which work is being carried out shall be provided in the manner as existed before the start of the work.

(b) Temporary Drainage Works

All necessary temporary drainage works required for proper surface run-off, such as side drains, catch drains, temporary cross-drainage structures, etc. shall be constructed.

(3) Construction Safety and Control

The Contractor shall provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required for the information and protection of human. Barricades, traffic signs and warning boards shall be provided as per the requirements of RUB or as per code of practice. Suitable regulatory and/or warning signs shall be installed for the guidance of the passers.

Measurement and Payment

No measurement and/or payment shall be made for works required under Clause 04 of the Technical Specifications. All costs in connection with the work specified herein shall be considered to be included with other related items of the work in the Bill of Quantities or Mile Stone package.

05 MAINTENANCE OF SERVICES

(1) If any government, publicly and privately owned service for drinking water, electricity, drainage, irrigation channels, sewers, telecommunication cables/lines and other services and structures, passing through the site is affected by the works, the Contractor shall provide a satisfactory alternative service in full working order to the satisfaction of the owner of the services and of the Engineer before terminating the existing service.

(2) Drawings and scheduling the affected services like water pipes, sewers, cables, etc. owned by various authorities including government and public undertakings and local authorities shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

(3) The Contractor must also allow for any effect of these services and alternations upon the works and for arranging regular meetings with the various bodies at the commencement of the contract and throughout the period of the works in order to maintain the required co-ordination.

(4) No clearance or alterations to the utility shall be carried out unless ordered by the Engineer.

(5) Any services affected by the works shall be restored immediately by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the works.

(6) The Contractor may be required to carry out the permanent removal or shifting or diversion of certain services/utilities on specific orders from the Engineer. Such works shall be taken up by the Contractor only after obtaining clearance from the Engineer and ensuring adequate safety measures.

Measurement and Payment

No separate measurement and payment shall be made for the work of temporarily supporting; maintaining and protecting the government, publicly and privately owned services. All costs in connection with the work specified herein shall be considered to be included with other related items of the work.

06 SURVEY AND SETTING OUT

(1) During the period of Commencement of works the Contractor shall resurvey the Base Lines, Traverse Points, Bench Marks and confirm the co-ordinates and levels of the stations. He shall immediately notify the Engineer of any discrepancies and shall agree with the Engineer any amended values to be used during the contract, including replacements for any stations missing from the original stations.

(2) All stations and reference points shall be clearly marked and protected to the satisfaction of the Engineer.

(3) The center lines shall be accurately referenced in a manner satisfactory to the Engineer.

(4) The Contractor shall provide the Engineer with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the Engineer needs to carry out in connection with the contract during the entire period of contract.

Measurement and Payment

No separate measurement or payment shall be made for the work required under Clause 06 of the Technical Specifications. All costs in connection with the work specified herein shall be considered included in the related items of the works.

07 ACCESS TO ABUTTING PROPERTIES

For the duration of the works the Contractor shall at all times provide convenient access to site or drives for all entrances to property abutting the site and maintain them clean, tidy, and free from mud or objectionable matter.

Measurement and Payment

No separate measurement and/or payment shall be made for the work required under Clause 07 of the Technical Specifications. All costs in connection with the work specified herein shall be considered included in the related items of the works.

08 NOTICE BOARD

The Contractor shall erect and maintain notice boards (2m x1.2m) at one end of the site giving details of the contract in the format and wording as directed by the Engineer. These boards shall be erected within 14 days after the Contractor has been given the Possession of Site. The Contractor

shall not erect any advertisement sign board on or along the work without the written approval of the Employer. All sign boards shall be removed by the Contractor by the end of the Defects Liability Period.

Measurement and Payment:

No separate payment shall be made to contractor and is deem to include in his BoQ.

09 ENVIRONMENTAL PROTECTION WORKS

The environment has been defined to mean surrounding area including human and natural resources to be affected by execution and after completion of works.

The Contractor shall take all precautions for safeguarding the environment during the execution of the contract. He shall abide by all prevailing laws, rules and regulations governing environmental protection. In particular, the Contractor shall fully comply with the Environmental Codes of Practice for Building Construction/Highways and Roads. The Contractor shall prohibit employees from unauthorized use of explosives, poaching wildlife, fishing and cutting trees. Where possible the workers must be provided with kerosene/electrical for cooking. Where it is not possible to get firewood must be provided by purchasing it through the local firewood contractor. Where there is no local firewood contractor, proper forestry permits must be obtained for collection of firewood. The Contractor shall be responsible for the action of his employees.

Environmental protection works, among others, shall also include the following:

(1) Provision and Maintenance of Camps, Offices, Stores, Equipment Yards and Workshops if any.

Various works defined under this item are related to provision and maintenance of camps for workmen and employees, Contractor's site offices, temporary accommodation to the supervision engineers, stores, equipment yards and workshops. These camps must be adequate, rain-proof, spacious, airy and hygienic with proper lighting and materials storage facilities. The area shall be kept neat and clean.

Permission may be granted by the Engineer to erect temporary suitable camps free of charge, if such establishments do not cause obstructions to human or animals, nuisance to works execution and adverse effect to the environment.

Written information must be given to and approval be taken from the Engineer regarding proper establishment and maintenance of such camps. Failure in compliance with Engineer's instruction in respect of overall standard will lead to reduction or with holding of any payment to the Contractor.

The Contractor shall ensure that proper drinking water, waste disposal and toilet facilities are provided to the camps. This arrangement shall be enforced to avoid proliferation and generation of various water borne diseases.

Provision of toilets for labour, employees and supervision engineers shall be made to avoid public nuisance as well as pollution of water courses and air. The Contractor shall construct suitable septic tanks and/or soak pits along with room of pit-type latrines. Sufficient water must be provided and maintained in the toilets. The contractor shall provide waste disposal facilities such as dustbins and waste disposal pits.

A first aid kit along with proper medical supplies must be available in the camps for treating injuries or common health problems. All workers shall be provided with adequate safety wear such as, water boot, gloves, face masks, ear plugs, helmets, safety jackets and safety belts to prevent injuries and health hazards.

The site engineer shall have the power to order basic facilities put in place through days work or local laborers and or procure such basic facilities to maintain adequate safety and hygiene for the contractors workers/employees and deduct the same from the contractor's running bill in the event the contractor does not comply the requirement as per environmental code of practice and or as per labour laws of the kingdom.

(2) Disposal of Spoil and Construction Waste

Materials in excess of the requirements for permanent works and unsuitable materials shall be disposed off in locations and in the manner as agreed with the Engineer. The locations of disposal sites shall be such as not to promote instability, destruction of properties and public service systems. Exposed areas of such disposal sites shall be suitably dressed and be planted with suitable vegetation. Provisions shall be made to facilitate proper drainage around the site.

(3) Hazardous Materials

The Contractor shall not store hazardous materials near water surfaces. The Contractor shall provide protective clothing or appliances when it is necessary to use some hazardous substances. High concentration of airborne dust resulting in deposition and damage to crops and water resources shall be avoided. The Contractor shall take every precaution to control excessive noise resulting in disruption to human population.

(4) Operation of Machinery and Equipment

The contractor shall regularly maintain all machinery and equipment in order to minimize exhaust pollution. Oil and lubricants must be stored properly to prevent any spills and leakage and pollution of the surrounding soil as well as water bodies.

10 PHOTOGRAPHS

The Contractor shall provide photographic/video clip records of work progress every end of month. Further, contractor will keep the photographic evidence of any important findings, events that related to the project.

11 CONSTRUCTION EQUIPMENT

In addition, the conditions of the contract, the following conditions regarding use of equipment in the Works shall be satisfied by the Contractor:

a) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer;

b) All the plant/equipment to be deployed on the works shall be approved by the Engineer for ensuring their fitness efficiency before commencement of work;

c) Any equipment not meeting the approval of the Engineer shall be removed from the site;

d) No equipment will be removed from site without permission of the Engineer; and

e) The Contractor shall promptly make available the equipment for site quality control work as directed by the Engineer.

No extra payment shall be made to the Contractor for fulfilling the above conditions regarding the use of equipment in the Works.

12 SITE INFORMATION

The information about the site of work and site conditions in the Bidding Documents is given in good faith for guidance only but the Contractor shall satisfy himself regarding all aspects of site conditions.

The Contractor shall have to make his own arrangement for the land required by him for site offices, labour camps, stores, etc.

It is assumed that the Contractor has inspected any quarries; borrow areas etc., before quoting his rates for the work to assess the availability of construction materials in required quantity and quality.

13 NOTES CONCERNING MEASUREMENT AND PAYMENT

(1) General Rules for the Measurement of Works for work execution

1.1 General

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant sections read in conjunction with the General Conditions of Contract. All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits.

i	length and breadth	10 mm
ii	height, depth or thickness of earthwork	10mm
ii	areas	0.1 sqm
iv	volume contents	0.1 cum

Notwithstanding the above, the measurements may be taken at closer intervals also, if so desired by the Engineer.

(2) Scope of Rates for Different Items of Work

2.1 ***For BoQ rate contract***, the contract rates for entire works shall be paid in full/partially for completing the work detailed in the relevant sections for these specifications under "Rates". In the absence of any directions to the contrary, the rates are to be considered as the full inclusive rate for finished works covering all labour, materials, wastage, transportation, temporary work, plant, equipment, overhead charges and profit as well as the general liabilities, obligations, insurance and risks arising out of General Conditions of Contract.

2.2 The Lump sum rates quoted by the contractor shall, unless otherwise specified, also include compliance with/supply of the following:

(i) General works such as survey and setting out, clearance of site before setting out and clearance of works after completion;

(ii) A detailed Program for the construction and completion of the works (using CPM/PERT techniques) giving, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials and equipment, fabrication of special products/equipment and their installation and testing, and for all activities of the Employer that are likely to affect the progress of work, etc., including updating of all such activities on the basis of the decisions taken at the periodic site review meetings or as directed by the Engineer.

(iii) Samples of various materials proposed to be used on the Work for conducting tests thereon as required as per the provisions of the Contract;

(iv) Design of mixes as per the relevant Clauses of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant clauses of the Technical Specifications to be submitted to the Engineer for his approval before use on the Works.

(v) All incidental costs

2.3 The other contractors employed by the Employer may be working in the vicinity of the Works being executed by the Contractor. The Contractor shall liaise with such contractors and carry out activities for the completion of work accordingly and no claim or compensation due to any reason whatsoever will be entertained on this account.

14 EQUIVALENCY OF STANDARDS

Wherever reference is made in these Specifications to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work to be performed or tested, the provisions of latest current edition or revision of relevant standards and codes in effect shall apply. Other authoritative standards which ensure a substantially equal or higher performance than the specified standards and codes shall be accepted subject to the Engineer's prior review and approval. In the event that the Engineer determines that such proposed deviations do not ensure substantially performance, the Contractor shall comply with the standards and codes specified in the contract documents.

15 FACILITIES FOR THE ENGINEER

(1) General

The Contractor shall provide, maintain and supply services to the site office, for use of the Engineer. All facilities provided to site supervising Engineer and his staff shall be new unless otherwise specifically stated. The full details of the facilities, which the Contractor proposes to provide for the site Engineer shall be submitted for the approval within 30 days of the Letter of Acceptance.

All furniture and equipment provided by the Contractor to facilities the Clint engineer shall become the property of the Contractor at the end of the Contract.

The contractor is required to provide, furniture, equipment and to maintain office/services, equipment and other related facilities.

A typical drawing, if required, shall be provided. All rooms for the office shall be adequately ventilated and fitted with sufficient ceiling lights and power outlets.

The office shall be suitably furnished and equipped by the Contractor in accordance with the schedules. The Contractor shall be responsible for the costs of installation and maintenance of office equipments and other associated cost.

I Schedule of Office Equipment & safety gadget:

a) White board and board marker – 1set
b) Good quality Helmet for visitors and staff -10Nos (white)
c) Gum boot (good quality) for visitors - 10 pairs
d) Safety boot(Steel toe) - 2 pairs

II Schedule of Furniture for the Office:

a) Office desk (1.5 x 0.75 m with 3 drawers) -1No
b) Half Revolving chair with arms - 1No
c) Meeting table (2 m x 1.2 m) -1Nos
d) Office chair, cushioned with arms - 4Nos
e) Book shelves (1.5 m x 2 m, 4 shelves) - 1No
f) Office cupboard, steel (1 m wide, 4 shelves) - 1No

III Site office, Field Lab cum Camp for site Engineers

Contractor shall construct decent site office, Field Lab and camp for the site engineers as per the instruction of Project Management. The temporary huts must be installed with power points, telephone line, and toilets with proper ventilations and locking systems. As per the requirement, Project Manager will provide the drawings/sketch and contractor shall maintain the shed and shall clear all the utility bills pertains to running the site office.

Measurement and Payment

No measurement and/or payment shall be made for works required under Clause 15 of the Technical Specifications.

16 HEALTH AND SAFETY

The Contractor shall take due care and ensure that first aid room are available at the camps, housing and on the jobsite at all times throughout the period of the contract and that suitable arrangements are made for the prevention of epidemics and for all necessary welfare and hygiene requirements.

Measurement and Payment

No separate measurement and payment shall be made for the works described in this Clause.

Chapter : 2

MATERIALS AND TESTING OF MATERIALS

01 SCOPE

This section covers the general requirements relating to materials; the specific requirements for basic materials and the tests and methods of testing which are required for the selection and quality control of materials.

02 QUALITY OF MATERIALS

The materials supplied and used in the works shall comply with the requirements of the Technical Specifications. They shall be new, except as provided elsewhere in the contract or permitted by the Engineer - in writing. The materials shall be manufactured, handled and used skillfully to ensure completed works to comply with the contract.

03 SOURCES OF MATERIALS

The use of any type of material from more than one source is prohibited, except by written permission of the Engineer. Such permission, if granted, shall set forth the conditions under which the change may be made. If the product of any source proves unacceptable, the Contractor shall make necessary arrangements for the supply of acceptable material. Any claims for compensation associated with such arrangements or changes shall not be considered.

04 INSPECTION AND ACCEPTANCE OF MATERIALS

Final inspection and acceptance of materials shall be made only at the site of the work. The Engineer reserves the right to sample, inspect, and test the materials throughout the duration of the Works and to reject any materials which are found to be unsatisfactory. The Contractor and Clint Engineer shall strictly follow the system of joint sampling and testing for material/ works as per normal format.

A preliminary inspection of materials may be made at the source for the convenience and accommodation of the Contractor, but the presence of a representative of the Engineer shall not relieve the Contractor of the responsibility of furnishing materials complying with their Specifications.

The Engineer shall have free entry at all times to those parts of any plant which concern production of the materials ordered.

09 SIEVES

IS sieves shall be used for all tests. Based on IS-460 the standard sieves series shall be used. Where test methods specify a non-standard sieve, results may be interpolated from the grading graph. In addition, sieves of other test standards shall be used as required in the Technical Specifications.

10 STONE, AGGREGATE, SAND AND FILLERS

(1) Sampling and Preparation of Samples

Sampling shall be carried out as per IS code and the samples shall be prepared in accordance with IS 2386 or according to sampling procedures specified for the Standard Methods of testing given in Table 2.2.

(2) Standards Methods of Testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard procedures given in the Table 2.2. The type of tests shall be as directed by the Engineer.

Table 2.2: Tests Procedures Applicable to Stone, Aggregate and Fillers

Tests	Test Procedure	
Determination of:		
a) Particle Size Distribution (Gradation)	IS 2386	Part 1
b) Clay, Silt, Dust in Aggregates	IS 2386	Part 2
c) Flakiness Index	IS 2386	Part 1
d) Specific Gravity	IS 2386	Part 3
e) Moisture Content	IS 2386	Part 3
f) Bulk Density, Voids & Bulking	IS 2386	Part 3
g) Mica Content	Manual mineralogical counting	
h) Water Absorption	1S 2386	Part 3
i) Crushing Ratio		
k) Los Angeles Abrasion		
l) AIV - ACV		

11 CEMENT

Ordinary Portland Cement (OPC) shall be sampled according to IS 3535 and tested according to IS 4031. The requirements on their physical characteristics shall be as given in Table 2.3.

Table 2.3: Requirements on the Physical Characteristics of Cement

S.N.	Physical Characteristics	OPC	Test Procedure
i)	Fineness, m2/kg: (by Blaine's Air Permeability method)	225	IS-4031 Part 2
ii)	Setting Time : (a) Minimum Initial Setting Time (minutes) (b) Maximum inal Setting Time (minutes)	45 600	IS 4031 Part 5
iii)	Soundness by Lechatelier method, mm, maximum	10	IS 4031 Part 3
iv)	Compressive Strength : Minimum Average Compressive Strength of three mortar ube(N/mm^2) (a) 3 days (b) 7 days (c) 28 days	 16 22 33	IS 4031 Part 6

12 CONCRETE

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 2.4. The type of tests shall be as specified by the Engineer.

Table 2.4: Tests Procedures Applicable to Concrete

Tests	Test Procedures
Determination of :	
(i) Compressive strength of concrete cubes	BS 1881–116
(ii) Water absorption	BS 1881–122
(iii) Mixing and sampling fresh concrete in laboratory	BS 1881–125
(iv) Normal curing of test specimens (20o C method)	BS 1881–111
(v) Making test cubes from fresh concrete	BS 1881–108

The test specimens shall be cured at a temperature of 27°C ± 2°C.

13 REINFORCING STEEL

All reinforcement for use in the Works shall be tested for compliance as specified in a Laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. In addition to the testing requirements described above, the Contractor shall carry out additional testing as instructed by the Engineer.

14 BRICKS

Bricks shall conform to the requirements of IS 1077.

1 General

Bricks required for brick work in cement mortar shall be adequately soaked in water before use. Brickwork shall be laid in English bond unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond. Closures, in such cases, shall be cut to the required size and used near the ends of the walls.

A layer of mortar shall be spread on full width over a suitable length of the lower course. Each brick shall be properly bedded and set home (in position) by gently tapping with handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. On the completion of course, all vertical joints shall be fully filled from the top with mortar.

Joints: Brick shall be so laid that all joints are full of mortar. The thickness of joints shall not exceed 10mm. All face joints shall be raked to a minimum depth of 15mm by raking tool during the progress of work when the mortar is still green so as to provide proper key for the plaster or pointing to be done. Where, plastering or pointing is not required to be done the joints shall be struck flush and finished at the time of laying.

Curing: Brickwork shall be protected from rain by suitable covering when the mortar is green. Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of seven days.

2 One Brick Masonry/Half Brick Masonry

The specification shall be same as explained above in general brick works. However, in special cases like one/half brick walls for water tanks and long length of half brick thick walls etc. where reinforcement is considered necessary from structural consideration, the same shall be provided at required intervals and the cost of reinforcement shall be paid for separately.

3 Water proofing materials: Water proofing materials shall be added in the cement mortar according to the specifications of manufacturer.

4 Brick/GRC Cornices

The cornice at each floor level shall conform in all respects to the approved design and made as per the direction of the Engineer. The plastered brickwork /GRC works shall conform to the dimensions and shape of the approved design. Care must be taken to maintain proper line and level.

5 Pointing on Brick Masonry

Preparation of Surface: The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before pointing is commenced.

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunk surface of the finished pointing or from the edge of the brick shall not be less than 12 mm.

Application and Finishing: The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raised, according to the type of pointing required. The mortar shall not spread over the corner, edges or surface of the masonry. The pointing shall be then finished with the proper tool, in the manner described below:

Flush Pointing: The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks, tiles or stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

Ruled Pointing: The joints shall be initially formed as for flush pointing and then while the mortar is still green, a groove of shape and size as shown in drawings or as instructed, shall be formed by running a forming tool, straight along the centre line of the joints. This operation shall be continued until a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical lines shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same.

Raised and Cut Pointing: Raised and cut pointing shall project from the wall facing with its edges cut parallel as so to have uniformly raised band about 6 mm raised and width 10 mm or more as directed.

The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is to the exact size and shape stipulated and the edges are straight, neat and clean.

Curing: The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages. The pointing lines shall be truly horizontal and vertical except where the joints are slanting as in random rubble masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

Chapter : 3

QUALITY CONTROL

01- QUALITY CONTROL

This Section covers the Quality Control System and procedures; Quality Assurance Plan; program of tests; trials; and general procedures for acceptance as well as laboratory arrangements and related facilities which are required for the selection and control of the quality of materials and workmanship.

02 CONTRACTOR RESPONSIBLE FOR THE QUALITY OF THE WORKS

All materials incorporated and all workmanship performed shall be strictly in conformity with the requirements of the Technical Specifications and the Contractor shall be responsible for the quality of the works in the entire construction within the contract.

Laboratory equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with these Specifications. The Contractor shall assume that tests shall be required on all materials to be used in the works and on all finished works or part of works.

03 QUALITY CONTROL SYSTEM

The Quality Control System comprises the methods, procedures and organization for the Quality Control of the works. The Contractor shall implement the Quality Control System in the following sequences:

In certain circumstances, tests may be carried out at the place of manufacture as per the Conditions of Contracts. Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down specifications and tolerances to the satisfaction of the Engineer.

04 QUALITY ASSURANCE PLAN

The Contractor shall submit to the Engineer for his approval, the Quality Assurance Plan (QAP) which shall be based on the detailed Program of the Works as the Technical Specifications.

The Contractor shall monitor and update the QAP on the basis of the decisions taken at the periodic review meetings or as directed by the Engineer and in accordance with the program of the works.

05 TESTING PROCEDURES AND SET OF TESTS

For ensuring the quality of the work, the materials and the workmanship shall be subjected to testing in accordance with procedures, sets of tests and frequencies as specified and respective Sections of these Specifications. The specified testing frequencies are not restrictive. The Engineer shall direct for the tests to be carried out as frequently as deemed necessary that the materials and workmanship comply with their Specifications.

Where no specific testing procedure is mentioned in the Specifications, the tests shall be carried out as per the prevalent accepted engineering practice or directions of the Engineer.

06 LABORATORY TRIALS TO CONFIRM COMPLIANCE WITH SPECIFICATIONS

(1) Concrete

Laboratory trials for concrete mixes as specified shall be carried out by the Contractor to demonstrate that the composition of the mixes proposed for the concrete meets the requirements of the Technical Specifications.

The compositions of concrete mixes which meet the specified requirements and are accepted by the Engineer shall be then used for mass concerting

07 SITE TRIALS OR TRIAL SECTIONS

(1) Concrete

Site trials for concrete mixes as specified shall be carried out by the Contractor to demonstrate the suitability of his mixing equipment. During the site trials, compliance with the Specifications for weighing equipment, storage of ingredients, means of transport for concrete, placing, compaction and curing shall be checked by the Engineer.

08 FIELD LABORATORIES

(1) Scope

This Clause covers the laboratories as required for testing of materials as part of quality control for the construction works executed under the contracts for the project. The following laboratory provision will be required to cover the quality control of construction materials.

1.1 Establishment of Field Laboratory

The Contractor shall establish a small and affordable field laboratory. The laboratory shall be manned by the contractor with suitable laboratory technicians. The space should be adequate to provide testing facilities for construction works. As required, the space shall be partitioned to provide rooms/space for testing, sample preparation, sample storage.

The Contractor shall give the following consideration to the preparation of space for laboratory. Sufficient power for lighting and other electrical appliances and test apparatus shall be provided.

All the establishment cost shall be deem to be included in his overhead cost and no additional claim shall be entitled.

(2) Laboratory Equipment

All equipment necessary for testing of materials and workmanship shall be deemed to form part of the permanent works unless otherwise provided in the contract. It shall be delivered to the site in accordance with the schedule of requirements for such equipment described in the contract. However the non-inclusion of any item of such equipment in the schedule of requirements shall not relieve the Contractor of the responsibility to supply if it is required for the proper control of the quality of the materials and/or workmanship, notably when identified in the list of appropriate equipment to be supplied

Table 2.0 : Schedule of Laboratory Equipment

Sl. No	Item Description	No. of Items

1.	Concrete Test and Slump Cone Apparatus	
	- Cube Moulds (150 mm)	9 nos.
	- Cube mould (50mm)	3Nos
	- Slump cone apparatus	2 nos.
	- Tamping rod (16 mm dia)	2 nos.
	- Steel ruler (calibrated)	2 nos.
2.	Compression Testing machine set (hand driven), 100 tons	Nil
3.	Flakiness and Elongation Index	
	- Set of Flakiness and Elongation gauges	1 no.
4.	Balances: (as specified)	
	a) Electronic Balance, 500 gm nominal capacity, 0.01 g accuracy	1 no
	b) Electronic Balance, 2500 g nominal capacity, 0.1g accuracy	1 no
	c) Electronic balance with carrying case, 10 kg, 0.1 g accuracy	1 no
5.	Glassware: (as specified)	2 no.
	a) Flat bottom flasks 500 ml b) Volumetric Flask, 500 ml	2 no
	c) Graduated glass beakers (100 ml - 1000 ml)	3 no
	d) Measuring cylinder (100 ml - 1000 ml)	3 no
	e) Spring balance (100Kg)	1 No
	f) Measuring glass cylinder 250ml	4Nos
	g) Sprit level 1 mtr length	4Nos

(3) Ownership

Testing equipment and furniture procured for field laboratory shall become the property of the Contractor upon completion of the project and contractor is instructed to include the cost in his bid and no separate payment shall be made.

(4) Serviceability

The Contractor shall maintain all laboratory equipment in good working condition throughout the period of the contract at his own expense. Testing apparatus shall be maintained in serviceable condition and all measuring and control equipment will be checked and calibrated from time to time, as required by the Engineer, and immediately adjusted or replaced if it is found that correction is not possible. Any equipment, which become unserviceable during use shall be repaired or replaced by the Contractor at no extra cost to the Employer. The Contractor shall provide all tools, accessories, services for utility, communication, consumable items for testing and operating, and all the assistance as may be required by the Engineer and his staff for measuring and checking the works.

(5) Testing

Without relieving the Contractor of any of his responsibility for the testing of materials the Engineer may as and when he desires carry out any of the tests specified above using the

facilities. The Engineer may order the Contractor to carry out additional laboratory tests in an independent laboratory, as deemed necessary.

For all testing which cannot be carried out in the field Laboratory, the Contractor shall be responsible for arranging for such testing to be carried out at an independent laboratory to be approved by the Engineer. The Contractor shall be responsible for all attendance on staff from these approved testing laboratories, including if necessary the provision of transport for personnel, equipment and test specimens. No testing by external laboratories shall be carried out without the written instruction of the Engineer.

Measurement and Payment

No separate measurement and/or payment shall be made for the above work. All costs in connection with the quality control test equipment and the test specified herein shall be considered included in the related items of the works.

Chapter : 4

CLEARING, GRUBBING AND REMOVALS

01 CLEARING AND GRUBBING

(1) Scope

This Section covers the clearing and grubbing necessary for the construction of the works covered by the contract. Conservation of the top soil and flora is also covered under this Section.

(2) Description of Work

(a) Clearing: Clearing shall consist of the cutting, removing and disposal of all trees, bushes, shrubs, grass, weeds, other vegetation, anthills, rubbish, fences, top soil of thickness approximately 200 mm and all other objectionable material, resulting from the clearing. It shall also include the removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work.

(b) Grubbing: Grubbing may follow after clearing and includes the removal of topsoil and all roots and organic matter in the roadway. This shall including all trees up to 300 mm girth, stumps and roots which shall be removed to a depth of not less than 150 mm below the sub-grade level or a minimum of 600 mm below the original ground level whichever is lower.

(c) Disposal of Material: Material obtained from clearing and grubbing shall be disposed off in borrow pits or other suitable places and be covered up with soil or gravel as directed by the Engineer. The burning of combustible material shall not, normally, be permitted and may only be done with the prior written approval of the Engineer.

Chapter : 5

EARTHWORKS

01 SCOPE

This Section covers the works related to the building, roadway, site excess, water supply, sanitation work excavation, roadway filling, excavation for foundation for building works, backfilling, excavation for drains, channels, intercepting drains etc. The works shall consist of hauling and disposing of all unsuitable and excess materials and excavating, hauling, placing and compacting suitable materials, from areas of excavation or borrow, all as required to construct the graded areas, embankments, roads, drainage, building construction sites and parking, or other fill area. The work shall be done in accordance with these specifications and in conformity with the lines, grades, dimensions and typical cross-sections shown on the Drawings and directed by the Engineer.

Suitable materials taken from excavation shall be used in the backfilling or construction of structures all as indicated on the Drawings or as directed by the Engineer.

02 DEFINITIONS AND GENERAL REQUIREMENTS

(1) Earthwork includes two types of operations i.e.

(i) earth excavation and disposal of the excavated materials

(ii) earth excavation and use of excavated materials. The use of excavated materials may be in the form of filling embankment, backfilling (including grading and obtaining graded and structural backfill material) and filling other areas as required.

Earth excavation and disposal implies excavation of all types of materials including part of the structures below ground level within and outside of the limit of the right of way except for otherwise specified, shaping the exposed surface of excavation as specified or directed by the Engineer, removal, hauling and disposal of the excavated material at the locations and in the manner as specified or directed by the Engineer.

(2) The following definitions of earthwork materials shall apply to this and other Clauses of these specifications, if otherwise not specified.

(3) The Contractor shall ensure that earthwork operation do not cause interference to the public. If excavations are carried out within 5 m of buildings, the Contractor shall execute the work in a way that will minimize damage and disturbances. In general, vertically sided excavation will be required in such places and all necessary timbering or other support shall be provided. Under-excavation of excavation sides will not be permitted.

(4) No excavated suitable material other than surplus to requirements of the contract shall be removed from the site except on the direction of the Engineer. Should the Contractor be permitted to remove suitable material from Site to suit his operational procedure, then he shall make good at this own expense any consequent deficit of filling arising therefore.

(5) Material in surplus to the total requirements of works, and all unsuitable materials shall, unless the Engineer permits otherwise, be run to spoil dumps.

(6) Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable materials.

07 EXCAVATION FOR BENCHING OR GROUND LEVELING, FOUNDATION TRENCHING, PAVEMENT AND SLOPES

1. Excavation for Foundation

(1) Scope

Excavation shall consist of the removal of material for the benching for building layout as per the levels and foundations for footings, drainage structures, retaining walls and other similar structures to the lines and dimensions shown on the Drawing or as instructed by the Engineer in accordance with the requirements of these Specifications. The work shall include construction of protection and subsequent removal of all necessary sheeting, shoring, bracing, draining and pumping, and other deleterious matters and obstructions necessary for placing the foundations; trimming bottoms of excavations; and clearing up the site and the disposal of all surplus material.

