

SBCP-2021

**STANDARDIZATION OF
BUILDING CODES
STANDARDS AND
SPECIFICATIONS FOR LOW-COST
(AFFORDABLE) UNITS-2021**

**PAKISTAN ENGINEERING COUNCIL
NAYA PAKISTAN HOUSING & DEVELOPMENT AUTHORITY
PAKISTAN COUNCIL OF ARCHITECTS & TOWN PLANNERS**



*Standardization of Building Codes, Standards
and Specifications for Low-Cost (Affordable) Units*

*Pakistan Engineering Council, Islamabad
First Edition - Copyright © 2021*

PREFACE

Pakistan like most developing countries, is facing an acute shortage of housing. It is estimated that the annual demand for housing units is approximately 700,000 a year, whereas, only about half of this demand is met. On the whole, the housing deficit is estimated between 10 to 12 million units and is growing every year. To address the situation, the Prime Minister of Pakistan envisioned and initiated Naya Pakistan Housing Program (NPHP) *“to deliver five million housing units with allied amenities to all citizens, especially focusing on the financially underserved and middle-income communities, as a measure of comprehensive socio-economic uplift”*. The program would provide housing facility to the homeless people by accelerating the economic activity and also provides job opportunities to a large extent in the country. The Naya Pakistan Housing and Development Authority (NAPHDA) being a corporation was established on 15th January 2020 through an Act of Parliament for the purpose of planning, development, construction, and management of real estate development schemes and projects including housing. The Authority being the developing arm of the government is pursuing multiple objectives in the realm of housing and infrastructure development on both profit and non-profit basis throughout the country.

NAPHDA is very much committed to ensure quality assurance in the housing sector development projects especially the Low-Cost Housing Units. For the purpose, NAPHDA joined hands with Pakistan Engineering Council (PEC) for the development of Standards Specifications for Low-Cost (Affordable) Units. Accordingly, PEC notified a high profile **“Working Group for Standardization of Building Codes, Standards and Specifications for Low-Cost (Affordable) Units”** on 14th December 2020 which comprised the following eminent experts:

- | | |
|---|----------|
| 1. Engr. Prof. Dr. Sarosh Hashmat Lodi
Vice Chancellor, NED University of Engineering and Technology, Karachi. | Convener |
| 2. Engr. Brig. Abid Saleem
Executive Director (Monitoring) NAPHDA, Islamabad. | Member |
| 3. Arc. Plnr. Kalim Siddiqui
Chairman, Pakistan Council of Architects and Town Planners, Lahore | Member |
| 4. Chair Prof. Engr. Dr. Shuaib H. Ahmad
Head CAHSBE, NED University of Engineering and Technology, Karachi | Member |
| 5. Engr. Prof. Dr. Muhammad Ali Memon
Associate Professor Prof. Deptt. of Electrical Engineering, NED, Karachi | Member |
| 6. Engr. Zaigham Mahmood Rizvi
Chairman, Naya Pakistan Housing Program | Member |
| 7. Mr. Fayyaz Ilyas
Chairman, Association of Builders and Developers of Pakistan (ABAD), Karachi | Member |

- | | | |
|-----|--|------------------------|
| 8. | Dr. Engr. Fawad Ahmed Najam
Assistant Prof. Department of Structural Engineering, NUST, Islamabad | Member |
| 9. | Engr. Danish Bin Rauf
Chairman Southern Region, ABAD, Karachi | Member |
| 10. | Arc. Hammad Husain
President League of Architects Pakistan, Islamabad | Member |
| 11. | Arc. Azar Raza Khan
Principal Architect, Azar Raza Architects, Islamabad | Member |
| 12. | Engr. Faiz Muhammad Bhutta
Sr. Energy Consultant and CEO Techfa Consulting, Lahore | Member |
| 13. | Mr. Faiz ul Sibtain
Think Tank Department, Pakistan Engineering Council, Islamabad. | Secretary to Committee |

The Committee held various meetings and successfully developed “**Standardization of Building Codes, Standards and Specifications for Low-Cost (Affordable) Units**”. The Committee performed extraordinary hard work and completed this task within five months. The Convener highly appreciated the contribution of expert members and significant work of the “Editorial Committee”. This document is based on well-recognized standards and best practices developed by reputed national and international code developing organizations.

The feedback/ comments sought from the Provincials Departments were deliberated and the relevant inputs have been included in the document by the expert “Working Group”.

Preface	ii
SECTION 1 - GENERAL ITEMS.....	2
1.1 Definition.....	2
1.2 Purpose	2
1.3 Applicability	2
1.4 Interpretation.....	2
1.5 Licensed design professional	2
1.6 Authority Having Jurisdiction	2
1.7 The Engineer.....	2
1.8 Building Official.....	2
1.9 Quality of Units (Houses or Homes)	2
1.10 Materials	2
1.11 Approval of Materials, Products or Systems	2
1.12 Construction Practice.....	2
SECTION 2 - EXCAVATION	2
2.1 Scope.....	2
2.2 Clearing and Grubbing-Up	2
2.3 Excavation	2
SECTION 3 - PLAIN AND REINFORCED CONCRETE.....	2
3.1 Scope.....	2
3.2 General.....	2
3.3 Related Specifications.....	2
3.4 Materials	2
3.4.1 Aggregates	2
3.4.2 Cement and Cementitious Materials.....	2
3.4.5 Reinforcement.....	2
3.4.6 Reinforcement Fixing	2
3.4.7 Concrete.....	2
3.4.8 Tests for Concrete Quality	2
3.4.8.1 General.....	2
3.4.8.2 Samples.....	2
3.4.8.3 Adequacy of Mix	2
3.5 Repair of Surface Defects	2
3.6 Concrete Construction Tolerance	2
3.7 Tolerance for Pre-cast Concrete:	2
3.8 Tolerance for Pavements	2
3.9 Plant and Equipment.....	2

3.10	Acceptance of Structure.....	2
3.11	Methods of Measurement of Concrete Works.....	2
SECTION 4 – MASONRY – PART 1		2
4.1.	Concrete Block Masonry.....	2
4.1.1	Scope.....	2
4.1.2	Materials	2
4.1.3	Concrete, Masonry Units	2
4.1.4	Cement Mortar for Masonry	2
4.1.5	Masonry and Jointing.....	2
4.1.6	Coordination	2
4.1.7	Protection and Cleaning.....	2
4.1.8	Samples.....	2
4.1.9	Testing	2
4.1.10	Measurement and Payment	2
SECTION 4 – MASONRY – PART II.....		2
4.2.	Brick Masonry	2
4.2.1	Scope.....	2
4.2.2.	Codes and Standards	2
4.2.3.	Submittals	2
4.2.4	Tolerances.....	2
4.2.6.	Delivery and Storage.....	2
4.2.7	Mortar	2
4.2.8.	Bricks	2
4.2.9.	Scaffolding.....	2
4.2.10.	Execution	2
4.2.11	Repairing Brickwork.....	2
4.2.12.	Horizontal Damp Proof Course.....	2
4.2.13.	Vertical Damp Proof Course	2
4.2.14.	Measurement and Payment	2
SECTION 5 - CARPENTRY AND JOINERY		2
5.1	Scope of Work	2
5.2	Submittals	2
5.3	Applicable Standards.....	2
5.4	Tolerances.....	2
5.5	Delivery and Storage	2
5.6	Products	2
5.6.1	Timber.....	2
5.6.2	Hardware.....	2

5.6.3	Execution	2
5.6.4	Measurement and Payment	2
SECTION 6 - TERRAZZO WORK		2
6.1	Scope of Work	2
6.2	Applicable Standard.....	2
6.3	Materials	2
6.3.1	Cement, Sand, Aggregate and Water for Concrete.....	2
6.3.2	Marble Chips	2
6.3.3	Dividing Strips.....	2
6.3.4	Angle Clips	2
6.3.5	Bolts of precast toilet partitions	2
6.3.6	Terrazzo Tiles	2
6.3.7	Cleaning Compound	2
6.4	Samples.....	2
6.5	Execution	2
6.5.1	In Situ Terrazzo Flooring.....	2
6.5.2	Terrazzo Dado & Skirting.....	2
6.5.3	Terrazzo on Stairs	2
6.5.4	Terrazzo Finished Precast Partitions of Urinals.....	2
6.5.5	Terrazzo Tile Works	2
6.6	Measurements and Payments.....	2
SECTION 7 - CERAMIC TILES		2
7.1	General - Ceramic Tile Finishes.....	2
7.2	Coordination	2
7.3	Submittals	2
7.4	Quality Assurance	2
7.5	Mockups.....	2
7.6	Delivery, Storage, and Handling	2
7.7	Products	2
7.8	Execution	2
7.8.1	Examination	2
7.8.2	Preparation	2
7.8.3	Installation, General	2
7.8.4	Ceramic Tile Floor Installation Schedule.....	2
7.8.5	Ceramic Tile Wall Installation Schedule.....	2
7.8.6	Glass Mosaic Installation Schedule.....	2
7.8.7	Cleaning and Protecting	2

SECTION 8 - PLASTER AND POINTER	2
8.1. Scope of Work	2
8.2. Applicable Standards	2
8.3. General.....	2
8.4. Materials	2
8.5. Proportioning and Mixing	2
8.6. Preparation of Surface to Be Plastered.....	2
8.7. Application of Plaster.....	2
8.8. Metal Lath over Reinforced Concrete and Masonry Joint.....	2
8.9. Beads & Profiles	2
8.10. Cleaning and Protection	2
8.11. Tolerances	2
8.12. Pointing Work.....	2
8.13. Measurement and Payment	2
SECTION 9 - INTERIOR PAINTING.....	2
9.1 Part-I – General.....	2
9.1.1 Scope.....	2
9.1.2 Coordination:	2
9.1.3 Quality Assurance and Quality Control Requirements:.....	2
9.2 Submittals	2
9.2.1 General.....	2
9.2.2 Action Submittals	2
9.2.3 Informational Submittals	2
9.3 Quality Assurance.....	2
9.3.1 Quality System.....	2
9.3.2 Applicator Qualifications.....	2
9.3.3 Source Limitations.....	2
9.3.4 Proprietary Names	2
9.3.5 Comparable Product Requests	2
9.3.6 Definitions and Abbreviations	2
9.4 Preconstruction Testing.....	2
9.5 Mockups.....	2
9.6 Delivery, Storage, and Handling	2
9.7 Project Conditions.....	2
9.8 Part -II - Products	2
9.8.1 Manufacturers	2
9.8.2 Proposed Manufacturers.....	2

9.8.3	Decorative Paints and Coatings.....	2
9.8.4	Paint General.....	2
9.8.5	Material Compatibility	2
9.8.6	Material Quality	2
9.8.7	Colors, Textures, shades and Effects.....	2
9.8.8	Health and Environmental Requirements.....	2
9.9	Interior Primers	2
9.10	Interior Fillers and Putties	2
9.11	Acrylic Emulsion for Cement Based Surfaces	2
9.12	Epoxy Paint for Cement Based Surfaces.....	2
9.13	Polyurethane Paint for Cement Based Surfaces	2
9.14	Acrylic Emulsion Paint for Gypsum Boards and Cement Boards	2
9.15	Opaque Finish of Wood Surfaces.....	2
9.16	Ferrous Surfaces Finish Paint System (Architectural Work Items).....	2
9.17	Traffic-Related Paints	2
9.18	Execution	2
9.18.1	Examination	2
9.18.2	Maximum Moisture Content of Substrates.....	2
9.18.3	Suitability of Substrates	2
9.18.4	Coordination of Work	2
9.19	Preparation	2
9.19.1	General.....	2
9.19.2	Cleaning.....	2
9.19.3	Surface Preparation.....	2
9.19.4	Cement-Based Materials.....	2
9.19.5	Gypsum Boards.....	2
9.19.6	Ferrous Metals	2
9.19.7	Structural Steel Substrates	2
9.19.8	Wood Substrates	2
9.19.9	Material Preparation	2
9.20	Application.....	2
9.20.1	General.....	2
9.20.2	Scheduling Painting	2
9.20.3	Application Procedures.....	2
9.20.4	Brushes	2
9.20.5	Rollers.....	2
9.20.6	Spray Equipment.....	2

9.20.7	Minimum Coating Thickness.....	2
9.20.8	Mechanical and Electrical Work.....	2
9.20.9	Prime Coats.....	2
9.20.10	Completed Work.....	2
9.20.11	Tint.....	2
9.21	Field Quality Control	2
9.22	Cleaning and Protection	2
9.23	Interior Painting Schedule.....	2
9.23.1	Special Paint System.....	2
9.23.2	Concrete and Concrete Masonry Surfaces.....	2
9.23.3	Concrete Masonry Shaft Walls	2
9.23.4	Gypsum Board and Cement-Based Board	2
9.23.5	Woodwork and Hardboard.....	2
9.23.6	Ferrous Metal.....	2
9.24	Exterior Painting	2
9.24.1	Crete Sand Coating - (Free From Lead and Mercury).....	2
9.24.2	Surface Preparation	2
9.24.3	Technical Data / Specification	2
SECTION-10 - GLAZING		2
10.1	Scope of Work	2
10.2	Applicable Standards	2
10.3	General.....	2
10.4	Delivery Storage and Handling.....	2
10.5	Materials	2
10.6	Installation of Glazing	2
10.7	Protection and Cleaning Of Glazing.....	2
10.8	Measurement and Payment.....	2
SECTION 11 - ROOF WATER PROOFING SYSTEM.....		2
11.1	Scope of Works.....	2
11.2	Material (A)	2
11.3	For Normal To Moderate Rain Area (B)	2
11.4	For Heavy Rain Area (C).....	2
11.5	For Areas Where Greater Heat Insulation is required	2
11.6	Protection.....	2
11.7	Measurement.....	2
11.8	Rate and Payment	2
SECTION 12 - ALUMINIUM WINDOWS.....		2
12.1	Part 1 - General.....	2

12.2	General Performance Requirements	2
12.3	Submittals	2
12.4	Quality Assurance.....	2
12.5	Project Conditions	2
12.6	Warranty	2
12.7	Part 2 - Products.....	2
12.7.1	Manufacturers	2
12.7.2	Materials	2
12.7.3	Framing Systems.....	2
12.7.4	Glazing.....	2
12.7.5	Insect Screens	2
12.7.6	Hardware.....	2
12.7.7	Accessory Materials.....	2
12.7.8	Fabrication	2
12.7.9	Aluminum Finish	2
12.8	Part 3 - Execution	2
12.8.1	Examination	2
12.8.2	Installation	2
12.8.3	Adjusting, Cleaning, and Protection	2
SECTION 13 - TERMITE CONTROL		2
13.1	Part 1 - General.....	2
13.1.1	Performance Requirements.....	2
13.1.2	Submittals	2
13.1.3	Project Conditions.....	2
13.1.4	Coordination	2
13.1.5	Warranty	2
13.1.6	Maintenance Service.....	2
13.2	Part 2 - Products.....	2
13.2.1	Manufacturers	2
13.2.2	Soil Treatment.....	2
13.3	Part 3 - Execution	2
13.3.1	Examination	2
13.3.2	Preparation.....	2
13.3.3	Applying Soil Treatment	2
SECTION 14 - CAR PARK CURBS AND WALKWAYS		2
14.1	Part 1 - General.....	2
14.1.1	Submittals	2

14.1.2	Quality Assurance.....	2
14.2	Part 2 - Products.....	2
14.2.1	Formwork	2
14.2.2	Reinforcement.....	2
14.2.3	Cast-In-Place Concrete	2
14.2.4	Curing	2
14.2.5	Sealant Filled Joints	2
14.2.6	Ancillary Materials	2
14.2.7	Mix Designs.....	2
14.3	Part 3 - Execution	2
14.3.1	Execution, General.....	2
14.3.2	Curbs and Walkways	2
14.3.3	Finish	2
SECTION 15 - EXPANSION JOINT COVER ASSEMBLIES.....		2
15.1	Part 1 - General.....	2
15.1.1	Performance Requirements and Selection Criteria	2
15.1.2	Submittals	2
15.1.3	Quality Assurance.....	2
15.1.4	Coordination	2
15.1.5	Warranty	2
15.2	Part 2 - Products.....	2
15.2.1	Materials	2
15.2.2	Architectural Joint Systems, General.....	2
15.2.3	Joint Systems, General.....	2
15.3	Part 3 - Execution	2
15.3.1	Examination.....	2
15.3.2	Preparation.....	2
15.3.3	Installation	2
15.3.4	Protection.....	2
SECTION 16 - PLUMBING WORKS.....		2
16.1	Part 1 -Particular Specifications	2
16.2	Part 2 - Underground and Drainage System	2
16.3	Part 3 - Internal Sanitary System	2
16.4	Part 4 - Installation of Sanitary Appliances	2
16.5	Part 5 -Cold and Hot Water Supply	2
16.6	Part 6 - Pipe Work and Fitting	2
16.7	Part 7 - Pipe Work and Fitting – Fire Fighting	2

16.8	Part 8 – Plumbing Equipment- Equipment and Controls.....	2
SECTION 17 - ELECTRICAL WORKS		2
17.1	Section 1 - Technical Provisions	2
17.2	Section 2 - PVC Conduits and Accessories	2
17.3	Section -3 Wires, Cables and Cords	2
17.4	Section -4 Wiring Accessories.....	2
17.5	Section -5 Point Wiring, Circuit Wiring and Socket Outlet Wiring	2
17.6	Section -6 Light Fixtures	2
17.7	Section -7 Power Cable.....	2
17.8	Section -8 Main L.T. Switch Board.....	2
17.9	Section -9 Distribution Boards	2
17.10	Section -10 Earthing	2
17.11	Section -11 Testing and Commissioning	2
SECTION 18 - STEEL WORKS.....		2
18.1	Scope of Work	2
18.2	Submittals	2
18.3	Applicable Standards	2
18.4	Quality Assurance.....	2
18.5	Materials	2
18.6	Execution	2
18.7	Delivery and Storage	2
18.8	Measurement and Payment.....	2
SECTION 19 - ENVIRONMENTAL IMPACT ASSESSMENT		2
19.1	General.....	2
19.2	The EIA Process	2
19.3	Conducting an EIA	2
SECTION 20 - QUALITY ASSURANCE CRITERIA AND GUIDELINES FOR PREFABRICATED UNITS		2
20.1	General.....	2
20.2	Component and Structural-Level Tests for Prefabricated Units.....	2
SECTION 21 - GUIDELINES FOR SOLAR PV SYSTEM.....		2
21.1	General.....	2
21.2	Typical System Designs For Guidance Purposes – Not Mandatory	2
21.2.1	Solar PV System for Single Story House – Suitable for 05 Marla and 10 Marla Single Phase Connected House.....	2
21.2.2	5 KWP Rooftop Solar PV On-Grid without Battery with Net Metering for 10 Marla Single or Double Story Three Phase Connection House	2
21.2.3	Multiple Story Flats and Apartments.....	2
21.2.4	Prepaid Metering for Houses and Flats of 3 Marla or Less	2

APPENDIX-A	2
STRUCTURAL PRECAST CONCRETE.....	2
A-1 General.....	2
A-2 Performance Requirements.....	2
A-3 Action Submittals	2
A-4 Informational Submittals	2
A-5 Quality Assurance.....	2
A-6 Delivery, Storage, And Handling	2
A-7 Sequencing.....	2
A-8 Products -Fabricators	2
A-9 Form Materials.....	2
A-10 Reinforcing Materials	2
A-11 Form Fabrication.....	2
A-12 Fabrication	2
A-13 Insulated Panel Casting.....	2
A-14 Fabrication Tolerances.....	2
A-15 Finishes	2
A-16 Source Quality Control	2
A-17 Site Preparation For Execution	2
A-18 Examination	2
A-19 Erection.....	2
A-20 Field Quality Control	2
A-21 Repairs	2
A-22 Cleaning.....	2
APPENDIX B.....	2
HOLLOW & LIGHT GAUGE STEEL SECTIONS	2
B-1 General.....	2
B-2 Industry Codes And Standards	2
B-3 Definitions	2
B-4 Requirements	2
B-5 Materials	2
B-6 Material Specifications	2
B-7 Workmanship.....	2
B-8 Available Soft Wares	2
B-9 Available Manufacturers.....	2
APPENDIX-C.....	2
PAKISTAN STANDARDS AND QUALITY CONTROL AUTHORITY (PSQCA) STANDARDS	2

APPENDIX-D 2
METRICATION CONVERSION GUIDE..... 2

SECTION 1 - GENERAL ITEMS

1.1 Definition

According to State bank of Pakistan in consultation with stake holders defines the low-cost housing as follows:

- a. Covered area of the housing unit / apartment up to 850 square feet,
- b. Maximum value of the housing unit/apartment up to PKR 3.5 million,
- c. Loan size up to PKR 3.15 million.

1.2 Purpose

The purpose of this specification document is to provide for public health and safety by establishing minimum requirements for strength, serviceability, durability and integrity of affordable low cost units to be built in Pakistan.

1.3 Applicability

This specification document shall apply to affordable low cost units to be built in Pakistan under the requirements of the Building Code of Pakistan or the code adopted Authority Having Jurisdiction (AHJ). If no general building code is adopted, this document shall apply for the construction of the affordable housing units.

1.4 Interpretation

If conflicts occur between clauses of this document and those of standards and documents referenced in the beginning of individual sections of this document shall govern.

1.5 Licensed design professional

All references in this Code to the licensed design professional (LDP) shall be understood to mean the person who is licensed and responsible for, and in charge of, the Architectural/Structural design or inspection. For Architectural and Town Planning work, PCATP and for Engineering works PEC registered and licensed professional will be considered respectively.

1.6 Authority Having Jurisdiction

Authority Having Jurisdiction (AHJ) means an organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

1.7 The Engineer

The Engineer or Engineer of Record means a professional engineer who seals drawings, reports, or documents for a project. The seal shall acknowledge that the professional engineer prepared, coordinated, or had subordinates prepare under the direct supervision of the professional engineer, drawings, reports, or documents for a project.

1.8 Building Official

The officer or other designated authority charged with the administration and enforcement of this Specification.

1.9 Quality of Units (Houses or Homes)

- a. The standard of construction shall be adequate for a minimum service life of twenty five (25) to forty (40) years.
- b. Where materials or methods are not clearly defined in the project documents, the engineer shall assess contractor submittals for adequacy to required standards of construction
- c. Written submittal shall be provided to the Licensed Design Professional or the Engineer for all materials, products or systems for his approval. No material, product or system shall be used until written approval is given by the Engineer.

1.10 Materials

- a. The Contractor shall adhere strictly to all standard specifications, Codes of Practice, Building Regulations or similar which are referred to in the Contract Documents. If no standard is specified then the relevant IBC Standard will be deemed to apply, but the Engineer may at his discretion accept materials in accordance with other standards specifications if the quality is equivalent or superior to the Referenced Standards.
- b. The Contractor shall fully demonstrate in detail supported by written documentation that he has investigated all local manufactures of all products and materials listed in this specifications.
- c. Preference must be given to Pakistani produced materials and products. In the event that the correct quality or cost margins are not met these shall be brought to attention of the Employer prior to rejection. The Employer reserves the right to direct Contractors to purchase locally produced materials rather than overseas materials where all other factors are equal.
- d. All overseas material manufactures shall comply with ISO 9000 requirements.
- e. The abbreviations used in the document include:
 - A.S.T.M - American Society for Testing and Materials.
 - ACI – American Concrete Institute
 - AISC – American Institute of Steel Construction
 - AISI - American Iron And Steel Institute
 - ASCE – American Society of Civil Engineers
 - BS – British Standards
 - BCP – Building Code of Pakistan
 - I.S.O - International Standards Organization.

- IBC – International Building Code
- IRC – International Residential Code
- PSQCA - Pakistan Standards and Quality Control Authority

The applicable standard shall be the standard most recent date of publication. In addition Referenced standards are also listed in the individual sections of this document.

1.11 Approval of Materials, Products or Systems

- a. Approval of materials, products or systems in accordance with clause 1.1(c) shall not, in any way, relieve the Contractor of full responsibility under the contract.
- b. Approval of materials, products or systems not included in these specifications may be submitted for approval to the Authority Having Jurisdiction (AHJ) for evaluation and possible Approvals.
- c. For the certain materials and components which are specified on the Drawings using proprietary names, the Contractor may submit details of any alternative which meets the said standard and quality to the Authority Having Jurisdiction (AHJ) for evaluation and possible written approval.

1.12 Construction Practice

This document contains coverage for what is conventional and common in residential construction practice. While the document aims to provide needed coverage for most residential construction, it might not address construction practices and systems that are atypical or rarely encountered in the industry.

SECTION 2 - EXCAVATION

2.1 Scope

The work covered by this section of the specification consists in furnishing all plant, labour, equipment, appliances and materials, and in performing all operations in connection with excavation, trenching and backfilling, in strict accordance with this section of specification and the applicable drawings, and subject to the terms and conditions of the CONTRACT.

2.2 Clearing and Grubbing-Up

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

2.3 Excavation

- 2.3.1** All excavation, in any kind of soil encountered, shall be performed to the depths and widths indicated or as otherwise specified. This would vary with local site conditions. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving. Topsoil shall be stockpiled separately, for subsequent re-use as necessary. All excavated material unsuitable or not required for backfilling shall be removed and collected at a location approved by the SITE ENGINEER. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulated therein shall be removed by pumping or by other approved methods. Unless otherwise indicated or approved by the SITE ENGINEER, excavation shall be open cut.
- 2.3.2** It is anticipated that all excavation work under this CONTRACT, will be earth excavation. The term “earth” as used herein shall include all materials which do not in the opinion of the SITE ENGINEER, require blasting, barring or wedging of material for removal from its original bed.
- 2.3.3** The CONTRACTOR shall provide adequate timbering or sheeting for excavation where necessary, as part of the excavation work, to hold up the sides and ends of all excavations. Should the sides and ends of any excavation give away, the CONTRACTOR shall, at no extra cost to the EMPLOYER reinstate all disturbed ground. Any excavation carried beyond the limits shown on the drawings and specified herein as the payment limits, shall be treated as excess excavation and dealt with in the manner stated hereinafter.
- 2.3.4** When foundation level is reached, the SITE ENGINEER will inspect the exposed bottom and give directions as to what further excavation, if any, he considers necessary. The excavation shall be done in such a manner as to ensure that the work rests on a solid and perfectly clean foundation. Where excavation is to be covered subsequently by permanent construction, the CONTRACTOR shall, immediately after exposing the specified satisfactory foundation proceed with the construction on that foundation. If the CONTRACTOR allows any portion of such foundation to deteriorate due to exposure, he shall make good the foundations at no extra cost to the EMPLOYER and to the satisfaction of the SITE ENGINEER.

SECTION 2 – EXCAVATION

- 2.3.5** As part of the work, under the excavation items, the CONTRACTOR shall shore up all buildings, walls poles and other structures, the stability of which is liable to be endangered by the execution of the work and shall be fully responsible for all damages to life or property resulting from any default of the CONTRACTOR.
- 2.3.6** If ordinary open-cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations generally in accordance with the details shown on drawings to provide safe working conditions. The CONTRACTOR shall furnish and place all sheeting walls, braces, timbers, and similar items, necessary for the safety of the work, the general public and adjacent property. Sheeting and bracing shall be removed, as the work progresses in such manner as to prevent damage to finished work and adjacent structures and property. As soon as it is withdrawn, all voids left by the sheeting and bracing shall be carefully filled with selected material and compacted. The CONTRACTOR shall be fully responsible for the safety of work in progress, for the finished work, the workmen, the public and adjacent property. All sheeting and bracing shall be at the CONTRACTOR'S expense, as part of the work under the excavation items and at no extra cost to the EMPLOYER.
- 2.3.7** All excavation made hereunder shall be properly maintained while they are open and exposed. Sufficient suitable barricades, warning lights, signs and similar items shall be provided by the CONTRACTOR. The CONTRACTOR shall be responsible for any personnel injury or property damage due to his negligence.
- 2.3.8** As part of the work under the excavation items, and at no extra cost to the EMPLOYER, the CONTRACTOR shall build all drains and do ditching, pumping, well pointing, bailing and other work necessary to keep the excavation clear of ground, sewage or storm water during the progress of the work and until the finished work is safe from injury. The CONTRACTOR shall provide all necessary pumping equipment for the dewatering works as well as operating personnel, maintenance, power etc. all at no extra cost to the EMPLOYER. All water pumped or drained from the work shall be disposed of in a manner satisfactory to the SITE ENGINEER. Necessary precautions against flooding shall be taken.
- 2.3.9** The SITE ENGINEER may order, in writing, any or all shoring, sheeting and piling to be left in place for safety reasons, whether such sheeting was shown on drawings or not. If left in place, such sheeting shall be cut of at the elevation approved by the SITE ENGINEER, and shall be driven tight and shall be paid for at the tendered rates.
- 2.3.10** The CONTRACTOR shall take special precautionary and protective measures with existing subsurface facilities likely to be encounter during the execution of works such as sewers, drain pipes, water mains, conduits, electric cables, communication cables and the foundations of adjacent structures. The CONTRACTOR shall be responsible for damage to any such facility and shall repair the same at his expense whether or not this facility has been shown on the drawings.
- 2.3.11** All surplus material excavated by the CONTRACTOR shall be disposed of at locations approved by the SITE ENGINEER. The method of disposal shall not interfere with other works and shall not damage or spoil other material. When it is necessary to haul earth material over streets or pavements, the CONTRACTOR shall prevent such material from falling on the streets or pavements.
- 2.3.12** After the completion of water lines, sewer lines, drainage facilities, foundations, walls and other structures below the elevation of the final grade, all voids shall be backfilled with suitable materials, as specified below.
- 2.3.13** Backfilling operations for structure shall be performed as part of the CONTRACTOR'S work under the payment items for earth excavation, and at no extra cost to the EMPLOYER. Backfill material for foundations, walls and other structures shall consist of excavated soil

SECTION 2 – EXCAVATION

which is free from stones and hard clods, larger than 3 inches in any dimension and also free from trash, lumber and other debris. Backfill material shall have enough moisture for proper compaction, and shall be compacted in an approved manner to 85 percent of maximum density for cohesive soil and 90 percent of maximum density for cohesion less soil. Backfill shall not be placed against foundation walls earlier than 4 days after the placing of concrete or brick work. After compaction and satisfactory completion of backfilling the CONTRACTOR shall carry out the finished grading of the site to such grades and elevations as may be shown on the drawings or required for proper drainage of the site.

- 2.3.14** The trenches for sewers shall be backfilled to the specified level with selected excavated material or other approved material that is suitable for proper compaction. Trenches improperly backfilled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density.
- 2.3.15** Normal backfilling operations in trenches shall be performed as part of the CONTRACTOR'S work under the payment items for earth excavation and at no extra cost to the EMPLOYER.
- 2.3.16** Special sand backfill is to be provided when specifically required by the drawings or when ordered in writing by the SITE ENGINEER. This work shall consist of removal of the excavated material to waste and provision in lieu of graded clean and fill, free of all foreign matter, such that 100% passes a ¾" screen with not more than 5% passing a No.4 sieve. This shall be compacted to 95% of maximum density.
- 2.3.17** The maximum density of soil shall be determined in accordance with American Society for Testing Materials (ASTM) Standard D 698-58T "Moisture Density Relations of Soils, using 5.5 lbs. Rammer and 12 inch Drop".
- 2.3.18** The SITE ENGINEER will take tests using the calibrated sand cone method to determine the density of soil in place. If soil in place fails to meet the specified degree of compaction it shall be removed, replaced with approved material and compacted to the specified density in the manner directed by the SITE ENGINEER, in the areas represented by the failing tests at no additional cost to the EMPLOYER.
- 2.3.19** Where satisfactory materials for backfill are not available in sufficient quantity from required excavation, "Earth Borrow" shall be obtained from suitable sources at the CONTRACTOR'S responsibility as a separate payment item. The necessary clearing and grubbing of borrow areas, disposal and burning of debris there from the developing of sources including any access roads for hauling and the necessary right-of-way, and the satisfactory drainage of the borrow areas, shall be considered as incidental items to borrow excavation. "Earth Borrow" under this separate payment item shall be furnished and placed by the CONTRACTOR only where specifically called for by means of notes on the contract drawings or by written order of the SITE ENGINEER.
- 2.3.20** This section of specification covers the following payment items:

- a) Earth Excavation
- b) Special Sand Backfill
- c) Earth Borrow
- d) Shoring and Sheet piling Left in place

Measurement of Earth Excavation shall be carried out by computing the volume of earth excavation which is authorized for payment, as per dimensions shown on the drawings.

Payments for Earth Excavation shall be made at the respective unit rates per cubic feet as listed in the Bills of Quantities of this contract.

SECTION 2 – EXCAVATION

- 2.3.21** This payment item shall be used in connection with backfill in trenches, floors and foot paths etc. Measurement of special sand backfill shall be carried out by computing the volume of special sand backfill authorized for payment.
- 2.3.22** Payment for Special Sand Backfill shall be made at the unit rate per cubic feet stated in the applicable Bill of Quantities of this contract. The quantities indicated in the Bill of Quantities are provisional.

SECTION 3 - PLAIN AND REINFORCED CONCRETE

3.1 Scope

The work covered by this section of Specifications consists of furnishing all plant, labour, equipment, appliances and materials, and in performing all operation in connection with the supply and installation of plain and reinforced concrete work, complete in strict accordance with this section of the Specifications and the applicable drawings, subject to the conditions of the CONTRACT.

3.2 General

- a. Full co-operation shall be given to other trades to install embedded items.
- b. Suitable templates or instructions, or both will be provided for setting items not placed in the forms. Embedded items and their locations shall have been inspected and mix for concrete and test required for quality of other materials or for mechanical operations shall have been completed and approved, before concrete is placed.
- c. For special concrete finishes and for special methods of construction e.g. slip forms, form work shop drawings shall be designed and prepared by the CONTRACTOR at his own cost. Approval of shop drawings as well as that of actual samples of finished concrete shall be obtained before WORK is commenced.
- d. CONTRACTOR shall also prepare BAR BENDING SCHEDULE and get the same approved by the Project Manager prior to the commencement of work.
- e. Approximate equivalent conversion of F.P.S. and S.I. units are indicated in the text. Project Managers' decision on any specific conversion shall be final and binding on all parties.

3.3 Related Specifications

Latest editions of the following ACI, ASTM, CRSI, NRMCA, BS Standard are relevant to these Specifications and equivalent Pakistan Standards and Quality Control Authority (PSQCA) standards are also applicable.

For specific situation, only if provisions in the relevant ACI, ASTM, CRSI, NRMCA and PSQCA documents are not available, BS standard may be used. Use of other sources shall be approved by The Engineer.

American Concrete Institute (ACI)

- | | |
|---------------|--|
| ACI 117 – | Specification for Tolerances for Concrete Construction and Materials and Commentary |
| ACI 117M - | Specification for Tolerances for Concrete Construction and Materials and Commentary (Metric) |
| ACI 237R - | Self-Consolidating Concrete |
| ACI 301-16 – | Specifications for Structural Concrete |
| ACI 301M-16 - | Specifications for Structural Concrete (Metric) |
| ACI 304R - | Guide for Measuring, Mixing, Transporting, and Placing Concrete |
| ACI 305.1 - | Specifications for Hot Weather Concreting |

SECTION 3 – PLAIN AND REINFORCED CONCRETE

- ACI 306.1 - Standard Specifications for Cold Weather Concreting
- ACI 350.1 - Specifications for Tightness Testing of Environmental Engineering Concrete Containment Structures
- ACI 350.1M - Specifications for Tightness Testing of Environmental Engineering Concrete Containment Structures (Metric)
- ACI 350.5 - Specifications for Environmental Concrete Structures
- ACI 350.5M - Specifications for Environmental Concrete Structures (Metric)
- ACI SP-66 - ACI Detailing Manual

ASTM International (ASTM)

Ready-Mixed Concrete

- C 138-71 T Tentative Method of Test, for Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete.
- C 143-78 Standard Method of Test for Slump of Portland Cement Concrete.
- C 150-72 Standard Specification for Portland Cement.
- C 171-69 Standard Specification for Sheet Materials for Curing Concrete.
- C 172-71 Standard Method of Sampling fresh Concrete.
- C 173-71 Standard Method of Test for Air Content of freshly Mixed Concrete by the Volumetric Method.
- C 208-72 Standard Specification for Insulating Board (Cellulosic Fiber) Structural and Decorative.
- C 260-77 Standard Specifications for Air Entraining Admixtures
- C 309 Standard Specification for Liquid Membrane-Forming Compounds for curing Concrete.
- C 31/ C31M Standard Practice for Making and Curing Concrete Test Specimens in the Field
- C 33-78 Standard Specification for Concrete Aggregates.
- C 39-72 Compressive Strength of Cylindrical concrete Specimens.'
- C 42-77 Standard Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
- C 494-71 Standard Specification for Chemical Admixtures for Concrete.
- C 94-78 Standard Specification for Ready Mixed Concrete.
- C150/C150M Standard Specifications for Portland cement
- C330/C330M - 17a Standard Specification for Lightweight Aggregates for Structural Concrete
- C1602/C1602M – 18 Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
- C1602/C1602M Standard Specifications for Mixing Water Used in the Production of Hydraulic Cement Concrete
- C1603 - 16 Standard Test Method for Measurement of Solids in Water
- C1610/C1610M Standard Test Method for Static Segregation of Self-Consolidating Concrete Using Column Technique
- C1611/C1611M Standard Test Method for Slump Flow of Self-Consolidating Concrete
- C1621/C1621M Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring
- C1712 Standard Test Method for Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test
- C172-C172M Sampling Freshly Mixed Concrete

SECTION 3 – PLAIN AND REINFORCED CONCRETE

C1798 / C1798M - 19	Standard Specification for Returned Fresh Concrete for Use in a New Batch of Ready-Mixed Concrete
C231-72T	Tentative Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method.
C618	Standard Specifications for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C685 / C685M – 17	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
C920	Standard Specifications for Elastomeric Joint Sealants
C94 / C94M – 20	Standard Specification for Ready-Mixed Concrete
C989/C989M	Standard Specifications for Slag Cement for Use in Concrete and Mortars
D1751	Standard Specifications for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non extruding and Resilient Bituminous Types)
D5249	Standard Specifications for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
E 329-70	Recommended Practice for Inspection & Testing Agencies for Concrete & Steel as Used in Construction.
E1745	Standard Specifications for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

ASTM International (ASTM)

Admixtures

C1017 / C1017M - 13e1	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1582 / C1582M - 11(2017)e1	Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete
C1622 / C1622M - 10(2016)e1	Standard Specification for Cold-Weather Admixture Systems
C260 / C260M - 10a(2016)	Standard Specification for Air-Entraining Admixtures for Concrete
C494 / C494M - 19	Standard Specification for Chemical Admixtures for Concrete
C869 / C869M - 11(2016)	Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete

ASTM International (ASTM)

Reinforcing Steel

ASTM A615/A615M	Standard Specifications for and Plain Carbon- Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	Standard Specifications for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM International (ASTM)

Sealants

ASTM C 1193 – 16	Guide for Use of Joint Sealants.
ASTM C 834 – 17	Specification for Latex Sealants
ASTM C 920	Specification for Elastomeric Joint Sealants.
ASTM C 1311	Specification for Solvent Release Sealants.

Concrete Reinforcing Steel Institute (CRSI)

Manual of Standard Practice

National Ready Mixed Concrete Association (NRMCA)

Quality Control Manual - Section 3, Certification of Ready Mixed Concrete Production Facilities – Plant Certification Check List

Pakistan Standards and Quality Control Authority (PSQCA)

P.S. 232 1983 Ordinary Portland cement (4th Revision). 2008 (R) Specific composition and manufacture, fineness, chemical composition, strength, consistence of standard cement paste, setting, time, soundness, sampling and test method. 2015 (4th R)

P.S. 612 1989 Sulphate resisting Portland Cement Type A (1st Revision).

List of PSQCA Standards for Civil Construction are provided in **Appendix C**.

British Standards

B.S. 1881 Methods of Testing Concrete.

B.S. 3148 Tests for water for Making Concrete.

B.S. 4027 Sulfate-Resisting Portland Cement.

B.S. 4449 Hot Rolled Steel Bars for the Reinforcement of Concrete.

B.S. 4461 Cold Worked Steel Bars for the Reinforcement of Concrete.

B.S. 4466 Bending Dimensions and Scheduling of Bars for the reinforcement of Concrete.

B.S. 693 General Requirements for Oxyacetylene Welding of Mild Steel

B.S. 822-1201 Concrete aggregates from Natural Sources.

B.S.410 Test Sieves.

B.S.I 141 Cold. Worked Steel Bars for the reinforcement of Concrete. General Requirements for the Metal - Arc Welding of Mild Steel.