(2) Excavation

Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The depth to which the excavation is to be carried out shall be as shown on the Drawing or as directed by the Engineer.

(3) Preparation of Foundation Base

The bottom of the foundation pit shall be leveled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed, if surface is not wet. In the event the Contractor carries out excavation deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the Contractor shall make up the extra depth with concrete or masonry at the cost of the Contractor. Ordinary filling shall not be allowed for the purpose to bring the foundation to level.

After the excavation is completed, the Contractor shall inform the Engineer to that effect and no footing, bedding materials or structures shall be placed until the Engineer has approved the depth and the suitability of foundation material.

If, at any point, in any foundation excavation, material unsuitable for foundations is encountered, the Contractor shall, if so instructed by the Engineer, shall remove all such materials and refill with suitable materials thoroughly compacted by tamping or rolling in layers of not more than 150 mm thick each.

08 REFILLING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES

Backfilling material shall not be permitted under water unless specifically described in the contract or approved by the Engineer. It shall be placed and compacted in layers in compliance with the Drawings and specification. Any support structures for the excavation shall be withdrawn as the filling proceeds unless described in the contract or ordered by the Engineer to be left in. The backfill shall be placed in by such methods which shall avoid loading the structure in any manner which may affect its stability or overload its underlying foundation material or substructure.

No payment shall be made for the disposal of the excavated materials irrespective of all leads and lifts, preparation of foundation base, foundation sealing, dewatering including pumping, removal of logs and stumps, cleaning and grubbing.

STONE WORK

1 General

All stones shall be wetted before use. Masonry shall be laid truly in plumb or to required batter where so specified. Height of construction in a day shall not exceed 1m so as to avoid excess load on fresh mortar. There are three main varieties of stone masonry in common use namely random rubble, coursed rubble and ashlars.

2 Random Rubble Masonry

Dressing: Stones shall be hammer dressed, on the face, the sides and the beds, to enable it to come into close proximity with the neighboring stone. The bushing in the face shall not project more than 4 cm in an exposed face, and one cm on a face to be plastered. The hammer dressed stone shall have a rough tooling for a minimum width of 2.5 cm along the four edges of the face of stone.

Laying: Every stone shall be carefully fitted to the adjacent stones, so as to form neat and close joints. Stones may be brought to level courses at plinth, windowsills and roof level. Leveling up at plinth level, window sills and roof level shall be done with concrete comprising of one part of the mortar as used for the masonry and two parts of graded stone aggregate of 20mm nominal size and shall be-included in the items. The bond shall be obtained by fitting in closely, the adjacent stones and by using bond-stones. Face stones shall extend and bond well into the backing. These shall be arranged to-break joints as much as possible, and to avoid long vertical lines of joints.

The hearting or interior filling of the wall shall consist of rubble stones, which may be of any-shape but shall not pass through a circular ring of 15 cm inner diameter; thickness of these stones in any direction shall not be less than 10 cm. These shall be carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar, chips and spalls of stone being used wherever necessary to avoid thick mortar beds or joints and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The hearting will be laid nearly level with facing and backing, except that at about one meter intervals, vertical 'Plumb' projecting about 15 cm to 20 cm shall be firmly embedded to form a bond between successive courses.

Bond Stones: Bond or through stones running right through the thickness of walls, shall be provided in walls upto 60 cm thick and in case of walls above 60 cm thickness, a set of two or more bond stones overlapping each other by at least 15 cm shall be provided in a line from face to back.

At least one bond stone or a set of bond stones shall be provided for every 0.5 sq.m of the wall surface. All bond stones in stone masonry shall be marked suitably as directed by the Engineer-in-charge.

Quoins or corner stone: The quoins shall be of selected stones neatly dressed with the hammer and / or chisel to form the required angle, and laid header and stretcher alternately. The length of these stones shall be 45cm or more and at least 25% of the stones shall be 50cm or more in length.

Jambs: Stones used in jambs shall be similar to those in quoin, excepting the length of the stem, which shall be 45cm, or thickness of the wall whichever is less.

Joints: Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be thicker than 20 mm.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, the joints shall be raked to a minimum depth of 20 mm by raking tool during the progress of work, when the mortar is still green.

Curing: Masonry work in cement or composite mortar shall be kept constantly moist on all face

for a minimum period of seven days. In case of masonry with fat-lime mortar, curing shall commence two days after laying of masonry and shall continue for at least seven days thereafter.

Protection: Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

Measurement: The length, height and thickness shall be measured correct to 10 mm. The thickness of wall shall be measured at joints, excluding the bushings. Only specified dimensions shall be allowed; anything extra shall be ignored.

Square or Rectangular Pillars: These shall be measured as walls, but extra payment shall be allowed for stone work in square or rectangular pillars over the rate for stone work in walls. Rectangular pillar shall mean a detached masonry support rectangular in section, such that its breadth does not exceed three times the thickness.

Circular Pillars (Columns): These shall be measured as per actual dimensions, but extra payment shall be allowed for stone work in circular pillars over the rate for stone work in walls. The diameter as well as length shall be measured correct to a cm. Tapered walls, shall be measured net, as per actual dimensions and paid for as other walls.

Curved Masonry: Stone masonry curved on plan to a mean radius exceeding 6 meters shall be measured net and included with general stonework. Stone work circular on plan to a mean radius not exceeding 6 meters shall be measured separately, and shall include all cuttings and waste and templates. It shall be measured as the mean length of the wall.

Measurement: Measurement shall be same as for random rubble masonry in foundation and plinth.

3 Coursed Rubble Masonry

Dressing: Face stones shall be hammer dressed on all beds and joints so as to give them approximately rectangular block shape. They shall be squared on all joints and beds. The bed joint shall be dressed for at least 8 cm back from the face and side joints for at least 4 cm such that no portion of the dressed surface is more than 10 mm from a straight edge placed on it. The remaining portion of the stone shall not project beyond the surface of bed and side joints. The bushing on the face shall not project more than 4 cm on exposed face and one cm on a face to be plastered.

Laying: All stones shall be wetted before use. The walls shall be carried up truly plumb or to specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 15 cm nor shall more than 30 cm. Face stones be laid alternate headers and stretchers. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one third of the stone shall tail into the work for length not less than twice the height. The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds and mortar; chips and sprawl of stone being used where necessary to avoid thick beds of joints of mortar and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stones to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up regularly but where breaks are unavoidable, the joints shall be raked back at angle not steeper than 45 degree. Toothing shall not be allowed.

4 Dry Hand Packed Rubble Masonry

Stones as obtained from the quarry shall be used without dressing. The size of the stones shall be such that each is not less than .04 cum. Masonry courses shall be normal to-face batter. Each course shall be laid after spreading earth or stone dust. About half of the stone shall tail into the wall by twice their height, and their height shall not be less than 200 mm.

Measurements: The length, breadth and height shall be measured correct to 10 mm. and the volume calculated correct to 0.01 cum.

5 Stone Masonry in Concrete Mortar

Specification shall be as specified for random rubble masonry except that for bedding each course of stones instead of spreading earth or stone dust, cement concrete of specified mix shall be used to fill up all voids in the course already laid and to provide proper bedding to the course to be laid.

Measurements: The length, breadth and height shall be measured correct to 10 mm. and the volume calculated correct to 0.01 cum.

6 Stone Soling, Filling & Edging

Stones as obtained from the quarry shall be packed with their broader surface as base. The packing shall be as dense as possible and the interstice shall be filled with small stones. The height of stones shall be as per the thickness of soling required. The stones shall be arranged neatly and the joints shall be as thin as possible.

Measurements: The length, breadth and height shall be measured correct to 10 mm. and the volume calculated correct to 0.01 cum.

7 Stone Pavement

Stones shall be hammer dressed on the face, the sides and the beds to enable it to come into close proximity with the neighboring stones. The joints shall be grouted/filled as specified in the item.

Measurement: The length and width shall be measured correct to 10 mm. The area calculated correct to 0.01 sqm.

8 Flat Stone (Local Dolep/Karapa stone) Paving

Stones shall be machine cut as specified, the sides and the beds to enable it to come into close proximity with the neighboring stones. The joints shall not be more than 10mm. Each stone shall be 20mm or more in thickness and laid over the concrete bed as per the instruction Engineer.

Measurement*:* The length and width shall be measured correct to 10 mm. The area shall be calculated correct to 0.01 sq.m.

9 Pointing in Stone Masonry

The holes left in masonry works for scaffolding purposes shall be filled and made good before pointing.

Preparation of Surface: The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence, if any, shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before pointing is commenced.

In case of concrete surface if a chemical retarder has been applied to the formwork, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface. The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of the stone shall not be less than 12 mm.

Mortar: Mortar of specified mix shall be used. The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raised, according to the type of pointing required. The mortar shall not spread over the corner, edges or surface of the masonry. The pointing shall be then finished with the proper tool, in the manner described below:

Flush Pointing: The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

Ruled Pointing: The joints shall be initially formed as for flush pointing and then while the mortar is still green, a groove of shape and size as shown in drawings or as instructed, shall be formed by running a forming tool, straight along the centre line of the joints. This operation shall be

continued till a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical lines shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same.

Raised and Cut Pointing: Raised and cut pointing shall project from the wall facing with its edges cut parallel as so to have uniformly raised band about 6 mm raised and width 10 mm more as directed. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is to the exact size and shape stipulated and the edges are straight, neat and clean.

Curing: The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages. The pointing lines shall be truly horizontal and vertical except where the joints are slanting as in random rubble masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

Measurement: Length and breadth shall be measured correct to a 10 mm and its area shall be calculated in square metres upto two places of decimals.

Chapter : 7

CONCRETE WORK

01 SCOPE

This Section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the works. It also covers reinforcement for concrete. This also includes plum concrete work.

02 DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced or plain concrete construction which is subject to stress. Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids, blinding foundations and similar purposes where it is not subjected to significant stress. A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

03 MATERIALS FOR CONCRETE

(1) General

The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the works until the Engineer has approved the materials of which it is composed. In accordance with Clause, approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

(2) Cement

Cement shall be ordinary Portland cement as per IS 8112 or IS 12269. The cement shall also meet all the requirements. Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather. Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level not less than 300 mm and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation with min gap of 500mm from outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. Stack of cement bags shall not exceed 8 bags in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks. Cement in bags shall be used in the order in which it is delivered.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement. Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement used in the works shall be tested by the manufacturer. The Contractor shall supply two copies of each certificate to the Engineer.

The Contractor shall constitute, from each delivery and each type of cement and not less than one samples for every 200 tones or part of it, representative samples to be tested when instructed by the Engineer in a laboratory acceptable to him, in case of the concrete mixes do not comply with the requirements of this Specification. Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tones or part thereof and at monthly intervals thereafter.

The Contractor shall keep full records of all data relevant to the manufacture, delivery; testing and the cement used in the works and shall provide the Engineer with two copies thereof.

(3) Fine Aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with IS 383. All the material shall pass through a 4.75 mm IS sieve and the grading shall be in accordance with IS 383. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source.

However, in respect of the presence of deleterious materials the fine aggregate shall not contain iron pyrites, iron oxides, mica, shale, coal or other laminar soft or porous materials or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in Clause and as per the direction of the Engineer, that the presence of such materials does not affect the properties of the concrete.

(4) Coarse Aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel. Coarse aggregate shall be supplied in the nominal size called for in the contract and shall be of the grading as single sized aggregate or graded aggregate of nominal size 40 mm, 20 mm, 12.5 mm and 10 mm in accordance with IS 383.

Other properties shall be as set out below:

Flakiness Index: When tested in accordance with IS 2386 Part 1, the Flakiness Index of the coarse aggregate shall be as set out hereunder:

For ordinary concrete : not more than 25

For high quality concrete : not more than 1

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

Water Absorption: The aggregate shall not have water absorption of more than 2 per cent when tested as set out in IS 2386 Part 3.

Los Angeles Abrasion (LAA): The aggregate shall have LAA not more than 45% for ordinary concrete, and not more than 35% for high quality concrete, when tested in accordance with IS 2386 Part 4.

Aggregate Crushing Value (ACV): The aggregate shall have ACV not more than 30% for pavement structure and not more than 45% for other structure when tested in accordance with IS 2386 Part 4.

(5) Testing Aggregates

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposed to use in the works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labeled to show its origin and shall be accompanied by all information called for in IS 2386 Part 1 to 8.

The test shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer. Acceptance of the material shall be based on the results of such tests. The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period that concrete is being produced for the works. The tests set out

below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided that the set of tests shall represent not more than 200 tons of fine aggregate and not more than 400 tons of coarse aggregate, and provided that the aggregates are of uniform quality.

Grading	:	IS 2386 Part 1
Silt, Clay Contents and Organic Impurities	:	IS 2386 Part 2

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented.

(6) Water for Concrete and Mortar

Water shall be clean and free from harmful matter and shall comply with the requirements of IS 456.

(7) Admixtures

(a) General

The use of admixtures in concrete may be required under the contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him in compliance with the Specification. In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it in the mix. The information provided shall include:

(i) The typical dosage, the method of dosing, and the detrimental effects of an excess or deficiency in the dosage.

(ii) Admixtures shall not be mixed together without the consent of the Engineer.

Admixtures may be supplied as liquid or as powder. They shall be stored in sealed and undamaged containers in a dry, cool place. Admixtures shall be dispensed in liquid form and dispensers shall be of sufficient capacity to measure at one time the full quantity required for each batch.

04 DESIGN OF CONCRETE MIXES

(1) Classes of Concrete: The classes of structural concrete to be used in the works shall be as shown on the Drawing. The characteristic strength fck at 28 days expressed in N/mm² and the maximal nominal size of aggregate in the mix expressed in millimeters.

(2) Design of Proposed Mixes

The Contractor shall design all the concrete mixes called for in the Drawing using the ingredients which have been approved by the Engineer in accordance with Clause and in compliance with the following requirements:

a) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.

(b) The cement content shall be such to achieve the strength but in any case not less than the minimum necessary

(c) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.

(d) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than 0.5 for classes of concrete above M20 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

(3) Laboratory Trial Mixes

For each mix of concrete for which the Contractor has proposed a design, he shall prepare the number of concrete batches specified hereunder:

Nominal composition: 3 separate batches

Modified compositions, the quantities of other constituents being unchanged:

Water : +10% 1 batch

Water : - 10% 1 batch

Cement : +15% 1 batch

Cement : - 15 % 1 batch

(a) The slump of the concrete shall be determined.

(b) Six tests cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 20 mm, 150 mm cubes shall be used. In the case of concrete containing lager aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 50 mm IS sieve shall be removed from the mixed concrete before casting the cubes.

(c) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

A "result" being the average strength of the three cubes from one batch, the average of the three results from tests at 28 days for the nominal composition shall not be less than the Minimal Target Strength.

(4) Site Trials : At least six weeks before commencing placement of concrete in the permanent works, site trials shall be prepared for each class of concrete specified. For each mix of concrete for which the Contractor has proposed a design and successfully tested in Laboratory, he shall prepare three separate batches specified hereunder using the materials which have been approved for use in the works and the mixing plant which he proposes to use for the works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the action taken similar to the above Sub-clause. The average of the three results of tests at 28 days shall not be less than the Minimal Target Strength.

Based on the results of the tests on the Laboratory trial and site trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Engineer.

(5) Quality Control of Concrete Production

(a) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described. Six 150 mm cubes as appropriate shall be made from each sample and shall be cured and tested in accordance with IS codes, three at seven days and the other three at 28 days. Where information samples are required, such as for post-tensioning operations, three additional cubes shall be made.

Until compliance with the Specifications has been established the frequency of sampling shall be three times; and minimum 3 samples for each class of concrete production in each plant or such lower frequency as may be instructed by the Engineer.

(b) Testing

(i) The slump of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the point of production and deposition or at the frequency instructed by the Engineer.

The slump of concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value whichever is the less.

(ii) compressive strength of the concrete at 28 days shall be such that no single result (average of 3 cubes) is less than the characteristic strength fck under the heading "early works test cubes" and also that the average of three consecutive results is not less than fc +4.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

(iii) When at least 20 consecutive results on tested batches are available for any class of concrete mixed in any one plant, no single result shall be less than fck-4 (N/mm^2) and also the average of any group of three consecutive results shall not be less than fck+4 (N/mm^2).

(v) Failure to comply with Requirements

If any one result in a group of three consecutive results is less than fck-4 (N/mm^2), but the other results of group satisfy the strength requirement, then only the batch from which the failed result was obtained shall be deemed not to comply with the Specification.

If the average strength of the group is less than the strength requirement then all the batches between those represented by the first and the last result shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the production procedure or the mix design subject to the agreement of the Engineer to restore compliance with the Specification.

05 MIXING CONCRETE

Concrete for the works shall be batched and mixed in one or more plants or concrete mixer unless the Engineer agrees to some other arrangement. If concrete mixers are used, there shall be sufficient number of mixtures including stand by mixers.

Batching and mixing plants shall be complying with the requirements of IS 1791 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall comply with the requirements of IS 4925 and shall only be used with the prior approval of the Engineer. If the plant proposed by the Contractor does not fall within the scope of IS 1791 it shall have been tested in accordance with IS 4634 and shall have a mixing performance within

the limits of IS 1791. All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that the drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt shall be removed. Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter at least once per hour and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specifications, has been added to the mix, no further water shall be added, either during mixing or subsequently.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixers shall be cleaned out before changing to another type of cement.

06 TRANSPORTATION OF CONCRETE

The concrete shall be discharged from the mixer and transported to the works by means which shall prevent adulteration, segregation or loss of ingredients, and shall ensure that the concrete is of the required workability at the point and time of placing. The capacity of the means of transport shall not be less than the full volume of a batch.

The time elapsing between mixing transporting placing and compaction altogether of a batch of concrete shall not be longer than the initial setting time of the concrete. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the works.

07 PLACING OF CONCRETE

(1) Consent for Placing

Concrete shall not be placed until the Engineer's consent has been given in writing. The Contractor shall give the Engineer at least two full working day notice of his intention to place concrete.

(2) Preparation of Surface to Receive Concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out. Before deposition of further concrete they shall be clean, hard and sound and shall be wet but without any free-standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump or be removed by other suitable method which will prevent washing away the freshly deposited concrete or any of its constituents. Any under drain constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive prior coating of cement slurry or mortar. The mortar shall be kept ahead of the concrete. The mortar shall be placed into all parts of the excavated surface and shall not be less than 5 mm thick.

(3) Placing Procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 300 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be thinner than four times the maximum nominal size of aggregate. Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. In dry weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

08 COMPACTION OF CONCRETE

Concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded item, without displacing them. Care shall be taken at arises or other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees another method. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective and some extent of vibration is overlapped.

Vibration shall not be applied by way of reinforcement nor shall the vibrators be allowed to touch reinforcement, sheathing ducts or other embedded items.

09 CURING OF CONCRETE

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperatures differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but not less than seven days or until the concrete is covered by successive construction whichever is the shorter period. The curing process shall commence as soon as the concrete is hard enough to resist damage from the process. The Contractor shall keep the exposed surfaces continuously wet by means of water spray or by covering with water absorbent material which shall be kept wet. Water used for curing shall be of the same quality as that used for mixing.

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances.

10 PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes. Concrete placed in the works shall not be subjected to any loading including traffic until it has attained at least its characteristic strength as defined.

11 CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the Sections shall be deemed a construction joint. Where construction joints are shown in the Drawing, the Contractor shall form such joints in such positions. The location of joints which the Contractor requires to make for the purpose of construction shall be subject to the approval of the Engineer. Construction joints shall be in vertical or horizontal planes except in

sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawing requires a different arrangement.

12 REINFORCEMENT

(1) General

Reinforcement as plain bars and deformed bars and steel fabric shall comply with the following Indian Standards: IS 1786 for high strength deformed steel bars IS 432 mild steel and medium tensile steel bars All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit the company certification mark or other test certificate from the manufacturer acceptable to the Engineer.

All reinforcement not complying with the Specification shall be removed from site.

(2) Storage of Reinforcement

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. Reinforcement shall be stored at least 150mm above the ground on a clean area free of mud and dirt and sorted out according to category, quality and diameter.

(3) Bending Reinforcement

Unless otherwise shown on the Drawing, bending and cutting shall comply with IS 2502. The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawing.

(4) Fixing Reinforcement

All dirt, scale, loose rust, oil and other contaminants shall be removed before placing it in position. If the reinforcement is contaminated with concrete from previous operations, it shall be cleaned before concreting in that section.

Reinforcement shall be securely placed and fixed in position as shown in the Drawing or directed by the Engineer. Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer.

The Contractor shall ensure that reinforcement left exposed in the works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars or six times the bar diameter for high yield bars. Bars complying with IS 1786 or other high tensile bars shall not be bent after placing in the works.

13 CONCRETE FOR SECONDARY PURPOSES

(1) Non–structural Concrete

Non-structural concrete shall be used only for non structural purposes where shown on the Drawing or as directed by the Engineer. The weight of cement mixed with 0.3 cubic meters of combined aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by

volume. The maximum aggregate size shall be 40 mm nominal. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand towels or rammers or by mechanical vibration as approved by the Engineer.

(2) No Fines Concrete

No Fines concrete is intended for use where a porous concrete is required and shall only be used where shown on the Drawing or instructed by the Engineer. The mix shall consist of Ordinary Portland cement and aggregate complying with this Specification. The aggregate size shall be 40 mm to 10 mm only. The weight of cement mixed with 0.3 cubic meters of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

(3) Hand Mixed Concrete

Concrete for structural purposes shall not be mixed by hand. Where non structural concrete is required, hand mixing may be carried out subject to approval of the Engineer. For making hand mixed concrete, cement, sand and aggregate shall be batched separately by volume or by weight as applicable. Then cement and sand shall be mixed dry to uniform color. The aggregate shall be stacked in a proper shape upon which cement sand mix shall be spread and whole mix shall be turned up and down to have uniform mix of all ingredients.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.25 cubic meter shall be mixed at one time. During windy weather precautions shall be taken to prevent cement from being blown away in the process of gauging and mixing.

14 FORMWORK

(1) Scope and Definitions

This Clause covers the preparation, construction and removal of false work and formwork for concrete structures. It also covers the quality requirements for surface finish on formed and unformed surfaces.

The Contractor shall be responsible for designing and constructing false work and formwork so that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic,

(2) Construction of Formwork

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous in a regular pattern. All joints in formwork shall be water tight. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete. Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork shall also be tied down or otherwise secured against floating within the body of the concrete.

Supports for formwork may be bolted to previously placed concrete provided the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be close to the face of the concrete by less than 50mm. Formwork shall not be re-used after it has suffered damage which is sufficient to impair the finished surfaces of the concrete. Where circumstances prevent easy access within the form, temporary openings shall be provided through the formwork for cleaning and inspection.

Shear keys of the size and shape as indicated on the Drawing shall be provided in all construction joints. Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of formwork as specified in the Specifications in respect of surface finish, strength and rigidity.

(3) Preparation of Formwork

Before any reinforcement is placed into position within formwork, the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or low viscosity oil containing chemical agents **(form work oil)**. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discoloration of the concrete, air holes on the concrete surface, or retards the set of the concrete or affects the strength of concrete. Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs. If any movement noticed, the formwork shall be set right immediately.

(4) Removal of Formwork

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand any stresses safely to which it may thereby be subjected. Alternatively, formwork may be removed when the concrete has attained the strength set, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

After removal of the formwork, the date of casting of concrete shall be marked on the surface of related concrete by water proof paint/marker for estimation of curing time.

Table 4.0: Minimum Periods for Formwork Removal

Position of Formwork	Minimum period for temperatures over 10° C	Strength to be attained
Vertical or near vertical faces of mass concrete	24 hours	0.2 fck
Vertical or near vertical faces of reinforced walls, beams columns	48 hours	0.3 fck
Underside of arches beams and slabs (formwork only)	4 days	0.5 fck
Supports to underside of arches, beams and slabs	14 days	Fck
Arched linings in tunnels and underground works	24 hours	4 N/mm²

15 EARLY LOADING

No load shall be applied to any part of a structure until the specified curing period has expired, and thereafter loading shall be allowed after approval by the Engineer. The Engineer's decision shall be based on the type of load to be applied, the age of concrete, the magnitude of stress induced and the propping of the structure.

No structure shall be opened to traffic until test cubes have attained the specified minimum 28 days strength as defined in Clause.

16 PLUM CONCRETE

(1) General: This work shall be required to provide lining of drains and drainage structures or other works as shown on the Drawings or as specified by the Engineer.

(2) Materials: The grade of concrete shall be as shown on Drawings or as directed by the Engineer. The stone shall comply with the requirements of above Section.

(3) Composition: Composition of plum concrete shall be 60 to 70 percent of concrete and 30 to 40 % percent of stones by volume or as instructed by the Engineer. About 3% non-shrinking agent by weight of cement shall be added to concrete at the time of mixing.

(4) Mock-up: Prior to commencement of plum concrete the Contractor shall construct a plum concrete panel of approximately 2000 mm x 1000 mm for inspection and approval of the Engineer. The thickness of mock-up shall be according to use of plum concrete in designated work.

(5) Construction: The place to be filled up with the plum concrete shall be cleaned and chipped for adhesion with the concrete. Following completion of form work a layer of concrete minimum 100mm thick shall be laid upon which clean and moist stones shall be placed at a distance of min 100mm measured from face to face in any direction. The distance between the outer edge of the concrete mass and the nearest face of the stone to the edge shall not be less than 100 mm. Then another layer of concrete having thickness not less than 100mm measured from the top of the stone to the top surface of the layer shall be laid and compacted. In case the proportion of concrete to stones is to be changed, the clear space between stones shall be adjusted as directed by the Engineer.

After compaction, again stones shall be placed on the layer as described above and the process shall be continued until the top layer of the concrete is completed. The placing of stones shall be staggered both in horizontal and vertical directions.

(6) Tests and Standards of Acceptance: Stones shall be tested for water absorption test. The test results shall meet the requirements as specified in these Specifications.

17 MEASUREMENT

Concrete laid in place as specified in the Drawing or directed by the Engineer shall be measured in cubic meter separately for each class.

Chapter : 8

WOOD WORK

01 Dressed Timber Framing

Specified timber shall be used, and it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The scantling shall be planed smooth and accurate to the full dimensions, rebates, rounding, and mouldings as shown in the drawings made, before assembling. Patching or plugging of any kind shall not be permitted except as approved by Engineer.

Joints: Joints shall be mortise and tenon type, simple, neat and strong. Mortise and tenon joints shall fit in fully and accurately without wedging or filling. The joints shall be glued, framed, put

together and pinned with hard wood or bamboo pins not less than 10mm dia. after the frames are put together pressed in position by means of a press.

Surface Treatment: Woodwork shall not be painted, oiled or otherwise treated before the Engineer has approved it. All portions of timber abutting against masonry or concrete or embedded in ground shall be painted with approved wood primer or with boiling coal tar.

Gluing of Joints: The contact surfaces of mortise and tenon shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Engineer.

Fixing in Position: Before the frames are fixed in position these shall be inspected and approved by the Engineer. The frames shall be placed in proper position, and secured to walls or columns as the case may be, with metallic fastener, iron holdfasts or as directed by the Engineer. In case of doorframes without sills, the vertical members shall be embedded in the flooring to its full depth. The door frames without sills, while being placed in position, shall be suitably strutted and wedged in order to prevent warping during construction.

02 Traditional Cornices

The cornice at each floor level shall conform in all respects to the approved design and made as per the direction of the Engineer. Care must be taken to see that the dimensions, rounding and mouldings are uniform all along the length of the cornice, which must be to true line and level. Preservative shall be applied to the unexposed surfaces.

03 Undressed Timber Framing

The **specification**, **measurement** and **rates** for this work shall be same as for dressed wood works in frames except that the scantling need not be planed unless otherwise specified.

The work shall be carried out as per detailed drawing. A full truss size diagram shall first be drawn on a levelled platform. From this full size diagram, templates of all joints as for tenons, mortises, scarf etc shall be made for use in the fabrication. The template shall be made to correspond to each member and plate hole for screws and bolts shall be marked accurately. Specified timber shall be used and sawn truly straight and square in the directions of the grains. The scantlings shall be accurately planed smooth to the full dimensions and rebates, before the same are framed. Patching and plugging of any kind shall not be allowed. The Engineer at his discretion may allow a tolerance of up to +/-2 mm in the finished cross sectional dimensions.

Joints: Joints shall be simple, neat and strong. All mortise and tenon joints, mitred joints, scarf etc shall fit in fully and accurately without wedging or fillings. The joints shall be as per detailed drawings.

04 Pre-fabricated Board

Plywood gusset shall be fabricated accurate to the correct dimensions as per the requirement for a particular truss connection and without defects of any kind. Holes of correct size shall be drilled before inserting screws/bolts. Holes for bolts shall be uniform in diameter. The size as specified shall be measured with a steel tape and accurately fabricated as per template of each truss member.

05 Partition

Specified timber shall be used, and it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions, rebates, rounding, and mouldings as shown in the drawings made before assembly. Patching or plugging of any kind shall not be permitted except as provided. All members shall be straight without any warp or bow and shall have smooth, well-planed faces at right angles to each other. All plywood shall be as specified and shall be free from defects.

The size of frame and panels shall be as specified in the items and spacing of framing shall be as shown in the drawing. However, frame spacing in both horizontal and vertical direction shall not exceed 1.2m in each direction.

Joints: Joints shall be mortise and tenon type, simple, neat and strong. Mortise and tenon joints shall fit in fully and accurately without wedging or filling. The joints shall be glued, framed, put together and pinned with hard wood or bamboo pins not less than 10mm dia. after the frames are put together pressed in position by means of a press.

Surface Treatment: Woodwork shall not be painted, oiled or otherwise treated before the Engineer has approved it. All portions of timber abutting against masonry or concrete or embedded in ground shall be painted with approved wood primer or with boiling coal tar.

Gluing of Joints: The contact surfaces of mortise and tenon shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Engineer.

Fixing in position: Before the frames are fixed in position these shall be inspected and approved by the Engineer. The frames shall be placed in proper position, and secured to walls or columns as the case may be, with metallic fastener, iron hold fasts or as directed by the Engineer.