R.S. 12-78 Portland Cement, Ordinary and Rapid Hardening (in lieu of C-150).

In addition, the latest editions of American Concrete Institute Standards, American Society for Testing and Materials Standards, British Standards and Equivalent Pakistan Standards and Quality Control Authority (PSQCA) may be specified by the Engineer or Project Manager.

3.4 Materials

3.4.1 Aggregates

- a. The sources of supply of all fine and coarse aggregates (including light weight aggregates) shall be subject to the approval of Project Manager and shall be obtained from a single source.
- b. All fine and coarse aggregates shall be clean and free from clay, loam, silt and other deleterious matter. If required, Project Manager reserves the right to have them washed by the CONTRACTOR at no additional expenses. Coarse and fine aggregates shall be delivered and stored separately at SITE. Aggregates shall not be stored on muddy ground or where they are likely to become dirty or contaminated.

SECTION 3 – PLAIN AND REINFORCED CONCRETE

- c. Fine aggregates shall be hard coarse sand, crushed stone or gravel screenings, and shall conform to requirements of ASTM C33/C33M
- d. The maximum permitted content of chlorides and sulphates are 0.03% by weight of aggregate (as acid soluble Cl-) and 0.4% by weight of aggregate (as acid soluble SO₃) respectively.
- e. The flakiness index shall not exceed 30%.
- f. Coarse aggregates shall be gravel or broken stone or hard, durable material free from laminated stone and conforming to ASTM C-33 graded as follows for use in mass concrete such as in foundations:

SIZE	TOTAL PASSING	PERCENT BY WEIGHT
2"	Sieve (50.00 mm)	100
1-1/2"	Sieve (38.10 mm)	95 - 100
3/4"	Sieve (19.00 mm)	35 - 70
3/8"	Sieve (9.50 mm)	10 - 30
No. 4	Sieve (4.75 mm)	0 - 5

Coarse aggregates for all cast-in-place concrete other than mass concrete and thick fair faced cast-in-place concrete shall be graded with the following limits:-

SIZE	TOTAL PASSING	PERCENT BY WEIGHT
1"	Sieve (25.00 mm)	100
3/4"	Sieve (19.00 mm)	90 - 100
3/8"	Sieve (9.50 mm)	20 - 55
No. 4	Sieve (4.75 mm)	0 - 10

Coarse aggregates for thin fair faced cast-in-place concrete shall be graded as follows:-

SIZE	TOTAL PASSING	PERCENT BY WEIGHT
1/2"	Sieve (12.50 mm)	100
3/8"	Sieve (9.50 mm)	85 - 100
No. 4	Sieve (4.75 mm)	10 - 30

- g. The nominal maximum size of aggregate for precast fair faced concrete shall be smallest of the following:
 - i. One-fifth of the narrowest dimensions between sides of forms.
 - ii. One-third of the depth of slabs.
 - iii. Three-fourth of the minimum clear distance between reinforcing bars or between bars and form.
 - iv. 1/2" (12.0 mm).
- h. The nominal maximum size of the aggregate for normal weight precast concrete shall be smallest of the following:-
 - i. One-fifth of narrowest dimension between forms.
 - ii. One-third of depth of slab.
 - iii. Three-fourth of clear distance between bars.
 - iv. 1 inch.

Note: The above suggestions for sieve analysis are subject to the sieve analysis of the approved design mix which the contractor will produce at that time.

- i. The aggregates shall be stockpiled for a period before use so as to drain nearly to constant moisture content (as long as SITE and other conditions permit, preferably for at least a day). The grading of the coarse and fine aggregates shall be tested at least once for every 50 tons (or 750 cft) supplied to ensure that the grading is uniform and the same as that of the samples used in the preliminary tests.

3.4.2 Cement and Cementitious Materials

- a. The cement shall be fresh and of approved origin and of an approved brand manufacture. All cement for work above ground slab level shall be 'Ordinary Portland Cement (OPC)' or Rapid Hardening Portland Cement and shall comply with the requirements of PS 232, ASTM C150/C150M, Type I or Type II. All cement for work below ground level or in contact with soil shall be 'Sulphate Resistant Portland Cement' complying with ASTM-C150-Type.
- b. All cement shall be of a brand approved by the Engineer. In addition all cement used in the works shall be low alkali cement containing less than 0.6% acid soluble alkali, when tested in accordance with ASTM Standard.
- c. Cement shall be delivered in manufacturer's sealed branded bags or barrels, each consignment accompanied by the manufacturer's test certificates. Damaged bags or barrels and any cement the Engineer considers unsatisfactory shall be rejected. Each bag shall be used on the day of opening. Bags opened on the previous day shall be rejected. All rejected cement including that which has become affected by damp conditions is to be removed from site immediately. Cement bags shall have a coding system for identifying date of manufacture.
- d. Sulfate resisting Portland cement (SRPC) ASTM C150 Type V or PS 612 should be used, where the risk of sulfate attack may be present.
- e. Only one brand of cement shall be used.
- f. All cement shall be stored in a suitable weatherproof building or silo. The building shall be painted a light color. Bagged cement is to be stored off the ground and it shall be used up in the order in which it is delivered to site.
- g. Different grades of cements shall be stored in separate areas. Cement temperature shall not exceed 50 deg C when used.
- h. If cement has been held in store for 3 months or more it shall be tested to satisfy the relevant ASTM standard. No cement shall be used after 6 months from its manufacturing date.
- i. Each consignment of cement delivered to the site must be accompanied by a certificate showing the place and date of manufacture and the results of standard tests carried out on the bulk supply from which the cement was obtained.
- j. Notwithstanding the above requirements and tests, the Engineer may reject any cement which in his opinion is unsatisfactory for any reason whatsoever.
- k. Fly ash may be used in accordance with ACI 301 / ACI 301M and shall be in accordance with ASTM C618, Class F unless otherwise specified in contract documents. Class C fly ash may be used if Class F is not available.
- l. Ground Granular Blast Furnace Slag (GGBFS) in accordance with ASTM C989/C989M may be used if available.
- m. Cementitious materials used for mass concrete applications shall be in accordance with ACI 301/ACI 301M Section 8.2.1.1. For applications designated as environmental engineering concrete structures in contract documents, cementitious materials used for mass concrete applications shall also be in accordance with ACI 350.5/ACI 350.5M.

- n. Cement shall be used in sequence of receipt of shipment, unless or otherwise directed. There shall be sufficient cement at SITE to ensure that each section of WORK is completed without interruption. If the cement is supplied by THE EMPLOYER, the CONTRACTOR shall inform Project Manager of his requirement much before its use in construction.
- o. Cement reclaimed from cleaning of bags or from leaky containers shall not be used.
- p. CONTRACTOR shall provide and erect, at his own cost, in a suitable place, dry, well ventilated, and water proof shed of sufficient capacity to store the cement.
- q. The cement shall be used as soon as possible after delivery, and cement which Project Manager considers has become stale or unsuitable through absorption of moisture from the atmosphere or otherwise shall be rejected and removed immediately from the SITE at CONTRACTOR'S expense. Any cement in containers, damaged so as to allow the contents to spill or access of the atmosphere to the cement prior to opening at the time of concrete mixing shall be rejected and removed immediately from the SITE at CONTRACTOR'S expense.
- r. The mixing together of different types of cement shall not be permitted.
- s. Any cement bag having lumps shall be considered as contaminated and not be allowed to be used in any work.
- t. Stacking of cement bags should not be of not more than 10 bags in height. Ventilation, allowing free flow of air through the stacks especially at the bottom of the stacks would be necessary.

3.4.3 Water

- a. Water used for mixing water, ice, curing, or any other function relating to placement of concrete shall be potable or meet the requirements of ASTM C1602/C1602M.
- b. Water for use in the washing of aggregate, curing, and in the production of concrete and mortar, shall be obtained from an approved source and shall be of such a quality as not to affect (1) the setting time, strength and durability of the concrete or mortar (2) the appearance of hardened concrete or mortar by discoloration of efflorescence and (3) the reinforcement at any age of the concrete or mortar.
- c. Water shall be clean, demineralized, blended or unblended, with a pH between 6.5 and 8.0 shall be tested. The following limits shall not be exceeded.

Total dissolved solids (TDS)	not greater than	2000	ppm
Suspended solids (TSS)	"	2000	ppm
Chloride as NaCl	"	800	ppm
Chloride as Cl-	"	500	ppm
Sulphates as SO ₃	"	1000	ppm
Alkali HC03/CO ₃	"	1000	ppm

- d. Water shall be stored in approved, clean, covered containers painted white and are protected from sun, wind and dust and from contamination from any other source. Pipework for water shall, wherever possible, be protected from the sun and insulated. Crushed ice may be used to bring the water temperature below 32° C but with the strict supervision of the Engineer only.
Sea water shall not be used for any reinforced concrete works or where concrete is later required to be plastered, painted or otherwise decorated.

3.4.4 Admixtures

- a. An admixture is a material other than water, aggregate and hydraulic cement that is used as an ingredient of concrete or mortar and is added to the batch immediately before or during its mixing.
- b. Admixtures to be used in concrete shall be subject to prior approval by the Engineer in writing and shall comply with ASTM C494 and ASTM C260.
- c. Only liquid admixtures will be permitted. They shall be chloride free and shall not contain other substances which adversely affect the durability and performance of the concrete. Admixtures that excessively retard or accelerate the setting time of concrete will not be permitted.
- d. The following information must be submitted to the Engineer for approval purposes:
 - i) The brand name, the manufacturer's name and address together with a copy of the manufacturer's recommendations for the admixture.
 - ii) The typical dosage and detrimental effects of under dosage and over dosage.
 - iii) The chemical type(s) of the main active ingredients in the admixture.
 - iv) Whether or not the admixture leads to air entertainment when used at the manufacturer's recommended dosage.
 - v) Confirmation that the admixture is chloride free.
 - vi) The length of time and conditions under which the admixtures should be stored.
 - vii) Special measuring devices or equipment whenever needed.
- e. The suitability and effectiveness of any admixture shall be verified by trial mixes and compared with concrete of the same class but containing no admixture (control mix) to determine the effects of the admixture especially regarding workability, strength, setting time and density.
- f. When more than one admixture is to be used simultaneously in the concrete, the compatibility of the various admixtures shall have been ascertained by various standard tests and certified by the manufacturers.

3.4.5 Reinforcement

- a. Steel Reinforcing bars shall be deformed billet steel in accordance with ASTM A615/A615M, Grade 60 (420) unless otherwise specified in contract documents.
- b. Reinforcing bars shall be uncoated unless otherwise specified in contract documents.
- c. Welded wire reinforcement shall be plain wire in accordance with ASTM A1064/A1064M. Wire shall be of sufficient size to fabricate in sheets. Rolls of welded wire reinforcement shall not be used.
 - i. Tie wire shall be black annealed wire, 16 gage (1.29 mm) minimum.
 - ii. All reinforcement shall be clean and free from materials that may cause corrosion of the reinforcement or the disintegration of the concrete and from pitting, seams, loose rust, mill scale, paint, oil, grease and other material that may impair the bond between the concrete and the reinforcement.
 - iii. Sheets of mesh fabric shall be flat unless specified as bent and any tendency to curve or twist shall be corrected by the contractor before fixing. Mesh fabric shall not be supplied in rolls.
- d. The Contractor shall furnish the Engineer with manufacturer's certificates for the reinforcing steel intended for use, including test results of the physical and chemical properties as in the relevant standard, all prior to use in the works.
- e. Reinforcement shall be stored on properly constructed racks at least 150 mm above ground

level. The storage, cutting and bending of steel reinforcement shall be carried out under cover, on an approved free draining platform. The method of storing shall be such as to prevent contamination or damage by weather or accident. All steel reinforcement shall be protected from humidity and salt laden dews when stored.

- f. If necessary, steel shall be tested in accordance with the requirements of the standard/s to which it has been manufactured.
- g. Reinforcement shall be obtained only from the manufacturer approved by the Project Manager. If and when required CONTRACTOR shall provide all necessary facilities to Project Manager for the selection of test pieces and shall cause these to be prepared and submitted where directed for tests at CONTRACTOR'S cost.
- h. If the reinforcement is to be supplied by the EMPLOYER, the CONTRACTOR shall inform Project Manager of his requirements much before its use in construction.
- i. CONTRACTOR shall report immediately on receipt of any consignment, having any deviation in the standard weights of the reinforcing bars beyond those allowed in respective standards mentioned herein before.

3.4.6 Reinforcement Fixing

- a. All metal for reinforcement shall be free from loose mill scale, loose rust, mud, oil, grease, or other harmful matter immediately before the concrete is placed.
- b. Reinforcement is to be accurately placed as shown in the Drawings, and secured against displacement by using 18-20 gauge black annealed wire ties or suitable slips at intersections and supported from the formwork by using concrete, metal or plastic chairs and spacers or hangers of an approved pattern. Where concrete blocks are used for ensuring the cover they shall be made of mortar not leaner than 1 part of cement to 2 parts of sand. Where the concrete surface will be exposed to the weather in the finished structure the portions of all accessories in contact with the formwork shall be galvanized or shall be made of plastic.
- c. Bars used for concrete reinforcement shall be fabricated in accordance with the dimensions shown in the Bending Schedule.
- d. The cutting tolerance for all bars shall be +/-1" (+/- 25 mm).
- e. Where an overall or an internal dimension of a bent bar is specified in the schedule, the bending tolerance, unless otherwise stated, shall be as in **Table 3-1**.

TABLE 3-1 - BENDING TOLERANCES

DIMENSIONS OF BENT BARS				TOLERANCE			
Over		Up to and Including		Plus		Minus	
Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
		36	915	1/8	3	1/4	6.0
36	915	72	1830	1/4	6.3	1/2	12.5
72	1830			1/2	12.5	1	25.0

- f. Bars shall be placed to the following tolerances:

i. Concrete cover to formed surface:	+/- 1/4" (6.0 mm)
ii. Minimum spacing between bars	+/- 1/4" (6.0 mm)
iii. Top bars in slabs and beams:	
• Members 8" (200 mm) deep or less:	+/- 1/4" (6.0 mm)
• Members more than 8" (200 mm)	
Till 24" (600 mm) deep:	+/- 1/2" (12.0 mm)
• Members more than 24" (600 mm) deep:	+/- 1" (25.0 mm)
iv. Crosswise of member:	space evenly with 1" (25 m)
v. Lengthwise of members:	+/- 2" (50.0 mm)

- g. Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed the above tolerances, resulting arrangement of bars shall be subject to approval of the Project Manager.
- h. Vertical bars in column shall be offset at least one bar diameter at lapped splices. To ensure proper placement, templates shall be furnished for all columns dowels.
- i. Reinforcement shall not be bent or straightened in a manner that will injure the material. No bars shall be bent twice in the same place, nor they be straightened after bending. Unless permitted by the Project Manager, reinforcement shall not be bent after being partially embedded in hardened concrete. Bars which depend for their strength on cold working shall not be heated for any reason (except for welding) Reinforcement larger than 1-1/2" (38.0 mm) in dia, may lie bent by the use of heat (not exceeding 1550 F). Bars bent shall not be cooled by quenching.
- j. No splice of reinforcement shall be made except as shown on the working Drawings.
- k. Welding shall be permitted for bars only under suitable conditions and with suitable safeguards in accordance with B.S 693. 1856, or AWS D 12.1 provided the type of reinforcement bars have the required welding properties. Tack welding may be used to fix in position bars that cross each other, only with prior approval of the Project Manager.
- l. Exposed reinforcement intended for bonding with future extensions is to be effectively protected from corrosion. Protection is also to be provided to reinforcement partly built into concrete exposed part to be built into later concrete.
- m. No concreting is to be carried out until the reinforcement has been checked and approved by the Engineer or Project Manager.

3.4.7 Concrete

3.4.7.1 General

- a. Only ready-mixed concrete (RMC) shall be used for substructure and superstructure elements and for other elements where the required quantity is more than 10 cubic yd.
- b. The name and address of the supplier is to be submitted to the Engineer and acceptance of the use of such supplier shall be obtained prior to placing the order. Notwithstanding any such authorization by the Engineer the Contractor shall take full responsibility for the ready- mixed concrete complying with the requirements of the Specification.
- c. The concreting materials shall comply with the requirements of this Specification and shall be tested in accordance with the Engineer's instructions. The cost of such testing

will be the responsibility of the Contractor. Test cylinders shall be taken on site by the Contractor.

- d. The Contractor is to ensure that a record is kept on the exact time when the concreting materials are mixed.
- e. Ready-mixed concrete shall be plant batched and mixed; truck mixed concrete will not be accepted. The concrete shall be carried in purpose-made agitators, operating continuously. The concrete shall be placed in its final position within 90 minutes of the time when the cement first came into contact with water or wet aggregates.
- f. Delivery notes shall record the following information:
 - (i) Cement content, type and grade of concrete.
 - (ii) Design slump
 - (iii) Temperature at mixing
 - (iv) Additives (if any).
 - (v) Mix code number
 - (vi) Time and date of mixing.
 - (vii) Time and date and of truck arrival.
 - (viii) Registration number of truck and name of depot.
 - (ix) Time when concrete placed in position.
- g. The following additional information shall also be recorded by the Contractor who shall submit to the Engineer a copy of the signed agreement, together with the mix designs, specifications and all other documents relating to the supply of concrete.
 - i) Mix grades and position in the structure where the concrete is placed.
 - ii) Whether test cylinders were taken from this delivery.
 - iii) Actual slump and details of additives.
- h. If the use of ready-mixed concrete has been approved by the Engineer, the Contractor shall submit to the Engineer a copy of the signed agreement, together with the mix designs, specifications and all other documents relating to the supply of concrete.
- i. Ready-mixed concrete shall comply in all respects with ASTM C94 / C94M - 20.
- j. Admixtures used in ready-mixed concrete shall comply in all respects with C494 / C494M - 19.
- k. Where small amount of non-structural concrete not exceeding 10 cubic yd is required, site mixing may be allowed subject to the approval of the Engineer.
- l. For concrete cast on site, the proportions of ingredients of structure concrete shall be decided by trial mixes / mix design for the concrete of required compressive strength and shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around reinforcement by the methods of placing and consolidation allowed to employ on the WORK, but without permitting the materials to segregate or excessive free water to collect on the surface. Specific approval of the Project Manager is required to waive limitations on mixture proportions.
- m. The proportions of ingredients shall be selected in accordance with **Section 5.8.1.6** to produce the proper placeability, durability, strength and other required properties.

3.4.7.2 Strength

- a. The Specified compressive strength of the concrete cylinder, shall be minimum of 2500 psi at 28 days except where otherwise noted on Drawings. Strength requirements shall be based on the sampling and testing methods of ASTM C 39-72. For seismic design, the Specified compressive strength of the concrete cylinder, shall be minimum of 3000 psi at 28 days except where otherwise noted on Drawings.

- b. The class of concrete to be used shall be as called for on the Drawings or as directed by the Engineer or specified in the special provisions. The following requirements shall govern unless otherwise shown on the Drawings.

Class of Concrete	Minimum Cement (lbs/cyd)	Max. Size of Coarse Aggregate (in)	Min. 28 days cylinder compressive strength (psi)	Slump Vibrated (in) Min	Slump Vibrated (in) Max	Max. Permissible w/c Ratio
A1	500	0.8	3000	1.0	3.0	0.58
A2	600	1.0	3500	4.0	6.0	0.58
A3	675	1.5	4000	4.0	6.0	0.58
B	420	2.0	2500	1.0	3.0	0.65
C	460	1.5	3000	1.0	3.0	0.58
D1	750	1.0	5000	2.0	4.0	0.40
D2	850	1.0	6000	2.0	4.0	0.40
D3	925	1.0	7000	2.0	4.0	0.40
Y	675	0.5	3000	1.0	3.0	0.58
Lean	300	2.0	1500			-

Class A1 concrete shall be used everywhere, for non-reinforced and reinforced concrete structures, except as-noted below or directed by the Engineer. Concrete placed underwater shall be Class A2 with a minimum cement content of three hundred fifty (350) kg per cubic meter of concrete with a slump between ten (10) and fifteen (15) cm. Concrete placed for piles shall be Class A3 with a minimum content of four hundred (400) kg per cubic meter.

Class B Concretes shall be used only where specified.

Class C concretes shall be used for cribbing, or as otherwise directed by the Engineer or specified in the Special Provision or on the Drawing.

Class D1, D2 or D3, concrete shall be used for pre-stressed and post-tensioned elements, as indicated on drawings.

Class Y concrete shall be used as a filler in steel grid bridge floors, in thin reinforced sections or as otherwise specified in the Special Provisions.

Lean concrete shall be used in thin layers underneath footings and when called for on the Drawings or directed by the Engineer.

3.4.7.3 Water Content of Concrete

Maximum permissible water-cement ratios for concrete in severe exposures to be as follows, unless lower water-cement ratio is required to meet specified strength limits:

Type of Structure	Water/Cement ratio
Thin sections & sections with less than 1 inch cover over steel.	0.45, 0.40 ²
Continuously wet or Frequently freezing and thawing	
Exposed to sea or sulfates	
All other Structures	0.50, 0.45 ²

NOTE:

- Concrete should also be air-entrained.
- If Sulphate Resistant (SR) Cement is used permissible water-cement ratio may be increased by 0.05.

3.4.7.4 Slump

Concrete of lower than usual slump may be used provided it is properly placed and consolidated. The slump shall be determined by the "Test for Slump for Portland Cement Concrete" (ASTM C-143).

3.4.7.5 Admixtures

- a. If required or permitted, admixtures used shall be in accordance with the manufacturer's instructions except as otherwise specified herein.
- b. Admixtures to be used in concrete shall be subject to prior approval by the Engineer in writing and shall comply with ASTM C494 and ASTM C260.
- c. Chemical admixtures may be used as per the recommendation of the suppliers to achieve the desired strength and workability.
- d. Mineral admixtures such as Silica fume and Fly ash and Ground Granulated Blast furnace Slag (GGBS) as partial replacement of cement may be used. These concrete mixes have to be designed to achieve the desired strength at the target ages.

3.4.7.6 Methods of Obtaining Mix Design

- a. For concrete of normal weight, mix proportions to provide the desired characteristics shall be developed by using the methods/procedure covered by the latest edition of Recommended Practice for Selecting Proportions for Normal Weight Concrete ACI 211.1.
- b. Trial mixtures having proportions and consistencies suitable for the WORK shall be made based on ACI 211.1, using at least three different water-cement ratios which will produce a range of strengths encompassing those required for the WORK. Trial mixes shall be designed to produce the specified slump. The temperature of concrete used in trial batches shall be reported.
- c. For each water-cement ratio, compression test of cylinder shall be made, cured, and tested in accordance with ASTM C - 39. From the results of these tests a curve shall be plotted showing the relationship between the water-cement ratio and compressive strength. From this curve, the water-cement ratio to be used in the concrete shall be selected to produce the required/specified design strength. The cement content and mix proportions to be used shall be such that this water-cement ratio is not exceeded when slump is the maximum permitted. Control in the field shall be based upon maintenance of proper cement content and slump.

3.4.7.7 Batching

- a. All cement, including cement supplied in bulk, shall be batched by weight. A bag of cement, unless marked otherwise, may be taken as 112 lbs (50 kg) or as directed by the Project Manager.
- b. Aggregate shall be batched by weight, duly allowance being made for water content. Aggregate may be batched by volume only with the prior permission of Project Manager. The apparatus for weight batching may be an integral part of the mixer or a separate unit of a type approved by Project Manager. It shall be accurate within 2% and shall be checked for accuracy at least once a week.

- c. Where the batching plant is of the type in which cement and aggregate are weighed in the same compartment, the cement shall be introduced into the compartment between two sizes of aggregate.
- d. Where volumetric batching of aggregate is permitted, gauge boxes shall be provided for measuring the coarse and the fine aggregate. These shall be deep and narrow rather than shallow and wide. Tests for the bulking of sand shall be made at intervals and the necessary quantity of sand added.
- e. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue to flow for a period which may extend to the end of the first 25 percent of the specified mixing time.

3.4.7.8 Mixing

- a. The concrete shall be mixed in an approved batch mixer. It shall be fitted with the manufacturer's plate stating the rated capacity and the recommended number of revolutions per minute and shall be operated in accordance therewith. It shall be equipped with a suitable charging mechanism and an accurate water measuring device.
- b. Mixing shall continue for the period recommended by the mixer manufacturer or until apparently the mix is uniform in color, whichever period is longer. If it is desired to use a mixing period less than 1-1/2 minute. Project Manager Approval shall be obtained in writing.
- c. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three quarters of the required mixing time shall take place after the last of the mixing water has been added.
- d. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixing blades, shall be replaced when they have lost 10% of their original height.
- e. Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be re-tempered, but shall be discarded.

3.4.7.9 Transportation

- a. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent segregation or loss or addition to ingredients. It shall be deposited as nearly as practicable in its final position so as to avoid re-handling or flowing. All skips, vehicles, or containers used for transporting the concrete shall be thoroughly cleaned.
- b. During hot or cold weather, concrete shall be transported in deep containers to minimize the loss of water/heat.

3.4.7.10 Placing

- a. Before placing of concrete, form works shall have been completed, water shall have been removed, reinforcement shall have been secured in place, expansion joint material, anchors, and other embedded items shall have been kept in position, and the entire preparation shall have been approved.
- b. No concrete is to be placed into the foundation trenches until the ground to receive the same has been examined and approved by Project Manager for this purpose.

- c. The actual sequence of construction proposed by CONTRACTOR shall be subject to Project Manager's approval before construction starts on any part of the structure, and this sequence shall not be varied without Project Manager's prior approval.
- c. The concrete shall be placed after it has been mixed as soon as practicable. Once the concrete has left the mixer no more water shall be added, although the concrete may be mixed or agitated to help maintain workability. The concrete shall not be used if, through any cause, the workability of the mix at the time of placing is too low for it to be compacted fully and to an acceptable finish by whatever means are available.
- d. The time between mixing and placing should be reduced if the mix is richer or the initial workability of the mix is lower than normal, if a rapid hardening cement or an accelerator is used, or if the work is carried out at a high temperature or exposed to a drying atmosphere. CONTRACTOR shall ensure that the delay between mixing and placing does not exceed 30 minutes under any circumstances. Any concrete which does not satisfy this requirement shall not be used.
- e. The concrete shall be deposit as nearly as possible in its final position to avoid re-handling. In no circumstances may concrete be made to flow along the forms by the use of vibrators, Concreting shall be carried out on as a continuous operation using methods which shall prevent separation loss of ingredients.
- f. The free fall of concrete shall not be allowed to exceed eight feet and where it is necessary for the concrete to be lowered more than this amount, it is not to be dropped into its final position, but it is to be placed through pipe, the lower end of which shall be kept in, or close to the freshly deposit concrete. The dia of the pipe shall not be than 4 times the maximum size of aggregate.
- g. For mass concrete, concrete shall be placed in layers approximately 18" (450 mm) thick. Vibrator heads shall extend into the previously placed layer.
- h. The workmen carrying concrete to the SITE, and all other workmen moving about before the concrete is placed shall move only along runways or planks placed over the forms.
- i. Prior to the laying of concrete on load bearing masonry walls, bearing plates and at other points, as may be directed by Project Manager, the surface will be brought to a true, hard smooth, level using a cement sand mortar in the ratio of 1 volume of cement to 3 volumes of sand. Two layers of building paper weighing 1.3 oz/sq. ft (400 g/m) will then be laid flat to separate the concrete from the surface on which it is to be laid.

3.4.7.11 Construction Joints

- a. Concreting shall be carried out continuously upto construction Joints, the position and arrangement of which shall be pre-determined with the approval of the Project Manager.
- b. Joints not shown on the Drawings shall be so made and located as to least impair the strength of the structure and shall need prior approval of Project Manager. In general, they shall be located near the middle of the spans of slabs and beams unless a secondary beam intersects a main beam at this point, in which case the joint in the main beam shall be offset to a distance equal to twice the width of the secondary beam. Joints in walls and columns shall be at the underside of floors slab or beams, and at the top of footings. Beams, brackets, columns, capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

- c. All reinforcing steel shall be continued across joints. Key and inclined dowels shall be provided as directed by Project Manager. Longitudinal keys at least 1-1/2 (40 mm.) deep shall be provided in all joints in walls and between walls and slab or footings.
- d. When the work is to be resumed on a surface which has hardened, such surface shall be roughened in an approved manner which will expose the aggregate Uniformly and will not leave laitance, loosened particles of aggregate or damaged concrete at the surface.
- e. The hardened concrete of construction joints and of joints between footings and walls or columns, between walls or columns and beams or floors they support, joints in un-exposed walls and all others not mentioned below shall be dampened (but not saturated) immediately prior to placing of fresh concrete.
- f. The hardened concrete of joints in exposed work, joints in the middle of beams, and slabs and joints in work designed to contain liquids shall be dampened (but not saturated) and then thoroughly covered with a coat of cement grout of similar proportions to the mortar in the concrete The grout shall be as thick as possible on vertical surface and at least 1/2" (12.0 mm) thick on horizontal surface. The fresh concrete shall be placed before the grout has attained its initial set.
- g. Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brush. Care being taken to avoid dislodging of particles of aggregate. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 6" (150 mm) in thickness, and shall be well rammed against old work, particular attention being paid to corners and close spots.
- h. Stop ends for movement joints or construction joints shall be made by splitting them, along the lines of reinforcement or the concrete. Stop ends made of expanded metal or similar material may only be left permanently in the concrete with prior written approval of Project Manager. Where such stop ends are used, no metal may be left permanently in the concrete closer to the surface of the concrete than the specified cover to the reinforcement. Wood strips inserted for architectural treatment shall be kerfed to permit swelling without pressure on the concrete.

3.4.7.12 Embedded Items

- a. The material, design and location of water stops in joints shall be as indicated in the Drawings. Each piece of pre-molded water stop shall be of maximum practicable length in order that the number of end joints will be held to a minimum.
- b. Joints at intersections and at end of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective water tightness fully equal to that of the continuous water-stop material, and shall permanently develop not less than 50% of the mechanical strength of the parent section, and shall permanently retain their flexibility.
- c. Electric conduits and other pipes which are planned to be embedded shall not, with their fittings, displace more than four percent of the area of the cross section of a column on which stress is calculated or which is required for fire protection. Sleeves, conduits, or other pipes passing through floors, walls, or beams shall be of such size or in such location so as not to impair unduly the strength of the construction. Such sleeves, conduits in compression in the displaced concrete, provided that they are not exposed to rusting or other deterioration, are of un-coated or galvanized iron or steel not thinner than standard steel pipe, having a nominal inside diameter not over 2" (50

mm) and are spaced at centers not less than thrice their diameter. Except when plans of conduits and pipes are approved by Project Manager embedded pipes or conduits other than those merely passing through, shall not be larger in outside diameter than one-third or the thickness of the slab, walls, or beam in which they are embedded nor shall be spaced closer than three diameters on center, nor so located as to impair unduly the strength of the construction. Sleeve pipes, or conduits within the limitations of this section may be embedded in concrete with the approval of Project Manager, provided they are not considered to replace the displaced concrete.

- d. All sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting.
- e. All-Contractors whose work is related to the concrete or must be supported by it shall be given ample notice and opportunity to introduce and/or furnish embedded items before the concrete is placed.
- f. Expansion joint material, water stop and other embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

3.4.7.13 Consolidation

- a. All concrete shall be consolidated by vibration, so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of form, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a minimum frequency of 800 vibrations per minute and sufficient amplitude to consolidate the concrete effectively.
- b. Vibrators shall be inserted and withdrawn at points approximately 18" apart (450 mm). At each insertions, the duration shall be sufficient to cause consolidation, generally from 5 to 15 sec. A spare vibrator shall be kept on the SITE during all concreting operations. Where the concrete is to have an as-cast finish, a full surface of mortar shall be brought against the form by the vibration process supplemented if necessary by spading to work the coarse aggregate back from the formed surface.
- c. If there is any tendency for the mix to segregate during consolidation, particularly if this produces excessive laitance, the mix proportions shall be modified to affect an improvement in the quality of the concrete to the satisfaction of Project Manager.
- d. Vibrators shall not be allowed to contact the form work for exposed concrete surface.
- e. Mechanical vibrators shall be of a type suited in the opinion of Project Manager to the particular conditions.
- f. Over-vibration or vibration of very wet mix is harmful and should be avoided.

3.4.7.14 Curing and Protection

- a. Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures, and mechanical injury, and shall be maintained with minimal moisture loss at a relative constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval of Project Manager.
- b. For concrete surfaces not in contact with forms, one of the following procedure shall be applied immediately after completion and finishing:
 - Ponding or continuous sprinkling.

- Application of absorptive mats or fabric kept continuously wet.
 - Application of water proof sheet materials approved by Project Manager.
 - Application of other moisture retaining covering as per approved.
- c. Application of curing compound conforming to ASTM C 309. The compound shall be applied in accordance with the recommendations of the manufacturer immediately after any sheen which develops after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other materials to be bonded unless it is proved that the curing compound will not prevent bond, or unless positive measures are taken to remove it completely from area to receive bonded applications.
- d. Moisture loss from surface placed against wooden forms or metal forms exposed to heating by the sun shall be minimized by keeping forms wet until they can be safely removed. After form removal, the concrete shall be cured.
- e. Curing shall be continued for at least 14 days in the case of all concrete except concrete with Rapid hardening Portland cement for which the period shall be at least 7 days.
- f. Alternatively if tests are made of cylinders/cubes kept adjacent to the structure and cured by the same methods, moisture retention measures unless stated otherwise on drawings, may be terminated when the average compressive strength has reached 70 percent of the minimum specified Works strength.
- g. When the mean daily outdoor temperature is less than 41 deg. F (5C) then temperature of the concrete shall be maintained between 50-68 deg. F (10C-20C) for the required curing period. When necessary arrangements for heating, covering, insulation or housing the concrete work shall be made in advance of placement and shall be adequate to maintain the required temperature without injury to concentration of heat. Combustion heaters shall not be used during the first 24 hours unless approved precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.
- h. When necessary, provision for windbreak, shading for spraying, sprinkling, ponding or wet covering with a light colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as concrete hardening and finishing operations will allow.
- i. Changes in temperature of the air immediately adjacent to the concrete during and immediately following the curing period shall be kept as uniform as possible and shall not exceed 5 deg.F (3C) in any one hour or 50 deg. F (28C) in any 24 hour period.
- j. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, heavy shock and excessive vibration. All finished concrete surfaces shall be protected from damage by construction equipment, materials or methods by application of curing procedures, and by rain or running water, self-supporting structures shall not be loaded in such a way as to over stress the concrete.

3.4.7.15 Works In Extreme Weather

- a. Unless adequate protection is provided and approval is obtained concrete shall not be placed during rain. Rain water shall not be allowed to increase the mixing water nor to damage the surface finish.
- b. When the temperature of the surrounding air is expected to be below 40 deg.F (4.4 C) during placing or within 24 hours thereafter, the temperature of the plastic concrete,

- as placed shall not be lower than 55 degrees F (13C) for sections less than 12" (300 mm) in any dimension nor 50 deg, F (10C) for any other sections.
- c. When necessary, concrete materials should be heated before mixing and carefully protected after placing; in general, heating of mixing water alone to about 140 deg.F (60C) may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing. No frozen material or materials, containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 5.5 gallons (25 liters) per bag of cement. If water or aggregate is heated above 100 deg F (38C) the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of wafer and "aggregate having a temperature greater than 100 deg.F (38C).
 - d. During hot weather, (lie temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash set, or cold joints and should not exceed 90 deg,F (32.C). For massive concrete this temperature should not exceed 70 deg.F (21C). When the temperature of the concrete exceeds 90 deg.F (32C), precautionary measures approved by Project Manager shall be put into effect. When the temperature of the steel is greater than 122 deg.F (50C) steel forms and reinforcement shall be sprayed with water just prior to placing the concrete. The ingredients shall be cooled before mixing, or flake ice or well-crushed ice of a size that will melt completely during mixing may be substituted for all or part of the mixing water if, due to high temperature, low slump, flash set or cold joints are encountered.
 - e. Other precautions recommended by ACI standard 305R-91 shall also be adopted.

3.4.8 Tests for Concrete Quality

3.4.8.1 General

CONTRACTOR shall make standard cylinder / cube (sample) by standard method of concrete for testing at Project Manager's direction. Proper facilities shall be provided for making and curing the test specimens in accordance with the specifications A competent person shall be employed by the CONTRACTOR whose first duty shall be to supervise all stages in the preparation and placing of the concrete. All test specimens shall be made and SITE tests carried out under his direct supervision and at CONTRACTOR'S cost.

Permanent record of concrete poured, samples made, and compressive strength results obtained shall be carefully maintained at the site.

3.4.8.2 Samples

Conduct compressive strength tests on at least, one test cylinder / cube sample per 50 cubic yards of concrete (38 cu meters) with a minimum of one sample per concrete pour. Each test sample shall consist of no less than three concrete test cylinders/cubes made from a single sample of concrete from a randomly selected batch of concrete, taken at point of discharge from mixer or truck, cured under standard conditions. One cylinder/cube from each sample shall be tested at age 3 days and two at age 28 days unless otherwise directed by the Project Manager.

3.4.8.3 Adequacy of Mix

In case of Concrete mix, the appropriate strength requirement shall be considered to be satisfied if none of the strengths of the specimen is below the specified strength or if the average strength of the three specimens is not less than the specified strength and the difference between the greatest and least strengths is not more than 20% of that average.

When the results of tests show that the strength of any concrete is below the minimum specified, Project Manager may give instructions for the whole or part of the work concerned to be removed and be replaced at the expense of CONTRACTOR. CONTRACTOR shall bear the cost of any other part of his, or any other CONTRACTORS work, which has to be removed and replaced as a result of the defective concrete. If any concrete is held to have failed. Project Manager may order the proportions of that class of concrete to be changed in order to provide specified strength.

3.4.9 Finishing of Formed Concrete

3.4.9.1 General

- a. After removal of forms the surfaces of concrete shall be given one or more of the finishes specified below in locations designated by the Drawing or as specified in Clause 8.5.
- b. When finishing is required to match a small sample furnished to CONTRACTOR, the sample finish shall be reproduced on nil area at least 100 square feet in an inconspicuous location designated by Project Manager before proceeding with the finish in the specified location.

3.4.9.2 As-Cast Fishes

a. Rough Form Finish:

No selected form facing materials shall be specified for rough form finish surfaces. Tie holes and defects shall be patched. Unless if required to be retained if so directed by Project Manager. Fins exceeding 1/4" (6 mm) in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

b. Smooth Form Finish:

The form facing material shall produce a smooth hard uniform texture on the concrete. It may be plywood, tempered concrete-form grade hardboard, metal, plastic paper, or other approved material capable of producing the desired finish. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to the practical minimum. It shall be supported by studs or other backing capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edge, patches, dents, or other defects which will impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched. All fins shall be completely removed.

3.4.9.3 Architectural Finishes

a. Textured Finishes

Textured form liners may be of formed plastic sheet, wood, sheet metal, or other material designated in Drawings. Liner panels shall be secured in forms by cementing or stapling,

but not by methods which will permit impressions of nail heads, screw heads washers, or the like to be imparted to the surface of the concrete, unless shown otherwise on the Drawings. Edges of textured panels shall be sealed to each other or to dividing strips, if specified or shown, to prevent bleeding of grout. The sealant used shall be non-staining to the surface.

b. Applied Finishes

When finishes of plaster or similar troweled materials are to be applied, the surface of the concrete shall be prepared to ensure permanent adhesion of the finish. If the concrete is less than 24 hours old, it can be roughened with a heavy wire brush or scouring tool. If the concrete is older the surface may be roughened mechanically or by etching with dilute hydrochloric acid. After roughening, the surface shall be washed free of all dust, acid, chemical retarder, and other foreign material before the final finish is applied.

3.4.9.4 Rubbed Finishes

The following finishes shall be produced on concrete with a smooth form finish. Where smooth rubbed finish is to be applied, the forms shall have been removed and necessary patching completed as soon after the cement of the concrete as possible without compromising any structural requirements.

a. Smooth Rubbed Finish

Smooth rubbed finish shall be produced on newly hardened concrete not later than a day following form removal.

Surfaces shall be wetted and rubbed with carborundum brick or other abrasive until uniform color and texture are produced. No cement grout shall be used other than the cement paste drawn from the concrete itself by the rubbing process.

b. Grout Cleaned Finish

No cleaning operations shall be undertaken until all contiguous surfaces to be cleaned are completed and accessible. Cleaning as the work progresses shall not be permitted.

Mix 1 part Portland cement and 1-1/2 part fine sand with sufficient water to produce a grout having the consistency of thick paint. While Portland cement shall be substituted for a part of the grey Portland cement in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch. Wet the surface of the concrete sufficiently to prevent absorption of water from the grout and apply the grout uniformly with a brush or a spray gun. Immediately after applying the grout, scrub surface vigorously with a cork float or stone and fill all air bubbles and holes. While the grout is still plastic, remove all excess grout by working the surface with a rubber float, sack or other means. After the surface whitens from drying (about thirty minutes at normal temperature) rub vigorously with clean burlap. The finish shall be kept damp for at least 36 hours after final rubbing.

c. Cork Floated Finish

1. Remove forms at an early stage, within 2 to 3 days of placement where possible.
2. Remove ties, and all burrs and fins.

3. Mix 1 part Portland cement and 1 part fine sand with sufficient water to produce a stiff mortar.
4. Dampen surface.
5. Apply mortar with firm rubber float or with trowel, filling all surface voids.
6. Apply a small amount of water with a fog spray to prevent too rapid drying of compressed mortar.
7. Apply a small amount of water with a fog sprayer.
8. Produce the final texture with a cork float using a swirling motion.

3.4.9.5 Unspecified Finishes

If the finish is not specified in the Drawings, the following finishes shall be used as applicable:

a. Rough Form Finish

For all concrete surface not exposed to public view and / or are specified to have subsequent finishing.

b. Smooth Form Finish

For all concrete surfaces exposed to public view and or are not required to have subsequent finishing.

3.4.9.6 Related Unformed Surfaces

Tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be floated to a texture reasonably consistent with that of the formed surfaces. Final treatment on form surfaces shall continue uniformly across the unformed surfaces.

3.5 Repair of Surface Defects

3.5.1 General

- a. Any concrete failing to meet the specified strength or not formed as shown on Drawings, concrete with surface beyond tolerances or with defective surfaces which cannot be properly repaired or patched in the opinion of Project Manager shall be removed and replaced at CONTRACTOR's expenses. Project Manager may reject any defective concrete and order it to be cut out in part or in whole and replaced at the CONTRACTOR's expense. Only in case of minor surface defects Project Manager may approve a surface treatment.
- b. All ties and bolt holes and all repairable defective areas shall be patched immediately after the removal of forms.

3.5.2 Repair of Defective Areas

- a. All honeycombed and other defective concrete shall be removed down to sound concrete. The area to be patched and area at least 6" (150 mm) wide surrounding it shall be dampened to prevent absorption of water from the patching mortar. A bonding grout shall be prepared using a mix of approximately 1 part cement to 1 part fine sand or an approved bonding agent shall then be well brushed/ applied into the surface.

- b. The patching mixture shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than 1 part cement to 2-1/2 parts sand by damp loose volume. White Portland cement shall be substituted for a part of the grey Portland cement on exposed concrete in order to produce a color matching the color of the surrounding concrete, as determined by a trial patch.
- c. The quantity of mixing water shall not be more than necessary for handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.
- d. After surface water has evaporated from the area to be patched, the bond coat shall be well brushed into the surface. When the bond coat begins to lose the water sheen, the premixed patching mortar shall be applied. The mortar shall be thoroughly consolidated into place and struck off so as to leave the patch slightly higher than the surrounding surface to permit initial shrinkage; it shall be left undisturbed for at least one hour before being finally finished. The patched area shall be covered by approved curing compound, except as specified in Clause 9.2 g. Metal tools shall not be used in finishing a patch in a formed wall which will be exposed.
- e. Whereas-cast finishes are specified, the quantity of patched area shall be strictly limited. The combined total of patched areas in as-cast concrete surfaces shall not exceed 2 square ft. in each 1000 square feet (2 sq. m in each 1000 sq.m) of as-cast surface. This is in addition to form tie patches, if the project design permits to fall within as-cast areas.
- f. Any patches in as-cast architectural concrete shall be indistinguishable from surrounding surfaces. The mix formula for patching mortar shall be determined by trial to obtain a good color match with the concrete when both patch and concrete are cured and dry. After initial set, surface of patches shall be dressed manually to obtain the same texture as surrounding surfaces.
- g. Patches in architectural concrete surfaces shall be cured continually for 7 days. Patches shall be protected from premature drying to the same extent as the body of the concrete.

3.5.3 Tie and Bolt Holes

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

3.5.4 Proprietary Materials

If permitted or required by Project Manager proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendation with prior approval of Project Manager.

3.6 Concrete Construction Tolerance

Where tolerances are not stated in the Specifications or Driving for any individual structure or feature, maximum permissible deviations from established lines, grades and dimensions shall conform to the following. The CONTRACTOR is expected to set and maintain concrete forms so as to ensure completed work within the tolerance limits. These allowable tolerances

shall not relieve CONTRACTOR of his responsibility for correct fitting of indicated materials. These tolerances are not cumulative.

3.6.1 Variation from the plumb (or as specified for sloped walls)

- a. In the lines and surfaces of columns, piers and walls.
 - Maximum for the entire length or height: 3/16" (4.5 mm)
- b. For exposed corner columns, control joint grooves and other conspicuous lines.
 - Maximum for the entire length or height: 3/16"(4.5 mm)

3.6.2 Variation from the levels or the grades indicated on Drawings

- a. In floors, ceilings, beam soffits and in arises.
 - Maximum for the entire length: 1/4"(mm)
- b. For exposed lintels, sills, parapets, horizontal grooves of 50 feet or more in length, and other conspicuous lines:
 - Maximum for the entire length: 1/4"(6 mm)

3.6.3 Maximum allowable constant Variation of the entire building lines from established position of property lines and related position of columns, walls and partitions.

- Maximum for the entire length: 1" (25 mm)

3.6.4 Variation of the size and locations of sleeves,

Floors openings and wall openings: 1/4" (6mm)

3.6.5 Variation in cross-sectional dimensions of columns and beams

Minus: 1/4" (6 mm)
 Plus: 1/2" (12.0 mm)

3.6.6 Thickness of Slabs & Walls.

1/4" (6 mm)

3.6.7 Footings

- a. Variations in dimensions in plan.
 - Minus: 1/2" (12.0 mm)
 - Plus (plus variation applied to concrete only, to bars dowels) 2" (50 mm)
- b. Misplacement or eccentricity of concrete.
 - 2 percent of the footing width in the direction of misplacement but not more than 2" (50 mm)
- c. Reduction in thickness
 - Minus 5 percent of specified thickness.

3.6.8 Variation in Steps

- a. Rise: 1/8" (3 mm)
 Tread: 1/4" (6mm)
- b. In consecutive steps
 Rise: 1/16" (1.0 mm)
 Tread: 1/8" (3 mm)

3.7 Tolerance for Pre-cast Concrete:

Forms must be true to size and dimensions of concrete members shown on the plans and be so constructed that the dimensions of the finished product will be within the following limits at the time of placement of these units in the structure, unless otherwise noted on Project Manager's Drawings.

- a. Overall dimensions of members per 10 ft (3 mm): +/- 1/16" (1.0mm)
- b. Cross-sectional dimensions' Section less than 3"(75 mm): +/- 1/8" (3 mm)
Section over 3" (75 mm) less than 18" (450 mm): +/- 1/8" (3 mm)
Section over 18" (450 mm): +/- 1/4" (6 mm)
- c. Deviations from straight lines in long sections. Not more than 1/8 inch per 10 ft. (3 mm / 3 m)
- d. Deviation from specified camber +/- 1/16" (1.5 mm) per 10 fl (3m) of span. Maximum differential between adjacent units in erected position. 1/4 inch (6 mm)

3.8 Tolerance for Pavements

a. Ramps

- Departure from established alignment +/- 1/4" inch (6 mm)
- Departure from established longitudinal on any line. +/- 1/4" (6 mm) grade
- Departure from transverse template colour except all transverse joints +/- 1/8 inch (+/- 3 mm)
- Departure from transverse template control at transverse joints 1/4" (+/- 6 mm) in width of one traffic lane

b. Pavements for Parking Areas

Twice values listed for ramp pavements.

3.9 Plant and Equipment

3.9.1 Formwork

- a. Forms shall be used, wherever necessary, to confine the concrete and shape it to the required dimensions. Forms shall have sufficient strength to with stand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.
Structurally adequate, form work shall also conform to the requirements of the special architectural finishes of the in-situ Plain and Reinforced Concrete specified/or shown on the Drawings. Shop drawings of such form shall be subject to the approval of the Project Manager prior to its use. Project Manager shall refuse concreting of any part which in his opinion may not yield specified finishes.
- b. Earth cuts shall not be used as forms for vertical surface or reinforced concrete work unless required or permitted.
- c. Mud centering shall not be permitted without the prior approval of the Project Manager.

- d.** Form work shall be made of either timber, steel, plywood, proprietary building boards and such special material, as may be shown on the drawings or approved by the Project Manager which gives the required finish to the surface of concrete. Wooden frame Work shall be free from loose knots and shall be well seasoned. For the external concrete finishes 1/16" (1.5 mm) thick mild steel sheet forms shall be used. CONTRACTOR shall furnish shop drawings of such form work prepared on the basis of architectural concept for the approval of the Project Manager.
- e.** Form work shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of concrete, and shall be sufficiently tight to prevent loss of cement slurry. The design and engineering of the form work, as well as its construction, shall be the responsibility of CONTRACTOR. Where necessary to maintain the specified tolerances, the form work shall be cambered to compensate for anticipated deflections in the form work due to the weight and pressure of the fresh concrete and due to construction loads.
CONTRACTOR shall establish and maintain in an undisturbed conditions and until final completion and acceptance of the WORK, sufficient control points and bench marks to be used for reference purpose to check tolerances.
- f.** Maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.
- g.** Where natural plywood form finish, grout cleaned finish, smooth rubbed finish, scrubbed finish, or sand floated finish is required, forms shall be smooth (faced with plywood, liner sheets, or prefabricated panels) and true to line, in order that the surfaces produced with required little dressing to arrive at true surfaces. Where any as-cast finish is required, no dressing shall be permitted in the finishing operation.
- h.** Whereas-cast surfaces, including natural plywood form finish, are specified, the panels of materials against which concrete is cast shall be arranged orderly with joints between panels planned in approved relations to opening, building corners, and other architectural features.
- i.** Where panels for as-cast surfaces are separated by recessed or otherwise emphasized joints, the structural design of the forms shall provide for locating form ties within the joints so that patches of the holes will not fall within the panel areas.
- j.** Forms shall not be re-used if there is any evidence of surface wear and tear or defect which would impair the quality of the surface. Forms shall be thoroughly cleaned and properly coated before re-use.
- k.** The formwork may be designed so that soffits of slabs and sides of beams, columns, and wall may be removed first leaving the forms to the soffits of beams and their supports in position.
- l.** Positive means, wedges or jacks of accurate adjustment and proper removal of shores and struts shall be provided and all settlement shall be taken up during placing of concrete. Forms shall also be securely braced against lateral deflections.
- m.** Where concreting of narrow members' is required to be carried out within form work of considerable depth, temporary openings in the sides of the form work shall be provided where necessary to facilitate the placing and consolidation of the concrete. Small temporary openings shall be provided at the bottom of the form work to columns, walls and deep beams to permit the cleaning out of debris and observations immediately before concrete is deposited.
- n.** Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete. After the ends or end

fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than twice the diameter or twice the minimum dimension of the tie from the formed faces of concrete to be permanently exposed to view except that in no case shall this distance be less than 3/4" (19 mm) when the formed Face of the concrete is not to be permanently exposed to view, form tie may be cut off flush with the formed surfaces. Through bolts shall be permitted provided that they are greased to allow for easy withdrawal and the holes subsequently made good. Through bolts are not to be used on water-retaining structures.

- o.** At construction joints, contact surface of the form sheathing for flush surfaces exposed to view shall overlap the hardened concrete in the previous placement by not more than 1" (25 mm). The forms shall be held against the hardened concrete to prevent offsets or loss of mortar at the construction joint and to maintain a true surface.
- p.** Runways or planks for moving labor and equipment shall be provided with struts or legs and shall be supported directly on the formwork or structural member without resting on the reinforcing steel.
- q.** All surfaces of the embedded items shall be cleaned and any accumulated mortar or grout from previous concreting and of all other foreign material is removed before concrete is placed in them.
- r.** Board forms having joints opened by shrinkage of the wood shall be swelled until closed by wetting before concrete is placed. Plywood and other wood surface not subject to shrinkage shall be sealed against absorption of moisture from the concrete either by (1) a field applied, approved form oil or sealer, or (2) a factory applied non-absorptive liner. When forms are coated to prevent bond with concrete, it shall be done prior to placing of the reinforcing steel. Care shall be taken that such approved coating is kept out of contact with the reinforcement. Whereas-cast finishes are required, materials, which will impart a stain to the concrete shall not be applied to the form surfaces. Where the finished surface is required to be painted, the material applied to form surface shall be compatible with the type of paint to be used.
- s.** In normal circumstances generally where temperatures are above 68 deg.F (20C) where ordinary cement is used, forms may be struck after expiry of the following periods.

• Walls, columns and vertical sides of beams	48 hours
• Slabs	14 days
• Beams soffits	14 days
• Removal of shores or props to slabs:	
1.Spanning over 14 ft (4 meters)	21 days
• Removal of shores or props of beams:	
1.Spanning upto 20 ft. (6 meters)	18 days
2.Spanning over 20 ft. (6 meters)	25 days

For rapid hardening cement 1/2 of the above period will be sufficient in all cases except vertical sides of slabs, beams and columns which should be retained for a minimum of 24 hours.

- t.** Proper allowance shall be made for the decrease in rate of hardening of concrete in cold weather and the minimum periods must be increased when the mean daily temperature is below 68 deg.F (20C).
- u.** When repair of surface defects or Finishing is required at an early age forms shall be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations.

- v. Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repairs or the treatment required on such sloping surfaces shall be performed at once and followed by the specified curing.
- w. All form work shall be removed without such shock or vibration as would damage the reinforced concrete.
- x. When re-shoring or re-propping is permitted or required, the operations shall be planned in advance and shall be subject to approval. While re-shoring is underway no live load shall be permitted on the new construction. In no case during re-shoring shall concrete in beams, slab, columns or any other structural member be subject to combined dead and live loads in excess of the load permitted by Project Manager for the developed concrete strength at the time of re-shoring. Re-shores shall be placed simultaneously with stripping operations are but in no case later than the end of working day on which stripping occurs.
- y. Re-shores shall be tightened to carry their required loads without over stressing the concrete. Re-shores shall remain in place at least until representative tests of the concrete being supported have reached specified strength.
- z. Floors supporting props or shores under newly placed concrete shall have their original supporting props or shores left in place or shall be re-shored. The re-shoring system shall have a capacity sufficient to resist the anticipated loads and in all cases have a capacity equal to at least one half of capacity, of the shoring system above. The re-shores shall be located directly under a shore position above unless other locations are permitted.
- aa. The re-shoring or re-propping shall extend over a sufficient number of story's to distribute the weight of newly placed concrete, forms, and construction live loads in such a manner that the design superimposed load of the floors supporting shores or props are not exceeded.
- bb. No loads, other than those permitted by the Project Manager in connection with the actual work in hand, shall be allowed on suspended floors until 28 days after concreting where ordinary Portland cement is used and 14 days when rapid hardening Portland cement is used.
- cc. It is required to give forms for reinforced concrete an upward camber to ensure that the beams or slabs including cantilever slabs do not have a sag when they have taken up their deflection. Camber, unless indicated otherwise on drawings, should be about 1/240 for supported beams and slabs and 1/180 for cantilevers.

3.10 Acceptance of Structure

3.10.1 General

- a. Completed concrete work which meets all applicable requirements will be accepted subject to the other terms of the CONTRACT Documents.
- b. Completed concrete work which fails to meet one or more requirements and which has been repaired to bring it into compliance will be accepted subject to the other terms of the CONTRACT Documents.
- c. Completed concrete work which fails to meet one or more requirements and which cannot be brought into compliance may be accepted or rejected as provided in these Specifications or in the CONTRACT Documents. In this event, modifications comply with the requirements.

3.10.2 Dimensional Tolerances

- a. Formed surfaces resulting in concrete outlines smaller than permitted by the tolerances of **Section 3.6** considered potentially deficient in strength and subject to the provisions of **Section 3.11.4**.
- b. Formed surfaces resulting in concrete outlines larger than permitted by the tolerances of **Section 3.6** may be rejected and the excess material shall be subject to removal. If removal of the excess material is permitted, it shall be accomplished in such a manner as to maintain the strength of the section and to meet all other applicable requirements of function and appearance. Permission is required if excess material is to remove in accordance with this section.

3.10.3 Appearances

- a. Architectural concrete with surface defects exceeding the specified limitations shall be removed in accordance with this Section.
- b. Concrete members cast in the wrong location may be rejected if the strength, appearance or function of the structure is adversely effected or misplaced items interfere with other construction.
- c. Inaccurately formed concrete surfaces exceeding the limits of **Section 3.6** & of **Section 3.11.4** and which are exposed to view, may be rejected and shall be repaired or removed and replaced if required.
- d. Other concrete exposed to view with defects which adversely affect the appearance of the specified finish may be repaired only by approved methods.
- e. Concrete not exposed to view, but of defective appearance, may be accepted at the discretion of the Project Manager.

3.10.4 Strength of Structure

- a. The strength of structure in place will be considered potentially deficient if it fails to comply with any requirements' which control the strength of the structure, including but not necessarily limited to the following conditions:
 - i. Concrete strength requirements not considered to be satisfied in accordance with Section 7.
 - ii. Reinforcing steel size, quantity, strength, position or arrangement variance with the requirements of the CONTRACT Documents.
 - iii. Concrete which differs from the required dimensions or location in such a manner as to reduce the strength.
 - iv. Curing less than that specified.
 - v. Inadequate protection of concrete from extreme temperature during the early stages of hardening and strength development.
 - vi. Mechanical injury, construction fires, accidents or premature removal of form work likely to result in deficient strength.
 - vii. Poor workmanship likely to result insufficient strength
- b. Structural analysis and/or additional testing may be required when the strength of the structure is considered potentially deficient.
- c. Core tests may be required when the strength of the structure is considered potentially deficient.
- d. If core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be required and their results evaluated in accordance with ACI Standard 318.

- e. Concrete work judged inadequate by structural analysis or by results of a load test shall be reinforced with additional construction, if so directed by Project Manager or shall be replaced, at the CONTRACTOR'S expense.
- f. The CONTRACTOR shall pay all costs incurred in providing the additional testing and/or analysis required by this Section,
- g. THE EMPLOYER will pay all costs of additional testing and / or analysis which is made at his request and which is not required by specifications, or the CONTRACT Documents.

3.11 Methods of Measurement of Concrete Works

3.11.1 General

- a. Unless otherwise specifically stated in the Bill of Quantities, or herein, all items shall be deemed to be inclusive of, but not limited to, the following:
 - i. Labor/plant and all costs in connection therewith.
 - ii. Materials, goods and all costs in connection therewith, e.g. conveyance, delivery, unloading, storing, returning, packing, handling, hoisting, lowering.
 - iii. All fixtures and all costs in connection therewith for precast works.
 - iv. Fitting and fixing materials and goods in position.
 - v. Waste of materials, and Square cutting.
 - vi. Mixing, transporting, hoisting, placing in from at any level, compacting through vibration &, curing etc. complete including the cost of form work & its removal (but excluding cost of reinforcement).
 - vii. Establishment charges, overhead charges and profit.
 - viii. All other expenses, charges and taxes specified in Conditions of CONTRACT.
- b. Works shall be measured net as fixed in position as per drawings and instructions of Project Manager. Each measurement shall be taken to the nearest 1/2" (12.0 mm). This rule shall not apply to any dimensions stated in the descriptions.

3.11.2 Concrete Measurement

- a. Concrete shall be measured as executed but no deduction shall be made to the following:
 - Volume of any steel embedded in the concrete.
 - Volume occupied by water pipes, conduits etc., not exceeding 4 square inch (2500 sq. mm) each in cross-sectional area.
 - Voids not exceeding 1 square foot in work given in square feet and 0.1 sq m in work given in sq meters. If any void exceeds above limit total void shall be deducted.
 - Voids not exceeding 1 cubic foot in work given in cubic feet. 0.03 cubic meter in work given in cubic meter. If any void exceeds above limit, unit total void shall be deducted.
- b. Voids, which are not to be deducted as per Section 3.11.2.a above, refer only to openings or vents which are wholly within the boundaries of measured areas. Openings or vents which are at the boundaries of measured areas shall always be subject to deduction irrespective of size.
- c. Junctions between straight and curved works shall in all cases be deemed to be included with the work in which they occur.
- d. Concrete work shall be classified and measured separately as follows unless otherwise described elsewhere:-
- e. Buildings, foundation beams, foundation slabs, footings, bases of columns, machine foundations, mass concrete etc., in cubic feet (Cubic meter).

- Floor slabs on ground with floor beams in cubic feet (Cubic meter).
 - Walls in foundations, plinth and superstructure in cubic feet (Cubic meter) stating thickness,
 - Columns, piers, pilasters, pillars etc., in cubic feet (Cubic meter).
 - Lintels, beams and brackets in cubic feet (Cubic meter).
 - Suspended floors, roofs and stair landings in square feet (sq. metre) stating thickness.
 - Stairs (including landing) in cubic feet (Cubic meter).
 - Railings in cubic feet (Cubic meter), square feet (Sq. meter), or linear feet (meter) stating description.
 - Parapets, purdees and the like in cubic feet (Cubic Meter) stating thickness.
 - Jali, blocks in square feet (Sq. Meter) stating thickness & description.
 - Precast concrete items shall each be enumerated except if otherwise shown in the Bill of Quantities, separately stating the description.
- c. Measurement of walls shall be taken between attached columns, piers or pilasters. The thickness of attached columns, piers or pilasters shall be taken as the combined thickness of the wall and the columns, piers or pilasters. Attached or isolated columns, piers, pilasters and the like (except where caused by openings) having a length on plan not exceeding four times the thickness shall be classified as columns. Those having a length over four times the thickness and caused by openings in walls shall be classified as walls.
- d. Columns shall be measured from the top of footings/beams or floor surfaces to the underside of beams or slabs as the case may be. Where the width of the beams is less than the width of columns, the extra width at the junction shall be included in the beam.
- e. The depth of the beams shall be measured from bottom of the slab to the bottom of the beams, except in case of inverted beams where it shall be measured from top of slab to the top of beam. The cross section below or above the slab.

3.11.3 Formwork Measurement

- a. Formwork if separate and extra payment is specifically stated in the Bill of Quantities shall be measured in square feet (Sq. m) as the actual surface of the finished structure which required to be supported during the deposition of the concrete, including the upper surfaces to the work sloping more than 15 degree from the horizontal. No allowance shall be made for overlaps and passing at angles and no deduction shall be made for the following:-
- Voids not exceeding ten square feet (1 Sq. m).
 - Intersections of main beams with walls or columns.
 - Intersections of secondary beams with main beams.
- b. Form work shall be deemed to be inclusive of, but not limited to items detailed in section 12.1 and the following:-
- Batten, struts, reversed cut strings, bolting, oiling, wedging, easing, striking, removing and making good exposed faces of concrete after removal of form work. Also yokes, wales sheathing, jack rods, jacks, working platforms and finishers, scaffolds, etc.
- c. Forming chamfers not exceeding 2" (50 mm) wide and forming splayed internal angles not exceeding 1/2" (12.0 mm) wide shall not be for extra.
- d. Temporary stop ends for constructed joints shall not be measured and for.
- e. Classification of formwork (if separate and extra payment is specifically stated in the Bill of Quantities) shall be as follows:-

- To horizontal or sloping soffits of suspended slabs, floors, roofs, staircases, landings and the like.
- To sloping upper surfaces of suspended slabs, floors, roofs and the like where more than 15 degree from horizontal.
- To vertical or battering sides of foundations, foundation beams and slabs, ground beams, machine foundations and the like.
- To vertical or battering sides of walls, solid balustrades and the like.
- To vertical or battering sides.
- To vertical or battering sides of stanchion casings, columns, piers, plasters and the like.
- To sides and soffits of openings in walls, recesses in walls, projecting panels on walls and the like.
- To sides and soffits of horizontal or sloping beam casings, beams, brackets, lintels, staircase, strings and the like.
- To sloping upper surfaces of beam casings, beams, brackets, lintels, staircase-strings and the like where more than 15 degrees from horizontal.
- To edges of beds, roads, footpaths, paving and the like.
- To edges of suspended slabs, floors, roofs, landing and the like.
- To risers of steps and staircases.
- To sides of kerbs, up stands and the like.
- Form work to throats, grooves, chases rebates, chamfers over 2" wide (50 mm) splayed internal angles over 1/2" wide (12.5 mm) moldings and the like shall each be measured separately in linear feet stating the size.

3.11.4 Reinforcement Measurement

- a. The rate tendered for any type of reinforcement by the CONTRACTOR shall also be inclusive of the cost of binding wire wastages, and the cost of concrete, metal or plastic chairs and spacers or hungers, etc.
- b. All reinforcement shall be provided in length shown in drawings and as per Specifications.
- c. Should the CONTRACTOR provide lengths of reinforcement which are greater than shown on the Drawings no payment of extra length shall be made? Overlaps, unless clearly shown in working Drawings, shall not be allowed and measured.
- d. The CONTRACTOR shall be paid for reinforcement by weight computed from **Table - 3-2** and from linear measurements of reinforcements actually used at SITE as per the Drawings, Specifications and instructions of Project Manager. No payment shall be made for steel chairs or wastage. CONTRACTOR shall not claim for the difference in the actual weights of bars and their standard weights given in **Table -3-2**.

TABLE 3-2 – BAR SIZES AND WEIGHT PER UNIT LENGTH

ASTM Bar Size	"Soft" Metric Size (SI)	Weight per unit length		Nominal Diameter		Nominal Area	
		(lb/ft)	(kg/m)	(inch)	(mm)	(inch ²)	(mm ²)
#2	#6	0.167	0.249	0.250	6.35	0.05	32
#3	#10	0.376	0.561	0.375	9.525	0.11	71
#4	#13	0.668	0.996	0.500	12.7	0.2	129
#5	#16	1.043	1.556	0.625	15.875	0.31	200
#6	#19	1.502	2.24	0.750	19.05	0.44	284
#7	#22	2.044	3.049	0.875	22.225	0.6	387
#8	#25	2.670	3.982	1.000	25.4	0.79	509
#9	#29	3.400	5.071	1.128	28.65	1.00	645
#10	#32	4.3030	6.418	1.270	32.26	1.27	819
#11	#36	5.313	7.924	1.410	35.81	1.56	1006
#14	#43	7.650	11.41	1.693	43	2.25	1452
#18	#57	13.60	20.284	2.257	57.3	4.00	2581
#18J	-	14.600	21.775	2.337	59.4	4.29	2678

SECTION 4 – MASONRY – PART 1

4.1. Concrete Block Masonry

4.1.1 Scope

The work covered by this section of the specification consists of furnishing all plant, labour, equipment, appliances and materials and in performing all the operations in connection with masonry work, complete in strict accordance with the specification herein and the applicable drawings subject to the terms and conditions of the CONTRACT.

4.1.2 Materials

4.1.2.1 Cement

Cement shall be Ordinary Portland cement meeting the requirements specified under “CONCRETE” in sub-section 2 of these specifications.

4.1.2.2 Aggregates

Aggregates used shall meet the requirements specified under “CONCRETE” in sub-section 2 of these specifications. All the aggregates dry and properly screened shall be acceptable for block making.

4.1.3 Concrete, Masonry Units

4.1.3.1 Concrete masonry blocks shall be made on the Project Site and shall be of the sizes required by the drawing and / or as directed by the CONSULTANT’S REPRESENTATIVE and shall be generally conform to the requirements of B.S.S. 2028, 1364: 1968 “Precast Concrete Blocks” unless specified otherwise in the Specifications.

4.1.3.2 The blocks shall be solid or hollow as required and shall be carefully made so that they are true in line and face with square corners and free from all defects. The ends of the blocks, which will form the grooved or as directed by the CONSULTANT’S REPRESENTATIVE. In the case of hollow blocks, the cavities shall be true to the shapes and sizes specified and shall have uniform wall thickness on the outside of the cavities.

4.1.3.3 The concrete for the blocks shall be mixed in a concrete mixer in the proportion of one (1) part of cement, three (3) parts of sand and six (6) parts of well graded coarse aggregate not exceeding ¾” in size or one (1) part of cement and seven (7) parts of well graded all in aggregates not exceeding ¾” in size.

4.1.3.4 Concrete blocks shall be machine moulded. The concrete shall be well worked into the moulds, vibrated, tamped and pressed to ensure that the moulds, vibrated tamped and presented to ensure that the blocks are dense and free from voids.

4.1.3.5 The blocks shall be cured by keeping moist continuously for a period of at least ten (10) days and then shall be allowed to dry in shade for at least twenty (20) days before being used in masonry.

4.1.3.6 All blocks shall have clean cut straight and true edges, smooth dense faces of uniform appearance without voids, honeycombs, projections and shall be free from cracks spalls, chips, ragged edges or other defects detrimental to their use.

4.1.3.7 Where blocks are to be plastered or rendered, the block surface shall have a coarse texture suitable for bonding the plaster as approved by the CONSULTANT’S REPRESENTATIVE.

4.1.3.8 The average compressive strength of any ten blocks picked at random after curing and drying shall be not less than 1500 lbs/sq. inch when tested in accordance with B.S. 1364: 1963 “Precast concrete blocks”.

4.1.3.9 The average moisture content of all the concrete masonry units shall not exceed 30 percent of the total water absorption of units. The shrinkage of cement concrete blocks is much greater at the time it dries for the first time after molding subsequent to curing. It is therefore, essential that CONTRACTOR shall take full care to see that blocks are sufficiently and thoroughly dried so that their initial shrinkage is completed before the blocks are laid in the wall. Not only well dried blocks shall be used, but the blocks shall also be laid dry without wetting except with slightly moistened surfaces on which mortar is to be applied to obviate absorption of water from the mortar and even during curing of the mortar joints the blocks shall be slightly moistened and shall not be allowed to be excessively wet till they receive any plaster or render.

4.1.3.10 The blocks shall be stored in such a manner so as to avoid any contact with moisture on the site of works. The blocks shall be stock piled on planks or other supports free from contact with the ground and if necessary cover for protection against wetting. The blocks right from casting to curing, drying, stock piling and their subsequent placing in masonry walls shall be handled with care.

4.1.4 Cement Mortar for Masonry

4.1.4.1 Proportions

Cement Mortar shall be composed of one part of ordinary Portland cement to 6 (six) parts of sand for all concrete block walls. Hand mixing when permitted by the CONSULTANT'S REPRESENTATIVE shall be done on clean hard platform as much as required for immediate use with only just sufficient water to produce mortar of a proper consistency. If directed by the CONSULTANT'S REPRESENTATIVE the mixing shall be done by mechanical mixers. Sand shall be of an approved quality and shall pass 100% through 3/16" sieve.

4.1.4.2 Gauging

The ingredients for mortar shall be measured in boxes. No re-tempering of mortar shall be allowed nor shall mixing of any anti-freezing ingredients in mortar be permitted.

4.1.4.3 Mixing

The dry materials shall be dry mixed for approximately 2 minutes and for 3 minutes after addition of water making total minimum time of 5 minutes in a mortar mixer. When hand mixing is permitted, or dry mix, shake well, turn over materials for each batch before adding water, until uniform color or mixed materials indicates cementitious material thoroughly distributed throughout the mass. After dry mixing is complete, add water until thoroughly mixed mortar of the required plasticity is obtained. If mixed is not satisfactorily done, then the CONTRACTOR shall take such steps as directed by the CONSULTANT'S REPRESENTATIVE. Mortar shall be used within half an hour of mixing. Mortar standing more than half an hour shall not be used.

4.1.5 Masonry and Jointing

4.1.5.1 All masonry shall be laid plumb, true to line and level in accurately spaced course with each breaking joints with the course below. Corners and reveals shall be plumb and true. Chases grooves, reglet blocks and raked out joints shall be kept free from mortar and other debris.

- 4.1.5.2** The thickness and length of various walls shall be indicated on the drawings. Usually English or Flemish bond is used, however Rat trap bond can be used for walling instead of English or Flemish bond.
- 4.1.5.3** Unless otherwise shown on the drawings or specified, the spaces around frames and other built-in items shall be solidly filled with mortar, except the joints that are to be pointing shall be raked out $\frac{3}{4}$ " deep.
- 4.1.5.4** Work required to be built in with masonry including anchors, wall plugs and accessories shall be built-in, as the work progresses. Wood plugs and blocking shall not be built into masonry.
- 4.1.5.5** All horizontal and vertical joints shall be completely and solidly filled with mortar as the blocks are laid. In horizontal bedding joints, mortar shall be spread over the entire top surface of the block to a uniform layer of $\frac{3}{8}$ " thick for vertical joints mortar shall be applied to a block unit when it is standing vertically, and then placing it horizontally on the horizontal bedding mortar and pressing it against the previously laid unit in that course, making a vertical joint of $\frac{3}{8}$ " thickness. In horizontal bedding joints mortar shall not be spread so much ahead of the actual laying of unit that it tends to stiffen and lose its plasticity resulting in poor bond. If it happens, then the stiffened mortar shall be removed and fresh mortar laid by the CONTRACTOR at his own cost. When the mortar has stiffened somewhat, it shall be firmly compacted with a jointing tool.
- 4.1.5.6** The thickness of joints shall not be exceed $\frac{3}{8}$ inch and the joints shall be raked $\frac{1}{2}$ inch deep when the mortar is still fresh, so as to provide for proper bond for the plaster. Any mortar which falls on the floor from the joints or is removed due to raking of joints shall not be re-used.
- 4.1.5.7** No masonry to be erected when temperature of outside air is below 40 oF unless suitable means as approved by the CONSULTANT'S REPRESENTATIVE are provided to heat the material and provide protection from cold and frost to ensure that it will harden without freezing.
- 4.1.5.8** When the masonry is to receive plaster on one side and pointing on the other, the block shall be placed in such a way that the better face shall be on the side of pointing.
- 4.1.5.9** Wherever blocks about columns, they shall be anchored there by means of anchor steel bars, as shown on the drawings or any other type of anchor steel bars, as shown on the drawings or any other type of anchors as approved by the CONSULTANT'S REPRESENTATIVE at a vertical spacing of approx. 12 inch for wall upto 6" thick and approximately 24" for walls more than 6" thick unless otherwise directed by the CONSULTANT'S REPRESENTATIVE. Alternatively the masonry may be built-up first leaving the dovetail type ends near the columns and the columns then be cast so that the concrete of the columns and the masonry make a dovetail type of joints, provided it is permitted in writing by the CONSULTANT'S REPRESENTATIVE.
- 4.1.5.10** Erection of partition and panel walls shall be delayed, wherever possible until the frame of the structure is taken up. Care should be taken that no deformation occurs due to structural loads. Otherwise the top course of partitions under slabs and beams shall not be laid until the form has been removed and the roof slab placed.
- 4.1.5.11** In damp soils to prevent the rise of moisture from the ground due to capillary action the foundation and basement masonry when, so directed by the CONSULTANT'S REPRESENTATIVE shall be laid in richer mortar than specified in which case the CONTRACTOR shall be paid the extra cost of cement used. In addition a damp proof course

shall be provided consisting of 1 to 2 inches thick layer 1:2:4 cement pudlow mortar or an approved type of bituminous course.

4.1.5.12 All masonry work and portions of walls shall be bonded together as directed by the CONSULTANT'S REPRESENTATIVE. In order to ensure appropriate bonding between walls, masonry bonds will be executed by extending alternate courses of units of an intersecting wall or partition through the thickness of the wall or partition it intersects.

4.1.6 Coordination

4.1.6.1 Cooperate with other trades in setting built-in items, taking special care in cutting fitting setting units so that built-in members are in their true, respective positions slush voids full.

4.1.6.2 For items provided in other sections such as door frames fasts, miscellaneous metal work occurring in the masonry sleeves, anchor's support nailing strips brace jambs, etc., are to be built in the masonry.

4.1.6.3 Special care shall be taken in building block at door frames, CONTRACTOR shall see that frames are square and plumb. Check frames before building work around or against them. The CONTRACTOR shall see that full electric conduits are not housed into frames, so as to prevent extension of frame anchor.

4.1.6.4 The CONTRACTOR shall be responsible for any damage to his own work and also to the work of other sections.

4.1.7 Protection and Cleaning

4.1.7.1 Surface of masonry, not being worked on shall be properly protected at all times during the construction operations. When rain is expected and the work is discontinued the top of exposed masonry walls shall be covered with strong water-proof membrane, well secured in place.

4.1.7.2 Exposed masonry surfaces shall be cleaned with water and fiber brushes as directed by the CONSULTANT'S REPRESENTATIVE.

4.1.7.3 Protect adjacent work during cleaning operations. Make good any damages from neglect of this precaution.

4.1.8 Samples

Samples of all kinds of materials, to be used on the job, shall be submitted to the CONSULTANT'S REPRESENTATIVE and shall be approved by him.

4.1.9 Testing

All the materials and completed masonry work shall be subjected to standard testing, and, if found below the given standard specifications, shall be rejected. Rejected material shall be removed from the site immediately. All testing shall be done at CONTRACTOR'S cost.

4.1.10 Measurement and Payment

Measurement and payment for all masonry and other items, covered under this section of the specifications, will be made for the actual works executed at the Unit Rates entered in the Bill of Quantities appended hereto and in accordance with the conditions of the CONTRACT and shall be the full compensation for furnishing all materials, labour complete in accordance with these Specifications.

SECTION 4 – MASONRY – PART II

4.2. Brick Masonry

4.2.1 Scope

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with furnishing and installing plain Brick Masonry and fair face Brick cladding (Gutka) of specified size in position complete in strict accordance with this section of the specifications and applicable drawings and or as established by the Engineer. Instead of Brick Masonry, compressed Earth block may be used subject to the approval of Engineer.

4.2.2. Codes and Standards

The work shall conform to the requirements of the following Codes and Standards, unless otherwise specified.

- ACI 530-88 Building code requirements for masonry structures
- ACI 530.1-88 Specifications for masonry structures
- PS 208 Classification, strength and properties of bricks
- ASTM C 67-81 Standard method for sampling and testing brick and structural clay tile
- ASTM C 144-81 Standard specifications of aggregates for masonry mortar
- ASTM C 150-81 Specifications for Portland cement
- UBC 2405 Quality control
- UBC 2406 Allowable stresses

4.2.3. Submittals

- a) The Contractor shall submit the following to the Engineer for his approval:
- b) Methodology and Sequence of work
- c) Specimen samples of bricks, aggregates for mortar or grout and Portland cement. Specimens of bricks shall be representative of a complete range of colors, textures and sizes
- d) Results of all the tests performed upon the materials and masonry units obtained from the site of work as per directions of the Engineer.

4.2.4 Tolerances

4.2.4.1 Brick

No overall dimension of brick (width, height and length) shall differ from the specified standard dimension by more than 1/8 inch (3 mm)

- Standard dimensions of brick = 9" x 4-1/2" x 3" (230 x 115 x 75mm)
- Fair face brick (gutka) = 9" x 2-1/4" x 2-1/4" (230 x 62 x 62 mm)

4.2.4.2 Brick Work

All brick work shall be erected true to line, plumb and level and the variation:

- Plumb in any length of wall shall not exceed 1/12" (2mm) in 3 feet (one meter)
- 3/8" (10mm) in a storey height or 1 inch (25mm) in the entire height.

4.2.5. Inspection and Testing

Regular inspections shall be carried out to control the quality of the works and to ensure that materials, construction and workmanship are in compliance with the plans and Specifications. Inspection and test records shall be maintained and made available to the Engineer as a routine, on each working day.

4.2.5.1 Inspection

Inspection for quality control shall include, but is not limited to the following:

- a. The masonry units i.e. bricks, reinforcement if used, cement, lime, surkhi, aggregate, water and all the other materials meet the requirements of the applicable standards of quality
- b. Materials are properly stored and prepared for use
- c. Mortar and grout are properly mixed using specified proportions of ingredients,
- d. The method of measuring materials for mortar and grout shall be such that the proportions of the constituents are entirely controlled.
- e. The bricks pass a visual inspection for soundness, compact structure, reasonably uniform texture and shape; and that the bricks are free from cracks, warp-age, large pebbles, balls of clay or particles of lime that would affect the serviceability or strength of the brick.

4.2.5.2 Testing

Burnt bricks shall be of uniform color, finish and free from cracks, warp-age, exposed stones, pebbles or particles of lime. The size of the bricks shall be in accordance with that shown on the Drawings. The testing of bricks shall comply with ASTM C 67. Physical requirements of the bricks shall be as given in **Table 4-1**.