06 Shutters

The frames shall be wrought, framed and fixed in position as per detailed drawing and as directed by the Engineer. Specified timber shall be used, and it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions, rebates, rounding, and mouldings as shown in the drawings made before assembly. Patching or plugging of any kind shall not be permitted except as provided.

Paneling: Timber panels shall be preferably made of timber of larger width, the minimum thickness of panel being 16 mm. When made from more than one piece, the pieces shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels. The grains of timber shall run along the longer dimensions of these panels. No single panel shall exceed 0.5 sq.m in area. The panels shall be framed into grooves to the full depth of the groove leaving an air space of 1.5 mm and the faces shall be closely fitted to the sides of the grooves.

Joinery work: All pieces shall be accurately cut and planed smooth to the full dimensions without any patching or plugging of any kind. The thickness of styles and rails shall be as specified for the shutters.

Tolerance: The finished work with a tolerance of + 1 mm in thickness and +2 mm in width of styles and rails shall be accepted.

Gluing of joints: The contact surfaces of tenon and mortise joints shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Enginer. Shutters shall not be painted, oiled or otherwise treated, before these are fixed in position and passed by the Engineer. Mountings and glazing bars shall be stub- tenoned to the maximum depth, which the member would permit or to a depth of 25 mm whichever is less. Thickness of each tenon shall be approximately one third the finished thickness of the members and the width of each tenon shall nor exceed five times its thickness.

Beading: Timber, plywood, hard board and particle board panels shall be fixed only with grooves but additional beading may be provided either on one side or on both sides. In so far as glass and asbestos panels are concerned, beading shall always be provided without grooves. Where beading is provided without grooves, the beading shall be only on one side, the other side being supported by rebate from the styles. For external doors and windows beading shall be fixed on the outside.

Glazing: The glass shall conform to the specifications given under materials. The glass panes shall be so cut that they fit slightly loose in the frame. A thin layer of putty (prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil to the mixture to form a stiff paste) shall be drawn along the inner edge of the rebate for bedding the back of the glass pane. The glass pane shall then be put in position pressed home against the thin layer of putty and secured in rebate by new brads (small nails). The putty shall then be applied in the rebate uniformly sloping from the inner edge of the rebate, taking care to keep the putty a little within the inner edge of the rebate and surplus putty removed so that none of it may show through the glass from the inside. The putty so filled shall be levelled smooth and

finished in a straight line. When dried the putty shall be covered with a coat of paint of approved quality and shade to match finish of joining work.

Fittings: Details of fittings to be provided shall be as per the schedule of fittings supplied by the Engineer in each case. The cost of providing and fixing shutters shall include the cost of hinges and necessary screws for fixing the same. All other fittings shall be enumerated and paid for separately. Screws used for fittings shall be of the same metal and finish as the fittings. Fittings shall be fixed in proper positions as shown in the drawings or as directed by the Engineer. These shall be truly vertical or horizontal as the case may be screws shall be driven home with screwdriver and not hammered in. Recess shall be cut to the exact size and depth for countersinking of hinges. Where fittings are stipulated to be supplied by the department free of cost, screws for fixing the fittings shall be provided by the contractor and nothing extra will be paid for the same. Wooden cleats and blocks shall be fixed to doors and windows as directed by the Engineer. The size and shape of cleats and blocks shall be as approved by the Engineer.

Styles and Rails: The specification shall be as described above. The styles and rails shall be given a rebate to receive the wire gauze, which shall form the panels.

Wire gauze: This shall unless otherwise specified, be of galvanized MS wire of I.S gauze designation 85G with wire of diameter 0.56 mm. The wire gauze shall be bent at right angles in the rebates of styles and rails, turned back, and fixed tight with blue tacks at about 75 mm centre, fixed alternately in two faces of the rebates. Over this, wooden beading shall be fixed with brads or small screws at about 75 mm centres. The space between the beading and rebates, where the wire gauze is bent, shall be neatly finished with putty, so that the end of the wire gauze may not be visible.

Fittings, wooden cleats, Blocks and **Measurement** shall be as specified under item described above for fixing of doors & windows shutters.

Battens: Planks for battens shall be as specified in the item and of uniform width of 125 to 175 mm. These shall be planed and made smooth and provided with minimum 12 mm rebated joints. The joint shall be chamfered. The finished work with a tolerance of +/-1 mm in thickness and +/-2 mm in width of battens etc. shall be accepted.

Ledges and Braces: The battens shall be fixed together by 25/38 mm thick (as specified) ledges and braces on the inside face of the door shutter with minimum two numbers 50 mm long wood screws per batten. The ledges shall be 225 mm wide and braces of 175 mm wide for garage doors and 175 mm and 135 mm respectively for other doors unless otherwise specified. The braces shall incline down wards towards the side on which the door is hung. Edges and ends of ledges and braces shall be chamfered.

07 Windows Accessories

MS bars/grills shall be fixed as per detailed drawing or as directed by the Engineer.

Fixing: For fixing MS bars in wooden frames of window etc. through holes shall be drilled in one side of the frame and in the other side of the frame, holes shall be drilled 5 cm deep. The bars shall be passed into the frame from one side and these shall be of correct length to fit in at one end and to flush with outside of the frame at the other end. Where there are MS flats provided along with the bars, these shall be fixed at the ends to the wooden frame with wooden screws. Holes for passing MS bars shall be punched in the flats at proper position. The grills shall be fabricated as per design and fixed to the frame by round headed bolts and nuts in new work, and by wooden screws in old work.

08 Shelving & Cupboards

The planks for shelves shall be plan on all faces and edges. These shall be supported on tees or angle iron, which shall be built in the walls at least 15 cm deep in cement concrete 1:3:6 (1 cement: 3 coarse sand: 6 graded stone aggregate 20 mm nominal size). When the shelves are up to 30 cm width, the supports shall be spaced not more than 75 cm apart. When the shelves are wider, the spacing shall be suitably decreased, as directed by the Engineer. The shelves shall be grooved to rest squarely on the supports, to which these shall be fixed with iron wood screws from below. The finished work with a tolerance of +/- 1 mm in thickness and + 3 mm and - 2 mm in width may be allowed.

Measurement: Length and breadth shall be measured correct to 10 mm. The area shall be calculated in square metre nearest to two places of decimal.

Rate: Rate includes the cost of materials and labour required for all the operations described above.

Shelves: The number, size and thickness of the shelves shall be as specified. The planks for shelves shall be of specified timber and planed on all faces and edges. The shelves shall rest on wood supports, 25x25 mm, for their full depth. The wooden supports shall be fixed in the masonry by means of wooden plugs and screws, at suitable intervals. The shelves shall be fixed to the supports with wood screws of suitable size at 10 cm centre to centre. The shelves, when, fixed shall be truly horizontal.

Hanger rod: The hanger rod, as shown in the drawings, or as directed by the Engineer, shall be provided at the top of cupboard. The clear gap above the rod shall be not less than 8 cm. The rod shall be of single piece. The diameter of wooden rod shall be 25 mm. The end support shall consist of wooden brackets of specified timber and shall be fixed to the side masonry of the cupboard with suitable plugs and screws.

Fittings: Two iron tower bolts of 200 mm size (one for inside and one on outside) and one 100 mm iron hasp and staple shall be provided.

Finishing: All woodwork shall be painted or polished as directed by the Engineer. After fixing the plugs for supports, the plaster should be neatly repaired with cement mortar 1:4 (1 cement: 4 sand). The inside plaster portion shall be finished with two coats of oil bound distemper or flat wall paint of approved colour, as directed.

09 Railing

The work shall be done as per standard design or as directed by the Engineer. The planing, joinery and tolerance shall be as specified for item under doors & windows frame. The height of railing shall be measured from out to out of top and bottom rails.

10 Pelmets

Sides, front and top of the pelmets shall be of 12mm planks or boards of specified width unless otherwise stated. These shall be projected from the wall face by 15 cm or as specified, and shall be securely fixed to walls with wood screws by means of wooden plugs and 10 cm long 25 x 3 mm MS flat bent in the form of angle or by any other device approved by the Engineer. The pelmets shall be provided with curtain rods and brackets. Intermediate wooden bracket shall be provided, if the front length of pelmets exceed 1.5 metres.

11 Frame Hold Fast

These shall be made from mild steel flat iron of specified size. Five cm length at one end of the hold fast shall be bent at right angles and one hole of 11 mm diameter shall be made in it for fixing to the frame with 10 mm diameter bolt. The bolt head shall be sunk into the frame and covered with wooden plug 10 mm long. At the other end, the hold fast shall be forked and bent at right angles in opposite directions and fixed in cement concrete block of specified size.

12 Timber Carving

Preparation of surface: Wooden Surface: The woodwork to be carved shall be dry and free from

moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sandpaper and shall be well dusted. Knots, if any shall be avoided within the area of carving.

Classification: Traditional Bhutanese timber carvings are classified into three categories namely rab, ding and thama. Bill of quantities shall be based on these three categories unless stated otherwise.

Usually timber carving is carried out in the following members unless stated by the client:

1. **Cornices:** Boh, Pem, Pedhen and Dung are the elements of cornice for carving.
2. **Rabsey:** Zhurkha/Zeko, Thangcho, gochu Zing, Kachung. Zhutse, Zhu langtho and Drar are the important elements of carving in Rabsey.
3. **Kachen:** Chang Khep, Geb Dezhu, Kachen Pem, Thangwa and Reb, Kachen zhing, Zhungtshe and Ghenchu are the elements in Kachen for carving.
4. **Zhathri:** Norbu- to , Pem, Zhuden, Tshe gey, Zhutshe and Tazee ar eteh elements of carving in railing, etc.
5. Tashi Dagey and other auspicious symbols, etc.

Drawing Chapa: Adjust the paper to the surface to be carved, draw the design on the paper, and prick the lines of design by a pin. Place the paper back to the surface to be carved and rub the powder soaked cloth on the design paper. When the paper is withdrawn, powder marks are left on the surface which is to be carved for specified carving. This process is continued for carving the required surface.

Physical Checking: Physical checking shall be carried out on the quality of carving. The following steps shall be used as thumb rule to check the quality of the completed works:

1. Measure the depth of the carving and compare with the specified carving depth.
2. Check for any loosely attached or broken piece of timber.
3. Check the location of the carving and proportioning with the timber member.

Applicability: Generally, the following types of carving shall be applicable against the type of structures specified unless otherwise directed and approved by the engineer.

Rab: Rab carving shall be used in office, dzong and other important places.

Ding: Ding carving shall be used in institutional buildings such as school, hospital, etc.

Thamar; Thamar carving shall be used in residential, staff quarter, and other similar buildings.

Chapter :9

STEEL & OTHER METAL WORK

01 Single Section

Fabrication: The steel sections shall be straightened and cut square or otherwise as required to correct lengths, measurement being done with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member. All straightening and shaping to form shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal.

Holing: The locations of the holes shall be carefully marked by measuring with steel tape and holes drilled. Finished holes shall be not more than 1.5 mm (in case of rivets/bolts passing through them being dia. 25 mm or less) or 2.0 mm (in case of rivet/bolts dia. being more than 25 mm). Holes may be punched if permitted by the Engineer. Gas cutting shall not be used to form the holes unless otherwise specified as gas cutting diminish the strength of the metal.

Painting: All surfaces, which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and rust. Surface not in contact but inaccessible

after shop assembly, shall receive the full-specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections. Parts to be encased in concrete shall not be painted or oiled.

Erection: Steelwork shall be hoisted and placed in position carefully without any damage to itself and other building work and injury to workmen. Where necessary mechanical appliance such as lifting tackles, winch etc. shall be used. The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of Engineer.

02 Built-up Section

Laying Out: Steel structure shall be laid out on a level platform to full scale. This may be done to full size or in parts, as shown on drawings or as directed by the Engineer. A steel tape shall be used for measurements.

Fabrication: Fabrication shall generally be done as specified below or as specified by the Engineer in special cases having complicated structures.

Straightening, Shaping to Form and Cutting: The steel sections as specified or required, shall be straightened and cut, square or otherwise as required and to correct lengths, and measurement being done with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member. All straightening and shaping to form shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal. In major work or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details of rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer. The drawings shall indicate the shop and field rivets bolts and welds.

Making Holes: Holes through more than one thickness of material for members, such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall be not greater than 16 mm.

Rivet holes: The diameter for rivets and black bolts holes shall be taken as the nominal diameter of a rivet plus 1.5 mm for rivets of nominal diameter less than or equal to 25 mm, and 2.0 mm for rivets of nominal diameter exceeding 25 mm, unless specified otherwise. Holes for turned and fitted bolts shall be drilled or reamed large by 0.2 to 8 mm depending upon the dia. of bolts.

Holes for rivets and bolts shall not be formed by gas cutting process. Holes for counter-sunk bolts shall be made in such a manner that their heads sit flush with the surface after fixing.

Assembly: Before making holes in individual members, for fabrication the steel work intended to be riveted or bolted together shall be assembled and clamped properly and tightly so as to ensure close abutting, or lapping of the surfaces of the different members. All stiffeners shall bear tightly both at top and bottom without being drawn or caulked. The abutting joints shall be cut or dressed true and straight, and fitted close together. Web plates of girders, which have no cover plates, shall have their ends flush with the tops of angles unless otherwise required. The web plates, when spliced, shall have clearance of not more than 5 mm.

Bolting: The nominal length of the bolt shall be the distance from the underside of the head to the further end of the shank. The nominal diameter of the bolt shall be the diameter at the shank above the screwed threads. Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil, before use. All bolts heads and nuts shall be hexagonal unless specified otherwise. The screwed threads shall conform to IS:1363 and the threaded surface shall not be tapered.

Erection: Steelwork shall be hoisted and erected in position carefully, without any damage to itself, other structure and equipment and injury to workmen. The method of hoisting and erection, proposed to be adopted by the contractor, shall be got approved from the Engineer.

03 Doors/Windows (Aluminum)

All Aluminum sections for doors, windows, ventilators, partitions and false ceiling shall be of specified sections and anodized to international standards. Windows and ventilators shall be fully weather sealed using high quality weather seals/strips to reduce ingress of air and water as well as the escape of interior atmosphere. All glass panes shall be 4 mm thick or as mentioned on drawings, clear transparent sheet glass. All such glazing shall be firmly secured with matching aluminum glazing beads and gaskets of PVC (ethylene-propylene).

Fixing of frame: Outer frames will be provided with fixing holes centrally in the web. The frame shall be fixed to the wall or other base by using the screws and lugs. Any steel lug coming in contact with aluminium shall be either galvanised or given one coat of bituminous paint.

04 Doors/Windows (Steel)

The windows, ventilators etc shall of the specified type viz. fixed, centre hung, top hung, bottom hung composite etc. The steel shall be of ST 32-0 grade conforming IS 1977. The doors, windows and ventilators shall be of approved make and manufacture to IS 1038. Steel doors and windows shall be so stacked as to keep them in time slope and without damage. They shall be fixed as follows:

Openings may be flush or rebated as shown in the drawings. Where openings are flush a clearance of 1.25 cm shall be provided between the steel frame and opening. In case of rebated jambs a minimum 1.25 cm clearance between frame and opening shall be provided.

Fixing in Masonry With lugs: Doors, windows and ventilator openings will be left out and frames filled afterwards so that minimum specified clearance between opening and frame is left all round. The position of the particular unit (door, window or ventilator) and fixing holes shall be marked on the joint. Necessary holes shall be made in the masonry and lugs not less than 10 cm long 15 x 3 mm size fixed in cement concrete blocks 15 x 10 x 10 cm size of 1:3:6 mix with 20 mm stone aggregate. The frame units shall be set in the opening by using wooden wedges at the jamb, head and sill (the wedges being preferably placed at glazing bar-frame junctions) and the frames plumbed in position. The oozing mastic shall be cleaned and flush pointed. The internal gap shall be filled with mastic to about 1/3 depth and the rest with cement mortar.

Fixing with screws and plugs: In R.C.C. work where lugs cannot be embedded, rawl plugs or other approved metallic fasteners may be fixed in proper position and frames fixed to them with 60 mm galvanised wood screws.

Glazing: Ordinary glazing panes of not less than 3 mm thick shall be provided. The panes shall be so cut that they fit slightly loose in the frames. Glazing shall be provided on the outside of the frame unless otherwise specified. Special metal sash putty of approved make (IS 420 or equivalent) shall be used for fixing the panes. Putty shall be applied between the glass panes and the glazing bars. Putty shall then be applied over the glass pane which shall stop 2 to 3 mm from the right side of the back rebate to enable the painting to be done up to the sight line to seal the edge of the putty to the glass. The oozed out back putty shall be cleaned and front putty cut to straight line. Quantity of putty shall not be less than 185 gm/metre of glass perimeter

05 Steel Fasteners

The holding down bolts shall be placed in the concrete foundation. These should be held in position with a wooden template. The bolts shall be provided with a suitable timber mould or pipe sheeve to allow for adjustment. The timber mould or pipe shall be removed after initial set

of concrete. The spaces left around holding down bolts shall have sloping channel leading to the side of the pedestal and on the underside of the base plate to allow the spaces being grouted up after the base plate is fixed in the position along with the column.

Fabrication: The steel sections as specified of required, shall be straightened and cut, square and to correct lengths and measured with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member. All straightening and shaping to form shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of metal. The holes of required diameter shall be done with drilling machine.

Painting: All surfaces, which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust. Surfaces to be encased in concrete shall not be painted or oiled.

Chapter :10

FLOORING

01 Brick Flooring

Bricks as specified shall be used. Broken bricks shall not be used in flooring except for closing the line. The bricks shall be laid on edge.

Mortar: The mortar used shall be as specified. In case of dry brick flooring fine sand shall be filled in the joints.

Sub-Grade: Flooring shall be laid on concrete sub-grade, where so provided. The sub-grade shall be provided with the slope required for the flooring. Floors in verandas, kitchens, baths, water closets and court-yards shall invariably be provided with suitable slopes to drain off washing and rain water. Plinth masonry off-set shall be depressed so as to allow the sub-grade concrete to rest on it. If the sub-grade consists of lime concrete, it shall be allowed to set for seven days, and the flooring shall be laid in the next three days. If the sub-grade is of lean cement concrete, the flooring shall commence within 48 hours of the laying of sub-grade failing which, the surface of sub-grade shall be roughened with steel wire brushes without disturbing the concrete. Before laying the flooring the sub-grade shall be wetted and smeared with a coat of cement slurry at 2kg of cement spread over an area of one sq.m so as to get a good bond between sub-grade and flooring. Where sub-grade is not provided, the earth below shall be properly sloped, watered,

rammed and consolidated.

Soaking of Bricks: Bricks required for flooring shall be adequately soaked in stacks before use, by profusely spraying with clean water at regular intervals for a period of not less than six hours so as to keep them wet to the satisfaction of the Engineer. In case the joints are to be filled with sand, the bricks need be soaked.

Laying: The bricks shall be laid on edge in plain, diagonal herring-bone bond, or other pattern as specified or directed by the Engineer. Bricks shall be laid on edge on 12 mm thick mortar bed, and each brick shall be properly bedded and set home by gentle tapping with handle of the trowel or wooden mallet. Its inside faces shall be buttered with mortar, before the next brick is laid and pressed against it. On completion of a portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface of the flooring during laying shall be frequently checked with a straight edge at least 2 m long so as to obtain a true plane surface with the required slope.

Joints: Brick shall be so laid that all joints are full of mortar. The thickness of joints shall not exceed 1.0 cm for brickwork with bricks of any class designation. All face joints shall be raked to a minimum depth of 15 mm by raking tool during the progress of work when the mortar is still green so as to provide proper key for the plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying.

Curing: Brick work shall be protected from rain by suitable covering when the mortar is green. Masonry work in cement mortar shall be kept constantly moist for a minimum period of seven days. Brickwork carried out during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

02 Concrete Flooring

Cement concrete: Cement concrete of specified mix shall be used. The concrete shall conform to specifications given under the head "**Concrete work**".

Sub-grade: Flooring shall be laid on concrete sub-grade where so provided. The sub-grade shall be provided with the slopes required for the flooring. Flooring in veranda, kitchens, baths, water closets and courtyards shall invariably be provided with suitable slope to drain off washing and rain water. Plinth masonry off-set shall be depressed so as to allow the sub-grade concrete to rest on it. If the sub-grade consists of lime concrete, it shall be allowed to set for seven days and the flooring shall be laid in the next three days. If the sub-grade is of lean cement concrete, the flooring shall be commenced preferably within 48 hours of the laying of sub-grade.

If the cement concrete flooring is to be laid directly on the R.C.C. slab, the surface of R.C.C. slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg of cement per sq.m shall be applied, so as to get a good bond between R.C.C. slab and concrete floor.

Laying: Flooring of specified thickness shall be laid in the pattern as given in the drawings or as directed by the Engineer. The border shall have mitred joints at the corners of the room and intermediate joints shall be in straight line with the panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sq.m.

Laying with strips: Normally cement concrete flooring shall be laid in one operation using glass/plain asbestos sheet strips at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels.

Strips fixing: Aluminium strips, Glass strips or plain asbestos sheet/strips shall be fixed with their top at proper level, giving required slopes.

Concreting: Cement concrete shall be placed in position, in one operation, in the panels. It shall then be levelled with the help of straight edge and trowel and beaten with a wooden rammer or mason's trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light but rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with cream of mortar. The surface shall be tested with straight edge and made true to required slopes.

Laying without Strips: Laying of cement concrete flooring in alternate panels may be allowed by Engineer in case strips are not to be provided.

Shuttering: The panels shall be bounded by wooden/angle iron battens. The battens shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level, giving required slopes. The surface of the battens or flats, to come in contact with concrete, shall be smeared with soap solution or non-sticking oil (form oil or raw linseed oil) before concreting. The flooring shall butt against the masonry wall, which shall not be plastered.

Concreting: The concreting shall be done in the alternate panels. The battens used for shuttering shall be removed on the next day of the laying of cement concrete. The ends thus exposed shall be repaired, if damaged, with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar droppings etc. and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over them.

Finishing: The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it. Excessive trowelling shall be avoided. Use of dry cement or cement and sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture, shall not be permitted.

Curing: The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty cement gunnies shall be avoided, as the colour is likely to be bleached with the remnants of cement matter from the bags.

03 Red Oxide Flooring

Cement concrete of specified mix shall be used and it shall conform to the specification given under section "Concrete Work".

Under layer: The under layer shall be of the concrete grade specified and shall be laid as specified for concrete flooring above except that:

a) The wooden batten/angle iron shuttering shall be to the full depth of the flooring i.e. under layer + top layer

b) The under layer shall left roughened with 2 mm deep diagonal cuts.

c) The shuttering shall only be removed 24 hours after the top layer has been laid.

Top layer: This shall consist of uniform and smooth layer of plaster of specified thickness and of mix 1:3 (1 cement: 3 sand) finished with a coat of neat cement. In both plaster and floating coat 3.5 kg of red oxide of approved quality shall be mixed with every 50 kg of cement. This ratio may be adjusted to get the tinge ordered by the Engineer. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour.

Laying: The top layer shall be laid the following day after the under layer has been laid. The plaster shall be done to a uniform thickness of 10 mm and finished smooth with cement slurry (2 kg of cement - red oxide mix- mixed in the ratio used per square metre of flooring). The surface shall then be brought to a fine polish by using polishing stones. In laying alternate panels and coloured plaster on top, care shall be taken that the concrete and coloured matter droppings do not disfigure the coloured topping previously finished.

Thickness: Thickness of under layer shall be as specified correct to 1 mm. The thickness of top layer shall not be less than specified.

Curing: The curing shall be done for a minimum of ten days commencing after hardening of the

top layer.

04 Surface Hardening

Wherever floors are required to withstand heavy wear and tear, 12 mm thick metallic hardener topping shall be used.

Metallic hardening compound: The compound shall be of approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease, sand, a soluble alkaline compound.

Under layer: Cement concrete flooring of specified thickness and mix shall be laid as under layer. The top surface shall be roughened with brushes while the concrete is still green and the form shall be kept projecting up 12mm over the concrete surface to receive the metal hardening compound topping.

Top layer: This shall consist of 12mm thick layer of mix 1:2 *(1 cement hardener mix: 2 stone aggregate, 6mm)* by volume with which metallic hardening compound is mixed in the ratio 1:4 (1 metallic hardener: 4 cement). The concrete hardener shall be dry mixed thoroughly with cement on a clean and dry platform. This dry mixture shall be mixed with 6mm aggregate in the ratio 1:2 (1 cement hardener mix: 2 stone aggregate, 6mm) by volume and add just enough water to make the concrete.

The specification for curing**, precautions, measurements** and rates shall be same as for cement concrete floor.

05 Terrazzo-Marble Chips Flooring

The thickness of the under layer shall be measured correct to a mm. The thickness of the top layer shall not be less than that specified.

Under layer: Cement concrete of specified mix shall be used and the specifications given under cement concrete work shall apply. The panels shall be of uniform size, not exceeding 2 sq.m in area and 2 m in length in inside situations. In exposed situations the length of any side of the panel shall not be more than 1.2 metres. Cement slurry @ 2.00 kg per sq.m shall be applied before laying of under layer over the cement concrete/R.C.C. surface.

Strip fixing: 4 mm glass strips or 2 mm aluminium strips shall be fixed with their top at proper level, giving slopes.

Top Layer: The mix for terrazzo topping shall consist of cement with or without pigment, marble powder, marble aggregate (marble chips) and water. The cement and marble powder shall be mixed in the proportion of 3 parts of cement to one part marble powder by weight.

The marble chips shall be hard, sound, dense and homogeneous in structure with crystalline and coarse grains. They shall be uniform in colour and free from stains cracks decay and weathering. Before starting the work, the contractor shall get the sample of marble chips approved by the Engineer. The cement to be used shall be ordinary grey cement or white cement, or cement with admixture of colouring matter of approved quality in the ratio specified in the description of the item or in the ratio to get the required shade as ordered by the Engineer. Colouring matter where specified, will be mixed dry thoroughly with the cement and marble powder and then marble chips added and mixed as specified above water to make it workable.

Polishing, Curing and Finishing: Polishing shall be done by machine. About 36 hours after laying the top layer, the surface shall be watered and ground evenly with machine fitted with special rapid cutting grit block (carborundum stone) of coarse grade (No.60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of cement or/and colouring matter in same mix and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then ground with machine fitted with fine grit blocks (No.120). The surface is cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with machine fitted with fine grade grit blocks (No.320) to get even and

smooth surface without pinholes. The finished surface should show the marble chips evenly exposed.

Where use of machine for polishing is not feasible or possible rubbing and polishing shall be done by hand, the same manner as specified for machine polishing except that carborundum stone of coarse grade (No.60) shall be used for the 1st rubbing, stone of medium grade (No.80) for second rubbing and stone of fine grade (No.120) for final rubbing and polishing. After final polish oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre sprinkled with water and rubbed hard with a pad of Woollen rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

Curing: Curing shall be done by suitable means such as laying moist sawdust or ponding water.

06 Skirting

A band of plaster at the bottom of wall not exceeding 30 cm in height above the floor shall be classified as skirting. It shall be flush with wall plaster or projecting out uniformly from the wall plaster, as specified. The work shall be preferably carried out simultaneous with the laying of floor. Its corner and junctions with floor shall be finished neatly as specified.

Thickness: The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e. grooves or open joints in brickwork. The average thickness shall not be less than the specified thickness. The average thickness should be regulated at the time of plastering by keeping suitable thickness "gauges". Extra thickness required in daubing behind rounding of corners at junctions of wall shall be ignored.

Preparation of wall surface: The joints shall be raked out to a depth of at least 15 mm in masonry walls, while the masonry is being laid. In case of concrete walls the surface shall be roughened by hacking. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

Finishing: The finishing of surface shall be done simultaneously with the borders of the adjacent panels of floor. The cement to be applied in the form of slurry for smooth finishing shall be at the rate of 2 kg of cement per litre of water applied over an area of 1 sq.m. Where skirting is flush with plaster a groove 10 mm wide and upto 5 mm deep shall be provided in the plaster at the junction of skirting with plaster.

Curing: Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently. It shall be continued for a minimum period of 7 days.

07 Marble/Kota Stone Flooring

The thickness of the slab shall be as specified in the item. Tolerance of +/- 2 mm shall be allowed in the thickness.

Laying: Sub-grade concrete or the R.C.C slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 sand) as given in the item. The average thickness of the bedding mortar under the slab shall be 20 mm.

The slab shall be laid as follows: Mortar shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with a wooden mallet and brought to level with the adjoining slabs

Polishing and finishing: Slight unevenness at the meeting edges of the slabs shall then be removed by fine chiselling. The surface, after curing for seven days shall be ground evenly with machine fitted with coarse grade grit blocks (No.60) water shall be used profusely while grinding. It shall then be thoroughly washed to remove all grinding mud cleaned and mopped. The surface shall be cured again. The second grinding shall then be carried out with machine fitted with fine grade grit blocks (No.120).

08 Timber Flooring

Supporting Joists: Main beams and joists of the class of wood and sections specified in the description of the item for beams and joists, or as instructed by the Engineer shall be fixed to position to dead levels. The width of the joists shall not be less than 50 mm. The arrangement and spacing of beams, joists, etc. shall be as per design furnished. The beams, joists etc shall be painted or treated with wood preservative as directed by the Engineer.

Boards: It shall be of the class of timber and thickness specified in the description of the item. Only selected boards of uniform width shall be used. Unless otherwise specified or shown in the drawings, the width of boards selected shall not be less than 100 mm nor more than 150 mm. The same width of boards shall be maintained throughout except where the width of the room is not an exact multiple of the width of boards. In the latter case the difference shall be equally adjusted between the two end boards (adjacent to walls). The length of the boards shall not exceed three metres anywhere. Ordinarily the minimum length of boards shall be such that the boards shall rest at least on three supports, except where otherwise required by the pattern specified in the drawings or as directed by the Engineer.

In case of timber plank: The boards shall be planed true on the top face only unless otherwise specified in the description of the item. Where the bottom face is exposed and it is also required to be planed, then such planing shall be paid for extra. The longitudinal joints of planks shall be tongued and grooved to a minimum depth of 12 mm or half lapped for 12 mm width while the heading joints shall be of the square butt type and shall occur over the centre line of the supporting joints. Heading joints in adjacent boards shall not be placed over the same joists.

Iron Screws: Iron screws shall be of the slotted counter-sunk head type, of length not less than the thickness of planks plus 25 mm subject to a minimum of 40 mm, and of designation No. 9 conforming to IS: 451.

Fixing: The joints on which the planks shall be fixed shall be checked and corrected to levels. The end boards shall be accurately fixed with the sides parallel and close to the walls. Each adjoining board shall be carefully jointed and shall be tightened in position and fixed with screws. The flooring shall be truly level and plane. The joints shall be truly parallel and or perpendicular to the walls, unless otherwise specified. The floor shall be planed in both directions and made perfectly even, true and smooth.

Finishing: The surface of the floor shall be bees waxed or finished otherwise as directed by the Engineer. The lower face shall be painted or treated with wood preservative as directed. The finishing shall be paid for separately.

09 Linoleum Flooring

The vinyl tile shall of a make, manufacture colour and pattern as approved by the Engineer. The adhesive to be used shall also be got approved. Care shall be exercised in laying the vinyl tile floor and the work shall be done by skilled and experienced tile layers. The sub-floor concrete shall be finished smooth and to the proper level. It shall be allowed to dry thoroughly. This may take 4 to 8 weeks, but it is essential to have a dry floor.

Bitumen is applied on the dry sub-floor in two coats at the rate of 1.5 kg/sq.m each coat. Over this bitumen layer the base concrete of the specified proportion is laid to a thickness of 25 mm and finished smooth and level, cured for 7 days. This base shall be perfectly dry and even before any laying work is started. After the base is dry, the tile layout shall be finalised and guidelines marked on the base. It is preferable to avoid laying of tiles under high humidity conditions.

The adhesive shall be applied by using a notched travel to the base as well as to the back of the tiles. In approximately half an hour, by which time the adhesive will be tacky to touch but will not mark the fingers, the tiles will be ready for laying. (The adhesive should not be left for setting too long as the properties may be lost due to dust and other causes).

Chapter :11

TILING - WALL & FLOOR

01 Glazed Tiles

Preparation of surfaces: The joints shall be raked out to a depth of at least 15 mm in masonry walls, while the masonry is being laid. In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned, thoroughly washed with water and kept wet before skirting is commenced.

Laying: 12 mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonally at close intervals. The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and correct to proper plane and lines. The tiles shall be set in the required pattern and butt jointed. The joints shall be as fine as possible.

Curing and Finishing: The joints shall be cleaned off the grey cement grout with wire brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement with pigments added if required to match the colour of tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

Preparation of surface and laying: Sub-grade concrete or the R.C.C. slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:3 (1 cement: 3 coarse sand). The average thickness of bedding shall be 12mm under any portion of the tiles.

Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank

across and squat on it. Over this mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

Pointing and finishing: The joints shall be cleaned off the grey cement grout with wire brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement with pigment added if required to match the colour of tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

Chapter :12

ROOFING

01 CGI sheet /Pre-painted Galvanized Iron Sheet

PPGI sheets shall be of the thickness specified, in the item. The sheets shall conform to IS:801 1975 in all respects.

Purlins: Wooden purlins of the specified wood or MS rolled sections of requisite size shall be fixed over the principle rafters. Maximum spacing of purlins shall not exceed 1.60 meter. The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top. Embedded portions of wooden purlins shall be coal tarred with two coats.

Slope: Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal.

Laying and fixing: The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer. The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

The sheets shall be laid with a minimum lap of 20 cm at the ends and two ridges of corrugation at each side. The above end lap of 20 cm shall apply to slopes of 1 vertical to 3 horizontal and flatter slopes. For steeper slopes the minimum permissible end lap shall be 15 cm. The minimum lap of sheets with ridge hips and valleys shall be 20 cm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shape of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge and chisel to give a smooth and straight finish.

Lapping in PPGI sheet shall be painted with a coat of approved steel primer and two coats of painting with approved paint for steelwork before fixing in place. Sheets shall not generally be built

into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at-least 7.5 cm. The laying operation shall include all scaffolding work involved.

Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with galvanised J or L hook bolts and nuts, 8 mm diameter, with bitumen and G.I. limpet washers or with a limpet washer filled with white lead as directed by the Engineer. The length of the hook bolt shall be varied to suit the particular requirements. The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins.

Wind Ties: Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eaves ends of the sheets. The fixing shall be done with the same hook bolts, which secure the sheets to the purlins.

02 Ridges and Hips

Ridges and hips of PPGI roofs shall be covered with ridge and hip sections of plain G.I. sheet with a minimum lap of 20.0 cm on either side over the PPGI sheets. The end laps of the ridges and hips, and between ridges and hips shall also be not less than 20.0 cm. The ridges and hips shall be of 60 cm overall width plain G.I. sheets and shall be properly bent to shape.

Fixing: Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins. Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible extra hook bolts shall be provided. The end laps of ridges and hips shall be joined together by galvanised iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or as directed by the Engineer. There shall be at least two such bolts in each end lap.

Finish: The edges of the ridges and hips shall be straight from end to end and their surfaces should be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

03 Gutters

Gutters shall be fabricated from plain G.I. sheets 24g. The overall width of the sheet referred to shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12 mm and beaten to form a rounded edge. The ends of the sheets at junctions of pieces shall be hooked into each other and beaten flush to avoid leakage.

Slope: Gutters shall be laid with a minimum slope of 1 in 120.

Laying and fixing: Gutters shall be supported on and fixed to M.S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 meters. Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bent to shape and fixed rigidly to the sides of rafters with 3 Nos. 10 mm dia bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be at 12cm centres.

Where the brackets are to be fixed to the purlins, the brackets shall consist of 40 x 3 mm M.S. flat

iron bent to shape, with one end turned at right angle and fixed to the purlin-face with a 10 mm dia. bolt, nut and washer. The perpendicular over hung portion of the 40 x 3 mm flat bent to right angle shape with its longer leg connected to the bracket with 2 Nos. 6 mm dia M.S. bolts, nuts and washers and its shorter leg shall be fixed to face of purlin with 1 No. 10 mm dia, bolt, nut and washer. The gutters shall be fixed to the brackets with 2 Nos. G.I. bolts and nuts 6 mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of G.I. sheet of the same thickness as the gutter and riveted to the gutter, the other end tailing into the socket of the rain-water pipe. Wherever necessary stop ends, angles, etc. should be provided.

Finish: The gutters when fixed shall be true to line and slope and shall be leak proof.

04 Wind Bracing

Wind ties shall be of 40 x 6 mm flat iron section. These shall be fixed at the eave end of the sheets. The fixing shall be done with same hook bolts, which secure the sheets to the purlin.

Chapter : 13

PLUMBING - INDOOR WORK

01 Water Supply (General)

General Requirements: All water supply installation work shall be carried out through skilled plumbers. It is most important that a wholesome water supply provided for drinking and culinary purposes shall not be liable to contamination from any less satisfactory water.

No piping shall be laid or fixed so as to pass into, through or adjoining any sewer, scour outlet or drain or any manhole connected therewith nor through any ash-pit or manure-pit or any material of such nature that would be likely to cause undue deterioration of the pipe. Where the laying of any pipe through fouled soil or pervious material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means. Any piping or fitting laid or fixed, which does not comply with the above requirements, shall be removed and re-laid in conformity with the above requirements.

02 Pipe works

For internal work, the pipes and fittings shall run on the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc., provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes may be buried for short distances provided adequate protection is given against damage and where so required joints are not buried. Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through a wall or floor for reception of the pipe and to allow freedom for expansion and contraction and other movements. In case the pipe is embedded in walls or floor it should be painted with anticorrosive bitumastic paint of approved quality.

Cutting and Threading: Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded with pipe dies and taps in such a manner as not to result in slackness of joints when the two pieces are screwed together. The taps and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads so as to make them slack as the later procedure may not result in a water tight joint. The screw threads of pipes and fittings shall be protected from damage until they are fitted.

Jointing: The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of pipes shall be oiled and rubbed with a white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc, with pipe wrench. Care shall be taken that all pipes and fittings are kept at all times free from dust and dirt during fixing. Burn from joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shape and size as to fit tightly on the pipes when tightened with screw bolts. The clamps shall be embedded in brickwork in cement mortar 1:3 (1 cement: 3 coarse sand.

Testing the joints: After laying and jointing the pipes and fittings shall be inspected under working conditions of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock and water hammer. The draw off taps and stopcocks shall then be closed and hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped the test pressure should be maintained without loss for at least half an hour. The pipes and fittings shall be tested in section as the work of laying proceeds, keeping the joints exposed for inspection during the testing.

03 STORAGE TANK

The tanks shall be made from best quality M.S sheet of thickness specified above. The sheets shall be welded to form a tank as per standard welding practice.

The tanks shall have net capacity as specified. The various sizes of tanks with their net capacities are given below.

Net Capacity of tank	**Size of tank.**
270 litres	90x60x60 cm.
810 litres	120 x 90 x 90 cm.
1620 litres	120 x 120 x 120 cm.

Fittings: Each tank shall be provided with 40 mm dia G.I scour pipe, which shall terminate into a socket and a plug, 25 mm G.I over flow pipe with fittings and brass mosquito proof coupling conforming to the municipal design and approved by the Engineer and ball valve with copper or plastic float of specified size and pressure. The ball valve shall be securely fixed to the tank independent of the inlet pipe and set in such a position that body of the ball valve cannot become submerged when the tank is full upto waterline. Each tank shall be provided with 40 cm dia standard mosquito proof C.I hinged cover weighing 8.15 kg and frame weighing 6.80 kg with locking

arrangements.

04 Sanitation (General)

General Requirements for Installation:

The work shall be carried out, complying in all respects with the requirements of relevant byelaws of the local body in whose jurisdiction the work is situated. Any damage caused to the building or to electric, sanitary water supply or other installations etc therein either due to negligence on the part of the contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the contractor. Nothing extra shall be paid for it except where otherwise specified.

In all the above operations the damaged portion shall be cut in regular geometric shape and cleaned before making good the same. All exposed G.I., C.I. or lead pipes and fittings shall be painted with approved quality of paint and shade as specified.

05 Pans & Cisterns

Flushing Cistern: The cistern shall be fixed on C.I. cantilever brackets, which shall be firmly embedded in the wall in cement concrete (1:2:4) block 100x75x150 mm. The cistern shall be provided with 20mm nominal bore overflow pipe. The outlet or flush pipe from the cistern shall be connected to the pan by means of cement or putty joint. The flush pipe shall be fixed to wall by using holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolts.

Painting: The cistern, brackets, overflow and flush pipe etc. shall be painted with two or more coats of paint of approved shade and quality.

Squatting pan: The pan shall be sunk into the floor and embedded in a cushion of average 15 cm thick cement concrete 1:5:10 (1 cement: 5 fine sand: 10 graded brick ballast 40 mm nominal size). The concrete shall be left 115 mm below the top level of the pan so as to allow flooring and its bed concrete. The pan shall be provided with a 100 mm S.C.I. (H.C.I.),'P' or 'S' type trap with an approximately 50mm seal and 50 mm dia. vent horn, where required by the Engineer. The joint between the pan and the trap shall be made leak proof with cement mortar 1:1 (1cement: 1 sand). Cost of concrete shall be paid separately.

06 Wash Basin

The wash basin shall be provided with one or two taps as mentioned in the item. The front edge of the wash basin from the floor level shall be 80 cm.

Fixing: The basin shall be supported on a pair of R.S. or C.I. cantilever brackets embedded in concrete (1:2:4) block of 100 x 75 x 150 mm size. The brackets shall be fixed in position before dado work is done. The wall plaster on the rear shall be cut so that overhang of the top edge of the basin can rest on it. After fixing the basin the plaster shall be made good and surface finished to match with existing one. The union shall be connected to 32 mm dia waste pipe which shall be suitably bent towards the wall and which shall discharge into an open drain leading to gully trap or direct into the gully trap on the ground floor and shall be connected to waste pipe stack through a floor trap on upper floors. The C.P. brass trap and union shall not be provided when the waste pipe is discharged through a floor trap or a surface drain leading to a floor trap. Where so specified C.P. brass trap and union shall be paid for separately. Where so specified a G.I. puff 20 mm terminating with perforated brass cap screwed on it on the outside of the wall or connected to the anti-syphon stack, will be provided.

07 Kitchen Sinks

The installation shall consist of assembling the sink, the brackets, trap, unions and waste pipe.

Fixing: The sink shall be supported on C.I. or R.S. brackets embedded in cement concrete 1:2:4 block of size 100 x 75 x 150 mm. Brackets shall be fixed in position before dado work is done. The C.P. brass (or P.V.C) union shall be connected to 40 mm nominal bore G.I. or P.V.C. waste pipe which shall be suitably bent towards the wall and shall discharge into a floor trap.

08 Bathroom Fittings

Only Government approved brands of fittings shall be used. The fittings of the type specified in the item shall be fully examined and cleared of all the foreign matters before being fixed. The fitting shall be fitted in the pipelines in workmen like manner. The joints between fittings and pipe shall be leak proof when pressure tested. The defective fittings and joints shall be replaced or redone.

09 Bathroom Accessories

The mirror shall be mounted on 4 mm thick plain asbestos sheet ground and shall be fixed in position by means of 4 C.P. brass screws and C.P. brass washers, over rubber washers and wooden plugs firmly embedded in walls. C.P. brass clamps with C.P. brass screws may be an alternative method of fixing, where so directed. Unless specified otherwise the longer side shall be fixed horizontally.

Chapter :14

PLUMBING - OUTDOOR WORK

01 Water Supply

The specified pipes and fittings shall be laid in trenches. The width and depths of the trenches of different diameters of the pipes shall be as shown in the table below.

Dia. of pipe	Width of trench	Depth of trench
15mm to 50mm	30 cm	60 cm
65mm and above	45 cm	75 cm

At joints, trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications for earthwork in trenches. In case of GI pipes, the pipes shall be painted with two coats of anticorrosive bitumastic paint of approved quality. The pipes shall be laid in a layer of 7.5 cm sand and filled upto 20 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be disposed off as directed by the Engineer. When excavation is done in rock, the bottom shall be cut deep enough to permit the pipes to be laid on a cushion of sand of minimum 7.5 cm. In case of bigger diameter pipes where the pressure is very high thrust blocks of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate of 20 mm nominal size) shall be constructed on all bends to transmit the hydraulic thrust without impairing the ground and spreading it over a sufficient area.

Testing the joints: After laying and jointing, the pipes and fittings shall be inspected under working conditions of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost. The pipes and fittings after they are laid shall be tested to hydraulic pressure of 6kg/cm^2 (60 metres). The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw off takes and the stop-cocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped the test pressure should be maintained without loss for atleast half an hour. The pipes and fittings shall be tested in sections as the work of laying

proceeds, keeping the joints exposed for inspection during the testing.

02 H.D.P.E Fittings

The fittings of the type specified in the items shall be fully examined and cleared of all foreign matters before being fixed. The fitting shall be fitted in the pipeline in a workman-like manner. The joints between fittings and pipes shall be leak proof when pressure tested to the extent specified by the Engineer. The defective fittings and joints shall be replaced or redone.

03 Push on Jointing for DI pipes

At joints, trench width shall be widened where necessary. The joints should satisfy the following basic requirements:

a. Cleanliness of all parts
b. Correct location of components
c. Centralization of spigot with socket, and
d. Strict compliance with the manufacturer's jointing instructions

The inside of sockets and the outside of spigots should be cleaned and wire brushed for a distance of 150 to 225 mm. Glands and Gaskets should be wiped clean and inspected for damage. When lifting gear is used to place the pipe in the trench, it should also be used to assist in centralizing the spigot in the socket.

Where the pipeline is likely to be subjected to movement due to subsidence or temperature variations, the use of flexible joints is recommended. A gap should be left between the end of the spigot and the back of the socket to accommodate such movement.

Flexible Joint: The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction.

Flanged Joints: Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually affected by means of a flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly. Gaskets of other materials, both metallic and non-metallic are used for special applications

04 C.I. Soil Waste Pipes & Fittings

Fixing and Jointing: Pipes shall be fixed on face of wall. Plain pipes (without ears) shall be secured to the walls at all joints with M.S. holder bat clamps. The pipes shall be fixed to the wall by embedding the hooks of the clamps in cement concrete blocks 10 x 10 x 10 cm 1:2:4 mix (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall, so as to facilitate cleaning and painting of pipes.

Height of ventilating pipes: The ventilating pipe or shaft shall be carried to height of at least one meter above the outer covering of the roof of the building or in the case of window in a gable wall or a dormer window it shall be carried upto the ridge of the roof or at least 2 meters above the top of the window

Preparing the joint: The interior of the socket and exterior of the spigot shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right upto the back of the socket and carefully entered by two or three laps of treated spun yarn, twisted into ropes of uniform thickness, well caulked into the back of the socket. No piece of yarn shall be shorter than the circumference of the pipe.

Leading: The leading of pipes shall be made by means of ropes covered with clay or by using special leading rings. The lead shall be melted so as to be thoroughly fluid and each joint shall be filled in one pouring.

Caulking: After the lead has been run into the joint the lead shall be thoroughly caulked. Caulking of joints shall be done after a convenient length of the pipes has been laid and leaded. The leading ring shall first be removed and any lead outside the socket shall be removed with a flat chisel and then the joint caulked round three times with caulking tools of increasing thickness and hammer 2 to 3 kg weight. The joints shall not be covered till the pipeline has been tested under pressure, though the rest of the pipeline should be covered up to prevent expansion and contraction due to variation in temperature.

Testing: All sand cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Engineer and left in working order after completion.

Smoke test shall be carried out as stated under: Smoke shall be pumped into the pipe at the lowest end from a smoke machine, which consists of a bellow and a burner. The material usually burnt is greasy cotton waste, which gives out a clear pungent smoke, which is easily detectable by sight as well as by smell if there is leak at any point of the drain.

05 PVC Soil Waste Pipes & Fittings

Underground installation: For laying PVC pipes in trenches, trench width shall not be less than pipe diameter plus 125mm in each side. Laying of pipes, trench filling, depth of trenches, precaution, etc shall be as described above for CI pipes.

Concealed installation: For concealing the drain lines, slots shall be made in the wall or concrete. The slot size shall be such that the system remains stress free at the time of installation. Sharp edges should be avoided. All PVC pipes and fittings shall be cleaned and a light coat of solvent cement applied externally before they are inserted in the slots. Leakage test shall be carried out before concealing the system.

Jointing: The commonly used joints are as follows:

a) Solvent welded joints,
b) Flanged joints
c) Screwed or treaded joints, and
d) Rubber ring joints.

Non-heat application method: In this method, the pipe shall be cut perpendicular to the axis of the pipe length with a saw. The pipe ends have to be beveled slightly with beveling tool at an angle of about 30-degree. The total length of insertion of socket shall be marked on pipe and checked how far the pipe end should go into the fitting socket up to 1/3 to 2/3 of the socket length. After cleaning, the coating of solvent cement shall be applied evenly on the inside of the fitting for full length of insertion and then on the outside of the pipe end up to the marked line.

Heat application method: This method of jointing makes use of spigot and socket shapes of pipes. The female end is beveled on the bore. The other pipe end to be inserted is beveled at an angle of 20 to 30 degrees on the outer periphery. The female end of the pipe is expanded by heating a length of 1.5 times the pipe diameter to a temperature of about 130-degree C by blowtorch or any other suitable medium.

06 Painting of Pipes

The primer shall be of approved brand and manufacture and the final paint anticorrosive bitumastic, aluminium or other type of paint as specified.

Preparation of Surface: All rust and scales shall be removed by scraping or brushing with steel wire brushes. All dust and dirt shall be thoroughly wiped away from the surface. If old surface is to be painted, it shall be rubbed with wire brushes and any loosened paint taken off. All dust shall be thoroughly wiped away.

07 Soak Pits

The earthwork excavation shall be as per general specifications given under "Earthwork". After

the excavation is complete, the soak pit shall be filled with brickbats. The brickbats shall be from properly burnt bricks.

Circular soak pit:

The earthwork excavation shall be carried out to the exact dimensions as given in the description of the item. In this pit, a honeycomb dry brick shaft 45x 45 cm and 292.5 cm high shall be constructed centrally. Round this shaft and within a radius of 60 cm shall be placed well-burnt brickbats. Around the brickbats upto a radius of 90 cms brick ballast of size from 50 to 80 mm nominal size shall be packed. The remaining portion shall be filled with brick ballast of 40 mm nominal size. The construction of the shaft filling of the bats and ballast shall progress simultaneously. Over the filling shall be placed single matting, which shall be covered with minimum layer of 7.5 cm earth. The shaft shall be covered with 7.5 cm thick stone or R.C.C slab. Brick edging 10 cm wide 10 cm deep shall be provided round the pit. The connection of the open surface drain to the soak pit shall be made by means of a 100 mm dia. S.W. pipe with open joints

08 Septic Tanks

Every septic tank shall be provided with CI ventilating pipe of at least 50mm dia. and extended to a height of 2m. The top of the pipe shall be provided with a suitable cage of mosquito proof wire mesh. Septic tank shall be located away from the nearest building as per the regulations of the local implementing authority.

Septic tank shall have minimum width of 750mm, and minimum liquid capacity of one cum. Length of the tank shall be 2 to 4m. However, the actual sizes of the tank shall be as per the standard size based on the number of users. The minimum size for different number of users for cleaning interval of 2 years is as shown below:

No. of user	Length(m)	Width(m)	Height(m)
15	2.00	0.90	2.00
25	2.60	1.30	1.80
50	4.00	1.40	2.00
75	5.00	1.50	2.00
100	5.70	2.10	1.70

Before the tank is commissioned for use, it shall be tested for water-tightness by filling it with water and allowing it to stand for 24 hours. It shall then be topped up, if necessary, and allow to stand for a further period of 24 hours, during which time the fall in the level of water shall not be more than 15mm.

Chapter: 15.

PLASTERING

01 Cement Plaster

Preparation of surface: The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface, if a chemical retarder has been applied to the formwork, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarder is left on the surface. The joints of masonry shall be raked out properly so that the plaster is well keyed with the masonry.

Application of Plaster: Ceiling plaster shall be completed before commencement of wall plaster. Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is taken down. To ensure even thickness and true surface, plaster about 15 x 15 cm, shall be first applied, horizontally ` and vertically, at not more than 2 meters intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness.

Finish: The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Thickness: The thickness of the plaster specified shall be measured exclusive of the thickness of key. The average thickness of the plaster shall not be less than the specified thickness and the minimum thickness over any portion of the surface shall not be less than specified thickness.

Curing: Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered. The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

02 Plaster Band

Plain band is a plaster strip of uniform width not exceeding 30 cm and of uniform thickness, provided for decorative or other purposes flush with, sunk below or projecting beyond, the wall

plaster. A flush band is one where due to the difference in mix or shade of the mortar, the band is executed as a separate and distinct operation from the wall plaster.

Thickness: The thickness of a raised band is the thickness of the projection beyond the plane of the wall plaster. In the case of a flush or a sunk band, the thickness will be the thickness of the wall plaster measured from the untreated wall-surface.

Preparation of Surfaces and Application: In the case of flush or sunk bands the joints shall be raked out properly. Dust and loose mortar shall be brushed out.

Efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned of and care shall be taken that none of the retarders is left on the surface.

Mortar: Mortar of the mix and type of sand specified in the description of the item shall be used.

Finish: The bands shall be finished exactly to the size as shown in the drawings. The horizontal or vertical lines of bands shall be truly parallel and straight and the surfaces shall be finished truly plane and smooth. The lines and surfaces shall be checked with fine threads for straightness and accuracy.

03 Cement Plaster with Floating Coat

The cement plaster shall be 12, 15 or 20 mm thick, finished with a floating coat of neat cement, as described in the item. Specifications for this item of work shall be same as described in plastering items above except for the additional floating coat, which shall be carried out as below. When the plaster has been brought to a true surface with the wooden straight edge, it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth; so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sq.m. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix.

Thickness, curing, measurements and **rate** shall be as specified above in the plastering items. Cement plaster shall be 6 mm thick finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.

Application: The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge, it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sq.m. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in "plastering works with floating coat of neat cement" shall apply.

04 Decorative Plaster

Roughcast finish comprises of a mixture of sand and crushed stone (or gravel) in specified proportions dashed over a freshly plastered surface. Scaffolding shall be done as specified above in ordinary plastering works.

Preparation of surface: The joints shall be raked out; dust and loose mortar shall be brushed out. The surface shall be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

Mortar: Mortar of specified mix using the type of sand described in the item shall be used. The plaster base over which rough cast finish is to be applied shall consist of two coats, under layer 12 mm thick and top layer 10 mm. The under layer shall be applied in the same manner as specified above in ordinary plastering works. The top layer shall be applied a day or two after the under layer has taken initial set. The latter shall not be allowed to dry out before the top layer is laid on. The mortar used for applying top layer shall be sufficiently plastic and of mix 1:3 (1 cement: 3 fine

sand) so that the mix of sand crushed stone (or gravel) gets well pitched with the plaster surface. In order to make the base plastic about 10% of finely ground lime by volume of cement shall be added.

Finish: It shall be ensured that the base surface, which is to receive roughcast mixture, is in plastic state. The roughcast mixture shall consist of sand and crushed stone (or gravel) of uniform colour from 2mm to 12 mm as specified to get the effect required. The mixture shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix gets well pitched with the plaster base. The mix shall again be dashed over the vacant spaces, if any, so that the surface represents a homogeneous surface of sand/stone (or gravel). A sample of the plaster shall be got approved by the Engineer.

05 Plaster of Paris

Frame*:* Timber frame of the class of wood and section as specified in the description of relevant item for the frame or as ordered by the Engineer shall be provided. The width of the scantlings provided shall be sufficient to provide a minimum nailing surface of 6 cm. The longitudinal and header scantlings shall be so arranged that the tiles can be fixed to form the panel arrangement required as per drawings, or as ordered by the Engineer and there is supporting scantling under each and every edge of the tiles. The framing shall be paid for separately unless specifically included in the description of the item. Plaster of Paris shall be Calcium Sulphate hemihydrates variety as specified.

Preparation of tiles: Tiles of plaster of Paris reinforced with Hessian cloth shall be prepared in suitable sizes as shown in drawings or as ordered by the Engineer. The maximum sizes of tiles shall be limited to 75 cm in each direction. Wooden forms of height equal to the thickness of tiles shall be placed on a truly level and smooth surface such as a glass sheet.

The section of form sides shall be such that the edges of the tiles shall be provided with a neatly formed chamfer around of 5 mm width and 8 mm depth, unless the tiles are to be provided with cover fillets over joints in which case the edges of the tiles shall be truly square. The glass sheet or surface on which form is kept and the form sides shall be given a thin coat of non-staining oil to facilitate the easy removal of the tile. Plaster of Paris shall be evenly spread into the form upto about half the depth and Hessian cloth weighing not less than 230 gm per square metre shall be pressed over the plaster of Paris layer. The ends of the Hessian shall be turned over at all edges to form a double layer to width of 5 cm. The Hessian cloth shall be of an open webbed texture so as to allow the plaster below and above to intermix with each other and form an integral whole. The form shall then be filled with plaster of Paris, which shall be uniformly pressed, and then wire cut to an even and smooth surface.

Fixing: The tiles so prepared shall be fixed to the cross battens of the ceiling frame with 40 mm brass screws at spacing not exceeding 20 cm centre to centre on all edges. The tiles shall be laid with their edges in just close position to the adjoining tiles without any gap in between. The line of screws shall be not less than 15 mm away from the edge of the tiles. The screws shall be slightly counter sunk into the tiles. Holes for screws shall be drilled. The counter sunk heads of screws shall be covered up with plaster of Paris and smooth finished. Where a surface unbroken by visible joints is required, then the joints shall be filled with plaster of Paris and trowelled smooth so that the whole surface appears as one without any joints. Nothing extra shall be paid for this closing of joints.

Chapter :16

PAINTING & WALL PAPER

01 General

Painting shall not be started until the Engineer has inspected the items of work to be painted and satisfied himself about their proper quality and given his approval to commence the painting work. Painting, except the priming coat, shall generally be taken in hand after practically finishing all other builder's work. Painting of external surface should not be done in adverse weather condition like hail or dust storm etc. The rooms should be thoroughly swept out and the entire building cleaned up at least one day in advance of the painting work being started. The contractor shall bring approved paints, oils and varnishes to the site of work, in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The empties shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer.

02 Preparation of surface

Wooden surface: The woodwork to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sandpaper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material with same shade, as paint shall be used where specified. The surface treated for knotting shall be dry before painting is applied. After the priming coat is applied, the holes and indentation on the surface shall be stopped with a glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in the stopping and the latter is therefore liable to crack.

Iron & Steel Surface: All rust and scales shall be removed by scraping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling, which becomes loose by rusting shall be removed. All dust and dirt shall be thoroughly wiped away from the surface. If the surface is wet, it shall be dried before priming coat is undertaken.

Plastered surface: The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

03 Primers

Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on asbestos cement surfaces before oil emulsion distemper paints are applied on them. The cement

primer is composed of a medium and pigment which are resistant to the alkalis present in the cement, lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper paints. Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion paints etc.

Application: The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion paint is applied. The specifications in respect of scaffolding protective measures, measurements and rate shall be as described above for surface preparation.

The primer for woodwork, ironwork shall be as specified in the description of the item. The primer shall be applied with brushes, worked well into the surface and spread even and smooth. Primers for plaster/wood/iron & steel/aluminum surfaces shall be as specified in the Table below:

04 Wall Washing

Preparation of lime wash: The wash shall be prepared from fresh stone white lime. The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 40 gm of gum dissolved in hot water shall be added to each 0.01 cubic metre of the cream.

The approximate quantity of water to be added in making the cream will be 5 litres of water to 1 kg of lime. Blue up to 3 gm per kg of lime dissolved in water shall be added and wash stirred well. Water then shall be added @ about 5 litres per kg of lime to produce a milky solution.

Application: The specified number of coats of the white wash shall be applied with the brushes. The operation for each stroke shall consist of a stroke of the brush given from the top downwards, another from the bottom upward over the first stroke and similarly one stroke horizontally from the right and another from left before it dries. Each coat shall be allowed to dry before the next one is applied. Further each coat shall be inspected and approved by the Engineer before the subsequent coat is applied. No portion of the surface shall be left out to be patched up later on.