TABLE 4-1

Bricks	Minimum Compressive Strength (brick flat wise)	Maximum water Absorption in 5 hour	Maximum Saturation Co-efficient
Individual	1300 psi	25%	0.90
Average of 5 bricks	1600 psi	22%	0.88

- a) The saturation coefficient is the ratio of absorption by 24 hours submersion in cold water and to that after 5 - hours submersion in boiling water.
- b) In case the bricks do not have the compressive strength as specified then the Engineer shall use his best judgment in permitting incorporation of the best bricks available in the area, taking into consideration the nature and structural stability of the works.

- c) If 10 bricks per thousand are defective or if the average weight of nominal 9” x 4-1/2” x 3” (230 mmx115x75mm) brick is between 3.2 kg – 4.2 kg (frog 6 mm deep) or the bricks are out of dimension the whole lot shall be rejected and the Contractor shall remove the rejected lots from the Site.

4.2.6. Delivery and Storage

4.2.6.1 Delivery

The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the bricks nor delay the use of mixed mortar.

4.2.6.2 Storage

Masonry materials shall be so stored that at the time of use the materials are clean and structurally suitable for use.

4.2.7 Mortar

4.2.7.1 Cement

All cement for mortar for brickwork shall conform to the applicable requirements set forth in Section Plain and Reinforced Concrete.

4.2.7.2 Sand

- a) Sand for mortar used in brickwork shall be furnished by the Contractor, and shall meet the requirements set forth in ASTM C 144. The Fineness Modules of the sand shall range between 1.9 & 2.8 and the grading shall be within the limits
- b) Sand shall be stored at the Site in such a manner that it is not mixed with foreign matter. Methods employed by the Contractor for unloading, loading, handling and storage shall be subject to the approval of the Engineer. Sufficient quantity shall be maintained at the Site at all times to assure continuous work.

4.2.7.3 Water

The water used in the manufacture of bricks and in the preparation of mortar shall be in complete conformity with the applicable requirements set forth for water in Section Plain and Reinforced Concrete.

4.2.7.4 Surkhi

Surkhi shall be prepared by grinding special bricks into powder form or may be obtained/purchased from approved manufacturers.

4.2.7.5 Mortar Composition

4.2.7.5.1 Cement Sand Mortar

Mortar for all brickwork shall, except as otherwise specified or directed by the Engineer, shall consist of one part Portland Cement to four parts of sand by volume for 4-1/2” (115 mm) thick walls and one part of cement in six parts of sand for 9” (230mm) and over thick walls for building works and one part of cement to 5 parts of sand for other works, and sufficient water to produce the proper consistency for the intended use. Where directed by

the Engineer for increased workability, hydrated lime putty, approved by the Engineer, shall be added to the mortar but shall not exceed 25 percent, by volume of the dry cement.

4.2.7.5.2 Mortar for fair face Brick Cladding (gutka)

The mortar for all fair face brick (gutka) masonry cladding shall consists of cement, surkhi and sufficient water to produce proper consistency in the following composition:

Cement: Surkhi

1: 4

OR

Swan pozzolana in the ratio as recommended by the manufacturer.

4.2.7.5.3 Mortar Batching

Methods and equipment used for mixing mortar shall be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except for the full amount of water, shall not be less than two minutes. Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within 30 minutes after addition of the water to the mix shall be wasted. Re-tempering of mortar will not be allowed. Mixing troughs pans shall be thoroughly cleaned and washed at the end of each day's work.

4.2.8. Bricks

4.2.8.1 Brick Materials

Bricks for plain brick masonry shall be first class bricks made from carefully selected earth which shall be good loam or clay. The earth shall be free from objectionable quantities of lime, gravel, coarse sand and roots and other organic matter. The salt contents shall not exceed 0.3 per cent and calcium carbonate content shall not exceed 2 per cent.

4.2.8.2 Brick Manufacture

All bricks shall be manufactured by the Trench Kiln Method or other standard method approved by the Engineer. The molds to be used in the manufacture of bricks shall be thoroughly sanded before each use and shall be sufficiently larger than the size of the bricks being manufactured to allow for shrinkage in drying and burning. Each finished brick shall be a nominal 230x115x75 mm in size, shall weigh between 3.2 and 4.1 kilograms and shall have a "frog" 6 millimeter deep on the upper face. The bricks shall be thoroughly burnt but without being vitrified. The bricks used shall be well burnt, uniform in shape, size, texture, color and should produce a ringing sound when struck. The bricks shall be free from flaws, cracks, chips, stone nodules of lime or kankar or other blemishes. Bricks over burnt, vitrified, irregular in shape or not having uniform colour or under burnt shall not be used. Bricks of uniform size shall be used throughout the work and the source of supply shall not be diversified.

4.2.8.3 Stacking and Sampling

The bricks shall be sorted and arranged in stacks of one or two thousands or as directed by the Engineer. Each stack shall be 10 courses high and two bricks thick so that at least 2 feet (0.6 meters) space between the stacks shall be left for the purpose of inspection. Each size or class

of brick shall be stacked separately. For purposes of inspection and tests the sample bricks shall be selected by the Engineer or a person authorized by the Engineer for this purpose. These samples shall be furnished by the Contractor without charge. The sampling shall conform to ASTM C 67. For the modulus or rupture, compressive strength and absorption determinations at least 10 bricks shall be selected from each lot of 25,000 bricks or a fraction thereof. For larger lots five additional bricks shall be selected from each 50,000 bricks or a fraction thereof contained in the lot. In no case shall less than 5 bricks be taken.

Additional specimens may be taken at the discretion of the Engineer. Each specimen shall be marked so that it may be identified at any time. Markings shall not cover more than 5 per cent of the superficial area of the specimen.

4.2.9. Scaffolding

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights. Scaffolding which in the opinion of the Engineer is unsafe, shall not be used until it has been strengthened and made safe for use of workmen to the satisfaction of the Engineer.

Damage to masonry from scaffolding or from any other causes shall be repaired by the Contractor.

4.2.10. Execution

4.2.10.1 Placing Brick Masonry

The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the brick nor delay the use of mixed mortar. Brick shall not be placed during rains sufficiently heavy or prolonged to wash the mortar from the brick. Mortar already spread which becomes diluted by rain shall be removed and replaced before continuing with the work. All brick to be used in brick masonry shall be moistened with water for three to four hours before they are used by a method which will ensure that each brick is thoroughly and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brick masonry.

Bricks shall be laid "frog" upward with mortar joints and in English/Flemish bond as shown on the Drawings or as directed by the Engineer. Both bed and vertical joints shall be approximately 6mm and 10mm in thickness completely filled with cement mortar as specified herein, and each brick shall be bedded by firmly tapping with the handle of the trowel. All horizontal joints shall be parallel and all vertical joints in alternate courses shall be directly over one another. Excess mortar at the outer edges shall be removed and joints drawn straight with the edge of a trowel and a straight edge. All anchors and similar work required to be embedded in the brick masonry shall be installed as the work progresses. At the completion of the work all holes or defective mortar joints shall be cut out and re-pointed.

Where shown on the drawing the exterior faces of the walls shall be finished by striking the joints as the work proceeds. The joints shall be struck by raking the green mortar after the brick work has been laid and finishing the joint with a pointing tool. Horizontal joints shall be struck to form a weathered joint and vertical joints shall be struck with a V notch. Care shall be taken that the striking tools do not develop a cutting edge as the object of striking the joint is to compress the mortar into the joints.

The exposed faces of all brick masonry shall be thoroughly cleaned and left bare with struck joints as specified above.

The fair face Brick cladding (gutka) shall be laid in running bond unless otherwise as shown on the drawing or directed by the Engineer.

4.2.10.2 Curing

All brickwork requiring mortar shall be cured by water or other acceptable methods. All methods and operations of the Contractor in curing the different portions of the work shall be subject to the approval of the Engineer. When curing by water, the brickwork shall be kept wet for 7 days unless specified otherwise or covered with water-saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, pounding or by any other approved method which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements for water used in the manufacture of bricks.

4.2.10.3 Finishing

All bricks shall be skillfully laid frog face up with level courses, uniform joints, square corners, plumb verticals and true surfaces, except when otherwise shown on Drawings or directed by the Engineer. Where the brickwork is required to be covered by mortar coating, the required finish shall be as indicated on the Drawings and shall meet with the requirements of the relevant specifications.

4.2.10.4 Cement Mortar Coating

Brickwork surfaces which are intended to receive paint coatings, shall have an over coating of cement mortar. The mortar shall consist of one part Portland cement to four parts of sand by volume and sufficient water to produce the proper consistency for the intended use. The surface on which mortar is to be applied shall be rough, clean and damp. The first layer of mortar, about 6 mm thick shall be forcibly dashed onto the surface so as to bond more tightly. The full thickness of the cement coating shall be ½” (12mm) except where otherwise shown on the Drawings or directed by the Engineer.

4.2.10.5 Pointing

Brickwork surfaces which are intended to receive pointing shall be given V-notch pointing by striking the joints. Tooling shall be done when the mortar is partially set but still sufficiently plastic to bond. All tooling shall be done with a tool which compacts the mortar. Raked joints shall be ½” (12mm) deep V-notch, 70 degree apex in order to give pressed and compacted surface. All joints shall be given finish with 1:3 cement sand mortar with a pointing tool.

4.2.11 Repairing Brickwork

- a) If, after the completion of any brickwork, brick is out of alignment or not level, or does not conform to the lines and grades shown on the Drawings, or shows a defective surface, it shall be removed and replaced by the Contractor at his expense, unless the Engineer grants permission in writing to patch the defective area.
- b) At the completion of the work, all holes and defective mortar joints shall be cut and repointed. Exposed masonry shall be protected against staining or other damages and excess mortar shall be cleared off the surfaces as the work progresses. All exposed

masonry shall be clean, smooth, plumb and shall be of acceptable finish. In the event ordinary cleaning is not adequate, special methods such as sand blasting or otherwise as approved by the Engineer, shall be used to clean the surfaces.

4.2.12. Horizontal Damp Proof Course

All Horizontal damp proof courses unless otherwise specified in the drawings shall consists of class 'B' cement concrete (3000 psi) 2" (50mm) thick, mixed with 2.5 kg of pudlo/bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be laid at required levels as per drawings and instructions of the Engineer. The D.P.C shall be tamped, consolidated, leveled and edges corners made to the requirements of the relevant drawings including finishing and curing complete. Including two float coat of hot bitumen 10/20 penetration grade shall be applied over the class "B" cement concrete @ 7 kg/100 sft.

4.2.13. Vertical Damp Proof Course

All vertical damp proof courses unless otherwise specified in the drawings shall consists of ½" thick cement sand plaster in 1:3, mixed with 2.5 kg of pudlo/bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be applied at required elevation as per drawings and instructions by the Engineer, including two float of hot bitumen 10/20 penetration grade shall be applied over plaster @ 7kg/100sft..

4.2.14. Measurement and Payment

4.2.14.1 General

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

- Cutting & chiseling of masonry wherever required.
- Cement sand mortar used in laying bricks including wastage.
- Curing and repairing the masonry work.
- All joint reinforcing bars, reinforcing anchor bars or hoop iron
- Horizontal Damp proof course of class "B" concrete (3000 psi) including damp proof materials.
- Vertical Damp proof course of 1:3 Plaster including damp proof materials
- Scaffolding for Masonry Work.
- 2-1/2" long steel nails to be fixed in Brick masonry after every 5th course at a distance 6" c/c for fair face Brick Cladding.
- Cement sand mortar in 1:4 at the back of the fair face brick (Gutka) cladding to make it in plumb if required.

4.2.14.2 Brick Masonry

4.2.14.2.1 Measurement

In case of different thickness of slab in different areas or room or for any other reason whatsoever, if chiseling of masonry is required, the Contractor shall do so at his own cost where, for any reason whatsoever, the height, of the wall is short of ceiling height, of the actual height shall be made good with 3000 psi nominal mix concrete. This concrete shall neither be measured nor be paid under item of concrete but will be paid for under item of wall masonry. Similarly where the lintel heights are such that the Contractor has to chisel the masonry or provide cast-in-place concrete to make up the height of the course, no payment will be made for chiseling, but where such cast- in-place concrete is provided, payment for the same will be made at the unit rate for masonry. Measurement of acceptably completed works of brick masonry will be made on the basis of number of cubic feet for 9” (230mm) thick and above and for 4-1/2” (115mm) thick and below in Sq. feet as provided & installed in position as shown on the Drawing or as directed by the Engineer. All opening more than 1 Sq. ft (0.1 Sq. meter) area left in the masonry wall shall be deducted.

4.2.14.2.2 Payment

Payment will be made for acceptable measured quantity of brick masonry on the basis of unit rate per cubic foot for 9” (230mm) thick and above and 4-1/2” (115mm) thick and below in square foot quoted in the Bills of Quantities and shall constitute full compensation for all the works related to the item.

4.2.14.3 Fair Face Brick Cladding in Cement Surkhi

4.2.14.3.1 Measurement

Measurement of acceptably completed works of fair face brick cladding will be made on the basis of actual area in Square feet of wall laid in position to the line, level as shown on the Drawing or as directed by the Engineer.

4.2.14.3.2 Payment

Payment will be made for acceptable measured quantity of fair face brick cladding on the basis of unit rate per Square foot quoted in the Bills of Quantities and shall constitute full compensation for all the works related to the item.

SECTION 5 - CARPENTRY AND JOINERY

5.1 Scope of Work

The work covered under this section of Specification consists of providing all material, labor, plant equipment appliances and performing all operations conducted with the fabrication and erection of all woodwork, millwork, construction, assembly, surface finish treatment and building in of all cabinet type items, supports, etc, of wood or metal and incidentals, associated woodwork appurtenances, procuring and applying preservatives, installation of "Finish Hard Ware" in connection with finish woodwork as per details shown on the drawings or as this section is covered with detailed specifications as laid down herein.

5.2 Submittals

The submittal should include:

- a. Samples of all the materials and components.
- b. Shop Drawings showing door types, details and locations, referenced to the door type and hardware group shown on door and hardware schedules.
- c. Certificates stating that doors were constructed with timber of the species specified having mixture content and meeting equilibrium and relative humidity requirements specified.
- d. Sample eface veneers for selection of colour and pattern.

5.3 Applicable Standards

Latest editions of following; ASTM Standards, Pakistan Standards and British Standards are relevant to these Specifications wherever applicable.

CP 112-71	The structural use of timber in buildings.
IBS 459-65	Match boarded doors.
168 565-72	Glossary of terms relating to timber and woodwork.
BS 745.69	Animal glue for wood.
881186-71	Quality of timber and workmanship in joinery.
BS 1202-74	Nails
BS 1203-79	Specifications for synthetic resin adhesive for plywood.
BS 1204-79	Synthetic resin adhesives for wood.
BS 1210-63	Wood screws.
BS 1245-75	Metal door frame (steel).
BS 1282-75	Guide to the choice, use and application of wood preservatives
6S 1455-72	Plywood manufactured from tropical hardwoods.
BS 1494-51	Fixing accessories for building purposes.
BS 1567-60	Wood door frames and linings.
BS 1579-60	Connectors for timber.
BS 3444-72	Block board and laminated board.
BS 3842-65	Treatment of plywood with preservatives.
BS 5268	Preservative treatments for construction timber.
Pt.5 1977	

5.4 Tolerances

- Size: Plus or minus 1.6 mm overall dimensions
- Maximum warp: 6 mm
- Squareness: Maximum diagonal difference 3 mm (between length of diagonal measured on face of door or window from upper right corner to lower left corner and length of diagonal measured from upper left corner to lower right corner).

5.5 Delivery and Storage

The delivery and storage items include:

- a. Deliver and store products in waterproof, protective containers with seals unbroken and labels intact until time to use.
- b. Keep products dry, stack products off ground on level platforms, fully protected from weather, including direct sunlight?
- c. Identify type, size and location of each door ventilator before delivery in order to permit installation at correct location.
- d. All materials and assembled units are to be protected from weather and stored in such a way as to prevent decay and attack by fungus and termites.

5.6 Products

5.6.1 Timber

5.6.1.1 General Characteristics

The timber shall be in accordance with the requirements of " BS: 1186 'Quality of Timber and Workmanship in Joinery', Part 1, 'Quality of Timber'. .

First quality timber shall be from the heart of a sound tree, the sap wood being entirely removed, the wood being uniform in substance, straight in fiber, free from large or dead knots, flaws, shakes or blemishes of any kind. The colour of good timber shall be uniform throughout and among coloured timbers darkness of colour is an apparent indication of strength' and durability.

For first quality deodar wood, the size of the knot shall not be more than 25 mm and there shall not be more than one knot in every 0.4 Sq. meter of timber.

5.6.1.2 Seasoning of Timber

Timber shall be properly seasoned. It shall be kiln or air dried to reduce the moisture content to a maximum of 15% of its natural weight.

5.6.1.3 Hard and Soft Wood

Door trances, glazed, semi glazed and paneled shutters and core of flush doors shall be made in soft wood unless otherwise specified.

Softwood consists of deodar, chili, partal and maranti. Unless otherwise specified or allowed by the Project Manager only deodar wood shall be used for softwood. Hardwood consists of Shisham, Teak, Iroko, Walnut, Mahogany, beach or oak whichever specified.

5.6.1.4 Preservation of Wood

Prior to installation of finish wood works in their respective positions, preservatives shall be applied to safeguard the wood work against fungus, termite and borers.

The preservatives shall be of the best available quality as approved by the Project Manager. The method of application shall be strictly in accordance with the manufacturer's instructions.

5.6.1.5 Plywood and Veneer

5.6.1.6 General

BS: 565 Section 5, 'Glossary of Terms Applicable to Plywood', defines plywood as 'an assembled product made up of plies and adhesives, the chief characteristic being the crossed plies which distribute the longitudinal wood strength. The term ply wood in general sense includes similar products such as laminated board, block board and batten board. BS: 1455 shall be used for acceptable standards of plywood.

5.6.1.7 Three Ply and Multi-Ply Wood

Three ply construction includes a 'face' a 'back' and a core of inner ply. Multi-ply includes a face, a back and a core of three or more inner plies. With very few exceptions the grain of each veneer in the core runs at-right angles to that of the veneers on either side of it.

The construction of plywood may be balanced with an odd number of Veneers arranged symmetrically or unbalanced. The tendency of the finished board to distort is reduced by adopting a balanced construction.

The construction may vary for a given panel thickness by the inclusion of veneers of various thickness. This will affect the strength properties.

5.6.1.8 Interior and Resin Bonded

Plywood according to BS: 1455 is classified into two main types, viz interior and resin bonded.

Interior type plywood is suitable for most interior work including flush doors, door panels, and any location where resistance to moisture is not required. Adhesive used include casein, soya, blood albumen and animal glues as well as synthetic resin extended with other substances.

Synthetic resin bonded plywood while being suitable for the same purpose as interior type, has a much greater resistance to moisture. The more resistant types are suitable for external flush doors and door panels,

Shop front facias, and for any purpose where it may be exposed to moisture. Adhesives used include urea, melaminephenol and resorcinol formaldehyde (arranged in order of increasing moisture resistance).

5.6.1.9 Veneer

Grade I Veneer shall be of one piece of firm smoothly cut veneer. The veneers shall be free from knots, worm and beetle holes, splits, dots, glue-stains, filling or inlaying of any kind or other defects. No end joints are permissible.

Grade II Veneer shall present a solid surface free from open defects. Veneer may be in one or two pieces. Pieces of Veneers when jointed need not necessarily be matched for colour or be of equal width. A few sound knots are permitted with occasional minor discoloration and slight glue stains, isolated pin holes not along the plane of the veneer.

The uses, for which plywood made with the grades defined above are considered useful, are outlined hereunder:

Grade I for Use in its natural state.

Grade II for use where subsequent painting and /or veneering is intended.

5.6.1.10 Laminated Board

This is built-up board, with narrow strip 3 to 7 mm wide, faced both sides with either one or two veneers from 1.2 mm to 3.7 mm thick. Where single or double face veneers are used, the grain usually runs at right angles to the grain of the core strip. This type of board when available varies between 13 mm to 25 mm in thickness and is an ideal base for the highest class of veneered wood. For detailed specifications BS; 3444 'Block Board and Laminated Board' shall be used.

5.6.1.11 Block Board

This board conforming to BS 3444 is of similar construction to laminated board but core is built-up of blocks upto 25 mm wide. It is used as a base for veneering and for painted work but is considered slightly inferior to laminated board for the former use. The range of size and thicknesses in which it is manufactured are similar to those of laminated board.

5.6.1.12 Adhesives

For joiners work animal glues complying with BS: 745, 'Animal Glues for Wood' or synthetic resin adhesive complying with BS: 1204, ' Cold Setting Synthetic Resin Adhesives for Construction Work in Wood' shall be used. For flush doors and other forms of construction that rely mainly upon the adhesive, and particularly where exposure conditions are severe and prolonged dampness is likely to occur, one of the more moisture resistant adhesives shall be employed, the choice depending upon the severity of the conditions to which the work will be exposed.

5.6.2 Hardware

5.6.2.1 Nails and Screws

For joiners work, wire nails oval, chequered head, lost head round or panel-pins complying with BS: 1202, ' Wire Nails and Cut Nails for Building Purposes' or wood screws in accordance with BS: 1210 shall be used. The gauge of nail or screw used shall be suited to the woods being fixed and to which a fixing is being made, and the length shall be such as will give a sufficiently strong and secure fixing. CP: 112. The Structural

Use of Timber in Buildings' shall be followed which gives relationship between gauge, amount of penetration and strength. All nails and screws used with reactive timber (becoming stained and dis-figured by reaction with ferrous metals) shall be of non-ferrous metals or shall be protected in some manner before use if the wood work is likely to be subjected to moist conditions, e.g. external doors.

5.6.2.2 Holdfast

- Crank shaped holdfast of size 200 mm x 40 mm x 3 mm made of steel plate. One end to be fixed with 100 mm x 10 mm long screws.
- Crank shaped holdfast of size 300 mm x 40 mm x 3 mm made of steel. One end to be fixed with 100 mm x 10 mm long screws.

5.6.2.3 Hinge

- Oxidized brass built hinge of size 100 x 50 mm weighing 0.14 Kg with the standard size of brass pins fixed with brass screws of required size.
- Double-action Oxidized brass, spring-butt-hinge of size 100 x 50 mm weight 0.28 Kg each with standard size pins and spring fixed with brass screws of required size'.
- Extra heavy steel-butt-hinge of size 130 mm x 80 mm weighing 0.45 Kg with standard size of pins fixed with appropriate size of steel screws.

5.6.2.4 Tower Bolt

- Oxidized brass, 150 mm long, weighing 0.14 Kg each fixed by means of appropriate size of brass screws;
- Sled, 150 mm long, weight 0.29 Kg each fixed by means of appropriate size of steel screws;

5.6.2.5 Handle

Oxidized brass or aluminum alloy, 100 mm long fixed with the screws of the material.

5.6.2.6 Stopper

Foot-operated friction door stopper of best quality available locally and is approved the Project Manager.

5.6.2.7 Lock

Automatic dead locking mortise lock with two beveled latches and handles and COLOMBO DESIGN locks and knobs complete or equivalent available locally and as approved by the Project Manager.

5.6.2.8 Hydraulic Door Closer

Single-action type, face fixing, best quality available and as approved by the Project Manager.

The size and weights of all the above materials are approximate.

Hardware shall be carefully and securely fitted. Upon handing over the work hardware shall be demonstrated to operate freely. Keys shall be placed into respective locks an upon acceptance of the work. keys shall be tagged and delivered to the Project Manager in duplicate.

5.6.3 Execution

5.6.3.1 Fabrication

All "Wrought" timber is to be sawn, planed, drilled or otherwise machined or worked to the correct sizes and shapes required.

The joiner shall perform all necessary mortising, tenoning, grooving, matching, tonguing, rebating and all other works necessary for correct jointing. He shall also provide all metal plates, screws, nails and other fixings that may be necessary for the proper execution of the joinery works specified. The joiner shall also carry out all works necessary for the proper construction of all framings, linings, holdfasts and other contrivances as per architectural details and/or instructions of the Project Manager for their adequate support and fixing in the building.

Loose joints are to be made where provision is required to be made for shrinkage or other movements acting in the direction other than that of the stresses because of loading. Glued joints are to be used where provision need not be made for shrinkage or other movements in the connection, and where sealed joints are required. All glued joints shall be cross-longed or otherwise reinforced. All nails, springs etc. shall be punched and puttied. All cutting edges of tools shall be sharp to avoid burnishing.

All wood work, as far as practicable, shall be assembled in shop, finished and prime coated before delivery for fixing. In addition to machine sanding, all woodwork shall be smoothed by hand using "00" sand paper to have the required smooth surface, free from machine and tool marks, abrasions, raised grains and other defects. All wood work shall be fitted to plaster and other finished work in a careful manner so as not to injure these surfaces. Where plaster or other work is damaged or disturbed, it shall be restored to its original state by the Contractor at no additional cost.

All wood work shall be neatly finished to the exact dimensions specified. All nails and screws shall be of approved type. Hammer shall not be used for driving in or starting in the screws. All screws shall be dipped in oil before they are inserted in the wood. The heads of nails or screws shall be sunk and puttied or dealt with as directed by the Project Manager.

5.6.3.2 Priming

Where priming is specified, the timber shall be coated with a thick mixture of red or white lead and linseed oil. The Contractor shall provide for priming and touching up primer where necessary during the progress of work.

5.6.3.3 Door frames

The door frames shall be secured in place by means of corrugated anchors of non-ferrous metal or galvanized ferrous metal bent up against the back of the jambs and screwed in place and built into the masonry as it is being constructed. There shall be one such anchor near the top and bottom of each jamb at not over 900 mm intervals between the top and bottom anchors. Frames shall be secured to the anchors by means of 9 mm diameter bolts or screws extending through the frames, heads of bolts or screws shall be countersunk and covered with the stops, which shall be screwed in place.

5.6.3.4 Door Jamb & Door Shutters

1. Door Jamb in GI sheets of 146swg
2. Door shutters:
 - a) Solid wood – too expensive
 - b) Flush doors made of plywood and veneer.

5.6.3.5 Flush Door

Providing and fixing 1-½" thick wooden flush doors with solid core with approved HDF MOULDED facing skin on both sides of the shutter, with matching hot Pressed PVC lipping on all sides of the door shutters, including 5" x 2" G.I (16 gauge) door frame, Complete in all respects.

Standard Sizes: 3' 6" x 7' 0"
 3' 0" x 7' 0"
 2' 6" x 7' 0"

5.6.3.6 Fitting Door Shutters

All the doors shall be fitted, hung and trimmed as hereinafter specified and as indicated on the Drawings.

Doors shall have a clearance, of 4 mm at sides and top unless otherwise directed by the Project Manager and shall have 20 mm clearance at bottom. All the doors having a thickness of 44 mm or more shall have the lock or latch edge beveled at the rate of 3.0 mm in 50 mm. Doors shall be hung and trimmed with hardware as specified. All the locks shall be installed at the same height. Knob locks and knob latches shall be located at height as directed by the Project Manager. Door locks shall have the center of the locks at the same height as the center of the knob locks.

5.6.4 Measurement and Payment

5.6.3.7 General

Except otherwise specified herein or elsewhere in the Contact documents, no measurement and payment will be made for the under mentioned specified work related to the relevant items of the bill of quantities. The cost thereof shall be deemed to have been included in the quoted unit rate of the respective items of the Bill of Quantities.

The Bill of Quantities to include:

- a. All finished hardware fittings in carpentry and joinery works.
- b. Glass and glazing including other materials and accessories required for installation and finishing.
- c. Prime coat, painting and wax polish in carpentry and joinery works.
- d. Ant termite treatment to wood works.
- e. Adhesives.
- f. M.S. steel plate, non-shrink grout, teak wood plank, rough wood, sleeve, lead caulking polishing and painting and as shown on drawings.

5.6.3.8 Measurement

Measurement of acceptably completed quantity of all types of polished wood works will be made on the basis of net actual area in sq.ft. meter, fabricated and installed in position as shown on the drawings or as directed by the Project Manager.

5.6.3.9 Payment

Payment will be made for acceptably measured quantity of all types of wood works on the basis of unit rate per sq.ft. meter quoted in the bill of quantities and shall constitute full compensation for all the work related to the item.

SECTION 6 - TERRAZZO WORK

6.1 Scope of Work

The work covered by this section of the specifications, consist of furnishing all plant, labour, equipment, appliances and materials and in performing all operations complete in strict accordance with this section of the specifications and the applicable drawings and subject to the terms and conditions of the contract. The work under the section includes the followings:-

- a) Precast terrazzo tiles flooring
- b) In situ terrazzo flooring
- c) Terrazzo Dado and Skirting
- d) Terrazzo on stairs
- e) Terrazzo finished precast partitions for Toilets

6.2 Applicable Standard

Unless otherwise specified, terrazzo work shall be in conformity with British Standard Code of Practice C.P. 204 In Situ Flooring Part 1, 'General' and Part 3. "Terrazzo Flooring" as applicable to the work shown on the drawings and specified in the Bill of Quantities.

6.3 Materials

6.3.1 Cement, Sand, Aggregate and Water for Concrete

Cement, Sand, Aggregate and Water for Concrete shall conform **SECTION 3** Specification for "Plain and Reinforced Concrete".

6.3.2 Marble Chips

Marble Chips shall be crushed marble and shall be best quality white or coloured sound and hard local marble chips approved by the Project Manager and of the as mentioned in the Bill of Quantities or as required by the Project Manager.

6.3.3 Dividing Strips

Dividing strips shall be glass, brass or marble strips 4-5 mm thick and 1-1/2" wide or as specified in the Bill of Quantities.

6.3.4 Angle Clips

Angle clips for precast toilet partitions shall be chromium plated steel or stainless steel clips as shown on drawings.

6.3.5 Bolts of precast toilet partitions

Bolts for precast toilet partitions shall be 5/16" inch bars bolts chrome-plated, with acron heads, fitted to wall anchors.

6.3.6 Terrazzo Tiles

Terrazzo tiles shall be first grade, mechanically compressed type conforming to PS-531. Tiles shall be 12"x12"x0.88" / 30.0x30.0x2.2cm with a topping of 0.4" or 10.00mm thickness composed of 1:2 cement & marble chips. The base being 1:3 cement mortar. The colour, quality and size of chips shall be as per Project Manager's approval.

6.3.7 Cleaning Compound

The Compound used for all cleaning of terrazzo shall be an approved neutral chemical cleaner free from acid and alkali or any other material that will affect the colour or otherwise damage the Terrazzo and shall not affect the conductivity of terrazzo floors.

6.4 Samples

All materials used for Terrazzo and marble work as well as samples of terrazzo floor and marble work shall be submitted to the Project Manager and his approval obtained. Same materials should also be tested and this shall be got done by the Contractor at his own expense from a Laboratory approved by the Project Manager.

6.5 Execution

6.5.1 In Situ Terrazzo Flooring

The floor shall consist of a wearing surface to consistency and net thickness as specified in Bill of Quantities, laid over 1:2:4 under bedding concrete of the specified thickness. The net uniform thickness specified for wearing surface shall be that obtained after grinding and polishing. The 1:2:4 concrete shall be mixed and laid in the manner specified for cement concrete floor using a minimum quantity of water.

The concrete shall be leveled with a trowel and straight edge consolidated and finished with steel trowels to an even but rough surfaces. The top layer of cement and marble chips mixed in the proportion of 1:2 (1 cement and 2 marble chips) shall be laid over it within 12 hours. The cement and marble chips must be mixed dry in such quantities that are sufficient for a unit area of one specified shade. Water shall be added to only such quantities that can be mixed thoroughly and consumed in less than 30 minutes, the quantity of water being the minimum for workability.

Mixing must to be done on water tight platform and any mix not used within 30 minutes shall be discarded and removed from the Site. A layer of cement and marble chipping mixture should be well troweled into the surface of the base concrete before filling to the

top level of the screeds. The layer should be well compacted and all voids shall be filled in. A layer of neat cement, of the specified colour shall then be well-troweled into a plain smooth surface. Floors shall be laid in panels of sizes as shown on drawings and in Bill of Quantities or as directed by the Project Manager. Dividing strips, as specified shall be provided and fixed to exact levels making an allowance for grinding.

Three days after laying, the top layer must be evenly and smoothly machine ground with Carborundum blocks of coarse, medium and fine grades so as to ensure that all marble chipping are evenly exposed all over the surface.

If marble chips are not evenly exposed the Contractor shall pull down the sin face and relay it at his own cost. The surface after grinding shall be left undisturbed and cured for 2 to 3 weeks after which it shall be cleaned of dirt and dust gently by rubbing with pumice stone or washing soda in sufficient water. Three days after the surface has been cleaned, it shall be rubbed hard with 1:10 solution of oxalic acid using fell. The surface shall then be cleaned and washed with plenty of water. After the surface has dried a final gloss shall be given by polishing surface to the satisfaction of the Project Manager.

6.5.2 Terrazzo Dado & Skirting

Marble chips and cement shall conform to specifications for floor. Mixing shall be done in the same manner and proportion. The plastered surface over which the dado/skirting is to be applied shall be well roughened and watered, cement mortal of specified ratio shall then be plastered over this well roughened surface to indicated thickness. Before the base course had set, the layer of terrazzo mixture of the specifications for flooring shall be well troweled into the surface of the base to a thickness which after, grinding shall result in the finished thickness as per Bill of Quantities. A layer of neat cement of the specified colour shall then he well troweled into the surface leaving a plain smooth surface. After 24 hours the Contractor shall start finishing as for floors specified above, Terrazzo skirting shall be provided around all terrazzo floors unless otherwise shown. Skirting and dado shall be straight, level and in plumb. Intersections at floors shall be straight and flush. They shall be with 1/4 radius coved at floor unless otherwise shown.

6.5.3 Terrazzo on Stairs

The stair risers and treads shall be finished according to exact sizes including the terrazzo making allowance for grinding of terrazzo.

6.5.4 Terrazzo Finished Precast Partitions of Urinals

Partitions walls of urinals shall be precast R.C.C. slabs finished will) 1/1" thick polished terrazzo on both faces. The finished thickness of these walls shall be 3" or as shown on drawings and BOQ R.C.C. slab shall conform to the specification for "Concrete" and terrazzo as per this section. Fixing of these partitions of floor walls etc. shall be as directed by the Project Manager and as shown on Drawings.

6.5.5 Terrazzo Tile Works

The terrazzo tiles will be laid to the required levels and grades over a bedding of cement mortar comprising of 1 part of cement and 3 parts of sand by volume. The thickness of cement sand bedding screed shall be as per Bill of Quantities.

The curing period of the bedding shall be as directed by the Project Manager. As large an area of bedding shall be spread at one time as can be covered with tiles before the mortar has set. Surplus mortar shall be removed. The thickness of bedding in any space shall not be less than 1/2" / 12.5mm.

Floor and wall surfaces to receive the tiles shall be thoroughly cleaned of all dirt, dust, oil and other objectionable matters. Tiles shall be laid out from the Centre line of each space in an outward direction and the pattern should be made symmetrical with a minimum number of cut tiles. Joints between the tiles shall be of uniform width. Tiles shall be cut with a suitable cutting tool and rough edges shall be pumice stone. Tiles shall be laid to the straight edges.

After seven days the terrazzo tile floors shall be machine ground to a true even surface using various grades of abrasive stones as required and directed by the Project Manager. After the first grinding the floor shall be grouted with the same colour composition as used for its manufacture. The grout shall be of the consistency of thick cream and shall be brushed over the floor to fill in the joints and after 72 hours the grouting coat shall be removed by grinding till a smooth and even surface is obtained. Area and portion of the floor inaccessible for the grinding machine shall be ground and rubbed by hand. The final gloss shall be given by polishing the surface to the satisfaction of the Project Manager.

The tiled floor shall be kept wet for at least 72 hours and no one should be allowed to walk on the tiles during that period.

6.6 Measurements and Payments

6.6.1 General

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

- i.** Grinding, washing polishing and finishing of Terrazzo work.
- ii.** Under bedding and screening.
- iii.** Preparation of concrete surface for Terrazzo works.
- iv.** Cement concrete base.

6.6.2 Measurement

Measurement of acceptable completed works of Terrazzo Flooring, Dado, Skirting, Treads, Risers etc., will be made on the basis of number of sq. ft. / square meter provided & installed in position as shown on the drawing or as directed by the Project Manager.

6.6.3 Payment

Payment will be made for acceptable measured quantify of Terrazzo Work on the basis of unit rates per.sq.ft / square meter quoted in the Bill of Quantities & shall constitute full compensation for all the works related to the items.

SECTION 7 - CERAMIC TILES

7.1 General - Ceramic Tile Finishes

7.1.1 Floor Finishes

- a. Unglazed ceramic floor tiles.
- b. Rectified ceramic tiles.
- c. Porcelain tiles:
- d. Porcelain fittings for staircases.
- e. Quarry tiles.

7.1.2 Wall Finishes

- a. Ceramic tiles for walls.
- b. Porcelain tiles for walls:
- c. Tile fittings.
- d. Stone thresholds installed as part of tile installations.

7.2 Coordination

1. Do not install ceramic tile finishes until predecessor construction activities in spaces are completed and ambient temperature and humidity conditions are being maintained to comply with referenced Standard Specifications and manufacturer's written instructions.
2. The works of ceramic tile finishes have to be coordinated with the works cement sand screeds specified under section and with mechanical and electrical works.
3. Refer to the Schedules at the end of Part 3 of this Section for setting main details.

7.3 Submittals

7.3.1 General

Contractor shall prepare and submit to the approval of Engineer the submittals listed here after in this Article in accordance with requirements of Conditions of the Contract and Section "Submittal Procedures".

7.3.2 Action Submittals

1. Qualification Data

For manufacturers of tiles, adhesives and grouts.

2. Product Data:

For each type of tile, mortar, grout, and other products specified.

- a. Include in product data submittal reports of test conducted by third party testing agency to demonstrate compliance of submitted product with specified requirements. Test reports shall not be dated more than one year old.

3. Shop Drawings: For the following:

- a. Tile patterns and locations.
- b. Widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
- c. Details of interface with adjoining floors.
- d. .For wall tiles installed to Tile backing gypsum board panels or cement boards, included calculations to proof that over-turning of tile and substrate will not occur.

4. Tile Samples for Initial Selection

Manufacturer's color charts consisting of actual tiles or sections of tiles showing the full range of colors, textures, and patterns available for each type and composition of tile indicated. Include Samples of accessories involving color selection.

5. Grout Samples for Initial Selection

Manufacturer's color charts consisting of actual sections of grout showing the full range of colors available for each type of grout indicated.

6. Samples for Verification:

7. Of each item listed below, prepared on Samples of size and construction indicated. Where products involve normal color and texture variations, include Sample sets showing the full range of variations expected.
 - a. Each type and composition of tile and for each color and texture required, at least 300 mm square, mounted on braced cementitious backer units, and with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by Engineer.
 - b. Full-size units of each type of trim and accessory for each color required.
 - c. Stone thresholds in 150-mm lengths.

8. Master Grade Certificates:

For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.

7.3.3 Informational Submittals

1. Product Certificates

Signed by manufacturers certifying that the products furnished comply with requirements.

2. Installer Experience

List of five projects (minimum) of a similar nature carried out successfully by the installer with the same product.

3. Qualification Data:

For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project

names and addresses, names of engineers and employers, and other any information required by Engineer.

4. Setting Material Test Reports

Indicate and interpret test results for compliance of tile setting and -grouting products with specified requirements.

5. Cleaning and maintenance data

Cleaning and maintenance data for inclusion in Project's Operation and Maintenance Manual.

1. Low Emitting Materials: Adhesives and Sealants

Submit material datasheet and other documents.

2. Regional Materials

Submit material datasheet and other documents.

7.4 Quality Assurance

A. Regularity Requirements

The works under this Section shall comply with requirements as applicable to this Project, unless otherwise more stringent requirements are specified throughout this Section.

B. Quality System

Provide the products of a manufacturer holding valid ISO 9001 certification.

C. Compliance Standards

The work of suspended gypsum board ceilings shall comply with the requirements of the Standard Specifications referenced in this Section.

D. Product Tests

Test reports obtained from manufacturer for tests run by a qualified independent testing agency, or third-party-witnessed in-house testing with calibrated test equipment's to demonstrate compliance of submitted ceramic tiles with dimensional and mechanical properties specified in this Sections. Section should have been conducted within maximum one year before date of submission, otherwise contractor will be requested to conduct pre-construction testing to proof the same at no extra cost. Tests should also have been run on samples obtained from the production of the factory or production unit producing ceramic tiles submitted for this project.

E. Installer Qualifications

Engage an experienced installer who has completed tile installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

F. Testing Agency Qualifications

An independent testing agency, acceptable to Engineer and qualified according to ASTM E 329 to conduct the testing indicated.