Protective Measures: Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed shall be protected from being splashed upon. Splashing and droppings if any, shall be removed by the contractor at his own cost. Damages if any to furniture or fittings and fixtures shall be recoverable from the contractor.

05 Cement Paint

Material: The cement paint shall be (equivalent to IS 5410) of approved brand and manufacture.

Preparation of Surface: For new work, the surface shall be thoroughly cleaned of all mortar dropping, dirt, dust, algae, grease and other foreign matter by brushing and washing. The surface shall be thoroughly wetted with clean water before the cement paint is applied. In the case of old work, all loose pieces and scales shall be removed and the surface shall be cleaned of all dirt, dust, algae, oil etc. by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement paint shall be applied over patches after wetting them thoroughly.

Preparation of mix: Cement paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement paint shall be mixed with water in two stages. The first stage shall comprise of two parts of cement paint and one part of water stirred thoroughly and allowed standing for 5 minutes. Care shall be taken to add the cement paint gradually to the water and not vice versa. The second stage shall

comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency.

Application: The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface, which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement paint shall be as per manufacture's specification. The completed surface shall be watered after the day's work. The second coat shall be applied after the first coat has set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

Precaution: Water cement paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, paints etc. It shall not be applied on gypsum, wood and metal surfaces.

06 Distemper

Materials: Dry distemper of required colour and (IS:427) of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer before application of the distemper. The dry distemper colour as required shall be stirred slowly in clean water using 0.6 litre of water per kg of distemper or as specified by the makers. Warm water shall preferably used. The mixture shall be allowed to stand for at least 30 minutes (or if practicable over night) before use. The mixture shall be well stirred before and during use to maintain an even consistency. Distemper shall not be mixed in larger quantity than is actually required for one day's work.

Priming coat: A priming coat of whiting shall be applied over the prepared surface in case of new work, if so stipulated in the description of the item. No white washing coat shall be used as a priming coat for distemper. The treated surface shall be allowed to dry before distemper coat is given.

Application: In the case of new work, the treatment shall consist of a priming coat of whiting followed by the application of two or more coats of distemper till the surface shows an even colour. For old work, the surface prepared shall be applied one or more coats of distemper till the surface attain an even colour. The application of each coat shall be as follows:

The entire surface shall be coated with the mixture uniformly, with proper distemper brushes (ordinary white wash brushes shall not be allowed) in horizontal strokes followed immediately by vertical ones, which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush marks. Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day. After each day's work, the brushes shall be washed in hot water and hung down to dry. Old brushes, which are dirty or caked with distemper, shall not be used.

07 Finishing Paints

Synthetic Enamel paint (conforming to IS:1932) of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of shade to match the top and as recommended by the manufacturer shall be used.

Painting on New Surface:

Preparation of Surface for Wood work: The surface shall be cleaned and all unevenness removed. Knots if visible, shall be covered with a preparation of red lead. Hole and indentations on the surface shall be filled in with glazier's putty or wood putty and rubbed smooth before painting is done. The surface should be thoroughly dry before painting.

Preparation of Surface for Iron and steelwork: The priming coat shall have dried up completely

before painting is started. Rust and scaling shall be carefully removed by scraping or by brushing with steel wire brushes. All dust and dirt shall be carefully and thoroughly wiped away.

Under Coat: One coat of the specified paint of shade suited to the shade of the topcoat shall, be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

Topcoat: Topcoats of specified paint of the desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

Painting on old surface:

Preparation of surface: Where the existing paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose paint and loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified paint. The surface shall again be rubbed and made smooth and uniform. If the old paint is blistered and flaked it will be necessary to completely remove the same. Such removal shall be paid for separately and the painting shall be treated as on new surface.

Painting: The number of coats as stipulated in the item shall be applied with the specified paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If, however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

Preparation of Surface:

Iron and Steel Work: If the old paint is sound and firm and its removal is considered unnecessary, it shall be rubbed with wire brushes and any loosened paint taken off. All dust shall then be thoroughly wiped away. This surface shall then be wiped finally with mineral turpentine to remove grease and perspiration of hand marks etc. and then allowed drying. If the old painted surface is in bad condition and blistered and flaked, the old paint shall be completely removed and such removal shall be paid for separately. The painting including the priming coat shall be treated as on new work and paid for accordingly.

Plastered surface: If before painting any portion of the wall shows signs of dampness, the causes shall be investigated and the damp surface shall be properly treated. Such treatment shall be paid for separately. A thin coat of white lead if so required shall be applied on the wet or patchy portion of the surface, before painting is undertaken and this shall be paid extra. The number of coats to be given shall be as stipulated in the description of the item.

Ready mixed paint, suitable for painting over GI sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered GI sheets shall be painted with a priming coat of one coat of red oxide zinc chromate paint. Primer shall be applied before fixing sheets in place.

08 Stains, Varnishes & Polishes

Pure shellac varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade.

Polishing New Surface:

Preparation of Surface: The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot.

Application: The number of coats of polish to be applied shall be as described in the item. A pad of woollen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened

with the polish and rubbed hard on the wood, in a series of over lapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surfaces shall have a uniform texture and high gloss.

Polishing Old Surface:

Preparation of surface: If the old polished surface is not much soiled it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sandpaper. If the old polished surface is much soiled then it will be necessary to remove the entire polish with patent paint remover or with caustic soda solution, as suitable and such removal shall be paid for separately outside the rate of polishing.

09 Wood Preservatives

Oil type wood preservative, of specified quality and approved make conforming to IS-218, shall be used. Generally, it shall be creosote oil type-I or anthracene oil.

Painting on New Surface: Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

Application: The preservative shall be applied liberally with a stout brush and not daubed with rags or cotton waste. It shall be applied with a pencil brush at the joints of the woodwork. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

Painting on old surface: The work shall be done in the same manner as on new surface except that only one coat shall be done. Such of the specifications given below, in so far as they are applicable shall also hold good.

Materials: Paints, Oils, and Varnishes etc of approved brand and manufacture shall be used. Ready mixed paint as received from the manufacturer shall be used without any admixture. If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer, shall be used.

Preparation of Surface: The surface shall be thoroughly cleaned and dusted. All rust and dirt scales, smoke and grease etc shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer after inspection, before painting is commenced.

Application: The paint shall be stirred thoroughly in its containers before pouring into containers for use and also while applying so that its consistency is uniform. The paint shall be laid on evenly and smoothly by means of "crossing and laying off" the latter in the direction of the grain of wood. In this process, no brush marks shall be left after the laying off is finished.

Brushes and Containers: After work, the brushes/shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

10 Wall Paper

Measurement: Length and breadth shall be measured correct to 10 mm and area shall be calculated correct to two places of decimal. The item shall include removing nails, making good

holes, cracks, patches etc. Work on old treated surfaces shall be measured separately. Measurement for jamps, soffits, sills, etc. shall be same as for plastering works.

11 Traditional Painting

Traditional Painting shall not be started until the Engineer has inspected the items of work to be painted and satisfied himself about their proper quality and given his approval to commence the painting work. Painting, except the priming coat, shall be started after practically finishing all other builder's work. Traditional Painting of external surface should not be done in adverse weather condition like hail or dust storm etc. The rooms should be thoroughly swept out and the entire building cleaned up at least one day in advance of the painting work being started. The contractor shall bring approved painting materials to the site of work, in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The empties shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer.

Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface being painted. For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal piece over which scaffolding planks shall be fixed. Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damages or scratches to walls.

Preparation of Traditional paint: Round mud paint (Sa-tshoen) as available in the market shall be put in a tin, filled with water and kept for about 25 to 30 minutes. Water shall then be poured out taking care that mud ball is not shaken / distributed. When the water is completely drained out, either animal glue or fevicol shall be mixed with the soaked mud ball as follows:

a) Mixing with animal glue: Animal glue and water shall be mixed in the ration of 1:2 (1 animal glue: 2 water) and boiled until whole of the glue is melted and it becomes sticky. The prepared gum shall then be mixed with mud ball already soaked in water in the ratio 1:1 (1 gum: 1 soaked mud) and the paint is ready for painting.

b) Mixing with fevicol: Fevicol shall be mixed with cold water and stirred well in the ratio 1:1 (1 water: 1 fevicol). The fevicol solution shall then be mixed with mud soaked in water in the proportion of 1:1 and stirred well. The paint is ready for painting.

Brush for painting: Selection of brush for painting shall be based on the painters' judgement. For design painting round brush is recommended.

Washable paint: The following steps shall be followed to prepare the washable paint:

1. Dry mud ball paint shall be ground to fine powder;
2. Fine powder shall be Sieved by a thin cloth;
3. The sieved powder shall then be mixed with synthetic enamel paint in the proportion one litre of synthetic paint with one kilogram of mud powder and kept for about 30minutes to get a thick paint;
4. A small quantity of turpentine oil shall be added to the thick solution and stirred; and
5. Packet colours shall not be added.

Precautions: All furniture, fixtures, glazing, floor etc. shall be protected by covering and stains, smears, splashing, in any shall be removed and any damage done shall be made good by the contractor at his cost.

Preparation of surface:

a) Wooden surface: The woodwork to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sandpaper and shall be well dusted. Appropriate filler material shall be used where specified. The surface treated for knotting shall be dry before painting is applied. Apply two coats of yutshon painting as primer on the surface to be painted.

b) Iron & Steel Surface: All rust and scales shall be removed by scraping or by brushing with

steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling, which becomes loose by rusting shall be removed. All dust and dirt shall be thoroughly wiped away from the surface. If the surface is wet, it shall be dried before priming coat (yutshon) is undertaken.

c) Plastered surface: The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer (yutshon) shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

Drawing Chapa: Adjust the paper to the surface to be painted, draw the design on the paper, and prick the lines of the design by a pin. Place the paper back to the surface to be painted and rub the powder soaked cloth on the design paper. When the paper is withdrawn, powder marks are left on the surface, which is to be painted for specified painting. This process is continued for painting the required surface.

Painting on old surface: If the old paint is firm and sound, it shall be cleaned of grease, smoke etc. The surface shall then be rubbed down with sandpaper and dusted. Rusty patches, etc shall be cleaned up. If the old paint is blistered and flaked, it shall be completely removed. Chadam (Bangchang + animal glue together) shall be boiled and applied on the surface to be painted. Drawing Chapa shall be same as for the new work.

Physical checking: Physical checking shall be carried out on the quality of painting only after two days after paintings. The following steps shall be used as thumb rule to check the quality of the completed works:

1. Rub the surface already painted with palm and feel for smoothness.
2 When rubbed with palm, the colour should not be seen in the palm. If the colour comes when rubbed, the mixture is not proper and vice versa.

Applicability: Generally, the following types of painting shall be applicable against the type of structures specified unless otherwise directed and approved by the Engineer.

I. **Sumdang**:

- Rab painting shall be used in office, Dzong and other important places;
- Ding painting shall be used in institutional buildings such as school, hospital, etc.
- Thama painting shall be used in residential, staff quarter, and other similar buildings

II. **Dangtshon:**

- All the three types of paintings (Rab, Ding, Thama) may be used for internal decoration of all types of buildings only and external decoration for Royal cottages

Chapter :17

ELECTRICAL ITEMS

1- ABBREVIATIONS

The following abbreviations wherever they appear in the specifications shall have the meaning or implication hereby assigned to them.

A	:	Ampere
A.C	:	Alternating Current
C.I	:	Cast Iron
CFLs	:	Compact Fluorescent Lamps
DB	:	Distribution Board
D.C	:	Direct Current
ELCB	:	Earth Leakage Circuit Breaker
G.I	:	Galvanized Iron
GLS	:	General Lighting Service
HF	:	High Frequency
HID	:	High Intensity Discharge
HRC	:	High Rupturing Capacity
HT	:	High Tension
I	:	Current
ICDB	:	Iron Clad Distribution Board
KV	:	Kilo Volt
KW	:	Kilo Watt
LT	:	Low Tension
MCB	:	Miniature Circuit Breaker
MS	:	Mild Steel
PVC	:	Polyvinyl Chloride
R	:	Resistance
RCCB	:	Residual Current Circuit Breaker
SDB	:	Sub Distribution Board
SPMCB	:	Single Pole Miniature Circuit Breaker
SPN	:	Single Pole & Neutral
TPN	:	Triple Pole & Neutral
V	:	Volt
W	:	Watt

2- DEFINITIONS

The definitions given below shall be applicable to all sections unless otherwise indicated.

2.1 **Accent lighting**: Directional lighting to emphasize a particular object or draw attention to a part of the field of view.

2.2 **Aluminium conductor steel reinforced**: In Aluminium conductor steel reinforced conductor, aluminium wires surround a core consisting of one or more steel wires.

2.3 **Arrester:** A non-linear device to limit the amplitude of voltage on a power line. The term implies that the device stops over voltage problems (i.e. lighting).

2.4 **Armouring:** : It consists of one or two layers of galvanized steel wire or steel tape, to protect the cable from mechanical injury while laying it and during the course of handling

2.5 **Alternating current:** The term alternating current refers to a current that reverses at regular recurring intervals of time and that has alternately positive and negative values.

2.6 **Arcing contacts (arcing horns):** Arcing contacts are the contacts on which the arc is drawn after the main contacts of a switch have parted.

2.7 **Bonding jumper:** A bare or insulated conductor used to ensure the required electrical conductivity between metal parts required to be electrically connected. Frequently used from a bonding bushing to the service equipment enclosure to provide a path around concentric knockouts in an enclosure wall: also used to bond one raceway to another.

2.8 **Bus-Bar:** A heavy, rigid conductor used for high voltage feeders.

2.9 **Binding wire:** Annealed aluminium wire is used for fastening conductor to pin and shackle insulator.

2.10 **Base:** A base of a switch is the main member to which the conducting parts or insulator unit are

attached. It may also have parts of the operating or control mechanism attached.

2.11 **Cables:** A length of one or more than one insulated conductors, which are laid up together and surrounded by a protecting cover.

2.12 **Clear lamps:** Clear lamps absorb least amount of light but due to high brightness need shielding from direct view.

2.13 **Conductor**: A substance, which offers low resistance to the passage of electric current.

2.14 **Cross arms**: It provides support to the insulators.

2.15 **Conduit**: A tubular raceway for data or power cables. Metallic conduit is common, although non-metallic forms may also be used.

2.16 **Conduit joints**: Since the conduits are available in smaller lengths, so to obtain a continuous length of the conduit the two are coupled together by means of coupling.

2.17 **Decorative lighting**: Decorative lighting is determined by the aesthetic and architectural considerations, utility lighting is primarily on economic considerations.

2.18 **Earthling**: Earthling or grounding is the term used for electrical connection to general mass of earth.

2.19 **Earth Ground**: A low impedance path to earth for the purposed of discharging lightning, static, and radiated energy, and to maintain the main service entrance at earth potential.

2.20 **Earth wire**: A conductor connected to earth and usually situated in proximity to the associated live conductors.

2.21 **Earth electrode**: A metal plate or pipe, which is electrically connected to the general mass of earth.

2.22 **Flexible cable**: A cable containing one or more cores, each formed of a group of wires, the diameter of the wires being sufficiently small to afford flexibility.

2.23 **Flood lighting**: It is the term used for lighting of construction projects, parking areas, recreation and sports ground, etc.

2.24 **Fixture**: The assembly that houses a lamp or lamps, and which may include a housing, a mounting brackets or pole socket, a lamp holder, a ballast, a reflector or mirror, and or a refractor, lens, or diffuser lens.

2.25 **Fuse**: A strip or wire or metal inserted in series with a circuit which, when it carries an excess of current over its rated capacity, will burn out.

2.26 **Fluorescent lamp**: The lamp is filled with low-pressure argon gas and a drop of mercury.

2.27 **Girder clips**: It is used to fix the conduit to the wooden plugs in the wall.

2.28 **Guard wires**: Wires which are used at all points where a line crosses a street or road and have to be earthed at all points where their continuity is broken.

2.29 **Grounded**: Conducted to earth or to some conducting body that serves in place of the earth.

2.30 **Ground**: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of earth**.**

2.31 **High Intensity Discharge Lamps (HID)**: A general group of lamps consisting of mercury, metal halide, high-pressure sodium, and low pressure sodium lamps.

2.32 **Incandescent lamp**: The light spectrum of an incandescent lamp is continuous, it contains all the colours, but contains relatively excess of red and yellow radiations and less of blue and violet radiations.

2.33 **Insulator**: A device for fastening and supporting a conductor. Glass and porcelain are employed almost universally for supporting overhead wires.

2.34 **Lamp**: The component of luminaries that produces the actual light.

2.35 **Lighting arrester or a surge diverter**: It is a protective device, which conducts the high voltage surges on the power system to the ground.

2.36 **Luminaries/Luminaries**: A complete lighting system, including a lamp or lamps and a fixture.

2.37 **Mercury vapour lamps**: In this lamp, the discharge tube is filled in a bulb of hard glass provided with an internal mirror reflector.

2.38 **Megger**: A test instrument for measuring the insulation resistance of conductors and other electrical equipment; specifically, a mega-ohm (million ohms) meter.

2.39 **Mercury lamps**: An electric discharge lamp in which the major portion of the radiation is produced by the excitation of mercury atoms.

2.40 **Metal halide lamps**: A discharge lamp in which the light is produced by the radiation from the mixture of metallic vapour and the products of disassociation.

2.41 **Pole**: A pole of a switch consists of the parts necessary to control one conductor of a circuit. A switch may be single pole or multiple, depending upon the number of single poles that are operated simultaneously.

2.42 **Reflector lamps**: A reflector lamp is provided with high quality internal mirror, which follows exactly the parabolic shape of the lamp.

2.43 **Stay wires**: Stay wires are required to be earthed with an earth wire unless there are insulated by a strain insulator placed at a height not less than 3m from the ground.

2.44 **Serving**: The protective material over the metal sheathing or the wire armour of a cable is known as serving.

2.45 **Struts**: Struts may be used, where it is not possible to use stay wires due to limitation of space.

2.46 **Socket outlet**: A device carrying three metallic contacts designed for engagement with

corresponding plug pins and arranged for connections to fixed wiring.

2.47 **Sodium lamps**: It is a low-pressure gas discharge lamp, consisting of a U-shaped glass tube, filled with an inert gas and some sodium, which can be seen in the form of solidified drops on the inner wall when the lamp is cold.

2.48 **Switch**: A device of making, breaking, or changing the connections in an electric current.

2.49 **Surge**: A short duration high voltage condition. A surge lasts for several cycles where a transient lasts less than one half cycle.

2.50 **Switchboard**: A large single panel, frame or assembly of panels having switches, over- current, and other protective devices, buses, and usually instruments mounted on the face are not intended to be installed in cabinets.

2.51 **Thyrite type arrester**: Thyrite type arresters incorporate non-linear resistors and are extensively used on systems operating at high voltages.

3- GENERAL

These Specifications are drawn to indicate the essential requirements and precautions to be taken regarding electrical installation for ensuring efficient, safe, economical and practical use of electrical materials and equipments including prevention of fire hazards.

The electrical installation and general safety precautions shall be carried out in accordance with the Specifications specified hereunder and shall be in conformity with:

- Building Code of Bhutan- 2003 (Part 2: Building Services);
- Any documents related to electrical installation, testing and commissioning published by the Bhutan Electricity Authority, Department of Energy and;
- Relevant Indian Standards wherever not covered in this specification.

3.1.1 Drawings

The works shall be carried out in accordance with the drawings enclosed with the tender documents and also with modifications thereto from time to time as approved by the Engineer-in-charge. All wiring diagrams shall indicate clearly in plan, the main switchboard, the distribution boards, the runs of various mains and their classification and controls. All circuits shall be indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit to which they are electrically connected. Distribution boards shall also be marked to indicate the circuit numbers controlled by them.

3.1.2 Materials

All materials supplied shall be new and conforming to relevant Standard Specifications wherever they exist. Materials approved/standardized by the Royal Government from time to time only shall be used in any electrical work unless otherwise stated or directed by the Engineer-in-charge.

3.1.3 Workmanship

Good workmanship is an essential requirement to be complied with. The entire work shall be carried out under the direct supervision of a licensed electrician and/or qualified supervisor employed by the contractor who shall rectify then and there, the defects pointed out by the Engineer-in-charge and/or senior officials of the Department during the progress of work.

3.1.4 Ratings of electrical components

All components in a wiring installation shall be of appropriate ratings of voltage, current and frequency as required at the respective sections of the electrical installations in which they are used.

All conductors, switches and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current that will normally flow through them.

3.1.5 Structural alteration to buildings

No alteration that shall affect the structure of building shall be done unless sanction of the Engineer-in-charge has first been obtained. All chases, ducts, holes etc. required in connection with the electrical works shall be provided and filled by the contractor at his own cost to the original architectural finish of the buildings. For new buildings, these chases, ducts, holes etc. shall be provided when the building is in progress.

3.1.6 Work in occupied buildings

When the building is occupied and major portion of the work is required to be done under that condition the work shall be carried out in such a way that there is minimum inconvenience to the occupants. In such cases, it may be necessary to work before and after office hours as required.

3.1.7 Testing and commissioning on completion

After completion of the works, and before handing it over to the client, it shall be ensured that the installation is tested and commissioned.

3.1.8 Additional load to an existing Installation

An addition, temporary or permanent, shall not be made to the authorized load of an existing installation until it has been definitely ascertained that the current carrying capacity and the condition of the existing accessories, conductors, switches etc. affected are adequate for the increased load.

3.1.9 Connection to ancillary buildings

Unless otherwise specified, electrical connections to ancillary buildings such as out-house, garages etc., adjacent to the main building at a distances not greater than 3 m and where no road intervenes shall be taken in an earthed G.I. pipe of suitable size in the exposed portion at a height of not less than 2.5 m. This applies to both runs of mains or sub mains or circuit wiring between the buildings. When the distance between the buildings exceed 3 m or a road way intervenes, separate mains shall be run from the main building to ancillary building and the portion of the same exposed to weather proof cable on G.I. bearer wire at a height not less than 4 m above the ground. Alternatively PVC insulated wire in G.I. pipe or underground cable may be used below ground level.

4- WIRING SYSTEM

The wiring shall be carried out on such a system as may be specified in the Tender Schedule. **Power** and **Heating** wiring shall be kept separately and distinct from **Lighting** and **Fan** wiring. Recessed conduit wiring system may generally be adopted for this purpose. The wiring shall be done on distribution system with main and branch distribution boards at convenient physical and electrical centres. All conductors shall run, as far as possible, along the walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. In no case, the open wiring shall run above the false ceiling without the approval of Engineer. In all types of wiring, due consideration shall be given for neatness, good appearance and safety.

4.1 PVC Casing and Capping

4.1.1 Fixing casing-capping

PVC casing and capping shall be of standard material free from defects of any kind. It should be properly finished and conform to relevant standards. This system of wiring is suitable for low voltage installation where polyvinyl chloride (PVC), rubber, plastic or other approved insulated cables shall be used in the wiring work carried within PVC casing enclosure. PVC casing and capping wiring shall not be used in damp or poorly ventilated places without taking suitable precaution.

PVC casing and capping should be strong and properly fitted so as to hold wires laid in it to its full capacity even under the ceiling. For this reason, the thickness of the PVC casing and capping shall be 1.6mm for sizes up to 25mm and 1.5mm or more for sizes up to 50mm. It should be rigidly screwed at 150mm interval crosswise with suitable wood screws of 25mm length turned in PVC sleeve inserted in neatly drilled holes of proper size and depth with cup washer to give proper grip over more surface area. Providing and fixing of PVC casing and capping include bends, elbows, tees, inside and outside corners, round blocks and painting. It can be run whether in horizontal or vertical position as required. As much as possible, the colour of the casing and capping shall match the colour of the surface on which it is laid.

When wiring is to be carried out in places where aesthetic views is of great concern and to harmonize the look with the site condition, special casing capping shall be submitted to the Engineer for approval prior to laying out for the work. The inspection shall be done from time to time as the work progresses. Capping shall not be put on until the work has been inspected after the wires are laid in position and approved by the Engineer-in-charge.

4.1.2 Providing earth continuity wires

The earth continuity wire shall be provided in the casing throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound

4.1.3 Size and Measurement

The length of the PVC casing capping is available from 1.8 to 3m.The unit of measurement shall be in metres, measured to the nearest cm. The width, depth and thickness of PVC casing and capping:

Table 1 gives the dimensions of PVC casing and capping and Table 2 shows the maximum number of PVC insulated 650/1100 V grade copper/aluminum conductors that can be drawn in a given size of casing.

Table 1: Dimension of PVC casing and capping

Width of casing or cap	No. of grooves	Width of grooves	Width of division	Thickness of outer wall	Thickness of casing	Thickness of capping	Thickness at back	Length
Mm	mm	Mm	mm	mm	Mm	mm	Mm	meter
44	2	6	12	10	16	6	6	2.5 to 3
51	2	9	13	10	19	10	6	
64	2	13	18	10	19	10	10	
76	2	16	24	10	25	10	10	
89	2	16	35	10	32	13	10	
102	2	19	38	10	32	13	13	

Table 2: No. of P.V.C insulated 650/1100 V grade (Copper or Aluminium) conductor cable that can be drawn in one groove of the casing

4.2

Nominal cross sectional area of conductor sq.mm	44 mm X 16 mm	51 mm X 19 mm	64 mm X 19 mm	76 mm X 25 mm	89 mm X 32 mm	102 mm X 32 mm
1.5	2	2	2	9	12	12
2.5	1	2	2	4	8	9
4	1	2	2	4	6	9
6	..	1	1	4	6	6
10	..	1	1	4	4	4
16	..	..	1	1	2	2
25	..	..	..	1	2	2
35	..	..	..	..	1	1
50	..	..	..	..	..	1
70	..	..	..	..	..	1

Conduit Wiring

a) Type and size of conduit

All conduit pipes shall be of approved gauge (Not less than 16 SWG for conduits of sizes upto 32 mm diameter and not less than 14 SWG for conduits of size above 32 mm diameter) solid drawn or reamed by welding finished with galvanized or stove enameled surface. All conduit accessories shall be of threaded type. The maximum number of PVC insulated 650/1100 V grade (copper or aluminum) conductor cable that can be drawn in one conduit of various sizes shall be as given in the Table 3 below, and the number of cables per conduit shall not be exceeded. No steel conduit less than 19 mm in diameter shall be used.

Table 3: Maximum number of PVC Insulated 650/1100 V Grade aluminium/copper conductor cable that can be drawn in one conduit.

Nominal Cross sectional area of conductor in sq.mm	20mm		25mm		32mm		38m		51mm		64mm	
	S	B	S	B	S	B	S	B	S	B	S	B
1	2	3	4	5	6	7	8	9	10	11	12	13
1.5	5	4	10	8	18	12	-	-	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-	-	-
4	3	2	6	5	10	8	-	-	-	-	-	-
6	2	-	5	4	8	7	-	-	-	-	-	-
10	2	-	4	3	6	5	8	6	-	-	-	-
16	-	-	2	2	3	3	6	5	10	7	12	8
25	-	-	-	-	3	2	5	3	8	6	9	7
35	-	-	-	-	-	-	3	2	6	5	8	6
50	-	-	-	-	-	-	-	-	5	3	6	5
70	-	-	-	-	-	-	-	-	4	3	5	4

1. The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.
2. The columns headed “S” apply to runs of conduit which have distance not exceeding 4.25 m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed “B” apply to runs of conduit, which deflect from the straight by an angle of more than 15 degree.
3. Conduit sizes are nominal external diameters

b) Fixing of conduit

Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable PVC sleeves or other equivalent type with screws in an acceptable manner at an interval of not more than one meter but on either side of the couplers or bends or similar fittings. Saddles shall be fixed at a distance of 30 cm from the centre of such fittings. The saddle should not be less than 24 gauge for conduits up to 25 mm dia. and not less than 20 gauge for larger diameter.

When conduits pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or glider clips as required by the Engineer-in-charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or glider clips and clamps shall not be less than as indicated in Table 4 below:

Table 4: Width and thickness of saddle clips

For clamps or ordinary clips		
Size of conduit	**Width of saddle clips**	**Thickness of clip**
20 mm	20 mm	20 SWG
25 mm	20mm	20 SWG
32mm & above	25mm	18 SWG

c) Conduit joints

Conduit pipes shall be joined by means of screwed couples and screwed accessories only. In long distance straight run of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam nuts shall be provided. In the later case the bare threaded portion shall be treated with anticorrosive preservative. Threads on conduit pipes in all cases shall be between 13 mm and 19 mm long sufficient to accommodate pipes full threads portion of couplers or accessories.

Cut ends of conduit pipes shall have no sharp edges or any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

d) Making of chase

The chase in the wall shall be neatly made and ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, conduits shall be finished neatly after erection of conduit. In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.

e) Fixing of conduit in chase

The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60 cm apart or by any other approved means of fixing. Fixing of standard bends shall be avoided as far as practicable and all curves/bend shall be maintained by bending the conduit pipe itself with a long radius that will permit easy drawing of conductors. All threaded joints of conduit pipes shall be treated with preservative compound to prevent from rusting.

f) Erection and earthing of conduit

Fixing of conduit shall have to be completed in all respect before the wires are drawn. After completing the fixing of conduit, it shall be tested for mechanical rigid and electrically sound continuity throughout its running length. Gas or water pipe shall not be used as earthing electrode. If conduit pipes are liable to mechanical damage they shall be adequately protected. In a conduit system pipe must be continuous when passing through walls and floors. Earthing wire shall run throughout its length and properly bonded to conduit pipe where possible to get uniform grounding effect.

g) Inspection boxes

Suitable size of inspection boxes to the minimum requirements shall be provided to permit periodical inspection and to facilitate drawing/replacement of wires conveniently. These shall be mounted flushed with the wall. Suitable ventilation holes shall be provided in the inspection box covers condensation and heat radiation.

h) Protection of conduits against rust

If the materials are of the GI or Steel, the outer surface of the conduit including all bends, unions, tees, junction boxes etc. forming part of the conduit system shall be adequately protected against rust when such system is exposed to weather by being painted with two coats of oxide paint applied before they are fixed. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anticorrosive preservation or covered with approved plastic compound.

i) Painting of conduits and accessories

After installation, all accessible surfaces of conduit pipes, fittings, switch and regulator boxes etc. shall be painted in compliance with clauses under Painting. No painting is required for PVC conduit/HDPE pipe and casing capping unless otherwise specified.

j) Glider Clips

For all sizes of conduit, the size of clamping rod shall be 7 SWG diameter.

k) Bends in conduits

All necessary bends in the system including diversion shall be formed either by bending the pipes by an approved method of heating, or by inserting suitable accessories such as bends, elbows or similar fittings, or by fixing cast iron inspection boxes whichever is most suitable. Radius of bends in conduit pipes shall not be less than 7.5 cm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.

l) Outlets

The switch box shall be made of either rigid PVC molding, or mild steel or cast iron on all sides except at the front. In the case of boxes, wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, upto a size of 20 mm X 30 cm and above this size 16 gauge M.S, boxes shall be used. Except when otherwise stated 3 mm thick phenolic laminated sheets shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern.