G. Source Limitations for Tile

Obtain each color, grade, finish, type, composition, and variety of tile from one source with resources to provide products from same production run for each contiguous area of consistent quality in appearance and physical properties.

H. Source Limitations for Setting and Grouting Materials

Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer.

I. Pre-installation Meeting

Conduct meeting at Project site to comply with requirements of "Project Meetings. Coordinate the work of ceramic tile with the work of other trades.

7.5 Mockups

Before installing ceramic tile, construct mockups, in accordance with requirements of "Quality Requirements". to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.

1. Build mockups for each form of ceramic tile construction and finish required.
2. Approved mockups in an undisturbed condition at the time of erecting subsequent work items may become part of the completed Work.

7.6 Delivery, Storage, and Handling

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirement of referenced Standard Specifications for labeling sealed tile packages.

B. Prevent damage or contamination to materials with water, foreign matter and soil, and other causes.

C. Compliance Standards

The work of suspended gypsum board ceilings shall comply with the requirements of the Standard Specifications referenced in this Section.

D. Product Tests

Test reports obtained from manufacturer for tests run by a qualified independent testing agency, or third-party-witnessed in-house testing with calibrated test equipment to demonstrate compliance of submitted ceramic tiles with dimensional and mechanical properties specified in this Sections. Section should have been conducted within maximum one year before date of submission, otherwise contractor will be requested to conduct pre-construction testing to proof the same at no extra cost. Tests should also have been run on samples obtained from the production of the factory or production unit producing ceramic tiles submitted for this project.

E. Installer Qualifications

Engage an experienced installer who has completed tile installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

F. Testing Agency Qualifications

An independent testing agency, acceptable to Engineer and qualified according to ASTM E 329 to conduct the testing indicated.

G. Source Limitations for Tile

Obtain each color, grade, finish, type, composition, and variety of tile from one source with resources to provide products from same production run for each contiguous area of consistent quality in appearance and physical properties.

H. Source Limitations for Setting and Grouting Materials

Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer.

I. Pre-installation Meeting

Conduct meeting at Project site to comply with requirements of Section "Project Meetings. Coordinate the work of ceramic tile with the work of other trades.

7.7 Products

7.7.1 Products General

A. Ceramic Tile Standard

Provide tile that complies with the following standard specification:

1. EN ISO 13006.
2. Provide highest quality grade (First or Master) in manufacturer's range.

7.7.2 Manufacturers

A. Proposed Manufacturers

Subject to compliance with Specifications and other Contract Documents, the following manufacturers are proposed for consideration of Contractor as offering products that may be incorporated into the Work:

1. Ceramic Tiles Manufacturers:

- a. Equal and approved unnamed manufacturer.

2. Ceramic Tiles Suppliers:

- a. Unnamed Supplier who provides equal and approved product.

3. Setting and Grouting Materials Manufacturers:

- a. Equal and approved unnamed manufacturer.

B. Standards for Tile Installation Materials:

Provide materials complying with ANSI Standards referenced in "Setting Materials" and "Grouting Materials" articles.

C. Colors, Textures, and Patterns

Where manufacturer's standard products are indicated for tile, grout, and other products requiring selection of colors, surface textures, patterns, and other appearance characteristics, provide specific products or materials complying with the following requirements:

1. Submit samples selected based on Material Selection Sheets.
2. Provide materials that match the samples that have been approved by Engineer.
3. Provide tile trim and accessories that match color and finish of adjoining flat tile and approved by Engineer.

D. Factory Blending

For tile exhibiting color variations within the ranges selected during Sample submittals, blend tile in the factory and package so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples.

E. Mounting

Where factory-mounted tile is required, provide back- or edge-mounted tile assemblies as standard with manufacturer, unless another mounting method is indicated.

1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for these kinds of installations and has a record of successful in-service performance.

7.7.3 Floor Tiling

A. Fully Vitrified Stoneware (Porcelain) Floors Tiles

Extremely compact-body impervious paver tiles, homogenous throughout the thickness fabricated in the dust-pressed method from clay mixed with Kaolin, quartz and feldspar or other porcelain mix and vitrified with lowest porosity through cycles of high-temperature firing in roller kilns. Stoneware tiles are to be manufactured to EN ISO 13006 Group B1a ($E \leq 0.04\%$) tiles and meet the requirements specified here after. Use of tiles to any other ISO-13006 Grade is not acceptable:

1. Characteristics

- a. Dimension: As indicated on Drawings and Finish Schedule.
- b. Nominal Thickness: Minimum 10 mm excluding keying ribs.
- c. Surface Condition: Plain with matt finish for floors.
- d. Color and Pattern: Match basis of design product.
- e. Back Condition: Raised pattern for keying.
- f. Edge Condition: Square.

2. Performance Properties:

- a. Bending Resistance: 27 N/mm² to ISO 10545.4.
- b. Abrasion Resistance: 205 mm³ to ISO 10545.6.
- c. Surface Hardness Mohs Resistance: 6.
- d. Resistance against Chemical Agents: Unaffected to ISO 10545.13.
- e. Linear Thermal Expansion Coefficient: 9 MK-1 to ISO 10545.9.
- f. Stain Resistance: Resistant to ISO 10545.14.
- g. Skid Resistance: 0.60 Wet Rubber or Dry Leather, B.C.R. test method, matt tiles.
- h. Color Stability: No change in brightness or color to DIN 51094.

3. Dimensional Tolerances

Tiles shall be tested to UNI EN ISO and meet requirements of EN ISO 13006.

B. Unglazed Ceramic Floor Tiles

Are to be manufactured to EN ISO 13006 group B1b (0.5% $E \leq 3\%$) tiles and meet the following requirements:

1. Characteristics:

- a. Manufacture: Dust pressed, burning to verification.
- b. Composition: White ware, ceramic mix.
- c. Size: As indicated on Drawings and Finish Schedule.
- d. Nominal Thickness: Minimum 8.00 mm excluding keying ribs.
- e. Surface Finish: Unglazed.
- f. Color and Pattern: Match basis of design product.
- g. Back Condition: Raised pattern for keying.
- h. Edge Condition: Square.

2. Performance Properties:

- a. Bending Resistance: 27 N/mm² to ISO 10545.4.
- b. Abrasion Resistance: 205 mm³ to ISO 10545.6.
- c. Surface Hardness: 6.
- d. Resistance against Chemical Agents: Unaffected to ISO 10545.13.
- e. Linear Thermal Expansion Coefficient: ≤ 9 MK-1 to ISO 10545.9
- f. Stain Resistance: Resistant to ISO 10545.14.
- g. Skid Resistance: 0.60 Wet Rubber or Dry Leather, B.C.R. test method, matt tiles.
- h. Color Stability: No change in brightness or color. to DIN 51094.

3. Dimensional Tolerances

Tiles shall be tested to UNI EN ISO and meet requirements of EN ISO 13006.

C. Rectified Ceramic Floor Tiles

Locally produced extra thick ceramic floor tiles complying with EN ISO 13006 Group B1b (0.5% $< E \leq 5\%$). Tiles shall be of pebble pattern on top surface with abrasive content.

1. Impact resistance to BS EN 10545, highest grade.
2. Skid Resistance: 0.60 Wet Rubber or Dry Leather, B.C.R. test method, matt tiles.
3. Pattern: Pebble pattern.
4. Metal Oxide: For coloring.
5. Thickness: 13 mm, minimum.
6. Size: As indicated on Drawings and Finish Schedule or selected by Engineer.

D. Porcelain Fittings for Staircases

Fittings for stair and step finishes are to be ready-to-set fittings inclusive of formed nosing and linear grooves designed to increase slip resistance. Surface finish is to be chemically treated matt surface for slip resistance

1. Characteristics

- a. Thickness: Not less than 10 mm.
- b. Surfaces Features: Acid-resistant, antibacterial, non-slip and wear resistant.
- c. Edges: Square.
- d. Style: Rustic Tiles.
- e. Color: As selected by Engineer from manufacturer's full range of colors.

2. Physical Properties

- a. Water Absorption: Maximum 0.5 % according to EN ISO 10545.3.
- b. Breaking Strength: Not less than 1300 N according to EN ISO 10545.4.
- c. Modulus of Rupture: Minimum 35 Mpa according to EN ISO 10545.4.
- d. Resistance to Deep Abrasion of Unglazed Tiles: $\square\square 175 \text{ mm}^3$ according to EN ISO 10545.6.
- e. Thermal Shock Resistance: Fully resistant according to EN ISO 10545.9.
- f. Resistance against Chemical Agents: Unaffected according to EN ISO 10545.13
- g. Slip Resistance: According to DIN 51130.

3. Fittings Components

- a. Step Tile: Matt Surface with Grooves, and of dimension as selected by Engineer from manufacturer's ranges.
- b. Size of Face Plate: As selected by Engineer from manufacturer's ranges.

4. Size of Tradition Tile for Landings

As selected by Engineer from manufacturer's range.

E. Quarry Tiles and Fittings:

Shall be heavy duty tiles, and fittings of color through body (homogenous throughout the thickness) fabricated in extrusion process, and burnt to above-red heat, from natural clay blend or shale with inclusion of abrasive aggregated of

silicone carbide, aluminum oxide or other rustproof abrasive of comparable hardness in the wearing surface.

Quarry tiles are to be manufactured to ANSI A 137.1 and meet the following requirements.

1. Characteristics:

- a. Size: As shown on Drawings.
- b. Nominal Thickness: 16.00 mm, minimum for tiles and 12.50 mm for trim units, minimum.
- c. Edge Condition: Square.
- d. Surface Condition: Plain and unglazed.
- e. Back Condition: Of raised or depressed pattern.
- f. Color: As selected by the Engineer from manufacturer's standard range.

2. Finishing

Provide straight or covered bases as indicated on finish schedule for each type.

3. Performances

- a. Water Absorption: Not exceeding 5% to ASTM C 373.
- b. Breaking Strength: 250 pounds average to ASTM C 648.
- c. Abrasive Hardness: Index of 35 or greater to ASTM C 501.
- d. Bond Strength: Greater than 3.5 kg/cm² ASTM C 482.

7.7.4 Wall Tiles

7.7.4.1 Glazed Ceramic Wall Tiles

Are to be manufactured to EN ISO 13006 group B 2a ($3\% < E \leq 6\%$) tiles and meet the following requirements:

1. Characteristics:

- a. Manufacture: Dust pressed, burning to verification.
- b. Composition: White ware, ceramic mix.
- c. Size: As indicated on Drawings and Finish Schedule.
- d. Nominal Thickness: Minimum 6.00 mm excluding keying ribs.
- e. Surface Finish: Glazed.
- f. Color and Pattern: Match basis of design product.
- g. Back Condition: Raised pattern for keying.
- h. Edge Condition: Square or cushioned, to match design product.

2. Performance Properties:

- a. Bending Resistance: 27 N/mm² to ISO 10545.4.
- b. Abrasion Resistance: 205 mm³ to ISO 10545.6.
- c. Surface Hardness: 6.
- d. Linear Thermal Expansion Coefficient: 9 MK-1 ISO 10545.9
- e. Stain Resistance: Resistant to ISO 10545.14
- f. Color Stability: No change in brightness or color to DIN 51094

3. Dimensional Tolerances

Tiles shall be tested to UNI EN ISO and meet requirements of EN ISO 13006.

7.7.4.2 Glass Mosaics

A. Glass Mosaics:

Are to comply with the following requirements:

1. Classification: Crystal glass.
2. Pattern: Square tiles, opaque solid color.
3. Thickness: 3 mm, minimum.
4. Surface Texture: Smooth and flat.
5. Edges: Sharp not cushioned.

7.7.4.3 Tile Fittings

A. General

Same material and method of manufacture as for adjoining tiles.

B. Grade

Highest in manufacturer's range.

C. Types

As indicated on Drawings

1. Cove base.
2. Internal and external corner fittings.
3. Other types as indicated on Drawings.

7.7.4.4 Stone Thresholds

A. General

Provide stone thresholds that are uniform in color and finish, fabricated to sizes and profiles indicated to provide transition between tile surfaces and adjoining finished floor surfaces.

- B.** Fabricate thresholds to thickness indicated, but not more than 12.7 mm above adjoining finished floor surfaces, with transition edges beveled on a slope of no greater than 1:2.

C. Marble Thresholds

Provide marble thresholds complying with ASTM C 503 requirements and with a minimum abrasive-hardness value of 10 per ASTM C 241. Match Engineer's approved sample for color and finish.

D. Granite Thresholds

Provide granite thresholds complying with ASTM C 615 requirements.

- E.** Match Engineer's approved sample for color and finish.

7.7.4.5 Setting and Grouting Materials

A. Prepackaged Setting Mortar

Proprietary factory-prepared blend of carefully selected raw materials, Portland cement and graded aggregates which is manufactured for use with latex mortar admixture to produce a latex Portland cement mortar of the following properties:

1. Service Rating to ASTM C 627: Extra heavy.
2. Water Absorption: Not more than 5 % when tested to test method referred to in ANSI A 118.4-6.1.
3. Compressive Strength: Minimum 34.00 MPa at 28 days when tested to ANSI A118.4-6.1.
4. Pot life: Not less than 1.00 hour.
5. Time to foot Traffic: Not more than 12 hours.
6. Time to Heavy Traffic: Not more than 72 hours

B. Latex-Portland Cement Adhesive (Thin Set Mortar)

ANSI A118.4 of the following compositions:

1. Prepackaged dry-mortar mix containing dry, re dispersible, ethylene vinyl acetate additive to which only water must be added at Project site.
2. Prepackaged dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive.

a. For wall applications, provide non sagging mortar that complies with Paragraph F-

4.6.1 in addition to the other requirements in ANSI A118.4.

3. Use for floor installation, unless other material is specified.

a. Use product of waterproofing properties. Water absorption value shall not exceed the water absorption value of tiles set with the thin set adhesive.

C. Chemical-Resistant, Water-Cleanable, Epoxy Tile Grout

ANSI A118.3 and requirements specified hereunder, with a VOC content of 65 g/L or less.

1. General Performance Properties:

- a. Needs no sealing.
- b. Recommended for exterior applications for case of joints subject to direct sun rays where used in swimming pools and other outdoors applications.
- c. Resistant to Bacteria attack.
- d. Inclusive of antimicrobial protection to block growth of mold and mildew when used with the antimicrobial protection product.
- e. High chemical resistance.

2. Physical Properties:

- a. Water Absorption to ASTM C-413: 0.19%, maximum.
- b. Water Cleanability: Pass 80 minutes.
- c. Initial Setting Time: Pass > 2.00 hours.
- d. Tensile Strength ASTM C-307: 20 MPa, minimum.
- e. Compressive Strength ASTM C-579: 57 MPa, minimum.
- f. Modulus of Rupture ASTM C-580: 37 MPa, minimum.
- g. Linear Shrinkage ASTM C-531: 0.07%, maximum.

- h. Sagging Test: Pass with no change; test method E5.4 to ANSI 118.3.
- i. Flexural Strength ASTM C-580: 26 MPa, minimum.
- j. Service Temperature: 80°C Continuous and 182°C Intermittent, minimum.
- k. Quarry Shear Bonds: 15 MPa, minimum.
- l. Bond Strength to Concrete ASTM C-321: 1.00 MPa, minimum.
- m. Chemical Resistant: Recommended for Intermittent exposure (3 days) to corrosive cleaners when tested to ASTM C-267.
- n. Use for tile installations (Floors) under this Section.

D. Chemical-Resistant, Water-Cleanable, and Epoxy Tile Adhesive

Epoxy adhesive designed for the installation of large format ceramic tiles, porcelain tiles, and stone on sound concrete, masonry and Portland cement plaster clean surfaces. The product shall be recommended for commercial and installations of porcelain tiles of sizes indicated on Drawings and which may be subject to physical abuse, shock, and mild chemicals in Interior and Exterior applications. Product proprietary tile adhesive product complying with requirements of ANSI A118.3 and the following Requirements.

1. Performances:

- a. Fast permanent bond.
- b. Water cleanable.
- c. High-bond strength.
- d. Non-sag consistency.
- e. Low modulus consistency.
- f. Solvent free.
- g. Can be used in spot application.

2. Mild Chemical Resistance Performance Properties:

- a. Water Absorption, ANSI A118.3-1999: 0.1%, maximum.
- b. Shear Bond Strength Marble/Concrete ANSI A118.3-1999: 5.8 Mpa, minimum.
- c. Compressive Strength ANSI A118.3-1999: 57.8 MPa, minimum.
- d. Modulus of Elasticity ASTM-D 695: 2×10^3 .
- e. Tensile Strength ASTM-D 638: 25.3 MPa.
- f. Elongation ASTM D 638: 1%.
 - 1) Use for tile installations (floors and walls) under this Section.
 - 2) Provide non-staining white formulation.

E. Polymer Modified Cement Grout

ANSI A 118.7.

- 1. **Polymer Type:** Acrylic resin or styrene-butadiene rubber in liquid-latex form for addition to prepackaged dry-grout mix.
- 2. Unsanded grout mix for joints (3 mm) and narrower.

7.7.4.6 Elastomeric Sealants

B. General

Provide manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated that comply with applicable requirements of Section "Joint Sealants."

B. Colors

Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints, unless otherwise indicated.

7.7.4.7 Miscellaneous Materials

A. Sand Beds

- B. Clean natural sand free from foreign matters and boulders or stones in any size, graded as fine to medium coarse sand to a Standard Specifications approved by Engineer, placed loosely, distributed and hand compacted in uniform thickness to obtain finish floor level of tile floors indicated on Drawings.

C. Trowelable Underlayments and Patching Compounds

Latex-modified, Portland-cement based formulation provided or approved by manufacturer of tile-setting materials for installations indicated. Comply with requirements in Section "Hydraulic Cement-Based Underlayment".

D. Tile Cleaner

A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

7.7.4.8 Metal Accessories

A. Dividing Strips

Shall be alloy 316 stainless steel with polished finish. Depth of divider is to give secure anchorage into mortar bedding and to finish to exact level of floor.

1. **Thickness:** 6.00 mm.

B. Metal Beads

Proprietary metal fittings, high quality produced for use in decorative applications, extruded aluminum alloy and temper 6063T5 and scratch-resistant colored polyester powder coating. Install one integral piece for each application.

1. Use for external corners and other locations where ceramic fittings are not indicated on Drawings or directed by Engineer.
2. Size as approved by Engineer.

C. Divider Strips and Edging

Metal or combination of metal and neoprene base, designed specifically for flooring applications, in longest lengths available, and as follows:

1. Exposed-Edge Material: Stainless steel; ASTM A 666, Type 316 or better.
2. Cross-Section Profile: Angle or L-shape.
3. Height: Equal to stone thickness plus depth of setting bed.

4. Width: 10 mm.
5. Control-Joint Filler: Neoprene, in color selected by Engineer from manufacturer's full range.
6. Extent: Extent Use combination metal\neoprene for movement and control joints through ceramic floor tiles as stipulated by requirements of referenced installation standards.

D. Accessories for Thick Set Mortar Installation:

1. **Reinforcing Wire Fabric:** Galvanized, welded wire fabric, 50.8 by 50.8 mm by 1.57-mm diameter; comply with ASTM A 185 and ASTM A 82 except for minimum wire size.
 - a. Use reinforcing wire fabric for installations over compressible thermal insulating materials.
2. **Expanded Metal Lath:** Diamond-mesh lath complying with ASTM C 847. Use for reinforcing separations between dissimilar backgrounds if wall tile is set with thick wet mortar bedding.
 - a. **Base Metal and Finish for Interior Applications:** Uncoated or zinc-coated (galvanized) steel sheet, with uncoated steel sheet painted after fabrication into lath.
 - 1) Configuration over Solid Surfaces: Self-furring.
 - 2) Weight: 0.7 kg/sq. m.

7.7.4.9 Mixing Mortars and Grout

- A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
- B. Add materials, water, and additives in accurate proportions.
- C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

7.8 Execution

7.8.1 Examination

- A. Examine substrates, areas where tile will be installed for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile. Curing may also be achieved through use of plastic sheets.
 1. Verify that substrates for setting tile are firm; dry; clean; free from oil, waxy films, and curing compounds; and within flatness tolerances required by referenced ANSI A108 series of tile installation standards for installations indicated.
 2. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed before installing tile.
 3. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not
 4. Coordinated, adjust latter in consultation with Engineer.

- B.** Do not proceed with installation until unsatisfactory conditions have been corrected.

7.8.2 Preparation

- A.** Remove coatings, including curing compounds, and other substances that contain soap, wax, oil, or silicone and are incompatible with tile-setting materials by using a terrazzo or concrete grinder, a drum sander, or a polishing machine equipped with a heavy-duty wire brush.
- B.** Provide concrete substrates for tile floors installed with dry-set or latex-Portland cement mortars that comply with flatness tolerances specified in referenced standard for tile installation.
 - 1. Use trowelable leveling and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.
 - 2. Remove protrusions, bumps, and ridges by sanding or grinding.
- C.** Provide substrates for wall tile installed with dry-set or latex-Portland cement mortars that comply with flatness tolerances specified in referenced ANSI A108 series of tile installation standards for installations indicated.
 - 1. Use cement plaster, with expanded mesh reinforcement where necessary, and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.

D. Blending

For tile exhibiting color variations within the ranges selected during Sample submittals, verify that tile has been blended in the factory and packaged so tile units taken from one package show the same range in colors as those taken from other packages and match approved.

E. Samples

If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

7.8.3 Installation, General

A. Tile Installation Standards

Comply with BS 5385.

- B.** Extend tile work into recesses and under or behind equipment and fixtures to form a complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

- C.** Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Jointing Pattern

Lay tile in grid pattern, unless otherwise indicated. Align joints when adjoining tiles on floor, base, walls, and trim are the same size. Lay out tile work and center tile fields in both directions in each space or on each wall area. Adjust to minimize tile cutting. Provide uniform joint widths, unless otherwise indicated.

E. Lay out tile wainscots to next full tile beyond dimensions indicated.

F. Expansion Joints: Locate expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.

1. Locate joints in tile surfaces directly above joints in concrete substrates.
2. Prepare joints and apply sealants to comply with requirements of Section "Joint Sealants."

G. Movement Joints: Provide 10 mm wide, non-structural, intermediate movement joint in floor tiling of all tiled areas, based on TCA handbook, extending to the full depth of the finishing layer:

1. At 9 m in any direction for ceramic tiles bedded in semi dry mix
2. At 15 m in any direction for other types of rigid floor tiles or slabs.

H. Stone Thresholds: Install stone thresholds at locations indicated; set in same type of setting bed as abutting field tile, unless otherwise indicated.

1. Set thresholds in latex-portland cement mortar for locations where mortar bed would otherwise be exposed above adjacent nontile floor finish.

7.8.4 Ceramic Tile Floor Installation Schedule

C. Joint Widths, General

Unless otherwise indicated elsewhere in Contract Documents or approved on site by Engineer, install tile on floors with the following joint widths:

1. Unglazed Ceramic Floor Tiles: 3.00 mm.
2. Rectified Ceramic Tiles: 3.00 mm.
3. Porcelain Floor Tiles: 3.00 mm.
4. Quarry Floor Tiles: 3.00 mm.

D. Level of Finished Flooring, General:

1. Wet Areas

Set ceramic tile finished in wet areas similar to bathrooms, toilets, powders, laundries, shower areas and the like sloped to floor drains to drain surface water. Arrange that tiles are sloped to floor drains from the four sides.

2. Dry Areas

Set ceramic tile finishes in dry areas (other building spaces) level at the Finish Floor Level (F.F.L.) indicated on Drawings.

E. Floorings; Bedding and Grout Details:

1. Wet Areas, Out-Flat Distribution Corridors, Commercial Areas and Heavy-Duty Applications: Set rectified ceramic tiles, porcelain, ceramic and quarry floor tiles with thin set adhesive mortar to cement-sand leveling screeds as specified in, Section “Cement-Based Screed”.

a. Bedding: Water cleanable epoxy-based adhesive.

b. Grout: Water cleanable epoxy-based grout

c. Contact Area: 100%.

2. Other Applications

Set ceramic tiles and porcelain, ceramic and quarry floor tiles with thick wet mortar bedding on a layer of clean loose sand bedding uniformly and manually distributed, leveled and compacted.

a. Bedding: Latex-modified cement-sand mortar prepared by through adding water and mechanical mixing as per manufacturer’s instructions.

b. Grout: Latex-modified Portland-cement-based grout.

c. Contact Area: 100%.

F. Bases

Set all types of ceramic bases in all types of applications to walls prepared with cement sand plastering with Latex-modified Portland cement setting adhesive. External and internal corners are to be metered at 45 degrees.

1. Joint Width: Respect joints and widths in adjoining flooring as long as tile sizes match. Otherwise, Joint width is to be 3.00 mm.

2. Bedding: Same as bedding material used in adjoining flooring.

3. Grout: Same as bedding material used in adjoining flooring.

4. Contact Area: 100%.

G. Stairs Finishing

Set porcelain floor tiles and fittings to smooth finished concrete stairs using water-cleanable epoxy-based adhesive as specified. Grout joints with epoxy grout. Set bases same as specified before.

H. Silicone Sealer

Silicone sealer to all grouted joints. Clean adjoining tile surfaces promptly.

7.8.5 Ceramic Tile Wall Installation Schedule

A. Joint Widths, General

Unless otherwise indicated elsewhere in Contract Documents or approved on site by Engineer, install tile on Walls with joints in widths specified hereafter. Respect joints in floors as long as interfacing dimensions of floor and wall tiles match.

1. Glazed Ceramic Wall Tiles: 3.00 mm.

2. Porcelain Wall Tiles: 3.00 mm

B. Bedding and Grouting Materials

Any used bedding or grouting material shall be certified as non-sag.

C. Setting to Concrete and Masonry Backgrounds

Set porcelain and ceramic with either of the following methods

1. **Adhered Tile Technique:** Latex-modified Portland cement setting adhesive on 15 mm thick coat of cement sand plaster (plaster base coat) of mix proportion similar to that specified for Portland cement plaster base coats in Section "Portland Cement Plaster" applied onto keying scratch (dash) coat as specified in same section. Separations between dissimilar backgrounds are to be fitted prior to plastering.

- a. Thickness of Adhesive Bedding: Comply with manufacturer's printed instructions.
- b. Contact Area: 100%.

2. **Back Battering Technique:** Thick wet cement-sand mortar bedding on concrete and masonry walls. Walls are to be prepared with Portland cement-sand keying spatter dash coat (scratch coat) of mix proportions and materials same as specified in Section "Portland Cement Plaster". Separations between dissimilar backgrounds (concrete and masonry units) are to be reinforced with galvanized metal lath as specified in this section. Wet cure dash coat for a minimum of 48 hours.

- a. Thickness of Mortar Bedding: 15-25 mm.
- b. Contact Area: 100%.

D. Setting to Gypsum Backing Panels or Cement Boards: Thin-set mortar on coated glass-mat, water-resistant gypsum backer board or cement board used as tile backing panels:

1. Bedding: Thin-Set Mortar: Latex-modified, premixed, portland cement mortar.
2. Grout: Water-cleanable epoxy grout.

E. Grouting: Grout porcelain and ceramic wall tiles with latex-modified Portland cement colored grout. Fill full depth of joints and finish flush with adjoining tile surfaces.

1. Apply silicone sealer to all grouted joints. Clean adjoining tile surfaces promptly.

F. Silicone Sealer: Silicone sealer to grouted joints in wet areas. Clean adjoining tile surfaces promptly.

7.8.6 Glass Mosaic Installation Schedule

- A. Set glass mosaic with proprietary glass mosaic adhesive as specified in this Section.
- B. Grout glass mosaics with unsanded modified cement-based grout as specified.
- C. Clean adjoining tile surfaces promptly from grout material.
- D. Apply silicone sealer to all grouted joints. Clean adjoining mosaic surfaces promptly.

7.8.7 Cleaning and Protecting

A. Cleaning

On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.

1. Unglazed tile may be cleaned with acid solutions only when permitted by tile and grout manufacturer's written instructions, but no sooner than 10 days after installation. Protect metal surfaces, cast iron, and vitreous plumbing fixtures from effects of acid cleaning. Flush surface with clean water before and after cleaning.
2. Remove temporary protective coating by method recommended by coating manufacturer that is acceptable to grout manufacturer. Trap and remove coating to prevent it from clogging drains.

B. Finished Tile Work

SECTION 7 – CERAMIC TILES

Leave finished installation clean and free of cracked, chipped, broken, unbonded, and otherwise defective tile work. Provide final protection and maintain conditions, in a manner acceptable to Engineer, that ensure tile is without damage or deterioration at the time of Substantial Completion.

1. When recommended by tile manufacturer, apply a protective coat of neutral protective cleaner to completed tile walls and floors. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear.
 2. Prohibit foot and wheel traffic from tiled floors for at least 7 days after grouting is completed.
- C. Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

SECTION 8 - PLASTER AND POINTER

8.1. Scope of Work

The work covered by this section of the Specifications consists of furnishing all plant, labour, equipment, appliances, materials and performing all operations in connection with providing and installation of cement plaster complete in strict accordance with this section of the Specifications, applicable drawings and subject to the terms and conditions of the Contract.

The scope of this section of specification is covered with detailed Specifications as laid down herein.

8.2. Applicable Standards

Latest editions of following Pakistani, British & ASTM standards are relevant to these specifications wherever applicable.

8.2.1 Pakistan Standard

P.S.23 Ordinary Portland cement.

8.2.2. ISO (International Organization for Standardization).

R.579 Definitions and terminology of cement.

R.579 Method of testing strength of cements compressive and flexural strengths of plastic mortar (Rilem-Cembureau method).

R.680 Chemical analysis of cement-Main constituents of Portland mortar cement.

R.682 Chemical analysis of cements-Determination of sulphur as sulphide.

8.2.3 ASTM (American Society for Testing and Materials).

C. 144 Aggregate for Masonry Mortar.

C. 631 Bonding Compounds for interior plastering.

8.2.4 BST (British Standards Institution)

812 Methods for Sampling and Testing of Mineral Aggregates, Sands and Filters.

1199 Sands for External Renderings. Internal plastering with Lime and Portland Cement and floor screeds. .

1369 Metal Lathing (Steel) for Plastering.

5262 External Rendered Finishes.

5492 Internal Plastering.

8.3. General

8.3.1 Except as may be otherwise shown surfaces specified, all plaster work, both internal and external, shall be ordinary Portland cement plaster of the required thickness shown on the Drawings.

8.3.2 Plastering shall not commence until electric conduits, drainage, sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are Fixed in position. It shall be the responsibility of the Contractor to make sure that all such work is carried out before starting of plaster work. Chiseling and repairing of cement plaster shall not be permitted without the approval of the Project Manager.

8.4. Materials

8.4.1 Cement

Cement for plaster shall be Portland Cement either ordinary rapid hardening 01 sulphate resisting cement as specified complying with P.S.232 01 BS-12 and shall conform to requirement specified in the sections plain and reinforced Concrete.

8.4.2 Sand

Sand for plaster shall comply with the requirement of BS 812, BS-11 99 and AS 1 M C-144.

It shall comprise natural sand crushed stone sand or crushed gravel sand. It shall be hard durable, clean and free from adherent coatings such as clay and from any appreciable amount of clay in pellet form. It shall not contain harmful materials to adversely affect the hardening, the strength, the durability or the appearance of the plaster or any materials in contact with it. The quantity of clay, silt and dust shall not exceed 5% by weight for sand or crushed gravel or 10% by weight for crushed stone sand.

The grading of sand for internal plaster work and external rendering shall be within the following limits.

Percentage by weight passing sieve sizes:

Sieve Size (mm)	Internal Cement Plaster work and external rendering W
0.275.00	100
0.09472.34	90-100
0.04771.18	70-100
0.02470.6	40-80
0.01270.3	5-40
0.00670.15	0-10

The grading specified above shall be suitable for smooth finishing coats, scraped finishes and for pebble-dash or dry-dash for textured surfaces, produced by the treatment of the freshly applied final coat with a tool, the coarser particles shall be removed by screening through a 1/12"/2 mm sieve.

8.4.3 Water

Water for plaster shall conform to requirements specified in the section for plain and reinforced concrete.

8.4.4 Additive

Additives for controlling the setting and working characteristics of plaster or for imparting anticorrosion, fungicidal or water proofing properties, shall be added to the plaster strictly in accordance with the particular manufacturer's written instructions. Good quality hair or manila fiber in reasonably well distributed proportion may be to the plaster to assist application and reduce droppings. No additives shall be used except as specified in the Contract Documents.

8.4.5 All materials and workmanship for plaster, not explained in these specifications shall comply with the requirements of relevant BS-CP 211 and CP-221 as directed by the Project Manager.

8.5. Proportioning and Mixing

8.5.1 Measurement of materials by volume shall be by containers of known capacity to maintain consistent proportions. No lumpy or caked material shall be used. Mixing equipment boxes and tools shall be clean. Materials shall be proportioned as specified on the drawings, in the Bill of Quantities or as directed by the Project Manager. Mixing shall be continuous until complete and all ingredients are evenly distributed.

8.5.2 Only limited water shall be added for proper workability and such quantity of the mortar shall be prepared as that which will be consumed in thirty minutes after preparation. - Preparation of mortar in bulk quantity for use during the entire day or for any other time more than that stipulated above is expressly prohibited. Re-tempering shall not be permitted and all mortar which has begun to stiffen shall be discarded.

8.5.3 Plaster ingredients shall be thoroughly mixed either by hand on a clean cement concrete platform or by a mechanical mixer, as directed by the Project Manager.

8.6. Preparation of Surface to Be Plastered

8.6.1 Surface to be plastered shall be cleaned to remove all grease, form oil and other surface impurities which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface of all concrete ceilings, beams and columns shall be lightly hacked by approved means to give the required key for plastering.

8.6.2 All masonry surfaces to be plastered shall be cleaned to remove all matter which will otherwise adversely affect the adhesion of plaster to the surface concerned. The surface shall be washed with clean water and kept damp for 24 hours before further treatment. The surface thus prepared shall be treated uniformly with cement and sand slurry. The slurry to be used shall be one part cement to one part sand by volume with water added to make a stiff creamy mix. The slurry shall be applied with a stiff brush on surface which has previously been well wetted. The surface so treated shall be left to cure for three days.

8.7. Application of Plaster

8.7.1 The plaster of a thickness less than the specified thickness shall be rejected. If the plaster is to be more than 1/2" /13mm thick, it shall be done in two coats. The surface of first coat shall be made rough before the second coat is applied. The plaster shall not have wavy surface and shall be perfectly in plumb. The edges and corners shall represent a straight line. The plaster shall be kept wet continuously for at least ten (10) days. No extra

payment shall be allowed for jambs, junctions, corners, edges round surfaces or for more than one layer of plaster required due to any unevenness in the work done by the Contractor. The plaster work is to cover all conduits, pipes etc. fixed, in the walls and ceiling. Wherever specified metal lath shall be nailed firmly before plastering is commenced. The plastered surface shall be tested frequently with 9.843'3 meter straight edge and plumb bob.

8.7.2 Plaster containing cracks, blisters, pits, discoloration or any defects shall not be acceptable. Any such plaster or loose plaster shall be removed and replaced with plaster in conformity with these specifications. The Contractor shall cut and patch all defective work at his own cost. All damaged plaster shall be patched as directed by the Project Manager. Patching plaster shall match with and shall be finished leveled with adjoining plaster.

8.8. Metal Lath over Reinforced Concrete and Masonry Joint

- a. Metal lathing shall be fabricated from sheet steel, and shall be of uniform quality and free from flaws broken strands, cracks and corrosive pitting, shall be rectangular and true to shape and shall comply with BS-1369.
- b. All lathing shall be galvanized. Where plastering material depends entirely on the lathing for its key, these shall be not less than two complete mesh openings per 1.12"/28 in one direction and the width of the aperture shall not be less than 0.2"/5mm.
- c. Sheet shall be not less than 1.60 Kg. /m² when fabricated, using 0.7mm thick steel sheet. Where used on smooth surfaces to form a key it shall be not less than 1.20 Kg /m² when fabricated, using 0.02"/0.5mm thick steel sheet. Typing wire shall be 0.048"/1.2mm diameter galvanized annealed iron wire.
- d. Before plastering, wherever block masonry meets with reinforced concrete member's 6"/150mm wide continuous strip of expanded metal lath shall be nailed to the masonry and the reinforced concrete member covering the joint completely to prevent cracking of the joint.

8.9. Beads & Profiles

- a. Angle beads, corner beads, stop beads, architrave beads, depth gauge beads, edging profiles, plaster dividing profiles, interior angle profiles, plaster borders and the like shall all be manufactured from sheet steel and galvanized after fabrication, all beads & profiles shall be perforated at edges to ensure good adhesion of the plaster work. Thickness and dimensions shall suit particular locations and plaster work thickness.
- b. Nails for fixing lathing shall be galvanized and have either clout heads or small flat heads to suit particular locations.
- c. All angle beads, stop beads, architrave beads, depth gauge beads, and the like are to be fixed in accordance with the manufacturer's instructions.

8.10. Cleaning and Protection

8.10.1 Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Project Manager. As each room or space is completed all rubbish, debris, scaffolding and tools should be removed to leave the room clean.

- 8.10.2** Prior to plastering all aluminium windows and finished metals should be covered by sheet of plastic or tarpaulin to protect damage.
- 8.10.3** Protect finished plaster from injury by any source. Contractor shall also protect walls floors and work of other trades from plaster materials.

8.11. Tolerances

- a. Surfaces of plaster work shall be finished with a true plane to correct line and level with all angle and corners to a right angle unless otherwise specified.
- b. Maximum permitted tolerances shall not exceed 1/8"/3mm in 6.562 ft/2m variation from plumb or level in any exposed line or surface and 0.06"/1.5mm variation between planes of abutting edges or ends.

8.12. Pointing Work

- a. Joints of masonry work to be pointed shall be properly raked to 1/2" depth, cleaned and wetted.
- b. For struck pointing the mortar shall be filled in the joints flush with masonry with a pointing trowel and then pressed with proper pointing tools to form weathered and struck horizontal and triangular or V-notched vertical joints.
- c. For flush pointing after pressing mortar in the joints these shall be tilled up with mortar and finished level with edges.
- d. After pointing the face of the work shall be cleared of all surplus mortar. No washing shall be done till the pointing has set. All defects shall be treated at Contractor's expense. All work shall be kept wet for 10 days and protected from extreme temperatures and weather.

8.13. Measurement and Payment

8.13.1 General

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

The work items include:

- a. Metal lath over reinforced concrete and masonry joint.
- b. Joints, junctions, corners, drip course, edges and rounding.
- c. More than one layer due to any unevenness in the finished works.
- d. Cutting & patching of all defective works.
- e. Surface preparation, cleaning and protection as specified.
- f. Water proofing agent for water proof plaster.
- g. Angles beads, corner beads, stop beads, architrave beads, depth gauge edging profiles, plaster dividing profiles, interior angle profiles and plaster borders used in plaster works as shown on drawings.

8.13.2 Measurement

Deductions shall not be made for ends of joints, beam posts, etc., and openings not exceeding 1.64 Sq. ft/0.5 Square meter each and no addition shall be made for reveals,

jamb, soffits, sills, etc. of these openings not for finishing the plaster around ends of joints, beams posts, etc.

In case of opening of area exceeding 1.64 sq.ft/0.5 square meter each, deduction shall be made for the openings and also addition shall be made for reveal jamb, soffits, sills, etc. of openings.

Measurement for acceptably completed works of plaster/ pointing will be made on the basis of number of Sq.ft. / Square meter of the surface area plastered/ pointed as shown on the drawings or as directed by the Project Manager.

8.13.3 Payment

Payment will be made for acceptable measured quantity of plaster / pointing basis of unit rate per sq.ft/m² quoted in the Bill of Quantities and shall constitute full compensation for all the works related to the item.

SECTION 9 - INTERIOR PAINTING

9.1 Part-I – General

9.1.1 Scope

Surface preparation and field painting of interior items and surfaces.

Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified in other Sections.

9.1.2 Coordination:

Coordinate the work of interior working with the works of all other trades. Paint exposed surfaces, except where these Specifications indicate that surface or material is not to be painted or is to remain natural. If an item or surface is not specifically mentioned, paint the item or surface the same as similar adjacent materials or surfaces. If color of finish is not indicated, Engineer will select from standard colors and finishes available.

Painting includes field painting of exposed bare and covered pipes and ducts (including color coding), hangers, exposed steel and iron supports, and surfaces of mechanical and electrical equipment that do not have a factory-applied final finish.

Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels. Prefinished items include the following factory-finished components:

- a. Finished mechanical and electrical equipment.
- b. Light fixtures.
- c. Any other item specified to have factory applied colored paint or coating system.
- d. Labels: Do not paint over UL, FMG, or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.
- e. Other requirements as specified in this Section.