4.2.1 PVC Conduits/HDPE Pipes

4.2.1.1 Surface

Providing and fixing of surface PVC conduit pipes include bends and circular boxes and painting if required. PVC conduits shall be of standard material free from defects of any kind. It should be properly finished and conforming to relevant standards.

Providing and fixing of PVC conduit 1.8 mm thick for sizes up to 25mm and 2mm thick from 32mm to 50mm, run whether in horizontal or vertical position as required. It should be rigidly fixed on the wall surface with conduit saddles of thickness 1.8mm for sizes up to 25mm and 2mm thick for pipe sizes from 32mm to 50mm at the spacing of not more than 50cm. However, saddles have to be provided at the ends of the pipes if bend and circular boxes are used. The saddles are to be rigidly fixed on the wall with wooden screws of sizes
50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits to required depth. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

4.2.1.2 Concealed

PVC conduits shall not be used for concealed/recessed wiring. Instead, wherever MS conduits are not feasible, HDPE pipes of appropriate size shall be used. However, PVC accessories like boxes, sleeves, corners may be used. The HDPE pipes can be run whether in horizontal or vertical position as required. It should be embedded in the wall up to depth from 16mm to 25mm from the finished plaster level. Where applicable, the pipe has to be secured by binding wire tied on the nail to hold it till the plastering sets to its strength. In case of the pipes laid in RCC works, it has to be tied securely by binding wire to the external reinforcement bars and should be flushed in the ceiling surface. Lay of pipe diagonally can be permitted in the brick/stone masonry wall, provided there is no crossing with other pipes or change in direction.

4.2.1.3 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound.

4.2.1.4 PVC conduit size

The length of PVC conduit shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm.

4.2.2 MS Conduits

4.2.2.1 Surface

Providing and fixing of MS conduit pipes includes bends and circular boxes including painting. The MS conduit pipe shall run whether in horizontal or vertical position as required. It should be rigidly fixed on the wall surface with conduit saddles of thickness 24SWG for sizes up to 25mm and 20 SWG for pipe sizes from 32mm to 50mm at the spacing of not more than 100cm. However, saddles have to be provided at the end of the pipes if bends and circular boxes are used. The saddles are to be rigidly fixed on the wall with wooden screws of sizes 50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

All conduit works shall be finished by filing the sharp edges and providing bushings and jam nuts from inside and outside the junction boxes, switchboards and DBs/SDBs where the wiring terminal ends from the pipe. Threading has to be provided at the pipe edge up to 20mm.

4.2.2.2 Concealed

Providing and fixing of MS conduit pipe of specified gauge as indicated against the sizes mentioned hereunder, run whether in horizontal or vertical position as required. It should be embedded in the wall up to depth from 16mm to 25mm from the finished plaster level. Where applicable, the pipe has to be secured by binding wire tied on the nail to hold it till the plastering sets to its strength. In case of the pipes laid in RCC works, it has to be tied securely by binding wire to the external reinforcement bars and should be flushed in the ceiling surface. Laying pipe diagonally can be permitted in the brick/stone masonry wall, provided there is no crossing with other pipes or change in direction.

4.2.2.3 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound.

4.2.2.4 Conduit size and Measurement

The length of MS conduit pipe shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm.

Providing & fixing MS conduit pipes include bends and circular boxes including painting. The unit of measurement shall be in metres and measured to the nearest cm.

4.2.3 Steel Conduits

4.2.3.1 Surface

Providing and fixing of surface steel conduit pipes includes bends and circular boxes. In the areas of aesthetic concern, stainless steel conduit pipe shall be provided. When surface steel conduit is provided, steel saddle of thickness 24SWG or base holder with coupler as applicable shall be used to match the looks. The steel saddles or base holders shall be provided at the spacing of not more than 30cm. The saddles have to be provided at the end of the bends, circular boxes and tees. The saddles are to be rigidly fixed on the wall with wooden screws of sizes 50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

4.2.3.2 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts including the pipes, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound

4.2.3.3 Conduit size and measurement

The length of PVC conduit shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm. The standard lengths available are from1.8 to 3m. The diameters shall be:

a. 20mm diameter,
b. 25mm diameter,
c. 32mm diameter,
d. 40mm diameter,
e. 50mm diameter,

Providing & fixing Steel conduit pipes include bends and boxes, etc. The unit of measurement shall be in metres and measured to the nearest cm.

5- INTERNAL WIRING PRACTICES

5.1 Circuit wiring

Circuit wiring shall mean portion of wiring from the distribution board to the switchboard. Where the circuit wiring is looped to more than one switchboard, such wiring shall be considered as circuit wiring and the wire size should remain the same. The measurement of the circuit wiring shall be on linear basis and the unit shall be in metres.

5.2 Sub-main wiring

Submain wiring is the wiring from outgoing terminal of the main/power distribution main bus-bars to the distribution switchgears. The measurement of such circuit wiring shall be on linear basis and the unit shall be in metres.

5.3 Power distribution mains wiring

In the large building/premises where the provision of main and submain switchgears alone is not feasible, the power distribution main needs to be provided. The wiring of such main shall be from the out-going terminal of the main control panel busbar to the incoming terminal of the power distribution main switch. The measurement of such circuit wiring shall be on linear basis and the unit shall be in metres.

5.4 System of wiring and loads

When the connected load of the building or premises exceeds more than 12KW, three-phase wiring shall be carried out. Lighting circuit (6 ampere) and power circuit (16 ampere rating) shall be separated from the distribution board in all types of wiring. Connected load of the circuit shall be equally distributed. In

case of three phase wiring, balancing of load among the phases shall be carried out as equally as possible. Due consideration shall be given for neatness, good appearance, safety and electrically and mechanically sound connections.
There shall not be more than 8 points and the load shall not exceed more than 800Watts on one particular lighting circuit controlled by a 6A MCB. Individual 16A MCBs shall be provided for every power socket.

5.5 Joints & looping back

The wiring shall be done in the "Looping system". Phase or live conductors shall be looped at the switch box and neutral conductor can be looped from the light, fan and socket outlet points. Where joint box is required due to unavoidable situation, mechanically and electrically sound connector shall make all joints in suitable and proper junction box. In both systems of wiring no bare or twist joints shall be made. In through run of cables, if the length of final circuit, sub-main is more than the length of the standard coil, joints shall be made by means of approved connectors in suitable junction boxes. The brass connectors are suitable for the mechanical and electrically connections.

5.6 Passing through wall

When wiring cables are to pass through walls, care shall be taken to see that the wires pass very freely through protective (PVC/steel) pipe or porcelain tube of suitable size, and that the wires pass through in a straight line without any twist or cross in them on either end of such holes. The ends of metallic pipes shall be neatly bushed with porcelain, PVC or other approved material.

5.7 Passing through floor

While passing through the floor or ceiling, care shall be taken to protect the conductor from mechanical damages. In order to protect from such damages, a solid pipe without any joint and bend shall be provided with bushes at both ends. Providing inspection box at both ends can enable easy drawing of wire.

All floor openings for carrying any wiring must be suitable sealed after installation.

5.8 Bunching of Cables

Cables carrying direct current may, if desired be bunched whatever their polarity, but cables carrying alternating current, if installed in metal conduit shall always be bunched so that the outgoing and return cables are drawn into same conduit. Should the bunching of return wire not be possible, the pipe shall be properly bonded with the earth wire.

6- POINT WIRING

Wiring shall include all works necessary for complete wiring of length up to 10m, including switch and circuit up to termination point as described below:

a) Lamp holder (includes the holders also in case of angle and batten points).
b) Pendant/fans/call bell points (up to and including ceiling rose)
c) Socket outlet (in case of light socket outlet point and includes a socket outlet).

The above applies surface or recessed/concealed wiring of all types as required.

6.1 Measurement of point wiring

Based on the lengths of wiring, points are classified as under:

Short point : Length of point not exceeding 3m.
Medium point : Length of point exceeding 3m but not exceeding 6m.
Long point : Length of point exceeding 6m but not exceeding 10m
The length of point exceeding 10 shall be measured on linear basis

7- BOXES (SURFACE/RECESSED)

7.1 Wooden, PVC and Steel boxes

Wooden boxes (hard wood), PVC boxes and steel boxes are normally available readymade in the following sizes. While wooden and PVC boxes are normally used for surface wiring, steel boxes can be used for surface as well as recessed wiring.

Table 5: Size of boxes

Hard wooden boxes	PVC boxes		Steel boxes
	without shutter	with shutter	

4" x 4" x 2 1/2 "	31 x 86 x 20 mm	31 x 86 x 20 mm	31 x 86 x 20 mm
6" x 4" x 2 1/2 "	86 x 86 x 20 mm	86 x 86 x 20 mm	86 x 86 x 20 mm
8" x 6" x 2 1/2 "	86 x 86 40 mm	86 x 86 40 mm	86 x 86 40 mm
10" x 8" x 2 1/2 "	146 x 86 x 40 mm	146 x 86 x 40 mm	146 x 86 x 40

7.2 MS Boxes

MS boxes are normally available in market in the sizes given below. 4 mm thick fibre sheet cover (Backlite) shall have to be provided. Such boxes are used for surface as well as recessed wiring**.**

a**.** 60 x 60 60 mm
b. 75 x 75 x 60 mm
c. 150 x 150 x 60 mm
b. 180 x 100 x 60 mm
c. 200 x 125 x 60 mm
d. 200 x 150 x 60 mm
e. 200 x 150 x 100 mm
f. 200 x 250 x 100 mm
g. 200 x 300 x 100 mm
h. 250 x 300 x 100 mm
i. 300 x 380 x 100 mm
j. 300 x 450 x 100 mm

8- FITTINGS, ACCESSORIES AND APPLIANCES

8.1 Fittings

The fittings can be classified as consumer's luminaries, rails, industrials fluorescent luminaries, integral high way luminaries, non integral highway luminaries, wall fixtures, well glass fittings, luminaries for hazardous areas, bulkhead, indoor decorative fittings (surface/pendent) , mirror optics (surface, pendent and recessed mounted) Modulus fittings HF ballast fittings, street light fittings, environmental light fittings, flood light fittings Accent lighting fittings, low and normal voltage lighting tracks with spot light fittings. These fittings are available in the range of PL lamp, florescent lamp, GLS lamp, argent lamp, reflector lamp, mercury vapour lamp, sodium vapour lamp and metal halide lamp of various voltage/wattage ratings.

8.2 Lamps

a) Incandescent Lamps

Incandescent light bulb shall consist of a coiled tungsten filament that glows (incandesces) when electric current passes through it. The filament shall be encapsulated in a glass bulb with an inert gas to prevent the filament from burning quickly. The glass bulb shall be set into a metal cap (BC/ES) with one electrical contact being the threads and the other being a small protrusion on the bottom. They shall be of lifetime 750 to 1500 hours and shall be dimmable. They shall be of the following types:

GLS Clear/Pearl/Argenta: GLS Clear/Pearl/Argenta shall be of tungsten filament for general lighting services with advantages of instantaneous light, low installation costs and warm color tone for a wide variety of interior/exterior lighting applications. They shall be of good colour, appreance, instantaneous operation and suitable for dimming. The ratings of such lamps are: 25, 40, 60, 100, 150, 200, 300 and 500 watts (W).

Argenta Superlux Lamps: Argenta Superlux Lamps shall be of distinctive mushroom shape specially designed to provide around 30% more light on the working plane. These are used in intricate tasks like on lathes and work benches in workshops, for needle work, on reading table, etc. for high intensity local lighting, and in shops, show-windows and for indoor games on card tables, carom board, etc. The rating of such lamps is: 40 and 60Wattage (W).

Special Incandescent Lamps (Pygmy, Candle, Night/Decoration and Clear): Special Incandescent Lamps (Pygmy, Candle, Night/Decoration and Clear) shall be clear, frosted or coloured version depending on type. These shall be of low-level illumination with minimum power consumption for applications in bedrooms, decorative lighting effects, signboards, Refrigerator lighting, and indicating lamp etc. The rating of such lamps are 15 Watts (W) Clear, Night, Coloured and pygmy and 25 Watts (W) Decoration Candle.

b) Reflector Lamps

The Reflector Lamps are intended to give directional light with substantially higher level of illumination against normal incandescent lamps of comparable wattage. These shall be with satin frosted front finish and high efficiency internal mirror reflector to achieve high intensity homogenous beam. The ratings of reflectors lamps 60W, 75W, 100W, 150W and250W.

c) Spotlighting Colour Lamps

Spotlighting colour lamps shall have silicon lacquer coating in different colours and shall provide a wide beam for creating distinctive lighting effects. Such lighting effect is generally required for security, patrolling and inspection purposes. The ratings of such lamps are 40w, 50w and 60w.

d) Infrared Heat Lamps

The Infrared heat lamps shall provide controllable Infrared radiant energy for a convenient, simple, safe, clean and easy method of heating for industrial, agricultural and other professional and domestic applications. The wattage shall be of 250W.

e) Halogen Lamps

Halogen Lamps have halogen vapour inside the lamp to create a regenerative cycle intended for higher efficiency, better colour of light and longer life. These shall be provided with low voltage halogen burner, optically positioned in a glass reflector which has special heat transmitting and light reflecting diachronic coating, with an integral front glass cover. These shall be characterized by their crisp white light, a colour temperature of around 3000K and a colour-rendering index approaching 100. The wattage of such lamp is 20w and 50W. The Capsule Halogen Lamps shall be single ended or double ended, extra low voltage halogen lamp with a quartz glass clear envelope provided with a standardized base. The wattage of single ended shall be of 12w and double ended shall be of 100w, 150w, 200w, 300w, 500w,750w and 1000w depending up on types like compact, small or large.

f) Compact Fluorescent Lamps (CFLs)

The compact fluorescent lamps are intended to be energy-efficient, long lasting with significant versatility and cost saving advantage over alternate light sources. They shall be of the same technology as linear fluorescent tubes but shall be smaller and shall often be integrated with ballast. Some other type shall have a screw base identical to conventional incandescent lamps. So, the compact fluorescent lamp shall be in two categories. i.e. Retrofit type : This type can directly can replace ordinary bulbs like GLS 25W, 40W, 60W, 100W, etc. Non-Retrofit type: This type requires special luminaries with built-in ballast.
The CFLs shall have the features like high efficiency, low wattage and Tri band Phosphors. It shall be compact, light in weight and consist of narrow fluorescent tubes. The Non- Retrofit shall have standardized base with two or four pins depending on the design. The geometric of CFLs available are: twin tubes, quad tubes, F-lamps, circular, and double-D lamps. They shall have lifetime up to about 10,000 hours.

g) Fluorescent Lamps

These are usually available in lengths of 0.61m and 1.22m. The tubes are usually coated inside with fluorescent materials and the colour of light given out by the tube depends on the fluorescent material used. The powder used as fluorescent material is activated by the ultraviolet rays generated in the tube. The popularity of these tubes in the daily lives is due to the reason that they have higher luminous efficiency as compared with the normal filament lamps, operate at low temperature, and have no glare. It shall not have black ends over life due to Anode Ring. The current ratings of the lamp are 0.37, 0.44 and 0.68A and wattage ratings are 18, 20, 36, 40, 58 and 65W. Linear fluorescent lamps shall vary from 2 feet to 5 feet in length, and from 5/8 to 1-1/2 inches in diameter. They shall have a lifetime of 10,000 to 20,000 hours.

h) High Intensity Discharge Lamps (HID lamps)

The type of lamp for high intensity discharge (HID) light are Mercury vapour lamps, Metal Halide lamps and Sodium Lamps. They shall require ballast similar to fluorescent lighting. The rating of HID lamps ranges from 35 to 2000 watts. The lamp has a lifetime of about 10,000 to 24,000 hours and shall not normally be dimmable.

Mercury vapour lamps: Mercury vapour lamps shall have quartz discharge tube enclosed in an internally phosphor coated outer shell and have universal burning position. It shall have high luminous efficacy, short run-up time and light output shall not be affected by temperature variations.

Metal Halide Lamps: Metal Halide Lamps shall have excellent colour rendering, crisp white light, high lumen output and high efficacy. The nucleus of the Metal halide lamp shall be the discharge tube manufactured from quartz. The discharge tube shall contain metal compounds, which have the effect of increasing the intensity of radiation in the three spectral bands: blue, green and yellow-red. The discharge tube shall be enclosed in an outer bulb with a fluorescent coating.

Sodium Lamps: High-pressure sodium vapour lamps shall be with a polycrystalline translucent Aluminum Oxide discharge tube enclosed in an outer glass envelope. The outer shell shall be internally

coated with a uniform layer of diffusing powder applied electrostatically. The discharge tube shall contain an amalgam of mercury and sodium along with Xenon gas as starting aid. They shall have very short run-up time and rapid re-strike time, excellent lumen-maintenance, and high efficacy.

Low-pressure sodium vapour lamps shall be with a discharge tube enclosed in a clear tubular bulb. They shall attain the highest luminous efficacy of any light source in the world. The discharge tube shall be made of special non-staining glass and the clear outer bulb shall be coated with an internal indium oxide layer. Low pressure sodium lamps shall have high visual acuity, sharp contrast, low luminosity, little glare and instant re-ignition at 190V and higher.

Blended light lamps shall not require any control gear. They shall have outer envelope coated with phosphor to give good colour radiation, shall have high luminous efficacy, and internal tungsten filament shall act as ballast.

8.3 Luminaries

8.3.1 Indoor Luminaries

8.3.1.1 Home lighting Luminaries

The luminaries for the fluorescent lamps shall comprise of:

- Channel made of CRCA sheet steel painted white, complete with electrical accessories like polyester filled copper wound ballast, specially designed lampholder and starterholder with starter, all pre-wired upto a terminal block.
- Lampholder brackets accommodating click-fix lampholder shall be made of sheet steel finished in stove enameled white. These shall be fixed at two ends.
- The copper wound ballast mounted on the channel of Copperstar shall be provided with specifically designed connector, which has a provision for the main input.

The luminaries shall be suitable for fixing on the wall/ceiling or suspension mounting with a conduit.The surface mounted and recessed luminaries suitable for Compact fluorescent lamps used in halls, corridors, staircase landings, offices and similar areas shall consist of a housing suitably painted. The housing shall accommodate an aluminium reflector, ballast, lampholder and earthing terminal. The luminaries shall also be fitted with a suitable screening device.

The table lamp shall consist of a base, an adjustable arm and an adjustable lamp unit. The base shall accommodate the ballast and also a balancing weight for enabling standing. The lamp unit shall house the lamp holder and a reflector. Each luminary shall be provided with an on-off switch. The lamp shall have glare free shade.

8.3.1.2 Luminaries for Commercial areas

The objective of lighting in commercial indoors is to create an optimum ambience combined with high efficacy; good glare protection and maximum comfort.

The commercial luminaries suitable for fluorescent lamps shall comprise of:

- mounting rail incorporating all accessories such as polyester filled copper wound ballast, click-fix lampholder, power factor improvement capacitor duly wired upto a terminal block.
- a frame assembly comprising two side panels painted white, two end plates made of high impact polystyrene. The entire assembly shall be mounted on specially designed lampholder brackets.
- a structured louver assembly shall provide for effective screening of the lamp in longitudinal and transverse directions.

The decorative recess mounted luminaries with flexibility in the choice of screening devices for various applications shall comprise of a sheet steel housing containing all accessories pre-wired upto the connector block and a louver/diffuser with a metal frame which shall be provided with mechanisms for fixing onto the housing. The luminaries shall be suitable for pendent or ceiling mounting. The pendant type shall be provided with two knockouts suitable for 19mm conduit.

8.3.1.3 Luminaries for decorative and accent lighting

The decorative recess mounted luminaries with flexibility in the choice of screening devices for various applications shall comprise of a sheet steel housing containing all accessories pre-wired up to connector and a louver/diffuser with a metal frame which shall be provided with mechanisms for fixing onto the housing. The fittings shall be suitable for surface/pendant mounting.

The decorative and accent lighting fixtures are basically same as commercial lightings. The difference is: the decorative and accent lighting fixtures are provided with reflector and it can be mounted surface, pendant, semi-recessed, recessed and down lighter suitable for use with fluorescent lamp, compact lamp, reflector lamps incandescent lamps. The fitting shall be provided with a pair of mounting clips for easy installation as per choice and the design of the fitting at site. The fitting shall consist of a ceiling ring made of suitable material, painted white in colour. A connector system made of glass-filled nylon shall be provided for cable termination. The fitting shall also be provided with an adjustable swiveling unit for adjusting lamp direction in the vertical plane.

Wall mounted decorative luminaries suitable for use with Compact fluorescent lamps shall consist of a

housing made of mild steel, which is suitably painted. The housing shall accommodate ballast, connector, lamp-holder and an earthing terminal. An acrylic diffuser shall help to curb the direct glare from the lamp.

Surface mounted luminaries suitable for use with CFLs shall consist of a housing made of mild steel, and suitably painted. A mirror system shall be fixed into the housing for directing light onto the working plane. The optical plane shall have a set of transverse louvers for limiting glare.

8.3.1.4 Luminaries for Industries uses

Industrial reflector luminaries suitable for use with fluorescent lamps shall comprise of:

- mounting channel made of CRCA sheet steel stove enameled grey which incorporates all accessories such as copper wound polyester filed ballast (s), click- fix lamp holder, starter holder(s) and starter (s) duly wired upto the connector block. The channel shall be provided with knockouts suitable for 19mm conduit.
- a cover for channel made of CRCA sheet steel stove enameled white, fixed by means of two knurl head screws. Stove enameled reflector shall be installed and removed with the aid of any tool.

The luminaries for the industrial uses shall be ceiling/suspension mounted.

The closed industrial luminaries suitable for fluorescent lamps shall consist of housing made of CRCA sheet steel painted grey with gasket, stainless steel toggles, cable entry gland and two brackets for mounting. The gear tray made of sheet steel shall house all the pre-wired accessories. The cover shall be made of Red acrylic. The fixture shall be mounted by use of clamps provided on the canopy.

8.3.1.5 Bulkhead luminaries

Bulkhead fixtures suitable for use with GLS lamp up to 100W and compact lamps from 9 to 18W shall have a cast-aluminium, stove-enamelled painted (white inside and grey outside) housing with fixing 19mm entry holes for wall mounting, a neoprene rubber gasket and a frosted thermal shockproof glass cover. It shall be provided with locking arrangement wire guard for mechanical protection.

8.3.1.6 Indoor industrial well glass luminaries

Indoor industrial well glass fixtures suitable for GLS lamp up to 500W, mercury vapour lamp up to 125W, MLN lamp up to 160 W and sodium vapour. The fixture comprises light weight corrosion-resistant, die-cast aluminium alloy housing, a porcelain lamp-holder, pre- wired up to connector terminal inside the housing, clear heat-resistance glass cover, wire guard, with an ethyl-propylene rubber gasket and a die-cast aluminium ring. A vitreous enamelled reflector and entry hole with inner threaded suitable for 19/20mm suspended MS pipe shall be provided.

Indoor Industrial low-bay luminaire suitable for HID lamps shall have housing made of sheet steel which shall enclose a specially designed mirror system for wide distribution of light as well as good vertical illumination. Acrylic covers and wires guard shall be available as options. The mounting shall be either by chain or through specially designed bracket arrangement.

Indoors industrial high-bay and medium-bay luminaries suitable for high-pressure sodium vapour lamp and high-pressure mercury vapour lamp shall comprise of:

a) a housing made from die-cast aluminium with low copper content offering excellent corrosion resistance painted black
b) an eyebolt of 30mm inside diameter for suspension
c) an eyebolt of 30mm inside diameter for suspension
d) anodized aluminium reflector

Closed industrial high-bay and medium-bay luminaries suitable for high-pressure metal halide lamps, high-pressure sodium vapour lamps and high-pressure mercury vapour lamps shall comprise of:

a) a housing made from die-cast aluminium with low copper content offering excellent corrosion resistance painted black
b) an eyebolt of 30mm inside diameter for suspension
c) anodized aluminium reflector
d) toughened glass cover assembly with safety chain

8.3.1.7 Luminaries for hazardous areas

Luminaries for hazardous areas are available in GLS, MLN and HPLN type of fixtures. But such fixture shall have flame proof features or capable of withstanding very high heat of not less than about 100^{O}C. Such fittings are normally used in ammunition go-down, chemical laboratories, painting workshop, POL de-pot, gas go-down etc.

8.3.2 Outdoor Luminaries

8.3.2.1 Public lighting luminaries

Public lighting luminaries shall be of a very efficient optical design resulting in uniformity of lighting levels along and across the road apart from spread of light on both sides of the luminaries. Such fixture shall have to ensure complete immunity of the housing from insects and rainwater. The fixtures are available in fluorescent lamps, GLS lamp, HPLN lamp and sodium vapour lamp. The florescent lamp fixture comprises of a sheet aluminium canopy finished in stove grey, detachable CRCA sheet stove enamel white reflector, tray with pre- wired ballast(s), capacitor, starter(s), and other accessories up to the connector terminal. High transparent clear, ribbed, activity cover shall be held in an aluminium frame and secured to the canopy against a rubber gasket with hinge arrangement on one side and four toggle latches on the other side. The fixture shall be suitable for side entry mounting and shall also be supplied with top suspension arrangement if required.

Street lighting fixture suitable for sodium vapour and other HID lamps shall have a lamp compartment made of sheet aluminium and a separate ballast housing. An acrylic cover shall ensure satisfactory insect-free and ingress of water. High transparent clear, ribbed, activity cover shall be held in an aluminium frame and secured to the canopy against a rubber gasket with hinge arrangement on one side and four toggle latches on the other side.

Compact Post-Top lantern suitable for use with sodium vapour, GLS, MLN and HPL-N lamps. A cast aluminium spigot for satisfactory corrosion free performance and shall be provided with a double conical HDP/ellipsoidal/spherical or any other suitably shaped cover for satisfactory insect-free and ingress of water.

8.3.2.2 Luminaries for Environment lighting

Environmental fixture suitable for use with GLS and Compact fluorescent lamp fixtures, the housing shall be made of coloured FRP. A clear acrylic cover shall protect the housing from the immediate environment such as satisfactory performance insect-free, ingress of water and high resistant to extreme climatic condition.

8.3.2.3 Floodlighting Luminaries

Floodlighting fixture shall have a spun aluminium/cast aluminium housing for corrosion resistance, the inside of which is anodised. A glass cover shall be provided to ensure satisfactory insect-free operation and the ingress of water. The fitting shall be suitable for GLS lamp, HPL-N lamp, SON lamp, Metal Halide lamp and Halogen lamp. The fixtures are provided with individual choke and condenser. The wattage rating of the fixture ranges from 150 to 500W. In case of halogen lamp fixture, the wattage rating is up to 2000 watts. So, each fixture shall have to be provided with individual control switches.

8.4 Accessories

All accessories such as switches, socket outlets, ceiling rose, lamp holders, call bell etc. shall be either flush mounted surface mounted as per the type of wiring. Similarly, the boxes shall be flush mounted or surface mounted. When metal box is used, it shall be efficiently earthed.

8.4.1 Switches

Switches are available in one way, two way and intermediate way. Only live wire shall be connected to the switch. 6-ampere rating switch shall be used for light, fan and 6-ampere socket outlets and 16-ampere rating switch shall be used for 16 socket outlets. Switch shall be so connected that when the circuit is opened when button position shall be “UP” and when the circuit is closed, the button position shall be “DOWN”.

8.4.2 Lamp Holders

Lamp holders may be batten, angle, pendant or bracket holder type as required. The holder shall be made of brass and there should be sufficient threading for fixing the base to the lamp holder parts. Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple and all those for use with flexible pendant shall be provided with cord grips. All lamp holders shall be provided with shade carriers. Where center contact Edison Screw lamp holders are used, the outer or screw contact shall be connected to the live conductor and neutral to the earthed/neutral conductor of the circuit.

8.4.3 Ceiling Rose

A ceiling rose shall not be used on a circuit, the voltage of which normally exceeds 240 volts. Normally only one flexible cord shall be attached to ceiling rose. Specially designed ceiling roses shall be used for multiple pendants. A ceiling rose shall not embody fuse terminal as an integral part of it

8.4.4 Socket Outlets

Plugs and socket outlets of rated voltage upto and including 250 volts and rated current upto and including 16 amperes shall conform to Indian Standards IS 1293 as revised from time to time

A socket outlet shall not have fuse terminal as integral part of it. But the fuse may be provided which shall be non-reversible and so arranged that the fuse is connected to live conductor. Every socket outlet

shall be controlled by a switch. 16 amperes socket outlet point shall normally be fixed at 25 cm above the floor level. In case of toilet and kitchen, it shall be placed at light point switch level. 6 amperes socket are normally placed at lighting point switch level. When 6 ampere rating is required at 25cm above floor level, 16 ampere socket outlet shall be replaced by 6/16 ampere socket outlet.

In a room containing a fixed bath or shower, there shall be no socket outlet and there shall be no provision for connecting a portable appliance. Any stationary appliance connected permanently in the bathroom shall be controlled by an isolator switch or circuit breaker.

The socket outlet and plug shall be of the three-pin type and the third pin shall be connected to earth. Conductors connecting electrical appliance with socket outlet shall be of flexible twin core with an earthing cord that shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance. The socket outlets used at 25cm above floor level shall be shutter type or interlocking type.

8.4.5 Socket outlet for call bell

Socket outlet for call bell shall be 2 pin type and not more than 6 ampere rating. When the socket is provided for the call bell, push type pendant switch is connected with a flexible wire through 2 pin plug. Such socket is normally mounted at 25cm above floor level. When flush type switch is used for the call bell, it is normally mounted at the light point switch level.

8.4.6 Socket outlet for telephone

Socket outlet for telephone shall be 2pin, RG11 type and not more than 6 ampere rating. It is normally mounted at 25cm above floor level. The socket and line shall be minimum 0.5m away from any electrical point or wiring of 240 volt. The telephone shall be connected to the socket by telephone wires through 2pin plug.

Industrial socket outlet: Industrial socket outlets are normally used in workshop, factories and laboratories, where heavy-duty (single as well as three phase) equipment or appliances are used. It is available in 3pin for single-phase and 4pin for three-phase. The rating for single is up to 20 ampere and three-phase rating is higher than 63 ampere. In practice, using socket out rating shall not exceed more than 63 ampere. All industrial type socket outlet shall be connected through correct rating RCCB and miniature circuit breaker.

8.4.7 Attachment of fittings and accessories

In casing capping and wooden batten wiring, accessories like ceiling rose, brackets, batten holders and stiff pendants holders shall be mounted to ceiling or wall on substantial blocks of hard wood double board varnished both inside and outside including base. Blocks shall not be less than 5.5 cm deep. Fan regulators shall be mounted on well-seasoned hard wood of suitable size to accommodate the number of fittings. The board shall be well varnished on all sides, both inside and outside, irrespective of being painted to match the surroundings.

The board shall be divided into two sections, one for the switches, which shall be flush mounted, and the other for mounting regulators with suitable screws.

In case of conduit wiring, all accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes conforming to relevant standards. Accessories like ceiling roses, brackets, battens, stiff pendants etc. shall be fixed on metal outlet boxes which shall be bonded to earth wires.

8.5 Appliances

8.5.1 Ceiling Fans

Ceiling fan including their suspension shall conform to IS: 374:1979. All ceiling fans shall be wired, ready for connection to ceiling roses and to suspend on hooks. There shall be no joints in the suspension rod. For wooden joists and beams, the suspension shall consist of M.S. flat of size not less than 40mm x 6mm. For secure suspension of ceiling fan, the flat shall be projected above the beam or joist by about 30mm and either bend to "L" inward or a through-bolt of size not less than 16mm diameter shall be placed above the beam. In either case, the flat shall be secured on the sides of the joists or beams by means of two coach screws of size not less than 5 cm for each flat to prevent from movements. A hook consisting of M.S. rod of size not less than 16mm diameter shall be inserted between the MS flat through oval holes on their sides for the suspension of ceiling fan.

In the case of 'I' beams, flats shall be shaped suitably to hold the flanges and shall be held together by means of a long nuts & bolts. For concrete roofing or ceiling, ceiling fan hooks shall be made of MS rod of size not less than 16 mm diameter. The shape of the hook can be made like an inverted 'U' of width not more than 1.5cm. Both vertical legs shall be bent horizontally at the outward up to length of 19cm. The height of the hook from the bend shall not be more than 18cm and 13cm shall be projected outside the finished ceiling.

In building with concrete roofs having a low ceiling height i.e. less than 2.5m, ceiling fan shall not be used. If the ceiling permits to recess the fixture, fan with suspension clamp shall be recessed in the ceiling and the clearance from the floor shall not be less than 2.5m. In normal cases, fans shall be hung 2.75m

above the floor. There shall minimum clearance between the blade of fan and the ceiling of not less than 23cm. Alternatively, wall fan, cabin fan and pedestal fan be used if the recessed type erection is not feasible.

The point of fan shall be provided as near as possible to the hook. The connection shall be made with flexible cord, coloured red, black and green. The green core shall be connected to the earth terminal. Care shall be taken that the blades rotate in the proper direction.

8.5.2 Exhaust Fan

Exhaust fan shall conform to IS: 2312:1967. The purpose of exhaust fan is to circulate the air i.e. evacuation of unhealthy air and to inlet the fresh air to and from the atmosphere. Such fan is required to be provided in places like: bath room, public toilet, kitchen, workshop, chemical laboratory, go-down and community hall etc.

For fixing an exhaust fan, a circular hole shall be provided on the wall to suit the size of the frame at suitable height below the beam or ceiling and above the lintel level. The hole shall be neatly plastered to the original finish of the wall. The point of exhaust fan shall be provided as near possible to the hole for fixing the fan. The connection shall be made with 3 core, coloured red, black and green. The green core shall be connected to the earth terminal. Care shall be taken that the blades rotate in the proper direction. The exhaust fan shall be so erected that the blade lies in centre of the wall. Protective wire mesh or any other device shall be provided within the surface of the outside wall. To prevent from corrosion effect, the fan shall be painted with special PVC paint or chlorinated rubber paint.

8.5.3 Fan Regulators

Use or all the fan regulators shall be power saving oriented example: electronic regulators rated to 300W. The resistance type regulators shall not be preferred for regulating the fan speed due to big space required and high energy consumption during slow running. Besides less power consumption, electronic regulators are usually compact, good looking and easy to fit on small boxes.

8.5.4 Immersion Water Heater and Geyser

Bare heater coil shall not be used in place of immersion water heater. Any type of immersion water heating element shall have minimum initial resistance of not less 40 ohms, power rating of not more than 1000 Watts. The connection of immersion heater shall be made with 3 core, steel and cotton breaded flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere 3 pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton breading shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

In case of geyser, the power rating shall not exceed more than 2000Watts. Where ever possible, the geyser shall be placed outside the bathroom. If erected inside the bathroom, care shall be taken to locate at suitable height to avoid touching by the children. The geyser shall be provided with a thermostat and indicating lamp. The connection shall be made with 3 core, steel and cotton breaded flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere 3 pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton breading shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.5 Electric Stove

The power rating of electric shall not exceed more than 2000 watts. Should the rating requires to exceed 2000 watts but not exceeding 5000 watts, the wiring shall be carried out with minimum 6 sq.mm, 1.1kV grade, copper wire. Under such condition of wiring, it shall be connected directly to separate distribution mains through earth leakage (RCCB) as well as over current (MCB) protective devices of not more than 32 ampere rating. The connection shall be made with 3 core, steel and cotton breaded flexible cord of size not less than 6sq. mm copper wire. The cooking appliance shall be securely connected to earth terminal of not less than 4 sq.mm or 12SWG bare copper conductor. Both phase and neutral wire shall have insulation resistance of not less than 1 mega-ohm.

8.5.6 Room Heater

Power rating of room heater shall not exceed more than 2000 watts. A switch of rating not less than 16 ampere shall be provided as an integral part of the appliance. The connection shall be made with 3 core, steel and cotton breaded flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere, 3 pin plug and third pin shall be connected to earth wire. Outer insulation rubber, steel and cotton breading shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.7 Air Cooler and Refrigerator

Power rating of air cooler and refrigerator shall not exceed more than 2000 watts and100watts respectively. A switch of rating not less than 16 ampere, thermostat and indicating lamp shall be provided

as an integral part of the appliances. In case of air cooler, a selector- switch for low, medium and high shall also be provided. The connection shall be made with 3 core, steel and cotton breaded flexible cord of size not less than 4sq.mm copper wire. Connection to the socket outlet shall be made by 16 ampere, 3-pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton breading shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.8 Electric iron, rice/curry cooker and water boiler vacuum cleaner, drier, iron, mixture

Power rating of electric iron, rice/curry cooker, water boiler, vacuum cleaner, drier, and, mixture shall not exceed 1000W. Separate switch of 6/16 ampere rating and indicating lamp shall be provided as an integral part of the appliances. In case of cooker and boiler, bimetallic operated auto off switch with cook/warm or boil warm indicating lamp are normally provided. The connection shall be made with 3 cores, flexible cord of size not less than 2.5sq.mm copper wire. Connection to the socket outlet shall be made by 6/16 ampere, 3-pin plug. Outer insulation rubber shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

9- CABLES

9.1 Cable Types and Classification

All cables shall conform to IS: 694 as revised from time to time. Conductors of all cables shall be of copper or aluminium. The smallest size of conductor for the final circuit shall have a nominal cross sectional area of not less than 1.5 sq. mm. The minimum size of cables for power point wiring shall be 4 sq.mm. Types of cable are unsheathed, sheathed copper or aluminium conductors, and can be classified as follows:

a) *House wiring cables*
House-wiring cable shall conform to IS 694. House wiring cables are available in single core as well as twin core. Conductor of house wiring cable shall be made of aluminium as well as copper. The size of aluminium house wiring ranges from 1.5 sq.mm to 6sq.mm. The size copper house wiring ranges from 1 sq.mm to 6 sq. mm.

b) *Flexible cables*
Flexible cable shall conform to IS 694. Conductor of flexible shall be made of copper and tinted copper with minimum cross section area up to 0.5sq.mm. Flexible cables are multi- stranded of cross-section area of the strand ranges from 0.2 to 0.5sq.mm. Flexible cables are normally armoured with steel breading, tough rubber or PVC sheath protected. Unless the flexible cables are protected by armour, tough rubber or PVC sheath, it shall not be used in workshop and other places where they are liable to mechanical damage. Three core flexible cables shall be used for connecting single-phase appliances. The insulation rubber of the core shall normally be colour with red, black and green, denoting for phase, neutral and earth wire respectively.

c) *Power cables*
Cable for application of low and medium voltage supply are PVC insulated, PVC sheathed, steel wire/strip armoured and non-armoured conforming to IS 1554, part I, 1964. Power cables are available in single core, 2 cores, 3 cores, 3.5 cores and not more than 4 cores. The size ranges from 2.5 to 630 sq.mm for more than one core and 2.5 to 1000 sq.mm single core. Voltage grade for low voltage cable shall b not less than 1.1kV. Cable is manufactured with aluminium conductor as well as copper conductor. Steel wire or strip used for armouring shall be galvanised. The armouring at both end of the cable shall be connected to earth electrode and length of single core cable run shall not exceed 30m.

d) *High voltage cables*
Cable for application of high voltage supply is paper insulated, XLPE insulated, oil or gas filled, conforming to IS 692, 1962 as revised from time to time. Cable is normally steel wire/strip armoured or lead sheathed. High voltage cable are available in single core, 2 core,3 core, 31/2 core and not more than 4 core. The size ranges from 25 to 630 sq.mm for more than one core and 2.5 to1000sq.mm single core. Voltage grade for 11kV cable shall be not less than 28kV and 33kV shall be 78kV. Cable are manufactured with aluminium conductor as well as copper conductor. Steel wire or strip used for armouring shall be galvanised. The armouring at both end of the cable shall be connected to earth electrode and length of single core run shall not exceed 10m.

9.2 Cable Size Selection

Cable size shall be selected in accordance with the current carrying capacity, voltage drop, fault current level and the provision for future demand. The selection of cable can also be guided by current rating based on total load considering the future demand as per IS 3961 (part I & II) -1967, IS 5819- 1970 and 1255-1967. The voltage drop at the dead end or final end shall not be more than 5% regulation or

within the limits recommended by IS 732 –1963. While deciding cable size, the derating factor for type and depth of laying, bunching, ambient temperature, ground temperature and soil resistivity shall be taken into account.
The Building Code of Bhutan (Part II- Building Services)- 2003 can be referred for cable selection guideline charts.

9.3 Cable Storage and Handling

Cable drums shall be store in well drained, hard surface preferably concreted floor so that the drum do not sink in the ground causing rot and damage to the cable drums. It shall be ensured that both ends of the cables are properly sealed to prevent ingress or absorption of moisture or water in the insulation and the cable. The cable shall be store under the roof with proper ventilation to adequately dehumidify the store yard.

During storage, periodical rolling of drum up to 90^0 shall be done once in three months. The rolling shall be done as per direction of arrow shown on the drum. Cable drums are preferred to be stored on the flanges and not on the flat surface.
When cable drums are required to be shifted to a short distance, it shall be rolled in the direction of arrow indicated on the drum. For transportation over long distance, a shaft shall be inserted in the cable drum hole, tighten with steel rope and use the crane to load and unload the cable drums. Alternative, when the crane is not available, drum shall be rolled carefully by ensuring that the surface material do not damage the cable and using hard wooden battens for loading and unloading.
The cable shall not be bent sharp. Minimum bending radius shall not be less than 15 times its diameter.

9.4 Cable Installation

Prior to laying the cable, proper right off route shall be confirmed. Simultaneously, clearance shall have to be taken from the following authorities.

a. Municipal Corporation to avoid sewerage and water pipeline.
b. Telephone and telegraph authorities.
c. Civil aviation authorities,
d. Gas pipe line,
e. Other under takings and
f. Private land holding owners.

Cable with kinks and straightened kinks or with similar apparent defects, like defective armouring etc. shall not be installed. Cable stored precariously without any proper cap and storage shall be tested properly before installation. Cable run rout shall be as short as possible. However, cross country shall not be permitted to take the shortest rout. The cable running rout shall follow fixed developments such as: parallel to roads, footpaths and water supply line etc. Route identification marks shall be maintained and proper drawing shall be kept in proper custody for future maintenance.

While selecting cable line routs, corrosive soils such as ground surrounding sewerage effluent etc shall be avoided. Where, avoiding corrosive soil is not possible, adequate precaution shall be taken to install the cable. As far as possible, effort shall be made to run the cable of different voltage level in the same trench but in different tray to minimise the cost of laying the cables. When the cable of different voltage level is laid in the same trench, the cable for the highest voltage level shall be at the down most trenches. Power and communication cable shall not run in the same trench. he crossing of power and communication cable shall be made at right angles and where power cable are laid in proximity to communication cable, radial spacing of not less than 60cm.

9.5 Cable Laying

There are four methods of laying the cables such as: buried direct in ground, in pipe, closed ducts or trench, in open duct or on surface depending on environmental conditions. The brief note on all the method and application of laying the cable is described here below.

9.5.1 Directly buried

Normally, cable is directly buried in ground in remote and less clustered settlements. Minimum width and depth of trench shall be not less than 35cm and 75cm respectively. After the cable is laid, dry sand covering of depth not less than 17cm shall be provided over the cable. Unless otherwise specified, mechanical protection over the sand covering with second class brick, stone or prefabricated slab of minimum 5cm thick shall be provided. In case of protection with the brick, it shall be laid breadth-wise i.e perpendicular to the cable. The remaining portion of the trench shall then be back-filled with excavated earth free of sharp edged stone. The earth so filled shall be properly rammed and watered if necessary in successive layer of not exceeding 30cm. Unless otherwise specified, a crown of earth of not less than

100mm in the centre and tapered towards the side shall be left to allow the subsidence.

9.5.2 Laying in pipe

Cable is laid in pipe where the cable line passes through road crossing, termination to a building etc. When metallic pipe is used for mechanical protection of especially single core cable, the pipe shall be properly connected to the earth electrode by adequate size of earth continuity wire. Pipe size shall be so selected that 40% of its space is free.

9.5.3 Laying in closed duct or trench

Laying of cable in closed duct or trench is preferred in the thickly populated urban area. Construction of closed duct or trench includes stone soling, concreting, brick/stone masonry and covering with slab etc. Minimum width and depth of trench shall be not less than 35cm and 75cm respectively. When more than one cable is laid in the same duct or trench, the clearance whether vertical and horizontal shall be maintained as shown in the Table 6 given below:

Table 6: Spacing between cables

Serial No.	Voltage rating	Spacing between cables
1.	0.415kV to 11kV	40cm
2.	11 to 33kV	35cm

9.5.4 Laying on surface or open duct

Laying of cable on surface or open duct is done in workshop, large building complex, power house and switch yard, tunnel, rising mains in buildings through rock ways etc. Saddle or clip is used to fix the cable when laid on surface.

9.6 Cable Termination & Jointing

Cable termination is done with cable termination kid and cable jointing is done with straight through cable jointing box. Termination and jointing of cable shall be carried by a licensed or experienced cable jointer. At the preliminary stage of laying the cable, a proper jointing position shall be selected. Jointing pit shall be of sufficient dimension as to allow easy and comfortable working. Proper tenting with sufficient ventilation shall jointing box etc. be provided during cable jointing operation.

Cable jointing materials and accessories such as: conductor ferrules, solder, flux, insulating materials, protective tapes, filling compound and jointing boxes etc shall be of right quality and correct sizes conforming to relevant standard. Core of the cable have to be identified properly and jointing shall be carried out in proper sequence.

Cable termination shall be carried out by proper type and size of cable gland and termination box. Termination of cable up to 1.1kV grade shall be terminated using compression gland.

The nipple of the gland is first screwed to the switchgear to which the cable is to be terminated and locked with check nut from inside the housing. Compression ring, washer, rubber ring and another washer are slipped in succession over the cable. The cable sheath is removed to desired length and armour strands splayed out. The armour wire is then cut to the overall diameter of second washer. Sharp edges are removed and armour cleaned. a third washer is now slipped on to the trap, trimmed strands and armour between the second and third washer. The cable end is then pushed through the gland nipple. The compression ring is then tightened when the rubber ring will expand and hold the cable tight by the sheath. For the high voltage or oil filled cable joint, the termination box shall be properly sealed with cable jointing compound and there shall be no cavity or pinhole to let ingression the moisture or leakage of oil. All connection shall be done with correct rating cable socket.

10- CONTROL GEARS

10.1 Main Switchgears, Switchboard and their Location

All main switchgears shall be of metal clad and shall be fixed at close proximity to the point of entry of supply. Open type switchboards shall be placed only in dry situation and in well- ventilated rooms and they shall be placed in the vicinity of storage batteries and exposed to chemical fumes. Main switchboards shall be placed installed in rooms or cupboards having provision for locking arrangement so as to safeguard against operation by unauthorized personnel. In a damped situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switchboards shall be totally enclosed or made flame-proof as may be necessitated by the particular circumstances.

Switchboards shall not be erected above gas, stoves, or sinks or within 2.5 m of any washing unit in the washing rooms of laundries or in the bathrooms, lavatories, toilets or kitchen. Switchboards, if

unavoidably fixed in places likely to be exposed to weather, to drip, or to abnormal moist atmosphere the outlet casing shall be weather proof and shall be provided with glands or brushing or adopted to receive screwed conduit according to the manner in which cables are run. PVC and double-flanged bushes shall be fitted in the holes of the switches for entry and exit of wires.

A switchboard shall be installed so that its bottom is within 1.25 m above the floor unless the front of the switchboard is completely enclosed by a door, or the switchboard is located in a position to which only authorized person(s) have access. Switchboard shall be recessed in the wall if so specified in the Tender Documents. The front shall be fitted with hinged panel of wood of other suitable material such as bakelite in wood frame with locking arrangement, the outer surface of the door being flush with walls. Ample room shall be provided at the work for connections and at the front between the switchgear mountings and the door.

Equipment's, which are on the front of a switchboard, shall be so arranged that in adverting personal contact with live parts is unlikely during the manipulation of switchgears, changing of fuses or like operation. No holes other than the holes by means of which the panel is fixed shall be drilled closer than 1.3 cm from any edge of the panel.

The various live parts, unless they are effectively screened by substantial barriers of non- hygroscopic, non-inflammable insulating material, shall be so spaced that an arc cannot be maintained between such parts and earth. The arrangement of the gear shall be such that they shall be readily accessible and their connections to all instruments and apparatus shall also be traceable.

In every case in which switches and fuses are fitted on the same pole, these fuses shall be arranged that the fuses are not alive when their respective switches are in 'off' position. No fuses other than fuses in instrument circuit shall be fixed on the back of or behind a switchboard panel or frame.

All the metal switchgears and switchboards shall be painted, prior to erection with coat of antirust primer. After erection, they shall be painted with two coats of approved enamel or aluminium paint as required on all sides wherever accessible. All switchboards connected to medium voltage and above shall be provided with *"Danger Notice Plate"* conforming to the Standards.

10.2 Types of Switchboards

Metal clad switchgears shall preferably be mounted on any of the types of boards mentioned below.

10.2.1 Hinged Type Metal Boards

Such metal boards shall be suitable for mounting of metal clad switchgears consisting of not more than one switchgear and ICDB 4 way or 6 way 15 amperes per way. Metal boards shall consists of box made of sheet metal not less than 3 mm thick and shall be provided with a hinged cover to enable the board to be swung open for the examination of the wiring at the back. The joints shall be substantially welded.

Alternatively metal boards may be made of suitable size angle iron of minimum size 35 mm x 35 mm x 6 mm or channel iron of minimum size 353 mm x 25 mm x 6mm frame work suitably mounted on front with a 3mm thick M.S. Plate and on the back with 1.5 mm M.S. sheet. In case of wood casing or wood batten systems of wiring, 2.5 cm teak wood battens may replace the top and bottom members. The front sheet shall be provided with suitable hinges to enable the board to be swung open for examination of wiring. The joints shall be substantially welded.

The boards shall be securely fixed to the wall by means rag bolts and shall be provided with a locking arrangement and earthing stud. All wires passing through the metal boards shall be bushed. There shall be a clear distance of 3 cm between the front and back sheets. More space shall be allowed whenever necessary. A wooden board of thickness not less than 6 mm may be provided at the back. No control gears shall project beyond any edge of the panel. No fuse body shall be mounted within 2.5 cm of any edge of the panel.

10.2.2 Fixed Type Metal Boards

Such boards shall be suitable for large switchboards for mounting large number of switchgears and /or higher capacity metal clad switchgear. These shall consist of an angle or channel iron frame fixed on the wall or on the floor and supported on the wall at the top. There shall be a clear distance of 1 m in front of the switchboard and a working distance of 1 m behind the switchboard. The connections between the switchgear mounting and the outgoing cable up to the wall shall be enclosed in a protection pipe. The detailed dimensions and design of metal boards and angle iron frame work for switchgears, including the disposition of the various mountings, which shall be symmetrically and neatly arranged for arriving at the overall dimensions shall be prepared and submitted before hand and shall have the prior approval of the Engineer.

10.3 Marking of Apparatus

When a board is connected to voltage higher than 250 volts, all the terminals or leads of the apparatus mounted on it shall be marked in the following colours to indicate the different poles or phases to which

the apparatus or its different terminals may have been connected.

A.C	D.C
Three phase: Red, Yellow, Blue Neutral: Black	Three wired system, 2 outer wires: Red(+) and Yellow (+/equalizer), Blue(-) Neutral: Black

Where four-wire three-phase wiring is done, the neutral shall preferably be in one colour(Black) and the other three wires in another colour(Red,Yellow and Blue).
Where a board has more than one switchgear, each such switchgear shall be marked to indicate which section of the installation it controls. The main switchgear shall be marked as such, where there is more than one main switchboard in the building, each such switchboard shall be marked to indicate which section of the installation and building it controls.
All marking required under this rule shall be clear and permanent. All distribution boards shall be marked 'Lighting' or 'power' as the case may be and also marked with the pressure and number of phases of the supply. Each shall be provided with a circuit list giving details of each circuit that it controls and the current rating of the circuit and the size of the fuse element.

10.4 Main and Branch Distribution Boards and their Location

Unless otherwise specified, main and distribution fuse boards shall be of the metal clad type. Main distribution boards shall be controlled by a Residual current circuit breaker (RCCB/ELCB). Each outgoing shall be provided with a single pole circuit breaker for lighting 6Ampere and for power circuit 12.5Ampere to 16Ampere. Linked switch fuse unit with HRC fuse or a circuit breaker shall control branch distribution boards. The earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided on each branch distribution board.
The distribution fuse board shall be located as near as possible to the centre of the load they intended to control. These shall be of metal clad type, but, if exposed to weather or damp situations, they shall be of the weatherproof type and if installed where exposed to explosive dust, vapour or gas, they shall be flameproof type.
Where two or more distribution fuse boards feeding low pressure circuits are fed from a supply at medium voltage, these distribution boards shall be:

a) Fixed not less than 2 m apart; or
b) Arranged so that two cannot be opened at a time, namely they are interlocked and the metal case is marked "danger-400 Volts"; or
c) Installation in a room or enclosure accessible to only authorized person(s).

Single pole and neutral (SPN)/Triple pole and neutral (TPN) distribution boards shall be invariable, of single pole miniature circuit breaker (SPMCB) outgoing control.

10.5 Control at Point of Entry of Supply

There shall be linked main switchgear with HRC fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of linked switchgear. The neutral shall also be distinctly marked.
The main switchgear shall be situated as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid. On the main switchgear, where the conductors include an earth conductor (neutral) of a two-wire system, an earthed neutral conductor of a multi-wire system, which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earth neutral conductor.
Cables shall be connected to terminals only by *soldering lugs/crimping lugs with appropriate thimbles up to 200Amperes***,** unless the terminals are of such a form that they can be securely clamped without cutting the cable strands. All bare conductors shall be rigidly fixed in such a manner that a clearance shall be 2.5 cm is maintained between conductors of opposite polarity or phase and between the conductors and any materials other than insulating material. In a hinged board, the incoming and outgoing cables shall be neatly bunched and shall be capable of swinging through an angle of not less than 90º. A pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus of the board.

10.6 Bus-Bars and Bus-Bar chambers

10.6.1 Bus Bar Chambers

Bus bar chamber shall be fabricated with M.S. angles for frame work and covered all round with sheet steel of thickness not less than 1.5 mm in a box form. It shall be provided with detachable covers on all sides netted with dust excluding gasket, secured with sufficient numbers of cadmium plated iron screws to ensure that the covers are dust tight. Bus bar chambers for bus bar of more than 90 cm length shall have horizontal and vertical stiffeners welded to the main frame.

Alternatively the bus bar chamber shall be made of steel sheet of thickness not less than 3 mm with detachable covers on all sides excluding gasket. The joints shall be continuous welded. The detachable cover shall be secured to the box with sufficient number of cadmium plated iron screws to ensure dust tightness. This type of bus bar chamber shall be restricted for bus bars upto 90cm. length. Bus bar chambers size upto 90 cm shall have detachable end covers so that the same can be extended. The bus bar chamber shall be painted with a coat of primer red oxide paint and finished with two coats of enamel paint of approved shade.

10.6.2 Bus Bars

Bus bars shall be made of copper/aluminium alloy/wrought aluminium bars conforming to IS: 4171:1983 and shall be of sufficient cross section so that a current density of 130 amperes/sq.cm is not exceeded at nominal current rating copper bus bar is not advisable of rating more than 200Ampere. The cross section of the neutral bus bars shall be the same as that of the phase bus bar of capacities up to 200 amperes, and for higher capacities the neutral bus bar must not be less than half the cross section of that of the phase bus bar. The recommended sections of bus bars are given in Table 7 below.

10.6.3 Bus-Bar Supports and Attachments

10.6.3.1 Supports

Bus bars shall be firmly fixed on supports constructed from a suitable insulated material such as Phenolic laminated sheet. Alternatively bus bars shall be supported on insulators of suitable lengths conforming to relevant Indian Standards. The supports shall be sufficiently robust to effectively withstand electromechanical stresses produced in the event of short circuit.

10.6.3.2 Connections to Bus Bars

Connections to bus bars of ratings more than 200 amperes shall be made with clamping arrangement with bolts and nuts and for bus bars of smaller ratings, use of holes drilled into the bus bars may be made. The bolts and nuts used for connections to bus bars shall be made of aluminium alloy, tinned forged brass or galvanized iron. Suitable precaution shall be taken against heating due to bimetallic contact. Further for tapping off connections from bus bars, PVC insulated wire may be used for current capacities upto 100 amperes and for higher current capacities solid conductors/strips suitably insulated with PVC sleeve/ tape shall be used.

10.6.3.3 Clearances

The minimum clearances to be maintained for open and enclosed indoor air insulated bus bars/electrically non-exposed and working at system voltages upto 600 volts shall be as follows:

Between	**Minimum Clearances**
Phase to Earth	26 mm
Phase to Phase	32 mm

10.6.4 Bus Bar Markings

10.6.4.1 The colours and letters (or symbols) for bus bars

Main bus bar connection and Auxiliary wiring etc. shall conform to relevant Indian Standards. A brief from I.S. 375-: 1963 (superseded by I.S. 5578:1984 and I.S. 11353:1985) is given below for board guidelines.

(a) *For A.C. Bus Bars & main Connections*

Bus Bar and Main Connections	**Colour**	**Letter/Symbol**

Three phase	Red, Yellow, Blue	R,Y,B
Two Phase	Red, Blue	R,B
Single phase	Red	R
Neutral connection	Black	N
Connection to Earth	Green	E
Phase variable (such as connection to motors)	Grey	Gy.

(a) *For D.C. Bus Bars & main Connections*

Bus Bar and Main Connections	**Colour**	**Letter/Symbol**
Positive	Red	R or +
Negative	Blue	B or -
Neutral Connection	Black	N
Equalizer	Yellow	Y
Phase variable (such as connection to reversible motors)	Grey	Grey or Gy.

10.6.4.2 Phase sequence and polarity

Bus bars and main connections, when marked shall be marked in accordance with the following table to indicate the order in which the voltages in phases reach their maximum values.

System	**As indicated by colours or letter**	**Phase sequence as Vectorially**
Three phase	Red, Yellow, Blue	R.Y.B. R.B.
Two phase	Red, Blue	

10.7 Arrangement of Bus Bars and Main Connections

Bus bars and main connections, which are substantially in one plane, shall be arranged in order given as follows: -

10.7.1 A.C. System

1. The order of phase connections shall be Red, Yellow and Blue.
2. When the run of the conductors is horizontal, the Red shall be on the top or on the left or farthest away as viewed from the front.
3. When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.
4. When the system has a neutral connection in the same plane as the phase connections, the neutral shall occupy an outer position.
5. Unless the neutral connections can be readily distinguished from the phase connections, the order shall be Red, Yellow, Blue and Black.

10.7.2 D.C. System

1. When the run of the conductors is horizontal, the Red shall be on the top or on the left or farthest away as viewed from the front.
2. When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.
3. When the system is 3-wire with the conductors in the same plane, the neutral shall occupy the

middle position.

Table 7: Aluminium/Copper Bus-Bar sections

Current ratings in amperes upto	Recommended rectangular cross-section			
	Aluminium		Copper	
	No. of strips/phase	Size in mm	No. of strips/phase	Size in mm
100	1	20x5	1	20x3
200	1	30x5	1	25x5
300	1	50x5	1	40x5
400	1	50x6	1	50x5
500	1	75x6	1	60x5
600	1	80x6	-	-
800	1	100x6	-	-
1000	1	100x10	-	-
1200	1	125x10	-	-
1600	2	100x10	-	-
2000	2	125x10	-	-
2500	3	125x10	-	-

11- COMPOUND/STREET LIGHTING WORK

11.1 Outdoor Fittings

External and road-lamps shall have weatherproof fittings of approved design so as to effectively prevent the admission of moisture. An insulating distance piece of moisture proof material shall be inserted between the lamp holder nipple and the fitting. Flexible cord conductors and cord grip lamp holders must not be used where exposed to weather. In verandahs and similar exposed situations where pendants are used, they shall be of fixed rod type.