9.1.3 Quality Assurance and Quality Control Requirements:

As specified in this Section.

9.2 Submittals

9.2.1 General

Contractor shall prepare and submit to the approval of Engineer the submittals listed here after in this Article in accordance with requirements of Conditions of the Contract and Section “Submittal Procedures”.

9.2.2 Action Submittals

9.2.2.1 Qualifications Data

For manufacturer and third party testing agency.

9.2.2.2 Material List

An inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

9.2.2.3 Product Data

Product data should be indicated for each type of product.

9.2.2.4 Manufacturer's Information

Manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material.

9.2.2.5 Manufacturer's Color Chart for Initial Selection

Manufacturer's color chart should be indicated for each type of topcoat product.

9.2.2.6. Samples for Verification

For each color and material to be applied, with texture to simulate actual conditions, on representative Samples of the actual substrate.

- a. Provide stepped Samples, defining each separate coat, including block fillers and primers. Use representative colors when preparing Samples for review. Resubmit until required sheen, color, and texture are achieved.
 - 1) Include a list of materials and applications for each coat of each Sample. Label each Sample for location and application.
- b. Submit three Samples on each substrate indicated for Engineer's review of color and texture only.

9.2.3 Informational Submittals

9.2.3.1 Product Test Reports

For each submitted paint system as available with manufacturer. Test reports should have been prepared by or under the supervision of a third party testing agency on samples selected from current production runs. Submit test reports for the following paint properties. Test reports shall be fully descriptive and shall indicate number of tested samples, sample preparation, thicknesses of different layers, curing and setting time, painting procedure, reference standard for test and test procedure:

- a. Chemical composition.
- b. Specific gravity.
- c. Viscosity.
- d. Gloss degree.
- e. Adhesion to substrates as used in the project.
- f. Resistance to yellowing.
- g. Scrub resistant using brush scrapers.
- h. Opacity.

9.2.3.2 Products Certificates

From Manufacturer attesting compliance of submitted materials with specified requirements.

9.2.3.3 Qualifications Data

For installer.

9.2.3.4 Cleaning and maintenance

Cleaning and maintenance instructions for each paint system for inclusion in Project's Operation and Maintenance Manual.

9.3 Quality Assurance

9.3.1 Quality System

Provide the products of a manufacturer who holds valid ISO 9001 certification.

9.3.2 Applicator Qualifications

A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance. Paint applicators shall be identities that approved and accredited by Authorities Having Jurisdiction.

9.3.3 Source Limitations

Obtain fillers, putties, undercoats and primers for each coating system from the same manufacturer as the finish coats. Furnish paint materials as comprehensive integral paint system with all materials from same manufacturer or from sources recommended by top coat manufacturer in product's technical data sheet.

9.3.4 Proprietary Names

Use of manufacturer's proprietary product name in any tender or contract document to designate quality standard or aesthetics of paint is not intended to imply that products named are required to be used for exclusion of Work. Equivalent products of other unnamed manufacturers may be submitted by Contractor as comparable products.

9.3.5 Comparable Product Requests

Coordinate with requirements specified in Section "Product Requirements". Submit three copies of each request for consideration. Identify product to be replaced. Include a detailed comparison of physical properties, qualities and performance characteristics between specified and proposed comparable paint product, including as a minimum:

1. Chemical composition and properties.
2. Opacity
3. Clean-ability.
4. Scrub resistance, wet and dry.
5. Adhesion.
6. Exposure resistance.

9.3.6 Definitions and Abbreviations

1. Refer to, Section References.
2. General: Standard coating terms defined in ASTM D 16 apply to this Section.
3. Abbreviations:
 - a. DFT: Dry Film Thickness.
 - b. UL: Underwriter Laboratories.

9.4 Preconstruction Testing

9.4.1 Emulsion paint systems (latex water-based paints)

Emulsion paint systems (latex water-based paints) under this Section shall successfully pass tests to the requirements International Standards (ASTM, BS EN, ISO or DIN). Tests shall be conducted or witnessed and accredited by a third party testing agency qualified for paint testing for the following properties:

1. Quantitative material analysis.
2. Alkali and mildew resistance.
3. Abrasion resistance.
4. Flexibility.
5. Wash-ability.
6. Absorption.
7. Dry opacity.
8. Accelerated yellowness.
9. Recoating.
10. Skinning.
11. Color retention.

9.4.2 Testing Samples

Contractor shall prepare testing samples on substrates identical to substrates indicated in the project, using the approved paint material applied in accordance with submitted method statement. Prepare triplicate samples, two samples will be handed to laboratory and the third sample shall be submitted to Engineer. Samples shall be applied with motorized application method to ensure uniform paint film thickness. Samples shall be tagged on back face to state paint system information as specified before. For paints failing the tests, submit alternate products.

9.5 Mockups

9.5.1 Bench Mark Samples

Before painting, prepare bench mark as specified in, Section “Quality Requirements” to demonstrate aesthetic effects and set quality standards for materials and execution.

9.5.2 Apply mockup for each type of paint material, finish or color and for each substrate to receive paint finish. Area of each sample is to be 9 sq. m., unless lower area is directed or accepted by Engineer.

Engineer will select one surface to represent surfaces and conditions for application of each paint system specified in Part 3.

9.5.3 Apply benchmark samples after permanent lighting and other environmental services have been activated.

9.5.4 Final approval of color selections will be based on benchmark samples. If preliminary color selections are not approved, apply additional benchmark samples of additional colors selected by Engineer at no added cost to Employer.

9.6 Delivery, Storage, and Handling

9.6.1 Delivery

Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label and the following information:

1. Product name or title of material.
2. Product description (generic classification or binder type).
3. Manufacturer's stock number and date of manufacture.
4. Contents by volume, for pigment and vehicle constituents.
5. Thinning instructions.
6. Application instructions.
7. Color name and number.
8. VOC content.

9.6.2 Storage

Store materials not in use in tightly covered containers in a well-ventilated area at an ambient temperature as recommended by manufacturer in technical datasheet. Maintain storage containers in a clean condition, free of foreign materials and residue.

1. Keep storage area neat and orderly. Remove oily rags and waste daily.
2. Store materials that have low flashing point in strict accordance with manufacturer's printed instructions.

9.7 Project Conditions

9.7.1. Apply waterborne paints only when temperatures of surfaces to be painted and surrounding air are between 10 and 32 C.

9.7.2 Apply solvent-thinned paints only when temperatures of surfaces to be painted and surrounding air are between 7 and 35 C.

9.7.3 Do not apply interior paints in when relative humidity exceeds 85 percent; or at temperatures less than 3 C above the dew point; or to damp or wet surfaces.

9.8 Part -II - Products

9.8.1 Manufacturers

9.8.2 Proposed Manufacturers

Subject to compliance with Specifications and other Contract Documents, the following manufacturers are proposed for consideration of Contractor as offering products that may be incorporated into the Work:

9.8.3 Decorative Paints and Coatings

- a. Paints (for decorative paints and performance coatings).

b. Equal and approved unnamed manufacturer.

9.8.4 Paint General

9.8.5 Material Compatibility

Provide primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

9.8.6 Material Quality

Provide manufacturer's best-quality paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Paint-material containers not displaying manufacturer's product identification will not be acceptable.

9.8.7 Colors, Textures, shades and Effects

As selected by Engineer from manufacturer's full range.

9.8.8 Health and Environmental Requirements

The requirements in this Article shall apply to materials furnished under this Section.

9.8.8.1 VOC Content of Field-Applied Interior Paints and Coatings

Provide products that comply with the following limits for VOC content, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24); these requirements do not apply to paints and coatings that are applied in a fabrication or finishing shop:

1. Flat Paints, Coatings and Primers: ≤ 50 g/L.
2. Non-flat Paints, Coatings and Primers: ≤ 150 g/L.
3. Anti-Corrosive and Anti-Rust Paints to Ferrous Metals: ≤ 250 g/L.
4. Floor Coatings: ≤ 100 g/L.
5. Dry-Fog Coatings: ≤ 400 g/L.
6. Zinc-Rich Industrial Maintenance Primers: ≤ 340 g/L.
7. Pre-Treatment Wash Primers: ≤ 420 g/L.

9.8.8.2 Chemical Components of Interior Paints and Coatings

Provide topcoat paints and anticorrosive and anti-rust paints applied to ferrous metals that comply with the following chemical restrictions; these requirements do not apply to paints and coatings that are applied in a fabrication or finishing shop.

9.8.8.3 Aromatic Compounds

Paints and coatings shall not contain more than 1.0 percent by weight of total aromatic compounds (hydrocarbon compounds containing one or more benzene rings).

9.8.8.4 Restricted Components

Paints and coatings shall not contain any of the following:

- a. Acrolein.
- b. Acrylonitrile.
- c. Antimony.
- d. Benzene.
- e. Butyl benzyl phthalate.
- f. Cadmium.
- g. Di (2-ethylhexyl) phthalate.
- h. Di-n-butyl phthalate.
- i. Di-n-octyl phthalate.
- j. 1,2-dichlorobenzene.
- k. Diethyl phthalate.
- l. Dimethyl phthalate.
- m. Ethylbenzene.
- n. Formaldehyde.
- o. Hexavalent chromium.
- p. Isophorone.
- q. Lead.
- r. Mercury.
- s. Methyl ethyl ketone.
- t. Methyl isobutyl ketone.
- u. Methylene chloride.
- v. Naphthalene.
- w. Toluene (methylbenzene).
- x. 1,1,1-trichloroethane.
- y. Vinyl chloride.

9.9 Interior Primers

9.9.1 Interior Portland Cement Plaster Primer

Factory-formulated alkali-resistant acrylic-latex interior primer for interior application

9.9.1.1 Dry Film Thickness

As recommended by manufacturer but not less than 0.025 mm.

9.9.2 Interior Portland Cement Plaster Primer

Factory-formulated 100%-acrylic for sealing and priming stucco as standard with manufacturer for acrylic-based paints.

9.9.3 Interior Portland Cement Plaster Primer

Factory-formulated epoxy-polyamide based primer or other epoxy resin recommended by manufacturer for Portland cement plaster substrates. Use **DFT** as recommended by manufacturer but not less than 0.025 mm.

9.9.4 Interior Ferrous-Metal Primer

Factory-formulated quick-drying rust-inhibitive lead-and chromate- free epoxy-based metal primer.

9.9.5 Dry Film Thickness

As recommended by manufacturer but not less than 0.030 mm.

9.9.6 Primer coat

A primer coat shall be a second priming coat applied after installation in place on surfaces already prepared with first factory-applied priming coat.

9.10 Interior Fillers and Putties

9.10.1 General

Obtain from same manufacturer of the paint system and to be compatible with other coats of the system.

9.10.2 Block Filler

Latex block filler suitable for interior and exterior applications.

9.10.3 Acrylic Paint Systems

Use acrylic-based materials.

9.11 Acrylic Emulsion for Cement Based Surfaces

9.11.1 General

Interior Acrylic Emulsion Paints on Cement based Surfaces shall be based on 100% acrylic or acrylic-polymer-emulsions that are manufactured with high quality acrylic resins, approved by Engineer.

9.11.2 Testing

Shall meet requirements for excellent grade paints when tested according to ASTM Standards:

a. Polymer Content:

1) Quantitative Identification of Polymer Content: ASTM D 3168, or ISO 3233.

b. Performances during Application:

1) Sag Resistance (using Multi-notch Applicator): ASTM D4400.

2) Spatter Resistance (During Roller Applications): ASTM D4707.

- 3) Blocking Resistance: ASTM D4946.
- 4) Color Development in Tinted Latex Paints: ASTM D5326.
- c. Performances of Cured Paints:
 - 1) Fire Retardancy: ASTM D1360
 - 2) Hiding Power (Dry Opacity) for Roller Applied Paints: ASTM D 5150.
 - 3) Wet-to-Dry Hiding Change: ASTM D5007.
 - 4) Leveling of Paint (by Draw down Method): ASTM D4062.
 - 5) Gloss and Sheen Uniformity: ASTM D 3928.
 - 6) Burnish Resistance: ASTM D6736
 - 7) Leaching of Water Soluble Material: ASTM D7190.
 - 8) Practical Washability: ASTM D4828.
 - 9) Accelerated Efflorescence: ASTM D7072.
 - 10) Scrub Resistance (by Abrasion Weight Loss): ASTM D4213.
 - 11) Water Resistance in 100% humidity: ASTM D2247.
 - 12) Florescent UV Condensation exposures: D4597.
 - 13) Alkali and Mildew Resistance.
 - 14) Flexibility.
 - 15) Absorption.
 - 16) Accelerated Yellowness.
 - 17) Recoating.
 - 18) Skinning.
 - 19) Color Retention.

9.11.3 Acrylic Emulsion Paint

Factory-formulated flat acrylic-emulsion latex paint suitable for repeated washing. Paint shall be highly recognized as interior emulsion paint, of acrylic-polymer emulsion binder as specified before, of high leveling and hiding properties and excellent flow properties and wash-ability properties. Crack bridging capability of paint shall be 1.00 mm minimum. Paint shall be of anti-fungal and anti-bacterial properties. Solid content shall not be less than 36%, by volume when tested to above referenced standards.

9.11.4 First and Second Coats

Acrylic latex-based, interior paint applied at spreading rate recommended by the manufacturer to achieve a Dry Film Thickness (DFT) of not less than 0.060 mm per coat, and a total paint DFT of 120 microns.

9.11.5 Acrylic Emulsion Paint (Matt and Silk)

Interior 100% acrylic (pure) resin based emulsion to produce a highly durable, flexible and water-resistant coating suitable for repeated washing and scrubbing (not less than 3000 Cycles abrasion test), alkali resistant and excellent opacity and adhesion.

9.11.6 First and Second Coats

Acrylic latex-based, interior paint applied at spreading rate recommended by the manufacturer to achieve a Dry Film Thickness (DFT) of not less than 0.060 mm per coat, and a total paint DFT of 120 microns.

9.12 Epoxy Paint for Cement Based Surfaces

9.12.1 High performance architectural coating (HIPAC)

High performance, two-component chemically-cured waterborne epoxy coating for use as a hard, durable high performance architectural coating (HIPAC):

9.12.2 Special Qualifications

- a. Suitable for use on surfaces where the performance of resisting growth of fungus and bacteria is required.
- b. Applicable to walls (stands on walls).
- c. Applicable to concrete and cement sand plaster.

9.12.3 Performance Requirements

a. Film Properties

- 1) Abrasion Resistance: Good.
- 2) Pencil Hardness: Good.
- 3) Flexibility: Excellent.
- 4) Impact Resistance: Excellent.
- 5) Water Resistance: Excellent.
- 6) Chemical/Stain: Resistance Excellent.

b. Product Data

- 1) Pigment: Lightfast Non-Lead Pigments and Mineral Extenders
- 2) Binder: Polyamide Cured Epoxy.
- 3) Solvent: Aromatic Hydrocarbon and Alcohol.
- 4) Volume Solids: 43% +- 1% - varies with color.
- 5) Flame Spread Rating: Class A (0-25) over non-combustible surfaces.
- 6) Gloss Degree: Provide finished epoxy coating of matt, semi-gloss or gloss finish as per description given on Finish Schedule.

c. Application

- 1) Film Thickness:

2) Wet: 115-290 microns

3) Dry: 50-125 microns.

9.12.4 Anti-Toxic Epoxy Finish Paint

- a. High solids content, non-sag, epoxy –based finish paint.
- b. Recommended for water-submerged continuous service conditions in water tanks.
- c. Compatible with crystalline waterproofing specified for water tank waterproofing.
- d. Light color as selected by Engineer.

9.13 Polyurethane Paint for Cement Based Surfaces

9.13.1 Top and under coats

Top and under coats are to be spray-applied, aliphatic polyurethane based, non-toxic, air drying to a smooth, highly opaque surface to produce a durable, flexible and water-resistant coating with excellent adhesion and color retention. Undercoat is to be suitable to receive further coatings. Finish is to be highly gloss.

Color shall be as selected by Engineer from manufacturer’s full range.

Primer and Fillers for surface preparation are to be as recommended by manufacturer.

9.14 Acrylic Emulsion Paint for Gypsum Boards and Cement Boards

Same materials as specified for application onto cement based substrates.

9.15 Opaque Finish of Wood Surfaces

9.15.1 Polyurethane Paint System

Top and under coats are to be spray-applied, aliphatic polyurethane based, non-toxic, air drying to a smooth, highly opaque surface to produce a durable, flexible and water-resistant coating with excellent adhesion and color retention. Undercoat is to be suitable to receive further coatings. Finish is to be highly gloss.

Color shall be as selected by Engineer from manufacturer’s full range.

Primer and Fillers for surface preparation are to be as recommended by manufacturer.

9.15.2 Alkyd Paint System for Woods

Top and under coats are to be alkyd based, oleo-resinous, non-toxic, drying to a smooth, highly opaque surface to produce a durable, flexible and water resistant coating with excellent adhesion and color retention. Undercoat is to be suitable to receive further coatings. Finish is to be gloss or semi-gloss as selected by the Engineer.

9.16 Ferrous Surfaces Finish Paint System (Architectural Work Items)

9.16.1 Acrylic Aliphatic-Polyurethane Enamel

Two-pack acrylic resin based enamel cured with aliphatic polyisocyanate applicable on steel surfaces, steel surfaces primed with epoxy-based primers and steel surfaces coated

with zinc. Dry enamel film shall exhibit excellent gloss and color retention, durability, scratch and abrasion resistance and chemical resistance. Comply with the following:

1. Binder: Acrylic\aliphatic polyurethane.
2. Pigments: Rutile titanium dioxide and/or color pigments and functional extenders.
3. Appearance: Semi-Gloss.
4. % Solids, by Volume: 57, minimum.
5. Color: As selected by Engineer from manufacturer's full range of colors.
6. Application: Airless spray.
7. Primer: Epoxy-zinc-rich or epoxy-based as specified for substrate to be coated.
8. Thinners: As recommended by manufacturer.
9. Dry Film Thickness: Apply two coats at spreading rate recommended by manufacturer to achieve a dry film thickness of 75 microns per coat, minimum.

9.17 Traffic-Related Paints

9.17.1 Traffic Marking Paint

Refer to, Section "Traffic Coatings".

9.17.2 Curb Paint

Use pedestrian-grade traffic coating same as used for adjoining top surface of the reinforced concrete walkways.

9.17.3 Paint for Traffic Guide Wall Labels

Multi-purpose phosphoric paint

9.17.3.1 Performances

Additional visibility to traffic guide wall labels.

9.17.3.2 Binder

Acrylic resin.

9.17.3.3 Properties

- a. Solid Contents: 48%; minimum.
- b. Density: 1.06 kg/Liter; minimum.

9.17.3.4 Colors

White and Yellow.

9.17.3.5 Dry Film Thickness

50 microns, minimum.

9.18 Execution

9.18.1 Examination

Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of work.

Proceed with paint application only after unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.

Start of painting will be construed as Applicator's acceptance of surfaces and conditions within a particular area.

9.18.2 Maximum Moisture Content of Substrates

When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Wood: 15 percent.
3. Gypsum Board: 12 percent.
4. Plaster: 12 percent.

9.18.3 Suitability of Substrates

Verify suitability of substrates, including surface conditions.

9.18.4 Coordination of Work

1. Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates.
2. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.
3. Notify Engineer about anticipated problems when using the materials specified over substrates primed by others.
4. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.
5. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

9.19 Preparation

9.19.1 General

Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.

After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

9.19.2 Cleaning

Before applying paint or other surface treatments, clean substrates of substances that could impair bond of the various coatings. Remove oil and grease before cleaning.

Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

9.19.3 Surface Preparation

Clean and prepare surfaces to be painted according to requirements of BS 6150:1991 and manufacturer's written instructions for each particular substrate condition and as specified.

Remove and re-prime incompatible primers.

9.19.4 Cement-Based Materials

Prepare cement plaster, and mineral surfaces to be painted as follows:

- a. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen as required to remove glaze. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.
- b. Use abrasive blast-cleaning methods if recommended by paint manufacturer.
- c. Determine alkalinity and moisture content of surfaces by performing appropriate tests. If surfaces are sufficiently alkaline to cause the finish paint to blister and burn, correct this condition before application. Do not paint surfaces if moisture content exceeds that permitted in manufacturer's written instructions.
- d. Prepare surfaces with two coats of filler or putty that is compatible with under coats and finish coats and obtained from same manufacturer of paint coats:
 - 1) Use compatible acrylic-based filler under acrylic emulsion paints.
 - 2) Use oil-based filler under alkyd paints. Use of copolymer-based fillers under alkyd paints shall be subject to written approval of Engineer based on manufacturer's certification and submitted samples.
 - 3) Use alkyd based filler under epoxy based paints, unless otherwise recommended by manufacturer.
 - 4) Sand after setting of filler and patch remaining spots or irregularities and lightly sand to obtain perfect smooth uniform surface suitable for receiving paint coats.

9.19.5 Gypsum Boards

Preparation of joints and remedy of board defects induced during construction of gypsum board assemblies are specified in, Sections covering different gypsum board assemblies. Preparation of gypsum board surfaces shall comply with requirements of board manufacturer, referenced Standard Specifications and this Section Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by methods recommended by manufacturer and paint applicator.

- a. Apply one coat of wash primer to promote and enhance adhesion of paint system to the galvanized surface.

9.19.6 Ferrous Metals

Clean un-galvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with recommendations of SSPC standards and the following:

- a. Treat metal with a metal treatment wash coat before priming.

- b. Touch up bare areas and shop-applied prime coats that have been damaged. Wire brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.

9.19.7 Structural Steel Substrates

Clean structural steel surfaces; remove oil, grease, dirt, loose mill scale, and other foreign substances.

- a. Bare Structural Steel; Surfaces: Blast steel surfaces clean as recommended by paint system manufacturer and according to Swedish Standard SIS 05 59 00 – 1967, Sa 3: Blast cleaning to visually clean steel. Surface shall be completely free from oil, grease, mill scale and rust.
- b. Coated Structural Steel (before applying undercoat or Finish coat): Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat or the touch up material recommended by manufacturer of the paint system.

9.19.8 Wood Substrates

- a. Scrape and clean knots, and apply coat of knot sealer before applying primer.
- b. Sand surfaces that will be exposed to view, and dust off.
- c. Prime edges, ends, faces, undersides, and backsides of wood.
- d. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

9.19.9 Material Preparation

- a. Mix and prepare paint materials according to manufacturer's written instructions.
- b. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
- c. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
- d. Use only thinners approved by paint manufacturer and only within recommended limits.

9.20 Application

9.20.1 General

Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

Paint colors, surface treatments, and finishes are indicated in the paint schedules.

Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.

Provide finish coats that are compatible with primers used.

The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, louvers and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.

Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.

Sand lightly between each succeeding enamel or varnish coat.

9.20.2 Scheduling Painting

Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

The number of coats and film thickness required are the same regardless of application method. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, and does not deform or feel sticky under moderate thumb pressure, and until application of another coat of paint does not cause undercoat to lift or lose adhesion.

9.20.3 Application Procedures

Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.

9.20.4 Brushes

Use brushes best suited for type of material applied. Use brush of appropriate size for surface or item being painted.

9.20.5 Rollers

Use rollers of carpet, velvet-back, or high-pile sheep's wool as recommended by manufacturer for material and texture required.

9.20.6 Spray Equipment

Use airless spray equipment with orifice size as recommended by manufacturer for material and texture required.

9.20.7 Minimum Coating Thickness

Apply paint materials no thinner than manufacturer's recommended spreading rate to achieve dry film thickness indicated, unless higher thickness is recommended by manufacturer. Provide total dry film thickness of the entire system as recommended by manufacturer but not less dry film thickness specified.

9.20.8 Mechanical and Electrical Work

Painting of mechanical and electrical work is limited to items exposed in equipment rooms and occupied spaces.

9.20.9 Prime Coats

Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.

9.20.10 Completed Work

Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

9.20.11 Tint

Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

9.21 Field Quality Control

- a. Employer reserves the right to invoke the following test procedure at any time and as often as the Employer deems necessary during the period when paint is being applied.
- b. Engage the services of an independent testing agency to sample the paint material being used. Samples of material delivered to the Project will be taken, identified, sealed, and certified in the presence of the Contractor.
- c. Testing agency will perform appropriate tests as selected from tests specified under “Pre- Construction Testing” Article in this Section according to case and noted defects of technical observations.
- d. Employer may direct the Contractor to stop painting if test results show material being used does not comply with specified requirements.
- e. Contractor shall remove noncompliant paint from the site, pay for testing remove rejected paint from surfaces painted with it and paint the surface with alternative approved paint.

9.22 Cleaning and Protection

- a. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- b. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping without scratching or damaging adjacent finished surfaces.
- c. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

- d. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.
- e. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.
- f. Provide "Wet Paint" signs to protect newly painted finishes. After completing painting operations, remove temporary protective wrappings provided by others to protect their work.
- g. After work of other trades is complete, touch up and restore damaged or defaced painted surfaces.

9.23 Interior Painting Schedule

Coordinate the following paint coats with surface preparation steps as specified.

9.23.1 Special Paint System

Apply in compliance with recommendations in manufacturer's technical data and literature.

9.23.2 Concrete and Concrete Masonry Surfaces

Provide the following paint systems over interior concrete and brick masonry surfaces:

9.23.2.1 Acrylic Paint Finish on Concrete and Concrete Masonry Surfaces

Acrylic Paint Finish on Concrete and Concrete Masonry Surfaces should be direct application on Un-plastered Surfaces. There should be 2 finish coats over a primer.

- a. Surface shall be prepared and made good using acrylic based fillers and putties obtained from same manufacturer.
- b. Block Filler: Block filler, latex, interior.
- c. Primer: Alkali-resistant, acrylic-latex, interior primer applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.036 mm.
- d. Undercoat: same material for finish coats specified hereafter diluted to the manufacturer's recommendations.
- e. First and Second Finish Coats: Acrylic-latex, interior paint applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.06 mm per coat, and a total paint DFT of 120 microns.
- f. Sheen level: As selected by Engineer.

9.23.2.2 Epoxy Paint Finish

- a. 2 finish coats over primer.
- b. Surface shall be prepared and made good using acrylic based fillers and putties obtained from same manufacturer.
- c. Primer: 1 coat of manufacturer's standard water based epoxy primer.
- d. First and Second Finish Coats: 2 coats of Epoxy Paint finish as specified, to achieve a total dry film thickness of 125 microns, minimum.

9.23.3 Concrete Masonry Shaft Walls

Two coats of PVA paint on made-good masonry.

9.23.4 Gypsum Board and Cement-Based Board

Provide the following finish system over interior gypsum board and Cement-Based Board surfaces.

9.23.4.1 Acrylic Finish

- a. 2 finish coats over a primer.
- b. Primer: Latex-based, interior primer applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.031 mm.
- c. First and Second Coats: Acrylic-latex-based, interior paint applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.060 mm.
- d. Sheen level: As selected by Engineer.

9.23.4.2 Portland Cement Plaster

Provide the following finish systems over new, interior Portland cement plaster surfaces.

9.23.4.3 Acrylic Finish

- a. 2 finish coats over a primer.
- b. Primer: Alkali-resistant, acrylic-latex, interior primer applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.036 mm.
- c. Undercoat: same material for finish coats specified hereafter diluted to the manufacturer's recommendations.
- d. First and Second Finish Coats: Acrylic-latex, interior paint applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.06 mm per coat, and a total paint DFT of 120 microns.
- e. Sheen level: As selected by Engineer.

9.23.4.4 Epoxy Paint Finish

- a. 2 finish coats over primer.
- b. Primer: 1 coat of manufacturer's standard water based epoxy primer.
- c. First and Second Finish Coats: 2 coats of Epoxy Paint finish as specified, to achieve a total dry film thickness of 125 microns, minimum.

9.23.5 Woodwork and Hardboard

Provide the following paint finish system over new, interior wood surfaces:

9.23.5.1 Polyurethane Paint System

- a. 1 finish coats over a wood under coater.
- b. Undercoat: Polyurethane-based, interior enamel under coater applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.075 mm.
- c. Finish Coat: Full-gloss, acrylic/aliphatic polyurethane-based, interior enamel applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.075 mm.

9.23.5.2 Full-Gloss, Alkyd-Enamel Finish

- a. 2 finish coats over a wood under coater.

- b. Undercoat: Alkyd, interior enamel under coater applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.031 mm.
- c. First and Second Coats: Full-gloss, alkyd, interior enamel applied at spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.061 mm.

9.23.5.3 Zinc-Coated Metal

Provide the following finish systems over zinc-coated metal:

9.23.5.4 Acrylic\Polyurethane Enamel

- a. 2 finish coats over primer.
- b. Primer: Primer for Galvanized Steel

9.23.5.5 Washing Primer

Poly vinyl butaryl (PVB) etching primer.

9.23.5.6 Primer

Polyamide epoxy primer or other epoxy resin as recommended by manufacture.

9.23.5.7 Finish Coats:

Acrylic polyurethane coating as specified.

9.23.6 Ferrous Metal

Provide the following finish systems over ferrous metal:

9.23.6.1 Acrylic\Polyurethane Enamel

- a. 2 finish coats over primer.
- b. Primer: Epoxy polyamide or other epoxy resin as recommended by manufacture.
- c. Finish Coats: Acrylic/polyurethane coating as specified. Apply minimum two coats to obtain dry film thickness recommended by manufacturer but not less than 35-micron
- d. DFT per coat (70 microns of paint DFT)

9.24 Exterior Painting

9.24.1 Crete Sand Coating - (Free From Lead and Mercury)

- a. This product is composed of Natural Quartz, acrylic resins, pigments at high temperature, anti-bacterial and anti-fungus additives, anti-foaming agents, expanders and specially formulated base etc.
- b. It can adapt itself to any climate and its heavier textures can also easily cover the minor defects of cemented or plastered walls. This material also protects the walls from dampness, fungus, scratch, alkali, ultraviolet rays, fire and accumulation of humidity and water vapours.

9.24.2 Surface Preparation

The Surface to be applied must be free from grease, dust, loose or flanking paints, mold, algae, and other contaminants, cracks and chipped plaster should be repaired with cement

SECTION 9 – INTERIOR PAINTING

and sand mix and properly cured before coating. Previously painted surface must be thoroughly scraped out so that the plaster of the surface should vividly appear, before the use of ROCK SHIELD Textured Coatings. This process gives strong adhesion to the surface.

Applications	Drying Time	Coverage	Cleaning	Packing
It is speedily applicable product. It is ready to use from the pack depending upon the surface's porosity, if needed, 10% water can be added to it. ROCK SHIELD Crete Sand Coating is to be applied by a trowel. This is intended for interior or exterior use on cement sand plaster chipboard, plywood and asbestos.	In normal weather conditions; Touch dry: 4-6 hours. Proper curing 72 hours.	Crete Sand Coatings covers 100-125 sq. ft per 25 kg.	Clean the Equipment with plenty of water immediately after use.	Available in 25 kg. Bags

9.24.3 Technical Data / Specification

Type of Material	:Acrylic & Natural Quartz
Colour :	:Natural Iron Oxide
Freeze Thaw	:PROP/ETH Glycol
Dispersant	:Tamol 731 SD Potassium Tripoly
Wetting Agent	:Triton X-100
Ammonium Hydroxide	:Optimize PH
Antifoamer	:Nopco NDW
Titanium Oxide	:Tiona 575
Zinc Oxide	:AZO-11
Coalescent	:Texanol
Mildewcide	:Skane M-8
Thickeners	:TT-615/Natrosol250
Solvent :	Water
Thickness:	0.75 MM – 1 MM
Consistency	:Pasty
Extender :	Quartz – 290 Quartz 71 C/C 300 MICA 300 Dolomite 5 Micron

SECTION-10 - GLAZING

10.1 Scope of Work

The work covered under this section of the specifications consists of furnishing all labour, equipment, tools, appliances, scaffoldings and providing glass, gaskets, sealant, compounds and accessories required for performing all operations in connections with the installation and setting of glass, complete in every respect in accordance with the drawings or as directed by the Project Manager. The scope of this section of specifications is covered with detailed specifications as laid down herein.

10.2 Applicable Standards

Latest editions of following British Standards are relevant to these specifications wherever applicable.

- BSI (British Standards Institution)
- 952 Glass for double glazing.
- CP.152 Double glazing.

10.3 General

- a. Each type of glass shall have the manufacturer's label on each pane, and the labels shall remain on the glass until final cleaning.
- b. Glazing sealant shall be as recommended by the manufacturer for the particular application.
- c. Spacer shims (distance piece) shall be plasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on drawings between glass and rebates, bead or cleat. Depth shall give not less than 6mm cover of glazing sealant.
- d. Contractor shall submit samples for each type of glass, minimum 4"x4"/100mm x 100mm in size with protective edges. Samples of glazing sealant minimum 0.1 liter of specified types shall be submitted. Samples of minimum of three glass blocks shall also be submitted.
- e. Contractor shall submit 12"/300 mm long sample of each type of double glazing gasket.
- f. Contractor shall also submit printed materials manufacturers, installation instructions for specified glazing, gasket, compounds, sealant and accessories including description of required equipment, procedures and precautions to be observed.

10.4 Delivery Storage and Handling

10.4.1 Contractor shall deliver materials in manufacturer's original, unopened containers clearly labeled with manufacturer's name and address, material, brand, type class and railing as applicable.

10.4.2 Contractor shall store the materials in original unopened containers, with labels intact, protected from ground contact.

10.4.3 Contractor shall handle the materials in a manner to prevent breakage of glass and damage to surfaces.

10.5 Materials

10.5.1 General

Glass shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to fit the rebates so as to have a uniform clearance of 1.6 mm (1/6 inch) round the panes between the edges of glass and the rebates. All glass shall be of best quality manufacture as approved by the Project Manager.

10.5.2 Type of Glass

10.5.2.1 Plain / Tinted Glass

Glass for doors and windows shall be Local Float Glass where the sheet glass is to be used and for double glazing imported order made double layer vacuum glass of appropriate thickness tinted as selected and as approved by the Project Manager.

10.5.2.2 PSG Heat-strengthened glass or PSG Tempered glass

PSG Heat-strengthened glass or PSG Tempered glass, safe glass with a compressed layer on its surface manufactured by heating up flat glass to a temperature of around 700 C and then blowing air on to its surface, quenching it down swiftly and uniformly. It can be divided into two types depending on the degree of heat treatment, heat-strengthened glass or tempered glass PSG heat-strengthened glass in manufactured by controlling the tensile stress caused by heat treatment process with in a certain range of Temperature. PSG tempered glass has an impact strength which is 5 times higher than that of the annealed flat glass of the same thickness, as well as 3 to 4 times higher resistance to weight.

10.5.3 Rubber acrylic glazing sealant.

- a. Two component polysulfide glazing sealant.
- b. One component acrylic glazing sealant.
- c. Acrylic - latex glazing sealant consisting of modified latex rubber and acrylic emulsion, non-hardening, non-staining and non-bleeding.
- d. Cleaners, Primers and sealer as recommended by the sealant manufacturer.

10.5.4 Accessories

Vinyl Glazing Bead shall be for external windows and entry doors and shall be in accordance with glass manufacturer's recommendation.

10.5.5 Glazing Type

It shall be type or ribbon of polymerized butyl or mixture of butyl and polyisobutylene compounded with inert fillers and pigments, solvent based, 95 percent solids thread or fabric reinforcement, paintable, non-staining.

10.5.6 Setting Blocks

It shall be chloroprene (Neoprene) 70 to 90 durometer hardness, compatible with sealant used, channel shaped and of the necessary height for proper perimeter clearance.

10.5.7 Channels, Gaskets, and Spacer's.

It shall be chloroprene (Neoprene) 40 to 50 urometer hardness compatible with sealant used.

10.6 Installation of Glazing

- a. Glazing shall comply with the recommendations contained in the "MANUAL OF GLAZING" of the flat glass marketing Association or as specifically recommended otherwise by the glass and glazing materials manufacturers.
- b. Examine each piece of glass and discard and replace glass with new glass, if edge damage or face imperfection is found.
- c. Clean glazing channels and other framing members indicated to receive glass. Remove coatings which are not firmly bonded to the substrate, Remove lacquer from metal surfaces wherever elastomeric sealant are to be used. Apply primer and sealant manufacturer.
- d. Trim and clean excess glazing materials from surrounding surfaces immediately after installation and eliminate stains and discoloration.
- e. Cure glazing sealant and compounds in compliance with manufacturer's instructions, to obtain high early bond strength internal cohesive strength and surface durability.
- f. No glazing shall be considered complete until and unless paint and other stains have been removed from the surface of the glass.
- g. While glazing operation is in progress great care shall be taken to avoid breakage or damage to the glass and adjoining glazing. The Contractor shall make good at his own cost, all glass broken by his workmen while cleaning or carrying out other operations. On the completion of the glazing work, all glass that has been set by Contractor shall, if it becomes loose, within the maintenance period, to be re-fixed at Contractor's expense.

10.7 Protection and Cleaning Of Glazing

- a. Remove all smears, labels and excess glazing sealant, leave clean inside and outside and free from scratches. The Contractor shall be responsible for the protection of installed glass. Before final acceptance, damaged or broken glass shall be removed and replaced with new glass at no additional expense to the Employer.
- b. All glazed surfaces shall be washed clean both inside and outside within two weeks prior to final acceptance by the Employer.

10.8 Measurement and Payment

- a. No Payment shall be made for the works involved within the scope of this section of specifications unless otherwise specifically stated in the Bill of Quantities or herein.
- b. The Cost thereof shall be deemed to be included in the quoted unit rate of the relevant item of the Bill of Quantities.

SECTION 11 - ROOF WATER PROOFING SYSTEM

11.1 Scope of Works

The works covered by this section of the specifications consists of furnishing all plants, labor and material performing all operations. In connection of water proofing according to specifications given below;

This subsection covers furnishing and installing roof waterproofing system in accordance with the requirements shown in the drawings as specified herein:

- a) Sequence of operation: Sequence of operation depends upon the individual steps as are listed below for the application method.
- b) Preparation of surface, remove alt dirt and dust from the surface. Thorough clean-up of surface with a broom. The cleaned surface is then surveyed and all depressions and pits in the roof of size more than 5mm are replained with sand/cement mortar before prime coat.
 - i) Prime Coat: The surface to be sealed has to be cleaned of dirt, dust and all loosed materials by sweeping it thoroughly with a broom. The cleaned surface is then primed with bitumen (SIB) PB3 or PB4 with kerosene oil.
 - ii) Preparation of surface before water proofing.
 - iii) 0.157" (4mm) thick Ecogum torch on membrane.
 - iv) One layer of polythene sheet 0.008" thick.
 - v) 1-1/2" thick brick tiles in 1:6 cement mortar and joint filling in 1:3 cement mortar cleaning the surface curing etc. complete.

11.2 Material (A)

1. Prime coat of bitumen PB3 or PB4 with kerosene oil.
2. One layer of Polythene Sheet 0.008" thick.
3. 4" thick mud compacted and plastered with straw mixed.
4. 1½" thick brick tiles in 1:6 cement sand mortar and joint filling in 1:3 cement sand, cleaning the surface and curing etc. complete.

11.3 For Normal To Moderate Rain Area (B)

1. Prime coat of bitumen PB3 or PB4 with kerosene oil.
2. 0.157" (4 mm) thick ecogum torch applied membrane.
3. One layer of Polythene Sheet 0.008" thick.
4. 4" thick mud compacted and plastered with straw mixed.
5. 1½" thick brick tiles in 1:6 cement sand mortar and joint filling in 1:3 cement sand, cleaning the surface and curing etc. complete.

11.4 For Heavy Rain Area (C)

1. Prime coat of bitumen PB3 or PB4 with kerosene oil.
2. One layer of Polythene Sheet 0.008" thick.
3. One layer of high density thermo pore (30-50) Kg m³, 2" thick.
4. One layer of Polythene Sheet 0.008" thick.
5. 4" thick mud compacted and plastered with straw mixed.

6. 1½” thick brick tiles in 1:6 cement sand mortar and joint filling in 1:3 cement sand,
7. Cleaning the surface and curing etc. complete.

11.5 For Areas Where Greater Heat Insulation is required

The contractor shall get samples of all the materials used for the items under this section approved by the Engineer and the same type of materials shall be used throughout the work. Any materials required by the Engineer to be tested, shall be got done by the Contractor at his own cost from the Laboratory approved by the Engineer.

11.6 Protection

The Contractor shall take every care to maintain the slopes, levels and shall protect the work from any damage during the construction and maintenance period. The Contractor shall have to remove, replace and rectify such damaged work at his own cost and risk.

11.7 Measurement

Measurement of roofing, shall be in square Ft. of the actual surfaces complete and approved by the Engineer.

11.8 Rate and Payment

The rate for roofing shall include all materials used for roofing, all labour, equipment, heating and other operations required to complete the work in all respects to the satisfaction of the Engineer and as specified.

SECTION 12 - ALUMINIUM WINDOWS

12.1 Part 1 - General

Aluminum-framed windows glass windows:

1. Fixed windows.
2. Horizontal sliding windows.
 - a. Provide sliding insect screen operating on a special track in window mainframe.
3. Bottom-hinged in-ward awning windows.
 - a. Provide fixed insect screen with special framing

12.2 General Performance Requirements

Provide aluminum windows capable of complying with performance requirements indicated, based on testing manufacturer's windows that are representative of those specified, and that are of minimum test size indicated below.

A Size

Height as indicated on Drawings and width as long as available with manufacturer but not less than 1.20 meters.

B Structural Performance

Provide aluminum windows capable of withstanding the effects of the following loads demonstrated by testing units' representative of those indicated for Project according to test methods specified in this Section:

1. Design Wind Pressure:

Determine wind pressure based on wind load indicated on structural Drawing.

2. Structural Test Pressure

For uniform load structural test is equivalent to 150 percent of the design pressure.

3. Deflection

Design glass framing system to limit lateral deflections of glass edges to less than 1/175 of glass edge length or 19 mm, whichever is less, at design pressure based on testing performed according to test method and pressures specified in this Section.

C Thermal Movements

Provide aluminum windows, including anchorage, that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures:

1. Temperature Change (Range)

± 34 deg C, ambient; ± 50 deg C, material surfaces.

D Air Infiltration

Provide aluminum windows with maximum air leakage through fixed glazing and framing areas of 0.3 L/s per sq. m of fixed wall area when tested according to ASTM E 283 at a minimum static-air-pressure difference of 600 Pa.

E Water Penetration Under Static Pressure

Provide aluminum windows that do not evidence water penetration through fixed glazing and framing areas when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 600 Pa.

12.3 Submittals

A. General

Contractor shall prepare and submit to the approval of Engineer the submittals listed here after in this Article in accordance with requirements of Conditions of the Contract “Submittal Procedures”.

B. Action Submittals

1. Qualification Data

For manufacturer and coating applicator.

2. Product Data:

Include fabrication details, material descriptions, dimensions of individual components and profiles, and finishes for each type of product indicated.

3. Product Schedule For aluminum windows.

Use same designations indicated on Drawings.

4. Shop Drawings For aluminum windows.

- a Include plans, elevations, sections, details, and attachments to other work.
- b Include structural analysis data signed and sealed by manufacturer.
- c Include details of provisions for system expansion and contraction and for draining moisture occurring within the system to the exterior.
- d Include hardware schedule and indicate operating hardware types, functions, quantities, and locations.

5. Fabrication Sample

Of each vertical-to-horizontal intersection of systems, made from 300-mm lengths of full-size components and showing details of the following:

- a Joinery.
- b Anchorage.
- c Expansion provisions.
- d Glazing.

6. Samples for Color Selection

Color Chips of factory-applied color finishes.

7. Samples of each hardware piece to be used

8. Warranty

Draft of warranty certificate or form that be will submitted by manufacturer at time of Substantial Completion.

C. Informational Submittals

- 1. Product Test Reports:** Copies of test reports available with manufacturer performed by a qualified testing agency, for submitted aluminum windows.

2. **Product certificates:** Signed and sealed by manufacturer and coating applicator attesting that aluminum windows provided for the project comply with requirements specified.
3. **Maintenance Data:** For aluminum windows to be included in Project's maintenance manual.

12.4 Quality Assurance

- A. **Compliance Standard**
Provide aluminum windows that are fabricated according to the requirements of BS 4873
- B. **Aluminum Windows Fabricator**
Shall be employing CNC automated aluminum fabrication equipment, holding valid ISO 9001 certification and authorized by windows systems manufacturer to produce his system for not less than 10 years.
- C. **Installer Qualification**
Certified by manufacturer of aluminum system or installation shall be manufacturer's trained experienced staff.
- D. **Qualifications of Aluminum Finish Applicator**
Recommended by Aluminum windows fabricator and holding valid Quail-coat certification.
- E. **Project Meetings**
Conduct meetings on Project site to coordinate the works of aluminum windows with the works of other trades and with the works of other aluminum works manufacturers, where the work is divided between more than one manufacturer or subcontractor.
- F. **Copies**
Furnish copies of all meeting minutes to Engineer's information.

12.5 Project Conditions

- A. **Field Measurements**
Verify dimensions of actual rough openings for aluminum windows by field measurements before fabrication and indicate measurements on Shop Drawings.
- B. **Established Dimensions**
Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating aluminum windows without field measurements.
- C. **Construction Coordination**
Coordinate construction to ensure that actual dimensions correspond to established dimensions.
- D. Where use of sub-frames is necessary to adjust rough opening dimensions and install aluminum windows, provide, at no extra cost to Employer, extruded aluminum sub-frames to adjust rough opening dimensions. Where exposed, match finish of aluminum window and of mill finish where concealed from view.

12.6 Warranty

A. Special Assembly Warranty

Warranty certificate or form prepared, signed and sealed in which manufacturer agrees to repair or replace aluminum windows that fails in materials or workmanship within specified warranty period.

B. Failures

Failures include, but are not limited to, the following:

- a. Structural failures including, but not limited to, excessive deflection.
- b. Noise or vibration caused by thermal movements.
- c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
- d. Adhesive or cohesive sealant failures.
- e. Water leakage through fixed glazing and framing areas.
- f. Failure of operating components to function properly.

C. Warranty Period

Five (5) years from date of Substantial Completion.

D. Special Warranty for Aluminum Finish

As specified “Fluorocarbon - Powder Aluminum Openings Finish”.

E. Special Warranty for Glass: “Glass Glazing”.

12.7 Part 2 - Products

12.7.1 Manufacturers

A. Proposed Manufacturers

Subject to compliance with specifications and other contract requirements, the following manufacturers are proposed for consideration of Contractor as offering products that may be incorporated into the Work.

1. Aluminum Extruders

- a. Cable
- b. Aluminum
- d. Equal and approve unnamed manufacturer.

12.7.2 Materials

A. Aluminum

Alloy and temper recommended by manufacturer for type of use and finish indicated.

1. Sheet and Plate: ASTM B209 / B 209M.
2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221 / B 221M.
3. Welding Rods and Bare Electrodes: AWS A5.10/A5.10M.

12.7.3 Framing Systems

A. Aluminum Extruded Window Profiles, General

1. Design:

Thermal-broken profiles for opening frame of windows and non-thermally-broken for sash or ventilator profiles:

- a. **Thermal Breaks:** High-performance plastic (polyamide) connectors separate aluminum members exposed to the exterior from members exposed to the interior.
 - b. Profiles for opening frame shall overlap wall of installation face, otherwise provide aluminum architraves of matching finish.
 2. **Design:** Non-thermally broken profiles for ventilator or sash.
 3. **Alloy and Temper:** As recommended by aluminum window manufacturer for strength, corrosion resistance, and application of required finish, but not less than strength and corrosion resistance of alloy and temper 6063T5.
 4. **Thickness:** Not less than 2.00-mm thick at any location for the mainframe and sash profiles and not less than 1.00-mm thick for covers, beads and retainers.
 5. **Formation:** Shall include special grooves and channels for housing weather-stripping.
 6. **Width:** Provide medium aluminum profiles 89-mm wide.
 7. **Depth:**
 - a. Main Frame: According to system and as necessary to accommodate components of the aluminum window system
 - b. Sash: According to system and as necessary to accommodate the double insulating glass unit used for the window.
- B. **Fasteners:** Aluminum or hot-dip galvanized steel.
1. **Reinforcement**

Where fasteners screw anchor into aluminum less than 3.00 mm thick, reinforce interior with aluminum or nonmagnetic stainless steel to receive screw threads, or provide standard, noncorrosive, pressed-in, splined grommet nuts.
 2. **Exposed Fasteners**

Unless unavoidable for applying hardware, do not use exposed fasteners. For application of hardware, use fasteners that match finish of member or hardware being fastened, as appropriate.
- C. **Anchors, Clips, and Accessories**

Type 316 stainless steel.

D. **Reinforcing Members**

Aluminum or nonmagnetic stainless steel; provide sufficient strength to with stand design pressure indicated.

E. **Compression-Type Weather Stripping**

Provide compressible weather stripping designed for permanently resilient sealing under bumper or wiper action and for complete concealment when aluminum window is closed.

1. Weather-Stripping: Elastomeric gaskets complying with ASTM C 864.
2. Material: EPDM.

F. **Sliding-Type Weather Stripping**

Provide woven-pile weather stripping of wool pile and resin impregnated backing fabric.

G. **Replaceable Weather Seals**

H. Sealant

For sealants required within fabricated windows, provide permanently elastic, Non-shrinking, and non-migrating type recommended by sealant manufacturer for joint size and movement.

I. Additional Requirements:

1. Provide aluminum profiles that extend to overlay edges of opening jambs, sills and heads and form continuous cover or architraves, otherwise provide set-on architraves.
2. Furnish opening profiles of opened wipe holes to drain rain water to the outside.
3. Furnish all necessary trims and bead profiles.

12.7.4 Glazing

A. Glass and Glazing Materials

1. Glazing unit for each type of aluminum windows is indicated on Drawings.
2. Refer to Section "Glass Glazing" for glass units and glazing requirements applicable to glazed aluminum window units.

B. Glazing System

Manufacturer's standard factory-glazing system as indicated in "Glass Glazing."

C. Bond-Breaker Tape

Manufacturer's standard TFE-fluorocarbon or polyethylene material to which sealants will not develop adhesion.

12.7.5 Insect Screens

A. General

Design windows and hardware to accommodate screens in a tight-fitting, removable arrangement, with a minimum of exposed fasteners and latches. Fabricate insect screens to fully integrate with window frame. Locate screens on outside of window. For sliding windows, provide a special track in main frame for sliding screen to operate on and provide all necessary hardware for each operable exterior sash or ventilator.

B. Aluminum Insect Screen Frames

Manufacturer's standard profiles. Fabricate frames with mitered or coped joints or corner extrusions, concealed fasteners, and removable PVC spline/anchor concealing edge of frame.

1. Extruded-Aluminum or Aluminum Tubular Framing Sections and Cross Braces: Not less than 1.00-mm wall thickness.
2. Finish: Match aluminum window members.

C. Aluminum Wire Fabric

1.1-by-1.3-mm mesh of 0.28-mm- diameter, coated aluminum wire.
Wire-Fabric Finish: Black.

D. Wickets:

Provide hinged wickets, framed and trimmed for a tight fit and for durability during handling.

12.7.6 Hardware

A. General

Provide exposed hardware fabricated from aluminum or stainless steel complying with AAMA 907, or other corrosion-resistant material compatible with aluminum; designed to smoothly operate, tightly close, and securely lock aluminum windows, and sized to accommodate sash or ventilator weight and dimensions. Do not use aluminum in frictional contact with other metals.

Aluminum Hardware: Extruded, cast, or wrought aluminum. Finish of exposed aluminum hardware to match finish of windows.

B. Locks and Latches

Designed to allow unobstructed movement of the sash across adjacent sash in direction indicated and operated from the inside only.

C. Roller Assemblies Low-friction design

Refer to hardware set of sliding windows for other requirements.

D. Limit Devices

Provide limit devices as specified hereafter designed to restrict sash or ventilator opening.

E. Horizontal-Sliding Windows

Provide the following operating hardware

1. Sash Rollers: Stainless-steel, lubricated ball-bearing rollers with nylon tires.
2. Sash Lock: Spring-loaded, snap-type lock at jambs; one per sash.
3. Sash Lock: Spring-loaded plunger lock with keeper on meeting rail; one per sash.
4. Removable Lift-Out Sash: Design windows and provide with tamperproof, key-operated hardware to permit removal of sash from inside for cleaning. Provide keyed alike locks that can be operated with one key.

F. Projected Awning Windows

Provide the following operating hardware:

1. Hinge: 1-pair of aluminum butt hinge of matching finish as windows.
2. Handle: Outward operating handle located at mid of top rail of sash or ventilator.
3. Limit Device: Concealed friction adjustor, adjustable stay bar limit device; located on jamb of each ventilator.

12.7.7 Accessory Materials

A. Joint Sealants

For installation at perimeter of aluminum windows, paintable Acrylic/polyurethane sealants as specified in "Joint Sealants".

B. Isolation Tape

Proprietary prefabricated pressure-sensitive tapes or foam pads specially produced to prevent electrolytic reaction between aluminum and dissimilar metals or cementitious surfaces of opening jambs.

1. Provide tapes that are warranted for not less than 10 years.

12.7.8 Fabrication

A. Fabricate aluminum windows in sizes indicated. Include a complete system for assembling components and anchoring windows.

B. Framing Connections:

1. Pressed connections in hydraulic aluminum forming machines to produce accurate neat connections that are mitered at 45 degrees.
2. Reinforcing Brackets/Connection angles: Prefabricated from an aluminum alloy.
3. Mechanically fasten corners with reinforcing brackets that are deep penetration and fillet welded or that incorporate concealed tie rods.

C. Fabricate aluminum windows that are re-glazable without dismantling sash or ventilator framing.

D. Window Opening Frame (Main Frame): Provide thermal broken frames.

E. Weather Stripping: Provide full-perimeter weather stripping for each operable sash and ventilator.

1. Horizontal-Sliding Windows: Provide operable sash with a double row of sliding weather stripping in horizontal rails and single- or double-row weather stripping in meeting or jamb stiles, as required to meet specified performance requirements. Provide compression-type weather stripping at perimeter of each movable panel where sliding-type weather stripping is not appropriate.

F. Weep Holes: Provide weep holes and internal passages to conduct infiltrating water to exterior.

G. Mullions: Provide mullions and cover plates as shown, matching window units, complete with anchors for support to structure and installation of window units. Allow for erection tolerances and provide for movement of window units due to thermal expansion and building deflections, as indicated. Provide mullions and cover plates capable of withstanding design loads of window units.

H. Factory-Glazed Fabrication: Glaze aluminum windows in the factory where practical and possible for applications indicated. Comply with requirements in "Glass Glazing"

I. Glazing Stops: Provide Snap-On glazing stops coordinated with "Glass Glazing" and glazing system indicated. Provide glazing stops to match sash and ventilator frames.

12.7.9 Aluminum Finish

A Hyper durable fluorocarbon powder coating as specified "Fluorocarbon-powder Aluminum Openings Finish".

12.8 Part 3 - Execution

12.8.1 Examination

- A. Examine openings, substrates, structural support, anchorage, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work. Verify rough opening dimensions, levelness of sill plate, and installation clearances. Examine wall flashings, vapor retarders, water and weather barriers, and other built-in components to ensure a coordinated, weather tight window installation.
 - 1. Masonry Surfaces
 - 2. Visibly dry and free of excess mortar, sand, and other construction Debris.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

12.8.2 Installation

- A. Comply with Drawings, Shop Drawings, and manufacturer's written instructions for installing windows, hardware, accessories, and other components.
- B. Install windows level, plumb, square, true to line, without distortion or impeding thermal movement, anchored securely in place to structural support, and in proper relation to wall flashing and other adjacent construction.
- C. Set sill members in bed of sealant for weather tight construction.
- D. Install windows and components to drain condensation, water penetrating joints, and moisture migrating within windows to the exterior.
- E. Metal Protection: Separate aluminum and other corrodible surfaces from sources of corrosion or electrolytic action at points of contact.
 - 1. Where aluminum will contact dissimilar metals, protect against galvanic action by applying protection tape as specified or installing nonconductive spacers as recommended by manufacturer for this purpose.
 - 2. Where aluminum will contact concrete or masonry, protect against corrosion by applying tape as specified to contact surfaces.
- F. Determine compliance of replaced or additional work with specified requirements.

12.8.3 Adjusting, Cleaning, and Protection

- A. Adjust operating sashes and ventilators, insect screens, hardware, and accessories for a tight fit at contact points and weather stripping for smooth operation and weather tight closure. Lubricate hardware and moving parts.
- B. Clean aluminum surfaces immediately after installing windows. Avoid damaging protective coatings and finishes. Remove excess sealants, glazing materials, dirt, and other substances.
- C. Clean factory-glazed glass immediately after installing windows. Comply with manufacturers written recommendations for final cleaning and maintenance. Remove nonpermanent labels, and clean surfaces.
- D. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.
- E. Protect window surfaces from contact with contaminating substances resulting from Construction operations. In addition, monitor window surfaces adjacent to and below

SECTION 12- ALUMINIUM WINDOWS

exterior concrete and masonry surfaces during construction for presence of dirt, scum, alkaline deposits, stains, or other contaminants. If contaminating substances do contact window surfaces, remove contaminants immediately according to manufacturer's written recommendations.

SECTION 13 - TERMITE CONTROL

13.1 Part 1 - General

- A. Soil treatment with termiticide.

13.1.1 Performance Requirements

- A. **Termiticide Treatment**
Provide termiticide to prevent infestation of termites including, but not limited to, subterranean termites and white ants.
- B. **Service Life of Soil Treatment**
Soil treatment by use of a termiticide that is effective for not less than 10 years against infestation of subterranean termites.

13.1.2 Submittals

- A. **General**
Contractor shall prepare and submit to the approval of Engineer the listed here after in this Article in accordance with requirements of Conditions of the Contract.
- B. **Action Submittals**
1. Qualification data of manufacturer.
 2. Product Data: For termiticide; include copy of EPA label for product used.
 3. Detailed method statement describing the methodology maintained in applying each type of termite control applied under this section.
 4. Soil Treatment Application Report: After application of termiticide is completed, submit report for Employer's record information, including the following:
 - a. Date and time of application.
 - b. Moisture content of soil before application.
 - c. Brand name and manufacturer of termiticide.
 - d. Quantity of undiluted termiticide used.
 - e. Dilutions, methods, volumes, and rates of application used.
 - f. Areas of application.
 - g. Water source for application.
- C. **Warranty**
Draft of special warranty specified in this Section that will be submitted by manufacturer at date of Substantial Completion.
- D. **Informational Submittals**
1. Product Certificates: For termite control products, signed by product manufacturer.
 2. Installer Qualification Data: For Installer of termite control products.
 3. Manufacturer's recommendations that need to be included in maintenance manual.
- E. **Reference Standards and Codes**
1. Provide termite control product that is registered in Environmental Protection Agency (EPA) in United States of America (Registered Label).
 2. Formulation and application according to other equivalent or counterpart registration systems acceptable to Engineer may also be used.

F. **Source Limitations**

Obtain termite control products through one source from a single manufacturer for each product.

13.1.3 Project Conditions

A. **Environmental Limitations**

To ensure penetration, do not treat soil that is water saturated. Do not treat soil while precipitation is occurring. Comply with manufacturer's printed instructions.

B. Post warning signs in areas of application of termite control materials.

13.1.4 Coordination

A. Coordinate soil treatment application with excavating, filling, grading, and concreting operations.

13.1.5 Warranty

A. **Special Warranty**

Manufacturer's standard form, signed by Applicator and Contractor certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites and white ants. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

B. **Warranty Period**

10 years from date of Substantial Completion.

13.1.6 Maintenance Service

A. **Continuing Service**

Beginning at Date of Taking Over by Employer, provide 24 months continuing service including monitoring, inspection, and re-treatment for occurrences of termite activity. Provide a standard continuing service agreement. State services, obligations, conditions, and terms for agreement period; and terms for future renewal options.

13.2 Part 2 - Products

13.2.1 Manufacturers

A. **Proposed Manufacturers and Products**

Subject to compliance with specifications and other Contract requirements, the following manufacturers are proposed for consideration of Contractor as offering products that may be incorporated into the Work.

B. **Termiticides**

Equal and approved unnamed manufacturer.

13.2.2 Soil Treatment

A. Termiticide

Provide an EPA-registered termiticide in an aqueous solution formulated to prevent termite infestation of but not limited to, subterranean termites and white ants.

- B. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label or to other registration system accepted by Engineer during submittal stage.

13.3 Part 3 - Execution

13.3.1 Examination

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for moisture content of soil, interfaces with earthwork, slab and foundation work, landscaping, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

13.3.2 Preparation

A. General

Comply with the most stringent requirements of authorities having jurisdiction in Pakistan and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

B. Soil Treatment Preparation

Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides shall not be applied before placing compacted fill under slabs.

- C. Fit filling hose connected to water source at the site with a backflow preventer.

13.3.3 Applying Soil Treatment

A. Application

Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.

1. Treat soil that will not be saturated with water above water table after stopping of dewatering, at the following locations:

SECTION 13– TERMITE CONTROL

Slabs-on-Grade and Basement Slabs: underground-supported slab construction, including pile caps, footings, building slabs, and attached slabs as an overall treatment.

2. Treat soil materials before concrete footings and slabs are placed.
 3. Foundations: Adjacent soil including soil along the entire inside perimeter of foundation walls, along both sides of interior partition walls, around plumbing pipes and electric conduit penetrating the slab, and around interior column footers; also along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
 4. Crawlspace: Soil under and adjacent to foundations as previously indicated. Treat adjacent areas including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
 5. Masonry: Treat voids.
 6. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.
- B. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- C. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until formed-on ground-slabs or ground-supported slabs are installed. Use waterproof barrier according to EPA Registered Label instructions.
- D. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

SECTION 14 - CAR PARK CURBS AND WALKWAYS

14.1 Part 1 - General

Curbs and walkways to be constructed on top of reinforced concrete slab in car park floors.

1. **Curbs:** Cast-in-place reinforced concrete.
2. **Walkways:** Cast-in-place reinforced concrete.
3. **Finish:** Post-applied colored exposed-based traffic coating, or resinous floor coating.

14.1.1 Submittals

A General

Contractor shall prepare and submit to the approval of Engineer the submittals listed here after in this Article in accordance with requirements of Conditions of the Contract.

B Action Submittals

Unless otherwise submitted and approved under related Sections.

1. Product Data

For each material or product used in the work.

2. Typical Details

- a. For formwork, covering each case of rounds and curvatures.
- b. Typical reinforcement details.
- c. Typical contraction and isolation joint details.
- d. Mix design.

3. Mix Design

Mix design to ensure inclusion of minimum cement content, and fibrous reinforcement.

C Informational Submittals

1. **Mix Design:** Prepared by specialized ready mix supplier.
2. **Method Statement:** Detailing the sequential steps.

14.1.2 Quality Assurance

Mock-up for one walkway with curved curb should be made.

14.2 Part 2 - Products

14.2.1 Formwork

Formwork (Shuttering) is temporary support as a mould for fresh concrete, in which concrete is poured and cast in the desired shape and gain initial strength, hardened and matured. All concrete pours need to be contained, to hold the concrete in place until it hardens sufficiently to hold its own shape.

14.2.2 Reinforcement

Walkways Reinforcement: One layer of steel fabric; 10-mm-diameter deformed steel bars @200 mm in both directions will be used.

Curb Reinforced: 6-mm stirrups @ 200 mm intervals and 4 bars 16-mm diameter; one bar at each corner.

14.2.3 Cast-In-Place Concrete

Cast-in-place concrete is the preferred choice for concrete pavements. The concrete is typically transported to site in an unhardened state, often using a ready mixed concrete truck.

14.2.4 Curing

Dissipative temporary white compound should be used.

14.2.5 Sealant Filled Joints

- A **General:** Shall be detailed and erected as indicated on Drawings “Joint Sealants” and the Standard Specifications referenced there-in.
- B **Joint Filler:** Polyurethane compressible joint filler as specified, Section “Cast-in-Place Concrete” shall be used.
- C **Sealant Joints:** Colored traffic use polysulphide joint sealant as specified in, Section “Joint Sealants”.

14.2.6 Ancillary Materials

- A **Fibrous Reinforcement:**
100% virgin polypropylene, fibrillated fibers containing no Reprocessed olefin materials and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement. Proportion shall be in accordance with the written manufacturer instruction of the manufacturer.
Specific Gravity: 0.91. 2. Tensile strength: 345 - 758 N/mm².
- B **Bonding Agent**
ASTM C1059, acrylic polymer based.
- C Recycled rubber aggregate can be used in curbs and walkways, subject to the approval of the Engineer.

14.2.7 Mix Designs

- A Mixes are to be designed in laboratory.
 - 1. Maximum Aggregate Size: 10 mm.
 - 2. Minimum Cement Content: 280 Kg/m³.
 - 3. Compressive Strength: 300 Kg/m³ after 28 days.
 - 4. Water/Cement Ratio: 0.45, maximum.
 - 5. Synthetic fiber will be added to the mix.
- B One Layer of 10-mm steel fabric reinforced.

14.3 Part 3 - Execution

14.3.1 Execution, General

Execution requirements if each work or trade shall be same as specified in related Specification Section for the work or the trade.

14.3.2 Curbs and Walkways

A Curbs: External edges will be chamfered to details.

B Walkways

1. Embedded curb with chamfer to external edge.
2. Height: 150 mm.
3. Joints at Interface with walls: Sealants filled joints.
4. Exposed surface of walkways shall have steel trowel manual finish, and will be leveled to a maximum tolerance of 2 mm per m of uniform slope, maximum 6.00-mm in each length.

14.3.3 Finish

Colored epoxy-based traffic coating to exposed surfaces.

SECTION 15 - EXPANSION JOINT COVER ASSEMBLIES

15.1 Part 1 - General

This section includes

A Architectural joint systems for expansion joints.

B Prefabricated proprietary movement joint profiles

Prefabricated proprietary movement joint profiles includes within tile and paving floor finishes are not part of the work of this Section and are covered with, Section “Cement-Based Screed” Sections covering tile and paving Sections.

C Definitions

1. **Maximum Joint Width**

Widest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.

2. **Minimum Joint Width**

Narrowest linear gap a joint system tolerates and in which it performs its designed function without damaging its functional capabilities.

3. **Movement Capability**

Value obtained from the difference between widest and narrowest widths of a joint opening typically expressed in numerical values (mm or inches) or a percentage (plus or minus) of nominal value of joint width.

4. **Nominal Joint Width**

The width of the linear opening specified in practice and in which the joint system is installed.

15.1.1 Performance Requirements and Selection Criteria

A Seismic Requirements

Uniform Building Code (UBC), 1997 edition, Zone 2A.

B Selection Criteria for Heavy Traffic Areas Generally including, but not limited to, car parks:

1. **Movement**

Selected model shall have the capability to handle both thermal and seismic movements of the building.

2. **Joint-Gap Size**

Selected model Does shall have the correct dimensions to straddle the designed joint-gap.

3. **Load Capacity**

DIN 1055: Part 3: Loading of Fork Lift Trucks and Standard Vehicles.

4. **Height**

To be coordinated with height of finish flooring.

5. **Selection Criteria Other Areas and Buildings**

Same as specified before in previous two Clauses but considering the extreme loading case for each area and application.

6. Where more than architectural joint systems are selected at the same joint along different floors, the movement capability of different systems and the technique of handling the movement are to be coordinated between different systems.

15.1.2 Submittals

A **General:** Contractor shall prepare and submit to the approval of Engineer the submittals listed here after in this Article in accordance with requirements of Conditions of the Contract and Section “Submittal Procedures”.

B **Action Submittals:**

1. **Manufacturer’s Standard Details:** Sections, details, splices, block-out requirement, and attachments to other work.
2. **Placement Drawings:** Include line diagrams showing plans, entire route of each joint system and elevations. Where joint systems change planes, provide isometric or clearly detailed drawing depicting how components interconnect.
3. **Architectural Joint System Schedule:** Prepared by or under the supervision of the supplier. Include the following information in tabular form:
 - a. Manufacturer and model number for each joint system.
 - b. Joint system location cross-referenced to Drawings.
 - c. Nominal joint width.
 - d. Movement capability.
 - e. Classification as thermal or seismic.
 - f. Materials, colors, and finishes.
 - g. Product options.
 - h. Fire-resistance ratings.
4. **Samples for Initial Selection:** For each type of joint system indicated.
 - a. Include manufacturer's color charts showing the full range of colors and finishes available for each exposed metal and elastomeric seal material.
5. **Samples for Verification:** For each type of architectural joint system indicated.
 - a. Full width by one production length long, for each system required.
6. **Special Warranty:** Sample of manufacturer's special warranty that will be submitted by manufacturer at time of substantial completion.

C **Informational Submittals**

1. **Product Test Reports:** Based on evaluation of comprehensive tests performed by manufacturer for current products.

15.1.3 Quality Assurance

- A **Installer Qualifications:** An employer of workers trained and approved by manufacturer.
- B **Source Limitations:** Obtain architectural joint systems through one source from a single manufacturer.
- C **Product Options:** Drawings indicate size, profiles, and dimensional requirements of Architectural joint systems and are based on the specific systems indicated. Refer to Section "Product Requirements."
1. Do not modify intended aesthetic effects, as judged solely by Engineer, except with Engineer's approval. If modifications are proposed, submit comprehensive explanatory data to Engineer for review.

D Fire-Test-Response Characteristics: Provide architectural joint system and fire-barrier assemblies identical to those of assemblies tested for fire resistance per UL 2079 or E 1966 by a testing and inspecting agency acceptable to Authorities Having Jurisdiction.

1. Floor- to-Floor and Soffit-to-Soffit Assemblies: All assemblies are fire rated.
2. Floor-to-Wall Assemblies: All assemblies are fire rated.
3. Wall-to-Wall Assemblies: Assemblies in fire rated walls are to be fire rated.
4. Fire resistance rating of joint assembly is to be identical to fire rating of the construction to which joint assembly will be installed.

15.1.4 Coordination

On Structural Shop Drawings, Contractor shall be responsible to coordinate and confirm that the joint width or gap indicated on structural shop drawings matches with selected architectural joint system.

15.1.5 Warranty

A Architectural Joint Systems Warranty

Provide manufacturer's standard warranty in which Manufacturer agrees to repair or replace without limitations, all or any part of the architectural joint systems specified in this section which fails or becomes defective in materials or workmanship within specified warranty period.

B All architectural joint systems are guaranteed to be of good material and workmanship and free from defects that render it unserviceable for the use for which it is intended.

C Warranty shall also include:

1. Installation and finishing that may be required due to repair or replacement of defective metal fabrications.
2. Metal, sealants, fasteners, and all other components of architectural joint systems specified in this section.

D Failure includes, but is not limited to:

1. Deterioration in architectural joint systems materials and coatings; other than due to normal ageing and weathering; and any defects in glass, sealants, fixings, coverings and other components of the work.
2. Failure to withstand structural movement.

E Warranty Period: Five years from date of Substantial Completion.

15.2 Part 2 - Products

15.2.1 Materials

A Aluminum: ASTM B 221M, Alloy 6063-T5 for extrusions; ASTM B 209M, Alloy 6061-T6 for sheet and plate.

1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
2. Mill Finish: AA-M10 (Mechanical Finish: As fabricated, unspecified).

B Elastomeric Seals: Preformed elastomeric membranes or extrusions to be installed in metal frames. Provide seals from EPDM or Santoprene.

- C **Compression Seals:** ASTM E 1612; preformed rectangular elastomeric extrusions having internal baffle system and designed to function under compression.
- D **Strip Seals:** ASTM E 1783; preformed elastomeric membrane or tubular extrusions having an internal baffle system and secured in or over a joint by a metal locking rail.
- E **Elastomeric Concrete:** Modified epoxy or polyurethane extended into a prepackaged Aggregate blend, specifically designed for bonding to concrete substrates.
- F **Fire Barriers:** Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint and to meet performance criteria for required rating period.
- G **Moisture Barrier:** Flexible elastomeric material, EPDM, of minimum thickness 0.315 mm or Santoprene of manufacturer's standard thickness.
- H **Accessories:** Manufacturer's standard anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.

15.2.2 Architectural Joint Systems, General

- A **General:** Provide architectural joint systems of design, basic profile, materials, and operation indicated. Provide units with capability to accommodate variations in adjacent surfaces.
 1. Furnish units in longest practicable lengths to minimize field splicing. Install with hairline mitered corners where joint changes direction or abuts other materials.
 2. Include factory-fabricated closure materials and transition pieces, tee-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous joint systems.
 3. Color shall be as selected by Engineer from manufacturer's full range.
- B **Design Architectural** joint systems for the following size and movement characteristics:
 1. Nominal Joint Width: As indicated on Drawings.
 2. Movement Capability: Plus or minus 50 percent ($\pm 50\%$) unless otherwise indicated.
 3. Type of Movement: Thermal.
- C **Water Barrier:** Provide water barriers at exterior joints and where called for on drawings. Provide drainage fittings where required to protect underlying equipment, or apparatus.

15.2.3 Joint Systems, General

- A **General:** Provide Architectural joint systems that satisfy the performances and other technical requirements specified throughout this Section.
- B **Opening Width:** As indicated on Structural Drawings. Contractor shall confirm that the structural width indicated on his submitted shop drawings matches and concurs with movement capability and thicknesses/dimensions of system components in different stages of action.
- C **Height of Joint System:** To be coordinated with height of finish flooring.

- D **Sightline:** Sightline of selected model shall not exceed sightline of the basis of design product. Where no basis of design shown, Contractor shall obtain the written approval of Engineer for sight dimension of each employed joint system.
- E **Joint Frames Material:** Extruded aluminum of mill finish where embedded or concealed and colored baked-on finish where exposed to view.
- F **Joint Capping Material:** Where Architectural joint systems are inclusive of joint caps, joint capping material shall be Type 316 stainless steel. Satin finish No. 6.
- G **Barriers:** Provide separate barriers for fire and moisture.
 - 1. **Fire Barriers**
 - a. All floor-to-floor joint systems shall include fire barriers to provide same fire resistance rating of the fire rated construction within which barrier will be installed (For example floor-to-floor joints within reinforced concrete suspended slabs between floors shall satisfy minimum 2- hour fire resistance rating as the rating of the concrete slab) .
 - b. Provide blanket-type fire barriers.
 - 2. **Moisture Barrier**

Floor-to-floor joints systems and wall-to-wall joint systems within external building skin walls and roof-to-roof joint systems are to be inclusive of moisture barriers as specified.
- H **Architectural Joint System Seal Materials:** EPDM or Santoprene. Provide models that have easy-to-clean, easy-to-install snap-fit flush seals with no dirt traps.
- I **Recessed Joint Systems:** Recessed types/models that allow deferred installation of ceramic tile, marble, stone or thin finishes adhered to screeds designed to be fully integrated seamless floors, walls and suspended ceilings constructions.
- J **Floor-to-Wall Joint Systems:** Floor-to-wall joint systems from same manufacturer of floor-to floor assemblies, same series, configuration, movement capability and finish material.
- K **Ceiling-to-Ceiling Joint System:** To include aluminum framing and vinyl seal of color selected by Engineer. Finish of aluminum is to match finish of exposed ceiling suspension system. Coordinate with suspended ceiling system.
- L **Soffit-to-Soffit Joint Systems:** Compression seal. EPDM seals cast in or Compressed, lubricant adhesive adhered. Applications include, but shall not be limited to, exposed soffit to soffit joints in exposed suspended slabs, beams and the like.

15.3 Part 3 - Execution

15.3.1 Examination

Examine surfaces and block-outs where architectural joint systems will be installed for installation tolerances and other conditions affecting performance of work. Proceed with installation only after unsatisfactory conditions have been corrected.

15.3.2 Preparation

- A Prepare substrates according to architectural joint system manufacturer's written instructions.

- B Repair concrete slabs and block-outs using manufacturers recommended repair grout of compressive strength adequate for anticipated structural loadings.
- C Coordinate and furnish anchorages, setting drawings, and instructions for installing joint systems. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of joint systems.
- D **Cast-in Frames:** Coordinate and furnish frames to be cast into concrete.

15.3.3 Installation

Comply with manufacturer's written instructions for storing, handling, and installing architectural joint assemblies and materials unless more stringent requirements are indicated.

- A **Metal Frames:** Perform cutting, drilling, and fitting required to install joint systems.
 - 1. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
 - 2. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation. Notify Engineer where discrepancies occur that will affect proper joint installation and performance.
 - 3. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
 - 4. Locate in continuous contact with adjacent surfaces.
 - 5. Heavy-Duty Systems: Repair or grout block-out as required for continuous frame support and to bring frame to proper level. Shimming is not allowed.
 - 6. Locate anchors at interval recommended by manufacturer, but not less than 75 mm from each end and not more than 600 mm o.c.
- B **Seals in Metal Frames:** Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Provide in continuous lengths for straight sections.
 - 2. Seal transitions according to manufacturer's written instructions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.
 - 3. Installation: Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- C **Compression Seals:** Apply adhesive or lubricant adhesive as recommended by manufacturer to both frame interfaces before installing compression seals.
- D **Terminate exposed ends of joint assemblies with field- or factory-fabricated termination devices.**
- E **Fire-Resistance-Rated Assemblies:** Coordinate installation of architectural joint assembly materials and associated work so complete assemblies comply with assembly performance requirements.
 - 1. **Fire Barriers:** Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and field splices.

15.3.4 Protection

- A Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.
- B Protect the installation from damage by work of other Sections. Where necessary due to heavy construction traffic, remove and properly store cover plates or seals and install temporary protection over joints. Reinstall cover plates or seals prior to Substantial Completion of the Work.

SECTION 16 - PLUMBING WORKS

16.1 Part 1 -Particular Specifications

This section of the Contract involves the supply, installation, testing and commissioning of the hot and cold water plumbing, firefighting, gas supply sanitary drainage and rain water piping services proposed for the project.

16.1.1 Scope of Work

The work embraced by this Specification covers the supply, delivery on site, installation, testing and commissioning of the plumbing and drainage services, installation of the building in accordance with this Specification. This includes:

- A. Internal and underground sanitary drainage system
- B. Hot and Cold water system
- C. Water Storage tanks, pipe work, fittings and accessories
- D. Internal Natural Gas piping
- E. All external services such as
- F. Water supply system
- G. Sewerage network
- H. Storm water drainage
- I. Natural gas supply
- J. Installation of all sanitary wares and fittings including flush tanks, water closets, urinal, showers, water taps, wash basins and sinks
- K. Electrical equipment and installation work
- L. Acoustic treatment and vibration control
- M. All interfacing work with other trades including electrical, fire alarm/ protection, air-conditioning and mechanical ventilation, etc.
- N. Painting and labeling of pipe work and equipment
- O. Provision of all hold down bolts, spigots and struts required to be built in during construction
- P. Testing and commissioning

16.1.2 System Description- Water Supply System

The Water supply system shall as follows.

16.1.2.1 External

The contractor shall connect to the main water supply, install a main loop, provide connections to the building, all necessary valves with chambers fittings and other accessories as may be required to maintain a fully functional, balanced system.

16.1.2.2 Internal

A fully functional system, underground and overhead water tanks, water supply pumps, complete piping, fittings, valves and other accessories shall be provided.

A fully operational system shall be provided for the whole block, complete with pumps, tanks, pipe works, controls, conduits, wiring etc. in full compliance with all relevant specifications and requirements.

This shall consist of but not limited to the following:

1. Cold water supply system
2. Connection from water main loop running near the building to underground tank. This shall be deemed to include all necessary valves and fittings. The water tanks shall be complete with the following items;
3. High and low level alarms
4. Water level indicator
5. Vent pipe, overflow, drain off, access manhole, all required valve, etc.
6. Supply and installation of water supply pumps and pump rooms to supply water from underground to overhead tanks.
7. Complete hot and cold water pipe work with taps and relevant sanitary fixtures and fittings at toilets/ kitchens etc. as indicated in the drawings.
8. Water supply piping from overhead tank to all floors including all accessories as a part of gravity feed system.
9. Providing, fixing, jointing and testing Polypropylene Random (PPR) pipes make "Popular" or approved equivalent pressure pipe for cold water as per DIN 8077-8078 for pipes and DIN 16962, PN25 for fittings (polyfusion welded joints) inside building including fittings and specials (sockets, tees, elbows, bends, crosses, reducers, adaptor, plugs and union etc.) supported on walls or suspended from roof slab or run in channels including pipe hangers, supports, cutting and making good the holes, complete in all respects.
10. Standard Sizes: 1/2", 3/4", 1"

16.1.3 Sanitary and Water Drainage Systems

The Contractor shall supply and install the complete sanitary plumbing system. This shall be deemed to include all fittings, sanitary fixture, fittings and accessories etc. The conceptual design of the system is stated as follows:

Sewage and waste water system shall be double stack and waste water from toilets and kitchens will be discharged by gravity to ground floor from where that will eventually be connected to the inspection chambers (manholes) outside the building.

Connection of last inspection chamber(s) to main sewer network running near the building. This shall be made by the Contractor with the consent and approval of the engineer in charge.