11.2 Steel Tubular Poles

Steel tubular poles shall conform to I.S. 2713-1964. This shall be of seamless/swaged and welded type as specified and shall be in three stepped sections. Unless otherwise specified, $1/6^{th}$ of the length of the pole plus 15 cm from its base shall be coated with black bituminous paint, both internally and externally. The remaining portion of the poles shall be painted with one coat of red oxide on its external surface. The pole shall be complete with a cap and base plate. Spacing of the poles shall be such that in a residential area adequate street lighting can be provided.

The depth of foundation for steel poles shall be as per design or as directed by the Engineer but not less than $1/6^{th}$ the length of the pole. It shall be fixed in cement concrete 1:3:6, 40 mm aggregates, foundation with not less than 200 mm thick layer of concrete all around the support or as directed by the Engineer or as per the drawing supplied.

12- EARTHING

12.1 Types of Earth Electrodes

The Earth electrodes shall be of the following types:

a) Pipe earth electrode.
b) Plate earth electrode.

c) Strip or conductor earth electrode.

12.2 Selection of Earth Electrode

G.I. pipe or G.I. plate earth electrode shall be used except when it is unavoidable to use copper earth electrode due to corrosive soil conditions for direct current system or for large capacity substations. Strip or conductor electrode is recommended for hard and rocky soils and in locations where there are limitations to the use of the pipe or plate electrode. Where the soil is highly corrosive, the earth electrode shall be of copper. Where soil contains sulphur, copper electrode shall be adequately tinned.

12.3 Arrangement for Earthed Electrode

12.3.1 Pipe Earth Electrode

G.I. pipe shall be of medium class, 40 mm diameter and 4.5 m in length. Galvanization of the pipe shall conform to the relevant Indian Standards. G.I. pipe electrodes shall be cut tapered at the bottom and provided with holes of 12 mm diameter drilled not less than 7.5 cm from each other up to 2 m of length from bottom. The electrode shall be buried in the ground vertically with its top not less than 20 cm below the ground level.

12.3.2 Plate Earth Electrode

For plate electrodes minimum dimensions of the electrodes shall be as under:

(a) G.I. plate Electrode – 60 cm X 60 cm X 6 mm thick.

(b) Copper plate Electrode – 60 cm X 60 cm X 3 mm thick.

The electrode shall be buried in ground with its face vertical and top not less than 3 m below ground level.

12.3.3 Strip or Conductor Electrode

Strip electrodes shall not be less than 25 mm x 4 mm of galvanized iron and 20mm x 3mm of copper. For conductor electrode the size of round conductor shall be not less than 6 SWG of G.I. and 8 SWG of copper. The length of buried strip or conductor earth electrode shall be not less than 15 m. This conductor length shall be increased if necessary on the basis of the information available about soil resistance, so that the required earth resistance is obtained. Electrode shall be buried in trench not less than 0.5m deep. If conditions necessitate use of more than one strip or conductor electrode, they shall be laid as widely distributed as possible preferably in a single straight or circular trench or in a number of trenches radiating from one point. so that required earth resistance is obtained.

12.4 Method of Installing Watering Arrangement

In the case of plate earth electrode, a watering pipe of 20 mm diameter at least medium class G.I. pipe shall be provided and attached to the electrodes. A funnel with mesh shall be provided and attached to the top of this pipe for watering the earth. In the case of pipe electrode a 40 mm x 20 mm reducer shall be used for fixing the funnel. The watering funnel attachment shall be housed in mansonary enclosure of not less than 30 cm x 30 cm x 30 cm. A cast iron/M.S. frame with cover having locking arrangement shall be suitably embedded in the mansonary enclosure hinged with 30cmx30cm C.I/MS cover having locking arrangement.

12.5 Location for Earth Electrode

An earth electrode shall not be situated less than 1.8 m from any building. Care shall be taken that the excavations for earth electrode may not affect the column footings or foundation of the building; in such cases electrodes may be farther away from the building. The location of the earth electrode will be such where the soil has reasonable chance of remaining moist, as far as possible. Entrances, Pavements and roadways, are definitely avoided for locating the earth station/earth electrode.

12.6 Artificial Treatment of Soil

In case there is no option of site, earth electrode resistance shall be reduced by artificial chemical treatment of the soil. For this purpose, the most commonly used substances are sodium chloride (common salt), calcium chloride, sodium carbonate, copper sulphate and salt mixed with soft coke or charcoal in suitable proportion. But before any chemical treatment is applied, possible corrosive effect on the electrode material and connections must be taken into consideration. When this treatment is resorted to, the electrode shall be surrounded by charcoal/coke and salt. This treatment of soil shall be as specified in the Schedule of work and in such cases, excavation for earth electrode shall be as per dimensions of standard earthing drawing.

12.7 Number of Earth Electrodes for Installation

Metallic covers or supports of all medium pressure or HT apparatus or conductors shall, in all cases be connected to not less than two separate and distinct earths including electrodes. The number of earthing electrodes for substations having one transformer or one generating set shall be not less than four (two for neutral and two for earthing the metal frame). Separate earth electrodes shall be provided for lighting arresters/lighting conductor.

12.8 Resistance of Earth

No earth electrode shall have a resistance greater than 5Ω as measured by an approved earth testing apparatus. In rocky soils, the resistance may be upto 8Ω.

12.9 Size of Earthing Lead

12.9.1 Main earthing Lead

Main earthing lead shall be of G.I. wire, in the case of G.I. pipe earth electrode, G.I. wire/G.I. strip, in case of G.I. strip or G.I. plate earth electrode and copper wire or copper strip in the case of copper earth electrode. For all electrical installations except sub-stations and generating station, the earthing lead shall not be less than 8 SWG of copper or 6 SWG G.I. wire, copper strip 20mm x 3mm in case of copper earth plate and G.I. strip 25 mm x 4 mm in case G.I earth plate.

12.9.2 Size of Earth Lead for Substations/Generating Stations

The recommended size of copper earth bus in case of generating station and sub-stations shall be as shown in the table below.

Capacity of transformer/generating set	size of copper strip in mm
(a) Upto 300 KVA	20 x 4
(b) Above 300 KVA but not exceeding 500 KVA	32 x 5 or 40 x 4
(c) Above 500 KVA but not exceeding 800 KVA	40 x 6.3 or 50 x 5
(d) Above 800 KVA but not exceeding 1000KVA	50 x 6.3

12.9.3 Size of Earth Continuity Conductor

The nominal minimum cross sectional area of an earth continuity conductor not contained within a cable or flexible cord shall be 15/14 SWG copper or14/12 SWG of G.I.

12.10 Method of Connecting Earth Lead to Earth Electrode

In the case of plate earth electrode the earthing lead shall be welded/securely bolted to the plate with two bolts, nuts, checknuts and washers. In the case of pipe earth electrode, it shall be connected by means of G.I through bolt, nuts and washers and cable socket. All materials used for connecting the earth lead with electrode shall be G.I. in case of G.I. pipe and G.I. plate earth electrodes and of tinned brass/brass in case of copper plate electrode. The earthing lead shall be securely connected at the other end to the main board. Loop earthing shall be provided for all mountings of main board and other metal clad switches and distribution fuse boards with not less than 8 SWG copper/G.I.

The nominal minimum cross sectional area of an earth continuity conductor not contained within a cable or flexible cord shall be 15/14 SWG copper or14/12 SWG G.I.

12.11 Protection of Earthing Lead

The earthing lead from electrode onwards shall be suitably protected from mechanical injury by a 15 mm diameter G.I. pipe in case of wire and 40 mm diameter medium class G.I. pipe in case of strip. Portion of this protection pipe within the ground shall be buried atleast 50 cm deep. In case of road crossing and pavements shall be buried 0.6 to 0.7m.

13- PAINTING

13.1 Preparation of the surface

The surface shall be thoroughly cleaned and dusted before painting is started. The proposed surface shall be inspected by the Engineer or his authorized agent and shall have received the approval before painting is commenced.

13.2 Application

Paint shall be applied by spraying or with brush. The paint shall be spread as smooth and even as possible. Particular care shall be paid to rivets, nuts, and bolts and over lapping. Before drawing out, it shall be continuously stirred in the smaller containers with a smooth stick while it is being applied.

13.3 Scope

Painting on old surface in indoor situations will not include primer coat except where specially mentioned. However, where rust has formed on iron and steel surfaces the spots will be painted with one anti-rust primer coat prior to finish coat of painting.

13.4 Painting of Conduit and Accessories

After installation, all accessible surface of conduit pipe, fittings, switch and regulator boxes etc. shall be painted with two coats of approved enamel paint or aluminium paint as required to match the finish of surrounding wall, trusses etc.

14- TESTING OF INSTALLATION

On completion of installation the following tests shall be carried out

a) Insulation Resistance Test.
b) Polarity Test of Switch.
c) Earth Continuity Test.
d) Earth Electrode Resistance Test.

14.1 Insulation Resistance Test

The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section there-off with all fuses in place and all switches closed, and except in earth concentric wiring all lamps in position or both poles of the installation otherwise electrically connected together, a direct current pressure of not less than twice the working pressure provided that it need not exceed 500 volts for medium voltage circuits. Where the supply is derived from the three wire D.C. or a poly phase A.C. system, the neutral pole of which is connected to earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the phase conductor and the neutral.

The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the neutral or to the other pole or phase conductors of the supply with all lamps in position and switches in "off" position. The insulation resistance in Megaohms shall not be less than 50 Megaohms divided by the number of outlets or when PVC insulated cables are used for wiring 12.5 Megaohms divided by number of outlets.

Where a whole installation is being tested, a lower value than that given by the formula, subjected to a minimum of 1 Megaohm is acceptable. A preliminary and similar test may be made before lamps, etc. are installed, and in this event the insulation resistance to earth should be not less than 100 Megaohms divided by the number of outlets or when PVC insulated cables are used for wiring 25 Megaohms divided by number of outlets.

The term "outlet" includes every point along with every switch except that a switch combined with socket outlet, appliance or lighting fitting is regarded as one outlet.

Control rheostats, heating and power appliances and electric signs may, if required, be disconnected from the circuit during the test. In that event the insulation resistance between the case or frame work, and all live parts of each rheostat, appliance and sign, shall be not less than half a Megaohm.

14.2 Polarity Test of Switch

In a two wire installation a test shall be made to verify that all switches in every circuit have been fitted in the same conductor and such conductor shall be labelled or marked for connection to the phase conductor or to the non-earthed conductor of the supply. In a three wire or a four wire, installation test shall be made to verify that every non-linked single pole switch is fitted in a conductor which is labelled or marked for connection to one of the phase conductor of the supply. A test lamp, one lead of which is connected to the earth, shall test the terminals of all switches. Glowing of test lamp to its full brilliance, when the switch is in "on" position irrespective of appliance in position or not, shall indicate that the switch is connected to the right polarity.

14.3 Earth Continuity Test

The earth continuity conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance or earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

14.4 Measurement of Earth Electrode Resistance

Two auxiliary earth electrodes besides the test electrode are placed at suitable distance from the test electrode (see figure below). A measured current is passed between the electrode 'A' to be tested and an auxiliary current electrode 'C' and the potential difference between the electrode 'A' and auxiliary potential electrode 'B' is measured. The resistance of the test electrode 'A' is then given by: **R = V/R**

Where, R is Resistance of the test electrode in ohms.
V is Reading of the voltmeter in volts.

I is Reading of the ammeter in amperes.

Stray currents flowing in the soil may produce serious errors in the measurement of earth resistance. To eliminate this, hand driven generator is used. If the frequency of the supply of hand driven generator coincides with the frequency of stray current there will be wandering of instrument pointer. An increase or decrease of generator speed will cause this to disappear. At the time of test, the test electrode shall be separate from the earthing system.

The auxiliary electrodes shall be of 13 mm diameter mild steel rod driven upto 1 m into the ground. All the three electrodes shall be so placed that they will be independent of the resistance area of each other. If the test electrode is in the form of rod, pipe or plate, the auxiliary current electrode 'C' shall be placed atleast 30 m away from it and the auxiliary potential electrode 'B' shall be placed mid way between them. Unless three consecutive readings of test electrode resistance agree the test shall be repeated by increasing the distance between electrodes A and C upto 50 m and each time placing the electrode B mid way between them. On these principles "Megger Earth Tester" containing a direct reading ohm-meter, a hand driven generator and auxiliary electrodes are manufactured for direct reading of earth resistance of electrode.

15- PROTECTION OF BUILDING AGAINST LIGHTNING

Protection of buildings against lightning shall generally be done in accordance with I.S. 2309: 1989. A brief of the same is given below for guidance. Protection of special structures like trees, live stock in fields, structures supporting overhead lines, structures with highly combustible roof etc. shall be strictly done in accordance with I.S. 2309: 1989.

15.1 Principle of Protection

The principle for protection of buildings against lightning is to provide a conducting path between earth and the atmosphere above building through which lightning discharge may enter the earth without causing damage to the building. If adequately earthed metal parts of proper proportions are provided and spread properly on and around the building, damage can be largely prevented. The required conditions of protection are generally met by placing all the air terminals whether in the form of vertical finals or horizontal conductors on the upper most part of the buildings or its projections with lightning conductors connecting the air terminals with each other and to the earth.

15.2 Zone of Protection

The zone of protection of a lightning conductors provides protection against a direct lightning stroke by diverting the stoke itself. For a single vertical conductor, this zone is described as a cone with its apex at the highest point of the conductor and with an angle, called as protective angle, between the side of the cone and the conductor. In general, for the purpose of providing and acceptable degree of protection the protective angle of any single component part of an air termination network, namely, either one vertical or one horizontal conductor is considered to be 45°. Between two or more vertical conductors of equal height spaced at a distance not exceeding twice their height, the equivalent protective angle within the space bounded by the air terminations may be taken as 60° to the vertical, while the protective angle away from the conductors is still taken as 45° to the vertical.

15.3 Materials and Dimensions

The materials of lightning conductors, down conductors, earth termination etc. of the protective system shall be reliably resistant to corrosion or be adequately protected against corrosion. The materials recommended are:

Copper: Solid or flat copper strip of 98% conductivity conforming to relevant I.S. Specifications shall be used.

Copper clad Steel: Copper clad steel with copper covering permanently and effectively welded to the steel core shall be used. The proportion of copper and steel shall be such that the conductance of the material is not less than 30% of conductance of the solid copper of the same total cross sectional area.

Galvanized Steel: Steel thoroughly protected against corrosion by a zinc coating shall be used.

Aluminium*:* Aluminium 99% pure and with sufficient mechanical strength and protected against corrosion shall be used. Aluminium should not be used under ground or in direct contact with walls.

All air terminations shall be of G.I. and all down conductors shall be of G.I. or aluminium except where the atmospheric conditions necessitate the use of copper or copper clad steel for air terminations and down conductors.

The recommended shape and minimum sizes of conductors for use above and below ground are given in Table below.

Shapes and Minimum sizes of Conductors for use above Ground

Sl.No.	Material & Shape	Minimum size
1.	Round copper wire clad steel wire	6 mm diameter
2.	Stranded copper wire	50 sq.mm or 7/3 mm dia
3.	Copper strip	20 mm x3 mm
4.	Round galvanized iron wire	8 mm diameter
5.	Galvanized iron strip	20 mm x 3 mm
6.	Round aluminium wire	8 mm diameter
7.	Aluminium strip	25 mm x 3 mm

Shapes and Minimum Sizes of Conductors for use below Ground

Sl.No. Material & Shape	Minimum Size
1. Round copper wire or Copper clad steel wire	8 mm diameter
2. Copper strip	32 mm x 6 mm
3. Round galvanized iron wire	10 mm x 6 mm
4. Galvanized iron strip	32 mm x 6 mm

15.4 Design Considerations

When designing and installing lightning conductors, the following items should be taken into consideration:

1. The entire lightning protective system should be mechanically strong to withstand the mechanical forces produced in case of a lightning stokes.
2. The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the building.
3. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations or vertical finals is, therefore, not regarded as essential. An air termination may consist of a vertical conductor, single horizontal and vertical conductors for the protection of bigger buildings.
4. A vertical air termination where provided need not have more than one point and shall project atleast 30 cms above the project, salient point or network on which it is fixed.
5. Horizontal air terminations should be so interconnected that no part of the roof is more than 9 m away from the nearest horizontal conductor. For a flat roof horizontal air termination along the outer perimeter of the roof is used. For a roof of larger area a network of parallel horizontal conductors shall be installed.
6. Horizontal air terminations should be coursed along contours such as ridges, parapets and edges of flat roof, and where necessary over flat surfaces in such a way as to join each air termination to the rest and should themselves form a closed network.
7. All metallic finals, chimneys, ducts, vent pipes, railings, gutters, metallic flagstaff etc. on or above the main surface of the roof of the structure shall be bonded to, and form part of, the air termination network. If portions of a structure vary considerably in height, any necessary air termination or air termination network of the lower portions should in addition to their own conductors, be bonded to the down conductors of the taller portions.
8. All air terminals shall be effectively secured against overturning either by attachment to the object to be protected or by means of substantial braces and fixings which shall be permanently and rigidly attached to the building. The method and nature of the fixings should be simple, solid and permanent, due attention being given to climatic conditions and possible corrosion.

15.5 Down Conductors

The number and spacing of down conductors shall largely depend upon the size and shape of the building and upon aesthetic considerations. The minimum number of down conductors may however, be decided on the following considerations.

1. A structure having a base area not exceeding 100 sq.m may have one down conductor only, if the

height of the air termination provides sufficient protection. However, it is advisable to have atleast two down conductors except for very small buildings.

2. For structures having a base area exceeding 100 sq.m the number of down conductors required should be worked out as follows:

- One for first 100 sq.m plus one more for every additional 300 sq.m or part thereof or,
- One for every 30 m of perimeter. The smaller of the two shall apply.

Down conductors should be distributed round the outside walls of the structure. They shall preferably be run along the corners and other projections, due consideration being given to the location of air terminations and earth terminations. Lift shafts shall not be used for fixing down conductors. In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken into consideration.

15.6 Joints and Bonds

The lightning protective system shall have as few joints in it as possible. Wherever joints in the down conductor above ground level are necessary they shall be mechanically and electrically effective. In the down conductor below ground level there shall be no joint. The joints may be clamped, screwed, bolted, riveted, sweated, braced or welded. The bonding of the external metal forming part of a structure or drain water pipe shall have a cross sectional area not less than that employed for the main conductors. Gas pipe, however, in no case shall be bonded to the earth termination system.

15.7 Fasteners

Conductors shall be securely attached to the building or other object to be protected by fasteners, which shall be substantial in construction, not subjected to breakage and shall be of galvanized steel or other suitable materials with suitable precautions to avoid corrosion. The lightning conductors shall be secured at not more than 1.20 m apart for horizontal run and 1.00 m for vertical run.

15.8 Earth Terminations

Each down conductor shall have an independent earth termination. The interconnection of all the earth termination shall be preferable. It should be capable of isolation for testing purposes by 'testing joints'.

15.9 Earth Electrode

Earth electrodes shall be constructed and installed in accordance with the clauses under Earthing. The whole of the lightning protective system should have a combined resistance to earth not exceeding 10Ω before any bonding has been affected to metal in or on a structure or to surface below ground.

16- SAFETY PROCEDURE

The control switches and distribution boards duly marked, the distribution diagrams of sub- stations prominently displayed, sub-station premises, main switch rooms and Distribution Board enclosure are kept clean. Particular care should be taken to prevent the sub-station to be used as store for inflammable materials, broken furniture, wastage materials.

Rubber or insulation mats should be provided in front of main switchboards or any other control equipment's of medium voltage and above.

Necessary number of caution boards such as "***Man on Line, Don't switch ON***" should be readily available in each sub-station, enquiry office and important installations.

Charts (one in English and one in Dzongkha) displaying methods of giving artificial respiration to a recipient of electrical shock should be prominently displayed at appropriate places. Electrical wiring and control switches should be periodically inspected and any defective wiring, broken parts of switches that will expose live parts should be replaced immediately to make the installations safe for the user.

No work shall be undertaken on **Live** installations or on installations which could be energized unless one another person is present to immediately isolate the electric supply in case of any accident and to render First Aid if necessary.

When working on or near live installations suitably insulated tools should be used and special care should be taken to see that those tools accidentally do not drop on live terminals causing shock or dead short. The electrical switchgears and distribution boards should be clearly marked to indicate the areas being controlled.

Before starting any work on the existing installation, it shall be ensured that electric supply to that portion in which work is undertaken is cut off.

Before energizing on an installation after the work is completed, it should be ensured that all tools have been removed and accounted, no person is present inside any enclosure of the switchboard etc., any earthing connection made for doing the work has been removed.

In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switch off immediately removed from the live installation by pulling him with the help of his coat, shirt, wooden rod, broom handle or with any other dry cloth or paper. He should be removed from the place of

accident to a nearby safe place and artificial respiration continuously given.
These instructions should be explained in Dzongkha or English or in other local languages to those who are not familiar with such requirements.

Chapter: 18

LOCAL AREA NETWORK

General:

The following are some of the general description of the materials for LAN to guide the construction. However for the detail reference contractor will be provided with catalog for individual items/materials specified on the BoQ and shall executive the works as per the approval from the site engineer.

1. L2 Managed Switch

- 24x 10/100/1000 BaseT with Min 4x SFP combo Ports and 2x SFP+ slots.
- Combo ports should have the flexibility to be populated with 100Mbps or 1000Mbps single mode/multimode module.
- Should have min of 512MB RAM and 64MB Flash Memory.
- Switching Fabric should be 136Gbps or more
- Forwarding Rate should be 100Mpps or more
- Support for 9K Jumbo frame
- Min 16K MAC addresses & 4K VLANs
- Latency should be less than 4.2 micro seconds for 1G and 3.1 micro seconds for 10G for 64 bytes packets.
- Should support Dynamic VLAN assignment to end points.
- Should support Static, RIP, VRRP and Policy based Routing.
- Should support MAC-based, Web-based and IEEE 802.1x Authentication
- Should support Protocol based and Port based VLANs.
- Should support Dynamic & Private VLANs, Authentication-Fail and Guest VLANs for enforcing security policies.
- Should support MAC address filtering and MAC limiting / MAC Lock down functionality.
- Should support Policy-based QoS to classify traffic based on MAC , Port , VLAN and Protocols.
- Should support Access Control Lists (ACLs) and IEEE 802.1p Priority Tagging
- Should have GUI and industry standard CLI management interface.

2. Optic Transceiver

- Media Type: Multi mode
- Wave length: 850 nm
- Min. Data Rate: 10Gbps
- Distance support: Min 300 Meter
- Connector: LC Type
- Hot swap architecture
- Min. operating temperature range: 0 Degree C to 70 Degree C

3. Optic Fibre Cable

- 12 core 50/125µm OM3 Multi Mode optic fiber cable.
- Should be OM3 grade as per ISO/IEC 11081, ITU-T G652.d standards
- Max Attenuation: 3.0dB/km @850nm and 1.0dB/km @1300nm.

- Should support 1Gbps up to 1000mtr distance
- Should have industry standard color coded fiber cores enclosed inside a single jelly filled central tube.This central tube should be enclosed inside a PE sheath filled with water-blocking material.
- Should have Corrugated Steel Taped Armored for crash and rodent resistance.
- Should be applicable for direct burial installation.
- The outer jacket should be high density Polyethylene and Flame retardant.

4. Optic Fibre Patch Panel

- 06-Port 1U and 12-Port 1U, 19" Rack Mountable LIU
- Aluminium power coated housing with Built in Splice Tray and Cable Spool
- Front Sliding/ Drawer type
- Should Support LC, SC, ST, FC Adaptor
- Easy access to splice trays and internal fiber management
- Accepts all standard Connector types and cable designs
- Standard cable entry conduits with grommets
- RoHS Compliant
- Adapter Insert Loss: <=0.2dB
- Adapter Return Loss: 50dB (UPC), 60dB (APC)
- Adapter Durability : 1000 Mating
- 06-port LIU should bepopulated with 06 SC MM adaptors & 06 MM SC 1mtr. Pigtails.
- 12-port LIU should bepopulated with 12 SC MM adaptors &12MM SC 1mtr. Pigtails.

5. UTP CAT6 Cables

- UTP CAT 6 cable Solid 4 Pair Copper, 100 ohms, 23 AWG unshielded twisted pair.
- Performance optimized up to 600 MHz.
- Suitable for 10G application for channel length of 50mtr.
- Should be as per ANSI/EIA/TIA 568 B.2-1 CAT 6 and ISO/IEC 11801 standards.
- Should be UL94V-0 rated plastic
- Should be 3P Certified, UL Listed and ETL verified and ROHS/ELV Compliant
- Box of 305 meter

6. UTP CAT6 Patch Panel

- UTP CAT6 24-Ports Gigabit Modular Patch Panel with keystone jacks
- Configured as 6-Port Module with individually replaceable Cat-6 Jacks
- 1U Rack mountable
- Flame Retardant Plastic Body UL-94V-0 rated

- 50µ gold over 100µ nickel spring contact.
- Plug Insertion Cycle: 750 times.
- Clear label window for port identification.
- Should be as per ANSI/EIA/TIA 568-B.2-1 Cat 6 and ISO/IEC 11801 standards.
- Should be 3P Certified, UL Listed and ETL verifiedand RoHS Compliant.

7. MS Mount Box

- MS Mount Box for Information outlet (86mmx86mm)

8. UTP CAT6 I/Oand Face Plate

- Single and Dual Port
- Should have spring shutter front dust cover with Labeling icon and strip
- High impact ABS Flame Retardant plastic body, UL-94V-0 rated
- Insulation displacement connector for cable crimping and should accept 22-26AWG solid cable
- Should Support industry standards for EIA/TIA 568A and EIA/TIA 568B wiring options.
- Should be as per ANSI/EIA/TIA 568-B.2-1 Cat 6 and ISO/IEC 11801 standards.
- Should be 3P Certified, UL Listed and ETL verified and RoHS Compliant.
- Should include CAT6 Keystone UTP information outlet (RJ-45) capable of PoE.

9. UTP CAT6 Patch Cord

- UTP CAT6, Solid 4 Pair 100 ohms, 23 AWG twisted pair CAT 6 stranded cable.
- Highly flexible.
- Factory crimped gold over nickel connectors
- Should be as per ANSI/EIA/TIA 568-B.2-1 Cat 6 and ISO/IEC 11801 standards.
- Should be 3P Certified, UL Listed and ETL verified and RoHS Compliant.

9.1. Network Equipment Rack, 9U

- Dimension: 9U, 800mmW, 600mmD, 19"
- Type: Wall Mount Double Section Rack (Rear wall mounted section hinged to front section)
- Easy access to rear of the rack
- Top and bottom cover with cable entry provision,
- Front toughen glass door with lock & key,
- Side panel slam latch with locking facility & 1/3 vented,
- AC Fan Module at top
- Cable Manager
- Power Distribution Unit

- Front panel Mounting Hardware

10. 240 watt Mixer Amplifier, 2 Zone

- Minimum 6 microphone/line inputs plus 3 music source inputs
- 100 V, telephone and a call station input with priority & VOX
- 2 zones and announcement only output
- Voice activated emergency override
- High output power 120 and 240 Watts

11. Ceiling Speaker, 6W

- Suitable for speech and music reproduction
- Increased sensitivity
- Flush-mounted in ceilings
- Unobtrusive white metal grille
- Complies with international installation and safety regulation

12. Line Array Indoor Loudspeaker with stand

- Extended listening area
- Excellent intelligibility of speech and music
- Uniform distribution of natural sound throughout the room
- Provision for inside mounting the optional line/ loudspeaker supervision board
- EN 54-24 certified

13. Handheld Microphone with stand and cable

- Condenser transducer
- Unidirectional
- High speech intelligibility
- Low sensitivity to case noise and vibrations

14. Structured Cabling System

All cabling should be laid as per the ANSI EIA/TIA 568B and should be fully enclosed within proper conduits as required. The ANSI EIA/TIA 568B is the latest update from the EIA/TIA Commercial Building Telecommunication Standards and replaces the TIA 568A and the associated TSB and the addendum.

The horizontal cabling should be on a star topology. The horizontal cabling is that portion of the cabling system that extends from the horizontal cross connect (patch panel) in the telecommunication/wiring closet (rack housing patch panel and switches) and includes the horizontal cables, the information outlets/connectors with surface mount box in the work area, the mechanical terminations and patch cords.

The horizontal cable distance between the horizontal cross-connect (patch panel) and the information outlet should be limited to a maximum of 90 meters. The combined length of two patch cords at the two ends should not exceed 6 meters.

The backbone cabling that provides interconnection between cross-connects should be on a conventional hierarchical star topology wherein each horizontal cross-connect should be cabled to a main cross-connect or an intermediate cross-connect and then to a main cross-connect. There should be no more than two hierarchical levels of cross-connects in the backbone cabling.

14.1. Cable Trench

The outdoor optic fiber cable should be laid underground. The depth of the cable trench/route should be minimum 60cm. The cable should be laid on a sand bedding of 10cm and should be covered with 10cm layer of sand. The remaining portion of the trench should then be covered with excavated earth. Cable route markers should be placed at appropriate locations.

14.2. Cable Identification

All I/O outlet/mount box should be properly labeled to carry the cable identification number in the format below:

FF-XX-00 where;

FFa two digit number identifying the floors

XX a two-digit number identifying the patch panel. All patch panels should be numbered beginning at 01.

00 is a two-digit number corresponding to the port number in the patch panel. All ports of the patch panel should have its own identification number. For instance, if a mount box carries a number “00-02-23” then it means the other end of the cable is terminated on the port 23 of patch panel 02 on ground floor.

14.3. Test Reports and Documentation

The following test reports and documentation should be provided:

- OTDR test report of End-to-Endfiber consisting of Length, Delay, Near End Crosstalk, Attenuation, Impedance and Return Loss should be provided.
- Test report of End-to-End UTP Cable consisting of Length, Delay, Near End Crosstalk, Attenuation, Impedance and Return Loss should be provided.
- Schematic network diagram clearly showing the location of wiring closets, switches and cable identification format.
- Switch configuration document.
- Administration and maintenance manual.