Providing, fixing, cutting, jointing and testing (unplasticized) uPVC piping conforming to ISO 3633:1991 (wall thickness=3.2 mm) including uPVC fittings with solvent cement jointing, make "Popular Type B" or approved equal, clamping to walls and ceiling, hangers, supports, cutting through walls and providing sleeves through concrete slabs for pipelines and pipe fittings of the required diameter:

Standard Sizes: 2", 3", 4"

High Density Polyethylene (HD/PE)

Pipes for Water Supply 1/2"-24" dia

16.1.3.1 Schedule of Materials and Equipment

The following schedule consists of the relevant materials and equipment necessary for the completion of all sanitary and plumbing works.

16.1.3.2 Water Supply System

Following are the common types of overhead and underground tanks for water storages:

1. PVC Water Storage Tanks
2. Brick Water Storage Tanks
3. RCC Water Storage Tanks

Following are the common types of Pipes

1. Polyethylene pipes for supply to under and overhead tanks.
2. Polyethylene pipes complying ISO 4427:1996 & DIN 8074, 8075.
3. PPRC (Polypropylene Random Copolymer Type III tubing to DIN 8077, 8078 BSS 4991 & 5174 (for water supply to toilets/kitchen).

16.1.3.3 Soil and Waste Drainage

1. UPVC complying BS 5255/4514 (Soil, Waste, and vents).
2. RCC pipes complying with ASTM C60.

16.1.3.4 Storm Water Drainage

UPVC class B complying with BS 5255/4514

16.1.3.5 Gas Supply System

Galvanized iron (G.I) pipes

16.1.3.6 Pumps and Valves

1. Bronze bodies and trim, screwed connection up to 50mm dia.
2. Cast iron or cast steel bodies, bronze trim, flanged connections for greater than 50mm dia.
3. Non-slam type check valves at discharge side of water supply pumps.
4. Submersible centrifugal pump sets for water supply from underground to overhead tank.

16.1.3.7 Floor Traps/Floor Gully, Gully Traps Concrete Sump & Chamber Covers

1. UPVC bodies with stainless steel grating
2. Cast iron body and frame.

16.2 Part 2 - Underground and Drainage System.

16.2.1 General

The work includes the supply and installation of the whole of the entire underground sanitary drainage system including inspection chamber, concrete sumps, gully traps, grease interceptors, drain lines, all frames and covers, excavation. Concreting, piling, backfilling, re- installment of existing ground surfaces, and connections to the last manhole, all internal components of inspection chambers and sumps shall also be included.

16.2.2 Installation

16.2.2.1 Excavation

All excavation shall be carried out as necessary for the construction of the works. Excavation for pipe trenches shall not be less than 600mm wider than the diameter of the pipes and the ground near beds shall be carefully graded.

All excavation shall be kept free from water at all times by pumping or temporary drainage. In the event of the excavations being made deeper than necessary they shall be filled to the proper level with lean concrete.

16.2.2.2 Backfilling

All concrete shall be thoroughly set before refilling is commenced. In backfilling the excavation, only selected hard dry material free from lumps exceeding 75mm in size and from stones shall be used in the initial refilling and shall be carefully placed next to the permanent work and well packed and well rammed in layers of 150mm. The remainder of the excavations shall be filled in with the excavated material, in layers of not more than 300mm deep. Each layer shall be thoroughly rammed before the next layer is placed. Surplus soil shall be piled on top of the filling to the extent of possible subsidence. All refilled trenches shall be maintained to the satisfaction of the Engineer.

16.2.2.3 Pipeline Setting Out

Excavation for trenches shall be to straight lines and gradients required for the pipes and beds as specified. The trench bottom shall be of sufficient width to allow adequate working space for pipe layers and jointers but beyond these requirements, the width must be kept to a minimum.

16.2.2.4 Concreting Works

All Concreting works shall comply with specification of concrete given for Structural works.

All drain lines passing under buildings and driveways are to be surrounded with concrete which shall be carried up from the bed in a square section with a minimum of 150mm thickness over the barrel of the pipes. Traps and gullies shall be properly bedded on and surround with concrete.

16.2.3 Pipe Gradient

Pipe gradient for all sanitary drain lines and waste pipes shall be as shown on the drawings or otherwise indicated below:

Pipes Diameter	Gradient
100 mm (4")	1 in 20 to 1 in 60
150 mm (6")	1 in 30 to 1 in 90
225 mm (9")	1 in 40 to 1 in 150
300 mm (12") & above	1 in 150 to 1 in 250

16.2.4 Pipe Laying

The pipe shall be laid singly with the whole length of the barrel of each pipe on a solid concrete bed. No pipes shall be joined together before having been laid.

Flexible jointed pipes shall be laid completely embedded in granular material to a thickness of at least 100mm all around unless soil conditions and loads are indicated otherwise. Granular material for bedding shall be of such ranging from 3mm to 12mm or of free running coarse sand.

Socket shall face up the gradient. The spigot of each pipe shall be well driven home into the socket of the pipe previously laid and the joint completed as specified and the barrel of the pipe cleared of any obstruction before the next pipe is laid. Care shall be taken that there is no irregularity in the invert of the joints.

The level of each pipe shall be tested by a straight edge laid in the invert of the pipe previously laid and in the nearest level peg. If the bottom of the trench has been taken too low, it shall be made up with concrete or cement mortar or other approved granular material.

Pipes of 300mm/225mm diameter where shown laid through or under walls, shall be protected by means of sleeves in such a manner that the weight of the wall shall not bear on the pipes.

16.2.5 Inspection Chambers (Manhole)

The maximum distance between inspection chambers shall not be more than 100ft. inspection chambers shall be of concrete construction with suitable C.I. cover.

16.2.6 Concrete Sumps

Unless otherwise shown on drawings, concrete sumps shall have minimum internal dimension of 900mm in length and 700mm in width.

16.2.7 Pipe Sleeves

Pipe sleeves of an approved type shall be provided at all locations where pipe pass through wall, beams, floors. Where sleeves or piping pass through reinforced concrete walls below the water table, puddle flange shall be provided.

16.2.8 Tests

16.2.8.1 Pipe Work

Pipe work shall be hydrostatically tested to a water head of 1.2m at the high end and not more than 3.0m at the low end shall show no appreciable loss of water after elapse of four hours. Backfilling shall not commence until testing has been conducted to the satisfaction of the Engineer.

16.2.8.2 Manholes and Inspection Chamber

All manhole and inspection chambers shall be tested for water tightness by filling with water and observing for any drop in water level over a period of at least 4 hours.

16.2.8.3 Flow Test

Appropriate flow test shall be carried out to verify gradient of the underground pipe installed.

16.3 Part 3 - Internal Sanitary System

16.3.1 Piping Installation

16.6.2.1 Pipe Support

All pipe work shall be fixed at least 50mm away from the finished surface of the supporting structure. All fixing, hangers, holder bats, brackets, etc, shall be of mild steel and shall be given the same finish as the piping.

Vertical pipes shall be parallel to walls or column lines and shall be straight and plumb. Horizontal pipes shall be graded in the direction of flow as required.

Soil, waste or vent pipes shall be clamped or fixed at 1.8m centers split ring or clevis type hangers and clamps.

16.6.2.2 Vent Pipe and Stack

When more than one trap is connected to a discharge pipe or stack, each trap shall be provided with a vent pipe of not less than 50mm in diameter.

Each vent pipe shall be constructed upwards individually or be connected to a main vent stack. The top end of the vent pipe or main vent stack shall either terminate as high as the discharge stack or connect to the discharge stack at a point not less than 150mm above the top of the highest soil sanitary appliance or floor trap.

16.6.2.3 Termination of Discharge, Stack and Vent Stacks.

The top end of each discharge or vent stack shall project not less than 450mm above the eaves of a sloping roof or 150mm above a flat roof without a parapet, or in the case of a flat roof with a parapet to the height of parapet above the roof. If the roof is used for any purpose other than as a covering to the building, the discharge or vent stack shall be extended at least 2.5m above the roof level.

16.6.2.4 Cleaning Eyes and Inspection Openings

Inspection and cleaning eyes shall be provided on soil, waste or soil and waste pipes so as to provide access for the proper inspection and cleaning of the entire length of the pipe. In all cases where the vertical stack of soil or soil and waste pipe extends 1.2m or more above the ground level, an inspection opening of 200mm in length and 75mm width fitted with a cover fixed to a flange with bolts and nuts shall be provided near the foot of the stack.

16.3.2 Pipes Gradient

Pipe gradient for all horizontal sanitary plumbing piping shall be as shown on the drawings or otherwise as indicated in the Table below:

PIPE DIAMETER GRADIENT	
Diameter	Gradient
32mm to 80mm	1:40
110mm	1:60
160mm	1:80
200 and above	1:100

All vent pipes shall have a minimum gradient of 1:100

16.3.3 Pipe Size

Pipe sizes for all horizontal sanitary and waste piping shall be as shown on drawings or otherwise as indicated below.

CONNECTION PIPE SIZE	
Floor drain to floor drain 110 mm	(WC Compartment)
75mm	(Shower)
Floor drain to floor trap 75mm	(WC Compartment)
75mm	(Shower)
75mm (15m maximum)	Planter to discharge pipe
110 mm	(30m maximum)
160 mm	(over 30m)

16.3.4 Traps

All inlets into a discharge pipe or discharge stack shall be properly trapped to prevent the entry of foul air from the drainage system into the building.

16.3.5 Grating and Cover for Floor Trap and Waste

The grating and cover shall be constructed of stainless steel or bronze to the approval of the Engineer.

16.4 Part 4 - Installation of Sanitary Appliances

16.4.1 Water Closet

Joints between spigot cast iron pipe and fixture outlets shall be made with yarn and cement/ sand mortar not stronger than 1:2 and not weaker than 1:3 joints between un plasticized PVC pipes and fixture shall be made with approved rubber seal ring joints. The water closets shall be firmly bedded in cement mortar. Every pedestal water closet pan shall be secured to the floor using stainless steel or nonferrous screws. The joining of the outlet of the water closet pan to the branch drain-line or discharge pipe shall be made by an approved type pan collar.

16.4.2 Flushing Cisterns

Flushing cisterns shall be firmly fixed to the wall by means of either bolts and nuts or brackets. The flush pipe connecting a flushing cistern to a water closet shall be fixed as straight as possible and shall not be less than 32mm in diameter if the bottom of the cistern is fixed 1.5mm or more above the top of the water closet. The flush pipe shall not be less than 38mm in diameter if the bottom of the cistern is fixed less than 1.5mm above the top of the water closet. Flush pipes from the cistern to a squat pan shall be securely fixed to the wall. The Contractor shall apply a 12mm chromium plated stopcock for each flushing cistern.

16.4.3 Bath Tub

The bath tub shall be bound to the earthing system of the building. A separate floor waste shall be installed below the bath tub. Access opening shall be provided to reach the underside of bath for maintenance.

16.4.4 Shower Mixer

Where shower mixer is of concealed type, pipe union shall be provided to allow for connection to shower hose.

16.4.5 Waste Sanitary Appliances

Every waste sanitary appliance which is suspended shall be fixed to the wall by means of brackets which are built or screwed into the wall. Every floor mounted waste sanitary appliance shall be provided with pedestal, foot and leg. Any sink and wash basin may be mounted on a cabinet or mounted on wall. Refer to architectural drawings for detail. All fixing screwed shall be corrosion resistant. All joints between any waste sanitary appliance and the abutting wall shall be water-tight.

Every waste sanitary appliance shall be provided with a waste filling trap for connection to the waste pipe. The waste pipe shall connect to the floor trap above the water seal of the trap.

Where a group of 3 or more wash basins are connected in series, loop venting is required. However, the loop venting shall be terminated separately to the atmosphere. The minimum diameter of shall be 25mm. The Minimum Internal Diameter of Waste Pipe for each type of Sanitary Appliance is shown in the Table below.

Type of Appliance	Minimum Internal Diameter of Waste Pipe (mm)
Wash Basin	32
Sink (Single or double bowl)	40
Laboratory sink	40
Long bath/Shower Tray	40
Foot Bath	40
Wash Tub	50
Wash Trough/Custom-Made Sink	50
Drinking Fountain	50

Minimum number of waste sanitary appliance allowed on each diameter of common waste pipe for waste sanitary appliances connected in series is shown in the Table below.

Type of waste sanitary appliances connected in series	Minimum number of waste sanitary appliances allowed on common waste
Wash basin	3
Sink (Single or double bowl)	2
Laboratory Sink	2
Drinking Fountain	12
Wash Trough/Custom-Made Sink	2
Wash Tub	2

16.4.6 Grab Bars:

Grab Bar posts and bars will be stainless steel. Grab bars purchased or installed shall meet or exceed the applicable requirements of ANSI A117.1, ASTM F446, CSA B45 and CSA B651 standards.

The installed bars should be capable of withstanding the minimum of 500 lbs. 12” long grab bars would be used for vertical installation only.

The screws of grab bars should be mounted into the wood stud, each at least 16” apart for safe installation. A minimum of 1/8” hole is would be drilled for screws. Silicon Caulk will be used to protect water penetration.

16.4.7 Surgical Scrub sinks

Surgical Scrub Sinks installed will be 16 gauge stainless steel construction. They will include 4”-high backsplash, squared front and sides, will have removable access panel, temperature mixing valve, and electronic-eye faucet including flat strainer, with p-trap and tail piece. The standard model features will include deck-mount faucet and ADA-compliant model features splash mount.

16.4.8 Shower Seat

Fold down Shower Seat will be made of Aluminum and Teak Wood. The seats would be capable of bearing at least weight of 400 lbs.

4.9 Plumbing Fittings and Accessories

The contractor shall supply and fix all plumbing fittings such as water faucets, shower fittings, mixing valves, etc, in accordance with manufacturer’s instructions and connect to piping system. The contractor shall supply all fixing materials such as screws, rawl plugs, union, collars, compression fittings, etc. as required.

16.5 Part 5 -Cold and Hot Water Supply

16.5.1 General

A complete cold & hot water supply system shall be supplied and installed in accordance with the drawings and the requirements described hereunder.

SECTION 16– PLUMBING WORKS

The Contractor shall be solely responsible for the satisfactory performance of the whole water circulation system.

16.5.2 Water Service Connection

The Licensed Plumber shall apply for and make all necessary arrangements/inspections with the Local Authorities for the water connection.

16.5.3 Piping Materials

All piping materials shall be of type/brands found in the list of approved fittings and pipes for water service installation. Refer to “Pipe work materials” for water supply piping.

16.5.4 Piping Joints

Pipe joints for the pipes shall be as follows.

PPR-C Piping	Heat Fusion Welding as per manufacturer’s recommendations
--------------	---

16.5.5 Pipe Supports

16.5.5.1 Pipe work and fittings shall be supported by hangers or brackets so as to permit free expansion and contraction. Risers shall be supported at each floor with mild steel clamps. Where necessary to permit free movement for common group they shall be supported from a common hanger bar fabricated from mild steel sections.

16.5.5.2 Underground water mains shall be supported on continuous concrete benching and thrust blocks.

16.5.5.3 Pipe hangers shall be provided at the following maximum spacing and as per manufacture’s recommendations.

Pipe Dia	Hanger Rod Dia	Copper Pipe Max Spacing	Steel Pipe Max Spacing
mm	mm	m	m
Up to 25	6	2	2
32 to 50	10	2.5	2.7
80 to 100	12	2.5	2.7
125 to 150	16	3	3.6
200 to 300	19	3.6	5.3

Pipe Dia	Hanger Rod Dia	PPR-C Max Spacing	UPVC Class D&E Pipe Max Spacing
mm	mm	m	m
20	6	0.70	0.8
25	6	0.80	0.85
32	10	0.90	0.90
40	10	1.05	1.07
50	10	1.15	1.15
63	12	1.30	1.30

16.5.6 Testing of Main

Before the main is concealed, it shall be tested for leak to twice its normal working pressure or 690 Kpa, whichever is higher.

16.5.7 Sterilization of Main

After the pipe work has been tested and approved, but before it is coupled, it shall be sterilized with a solution of chloride of lime.

16.5.8 Valves

All valves shall be suitable for the working pressure involved but not less than 1MPa. Valves up to 50 mm diameter shall have bronze bodies and trim with screwed connections. Valves greater than 50 mm diameter and above shall have cast iron or cast steel bodies, bronze trim with flanged connections. Information on the Types of Valves is provided in the Table below.

Stop Valves	Stop valves shall be gate valves with non-rising stems, renewable seats and cast iron or plastic hand wheel
Stop Cocks	Stop cocks shall be chromium plated with renewable rubber disc seats to British Standard. A stop cock shall be provided to each water outlet point like basin, water cistern, bath tub and sinks.
Strainers	Strainers shall be Y-type with removable stainless steel basket.
Check Valve	Check valve up to 50mm shall comply with BS 1953 Class 125 or 5154 (M). Check valve above 50mm shall comply with BS 4090 Class 125 or BS 5153 (M)

16.5.9 Schedule of Valves

The contractor shall supply and install all valves to all fixtures as specified below.

WC Pan	25mm ball valve, similar to Ballo fix, with suitable 25mm union piece for connection to flush valve or 12mm union piece for connection to cistern.
Basin/sink	Ball valve of size to suit distribution pipe for multi-basin arrangement and 12mm ball valve for single-basin arrangement.
Kitchen	Ball valve of size to suit each branch pipe.

16.5.10 Trap

All taps for the garden, planters and in each plant rooms shall be of the brass type.

Using otherwise mentioned all taps for sinks in kitchen, utilities rooms shall be or chrome plated type.

16.5.11 Testing of Pipelines

All cold and hot water supply pipe work shall be subjected to a hydrostatically test pressure of 12 bar or 1-1/2 times the maximum working pressure, whichever is greater. The test period shall be two (2) hours during which no leakage is allowed.

16.5.12 Pipe Insulation (sound proofing)

The sound insulation of soil, waste, sanitary drainage and water pipes shall be from Armawave 2540 acoustic lagging or equivalent, manufactured with an acoustic isolation foam and a mass barrier to a total weight of not less than 5kg/m².

The insulation should comply DIN insulation standards. Where pipes are located in a wall or floor cavity, serves or passes through more than one sole-occupancy unit, the sound insulation should achieve an (airborne) of not less than 25 dB if the adjacent room is a kitchen or non-habitable room. If the adjacent room is a habitable room, the sound insulation shall achieve an (airborne) of not less than 40 dB.

The acoustic insulation shall be fiber-free and dust-free. It should be tested to AS1530.3 to show compliance with the fire performance requirements. The acoustic insulation shall be installed according to the manufacturer's specifications. It should be cut to size to neatly fit all pipe work, and incorporate overlaps on all joints. All joints shall be secured with an appropriate foil tape.

16.6 Part 6 - Pipe Work and Fitting

16.6.1 General

The word 'pipe work' or 'piping' shall mean all pipes, drains, tubes, pipe fittings, valves including hangers, brackets, anchors, expansion devices, sleeves, and all accessories connected there to for the complete piping installation.

Pipelines accessories such as gauges, meters, control devices, etc., shall have the same working pressure rating as the associated pipe work.

All pipes and fittings supplied shall conform to relevant codes as specified in these specifications.

Prior to any ordering or installation, the Contractor shall furnish the following information for endorsement.

- A Manufacturer for all pipes and fittings
- B Specification and standards for all pipes and fittings:

16.6.2 Pipe Joints

16.6.2.1 Different materials Joint

For UN plasticized PVC pipes, all joints shall be solvent weld/push fit joints made in accordance with manufacturer's recommendations and as per Clause 3 of this

section and to the approval of the Engineer. Joints shall be made with proper pipe fitting to BS 4346 and heating of for jointing shall not be permitted.

Joints between unplasticized PVC pipes and cast iron pipes shall be made with an approved jointing ring.

16.6.2.2 Weld Joints on UPVC Pipes

Work un-plasticized PVC pipe work shall be solvent or push fit ring jointed as recommended by the manufacturers and as detailed elsewhere in this Specification.

Where solvent welding is used, particular attention must be paid to preparation a abrasive paper and spirit cleaner must be used. When applying solvent, heat shall be avoided in order to prevent the cement drying before the chemical bond between the two surfaces is completed. Mating surfaces shall be turned for even spread of the solvent. Excessive cement shall be wiped off quickly.

16.6.3 Pipe Supports

Piping shall be supported from the building structure which shall support the sum of the load of a water-filled pipe and a minimum of 120 kg applied at the point of hanging. Vertical pipe work shall be supported at intervals of at least on per floor level.

Horizontal pipe work shall be supported by adjustable flat iron or clevis type hangers hung by hot rolled steel rods of the following diameters and spacing, and as per recommendations of pipe manufactures. For different diameters pipes, the distance between the supports and the diameter of the rod is shown below in the Table.

NORMAL PIPE	DISTANCE BETWEEN SUPPORTS	DIAMETER OF ROD
25 mm	1.8m	10
32 mm	2.4m	10
40 mm	2.7m	10
50 mm	2.7m	10
65-80 mm	3.0m	12
110 mm	3.0m	16
160-200 mm	3.6m	18

16.6.4 Pipe Sleeves

Pipe sleeves shall be provided and installed by the Contractor for casting in where pipes penetrate the concrete structure.

The minimum clearance between the pipe and pipe sleeve shall not be less than 25mm.

Sleeves through fire rated partitions or walls or floor shall be of galvanized wrought iron pipe. The annular space of pipe sleeves shall be tightly packed with approved fire-rated material.

Where sleeves occur in finished spaces, solid close fitted chrome plated steel plates secured by screws shall be provided.

16.6.5 Pipe Work installation

All pipe work shall be installed to meet structural, architectural, and functional conditions and shall not interfere with the work of other trades.

All pipe work shall be installed and supported so that it is free from excessive stresses due to weight from its contents plus its own dead weight, dynamic forces due to liquid movement, and expansion and contraction due to change in temperature.

Pipe work connected to the pumps shall be separately supported so as not to impose any load on the pump casings.

16.6.6 Valves

16.6.6.1 General

All valves shall be of approved manufacture complying with the appropriate British Standard and approved for the working pressure involved.

Valves shall be so installed as to be readily accessible for testing and maintenance. Valves shall close in less than 5 seconds when operated at maximum possible speed from fully open position.

Test cocks shall be provided at all locations shown on the drawing and the following locations

- a) 15mm diameter cock with hose bib attachment downstream of each flow switch.
- b) All valves in each instance shall be suitable in all respects for the class of service and function.
- c) All valves for all functions shall be identified by means of a tag or label which shall clearly indicate the following;
 - a. Service.
 - b. Valve number.

16.6.6.2 Isolation Valves (Gate Valve)

Up to 50mm: Bronze gate to BS 5154 series 'B', non-rising stem, solid wedge disc, inside screw, union bonnet; female threaded (BS 21) connection; fitted with enameled metal and hand wheel valves for working pressure above 16 bars shall be to BS 5154 PN 32 series B

65 mm and above: Cast iron body to BS 5150, bolted bonnet; solid wedge disc and bronze trim; inside screw, non-rising stem, flange connection (PN 16), fitted with cast iron hand wheel valves for working pressure above 16 bars shall be of Class 300 cast steel wedge gate valve with flanges to PN 25.

16.6.6.3 Check Valves

For valve size 65mm diameter and above, Provide silent check valves of the non-slam, center-guided globe type. Valves shall be so designed such that closing action is controlled by spring to return disc to seat before zero velocity and before reversal of flow takes place in pipe line. Valves shall be provided with flanges to PN 16 and

PN 25 (for valves with working pressure above 16 bars). Additional check items are listed below.

- A Discs shall be free floating, center-guided and controlled by velocity of flow without aid of grease or counter weight balance.
- B Check valves shall be designed to prevent grinding of seat and disc after assembly, with removable cap for inspection of bearings and disc movement.
- C Valves shall be flanged (PN 16) cast iron body, 316 stainless steel trim, spring and disc.
- D Swing check valve to BS 5154 series 'B' bronze with removable hinge pin and screwed cap, suitable for operation in either horizontal or vertical position. Threaded (BS 21) connection for 50mm and smaller. Flanged (PN 16) connection for valves above 50mm. for valves above 16 bar working pressure. It shall be of class 300 cast carbon steel swing check valve with PN 25 flanges.

16.6.6.4 Pressure Reducing Valve Set

Each pressure reducing valve set shall be complete with pressure reducing or pressure regulation valve, isolating valves, pressure gauges on inlet and outlet, pressure relief valves and filter on inlet.

Each pressure reducing valve shall contain loading neoprene diaphragm and a full floating, self-aligning, ignition resistant seat and shall be of the single stage, pressure reduction type with provision for manual operation.

Valves shall be capable of operation and maintaining automatically the respective delivery pressure and flow rates as indicated and shall not be liable to creep. Valves shall also be capable of maintaining the pre-set downstream pressure under static condition.

The filter on each inlet to a pressure reducing valve shall be of replaceable porous sintered metal type.

16.6.6.5 Pressure Relief Valves

- a Each pressure relief valve shall be of the fully enclosed type and fitted with hand easing gear.
- b Each pressure relief valve in a pressure reducing station shall give a flow capacity equal to that of the pressure reducing valve.
- c Pressure relief valves in locations other than reducing station shall have a flow capacity equal to that of the pressure reducing valve.
- d Pressure relief valves in locations other than reducing stations shall flow capacities equal to that of the associated equipment.

16.6.6.6 Globe Valves

- a Up to and including 50mm size shall be of bronze globe type with inside screw, stuffing box and screw end connections.
- b 65mm size and above shall be of cast iron ductile iron body for PN 16 and PN 25 respectively, with outside screw and yoker type. Flanged end connections to BS 4504.
- c Globe valves shall have re-grinding renewable disc and seat ring, bronze trimmed non-rising stem.

16.6.6.7 Ball (Float) Valves

Equilibrium type to BS 1212: Part 1. Foam plastic ball float with stainless steel rod and double lock nuts or copper ball float complete with brass rod. The valve shall be made of cast iron or bronze body and suitable for minimum working pressure of PN 16. Screwed joints shall be provided for up to 65mm diameter and flanged joints for 80mm diameter and above. Locking device to be provided, so that the valve can only be opened when the water level drop to a pre-determined level.

16.6.6.8 Automatic Air Vent (Air Relief Valve)

Provide automatic air vent at all high points, whether shown on the drawings or not. Automatic air vent shall be of float type. Drain pipe shall be provided and terminated at nearest floor drain or waste.

16.6.6.9 Strainers

- a. Strainers shall be installed on all system and equipment susceptible to damage from dirt, grit or foreign matter including, but not limited to pumps, control valves and where required and indicated.
- b. Strainer shall be Y –pattern bucket type of not less than full line size. Unit shall be constructed of cast iron or copper alloy body with stainless steel screen of perforations. The total perforation area shall not be less than twice the cross sectional area of the pump suction pipe. Strainer with working pressure above 16 bars shall be of cast steel type.
- c. Size up to 50mm, screwed connection shall be used whilst flanged joints (PN 16) shall be used. For 65mm and upward flanged shall be used up to PN 25. For valves with working pressure above 16 bars, drain cocks shall be provided.
- d. Size 15 – 50mm
- e. Y –type strainers with screwed cover, 18/8 stainless steel screen, 26 swg with 0.8mm perforation. Ends screwed BS 21 taper thread.
Service Rating: 10oC to 100oC
10.5 bar 186 deg C sat steam. Size 65 – 150
- f. Y –type single basket strainer. 20 mesh stainless steel screen, cover. Flanged and drilled to BS 5404. Size 200mm and above
- g. Bucker type strainers, 40 mesh stainless steel screen, bolted cover. Flanged and drilled to BS 5404.

16.6.6.10 Pressure Gauges

Pressure gauges shall conform to BS 5180 – “Bourdon tube pressure and vacuum gauges”. The maximum scale value of the gauge shall be about 150% of the anticipated maximum operating pressure. It shall be graduated both in imperial units (psi) and metric units (Kpa).

Provisions shall be installed to enable each pressure gauge to be easily removed without interruption to the installation.

16.6.6.11 Connector (Pipe Line Vibration Eliminator)

Flexible connectors shall be provided to prevent vibration from all rotating equipment. Flexible connectors shall be located as close to the rotating equipment as practical.

16.6.6.12 Water Level Controllers

Water level controllers shall be provided and fitted in all water tanks for monitoring the water levels in the water tanks and give the appropriate control/warning signals for the system. Water level controllers shall be of the float less type using water-proof sensing electrodes with controller containing the switching circuits and control relays, suitable for conductive liquids like water and dilute acidic fluid. It shall be used to automatically operate sequential pump sets and give low and high level alarms. However, provisions shall also be provided for manual override to enable manual operation of pump sets.

Sensing electrodes and the controller shall be suitable for operation temperature of up to 55°C.

16.7 Part 7 - Pipe Work and Fitting – Fire Fighting

16.7.1 General

- a The word ‘pipe work’ or ‘firefighting’ shall mean all pipes, drains, tubes, pipe fittings, valves including hangers, brackets, anchors, expansion devices, sleeves, and all accessories connected there to for the complete piping installation.
- b The Building is provided with wet fire fighting hose reel cabinets and sprinklers.
- c Pipelines accessories such as gauges, meters, control devices, etc., shall have the same working pressure rating as the associated pipe work.
- d All pipes and fittings supplied shall conform to relevant National Fire Protection Association (NFPA) codes.
- e Prior to any ordering or installation, the Contractor shall furnish the following information for endorsement.
 1. Manufacturer for all pipes and fittings
 2. Specification and standards for all pipes and fittings
 3. Technical submittals for Sprinklers and Fire Fighting Pump set

16.7.2 Pipe Materials

16.7.2.1 Material

All pipes shall be Seamless Mild Steel Schedule 40

16.7.3 Pipe Joints for ¾” dia upto 1-1/2” dia

Threaded fittings

16.7.4 Pipe Joints for 2” dia and above

Welded fittings

16.7.5 Pipe Supports

Piping shall be supported from the building structure which shall support the sum of the load of a water-filled pipe and a minimum of 120 kg applied at the point of hanging.

Vertical pipe work shall be supported at intervals of at least on per floor level.

Horizontal pipe work shall be supported by adjustable flat iron or clevis type hangers hung by hot rolled steel rods of the following diameters and spacing, and as per recommendations of pipe manufactures. Information about the Nominal pipe diameters, distance between the supports and the diameter of rod is shown below in the Table.

NOMINAL PIPE	DISTANCE BETWEEN SUPPORTS	DIAMETER OF ROD
18mm (3/4")	1.8m	10
25mm (1")	2.4m	10
32mm (1-1/2")	2.7m	10
50mm (2")	2.7m	10
63-75mm (2-1/2" to 3")	3.0m	12
100mm (4")	3.0m	16
150-200mm (6" - 8")	3.6m	18

16.7.6 Pipe Sleeves

- Pipe sleeves shall be provided and installed by the Contractor for casting in where pipes penetrate the concrete structure.
- The minimum clearance between the pipe and pipe sleeve shall not be less than 25mm.
- Sleeves through fire rated partitions or walls or floor shall be of galvanized wrought iron pipe. The annular space of pipe sleeves shall be tightly packed with approved fire-rated material.
- Where sleeves occur in finished spaces, solid close fitted chrome plated steel plates secured by screws shall be provided.

16.7.7 Pipe Work installation

- All pipe work shall be installed to meet structural, architectural, and functional conditions and shall not interfere with the work of other trades.
- All pipe work shall be installed and supported so that it is free from excessive stresses due to weight from its contents plus its own dead weight, dynamic forces due to liquid movement, and expansion and contraction due to change in temperature.
- Pipe work connected to the pumps shall be separately supported so as not to impose any load on the pump casings.

16.7.8 Valves

- All valves shall be of approved manufacture complying with the appropriate British Standard and approved for the working pressure involved.

- b Valves shall be so installed as to be readily accessible for testing and maintenance. Valves shall close in less than 5 seconds when operated at maximum possible speed from fully open position.
- c Test cocks shall be provided at all locations shown on the drawing and the following locations
- d 15mm diameter cock with hose bib attachment downstream of each flow switch;
- e All valves in each instance shall be suitable in all respects for the class of service and function.
- f All valves for all functions shall be identified by means of a tag or label which shall clearly indicate the following:
 - 1. Service.
 - 2. Valve number.

16.7.9 Hose Reel Cabinet

- a NFPA 14/24 approved cabinet - doors made of 1.5mm, steel sheet with all around folded edges door leafs hinged flush mounted on door frame, front door fastening recessed type of glass.
- b Hose reel cabinet shall be provided with nozzle and swinging type hose reel of 32mm dia Polyethylene (PE) pipe. Length of pipe in reel shall be 30m. Reducing tee 2-1/2" x 1" dia shall be built in cabinet.

16.7.10 Fire Hydrant (4-1/2" Main Valve)

- a Fire hydrants purchased or installed shall meet or exceed all applicable requirements and tests of ANSI and the latest revisions of NFPA Standard 14/24. Fire hydrants shall meet all test requirements and be listed by Underwriters Laboratories Inc.
- b Body material made of spheroidal graphite cast iron with two way delivery. 2-1/2" female instantaneous outlet to BS 336:2010 with corrosion protected operation threads for easy operation. The hydrant should be capable of withstanding the minimum pressure of 4.5 bars upto maximum of 16 bars, as mentioned by the Engineer.

16.7.11 Breaching inlet

Breaching inlet to be provided for firefighting purpose, fitted with inlet connection at fire brigades access level and outlet connection at specified points. The inlet should be manufactured complying BS 5041:33:1975 comprising of male instantaneous connections complying with BS 336:2010, drain valves complying with BS 5154, PN16 rated and non return valves. The breaching inlet and its fittings are suitable for a normal working pressure of 10 bar. The inlet is painted red internally and externally. Location as per NFPA codes or as specified by the engineer.

16.7.12 Landing Valve

- a Oblique type with flanged inlet complying with BS 5041 part 1 standard with delivery hose connection and blank cap complying with BS 336:2010 standard. The landing valves must be classified under low pressure and are suitable for use at nominal inlet pressure up to 15 bar.
- b Disc facing rubber is of replaceable type. Valves are provided with strap and pad lock so that the hand wheel can be secured to counter unauthorized use. The hand wheel

is black painted and the body of the valve is red in color. The landing valve has a water flow rate of 8.5 Liters/ second at 4 bar outlet pressure. The valve must fully be in compliance with NFPA codes.

16.7.13 Fire Extinguishers

- a All fire extinguishers complying with NFPA standard to be used as mentioned as per NFPA 10 code. Capable of fighting class A, B, C and E fires, to be installed as directed by engineer following the NFPA standards or install where engineer feel necessary. Extinguisher must have a controlled discharged, brass nickel plated head valve with simple squeeze operation, unique color coded handle and base (optional), safety pin with chain, pressure gauge, syphon tube, hose holder, discharge nozzle, discharge hose and it must be rechargeable and easy to service.
- b All extinguishers must be easily identifiable and easily accessible at each level for all the people inside the respective building fully in compliance with latest NFPA 10 code of firefighting.

16.8 Part 8 – Plumbing Equipment- Equipment and Controls

16.8.1 Water Transfer Pump

Providing, centrifugal pumps (2 Nos. - 1 running + 1 standby) specification of the pump will be as per Bill of quantity. The pump shall be provided with control panel having auto / manual switches, dry running protection, low / high level water controls with alternative standby duty operation system, pump head to be verified on site by the contractor. Similarly, water supply pumps need to be defined in terms of type and functionality. Following are the specifications for the pumps to transport water from ground water tank to overhead tank. It is recommended to use Centrifugal Mono Block Pump, as it fulfills the requirements and less expensive than submersible pumps. The information on the suction lift, discharge head and flowrate is presented in Table below.

Item	Suction Lift	Discharge Head	Flowrate
Mono Block Pump (0.5 hp)	22 ft	55 ft	50 – 80 lpm
Submersible Pump (0.5 hp)	50 ft	85 ft	30 - 100 lpm

16.8.2 Firefighting Pump

- a Horizontal centrifugal electric pump set as per specification provided in bill of quantity complete with automatic control panel, Pressure switch & Pressure gauge
- b Horizontal centrifugal diesel engine driven pump set as per specification provided in bill of quantity with automatic control panel, Pressure switch, Pressure gauge & diesel tank
- c Jockey electric motor driven pump set as per specification provided in bill of quantity complete with automatic control panel, pressure switch and pressure gauge.
- d Pump control cabinet for above mentioned pump.

NOTE: Head of the firefighting pump to be verified by the contractor on site.

Typical Drawings for Septic Tank, Sewerage Manhole and Underground Tank for Water Supply & Rainwater Harvesting and Overhead Tank are shown in the Figures below.

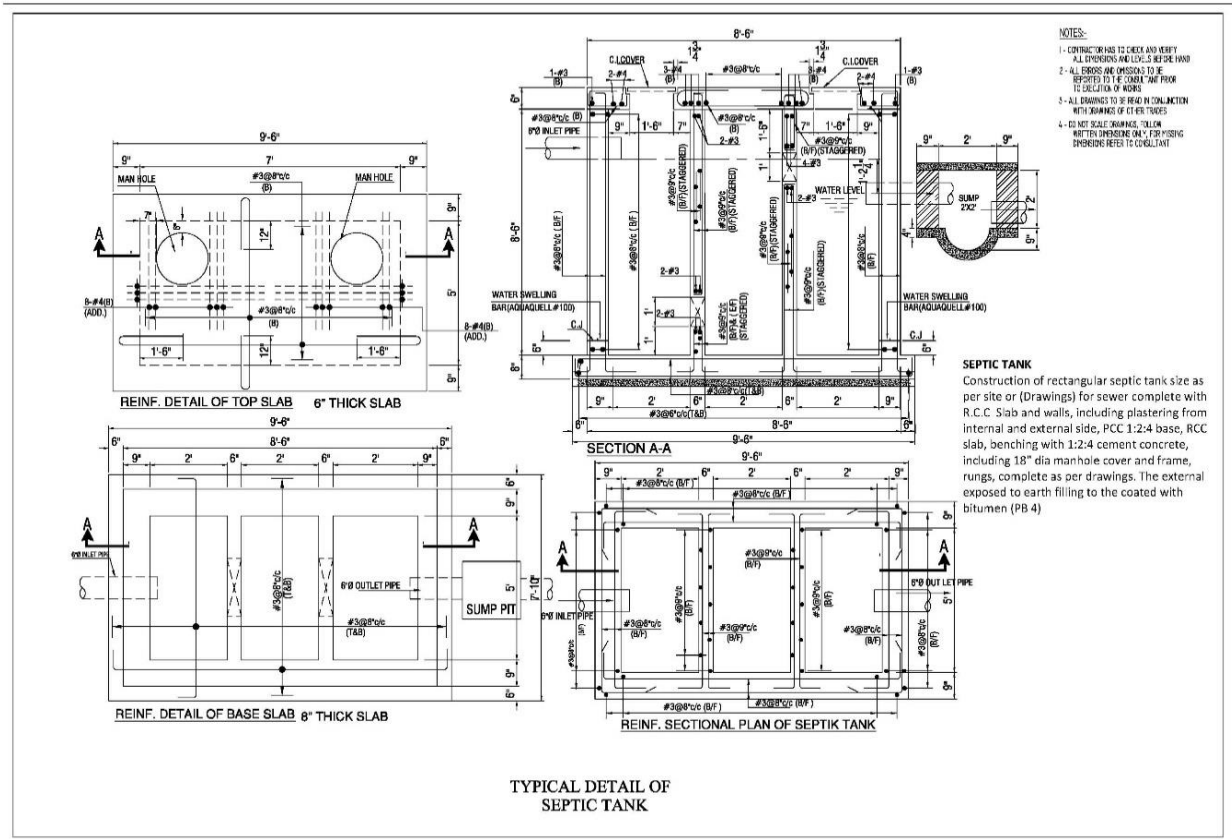


Figure 16-1 Typical Drawing for Septic Tank, Sewerage Manhole

PRECAST MANHOLE

Structure Sizing

Round Structures

- ASTM C478
- ASTM C497

Rectangle/Square Structures

- ASTM C913
- ASTM C890

- Lifting and Handling
- Corrosion Mitigation

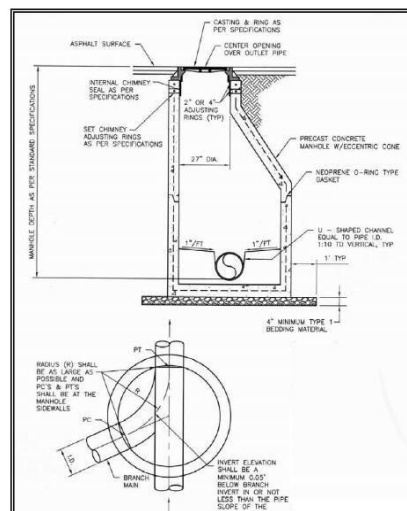


Figure 16-2 Typical Drawing for Precast Manhole

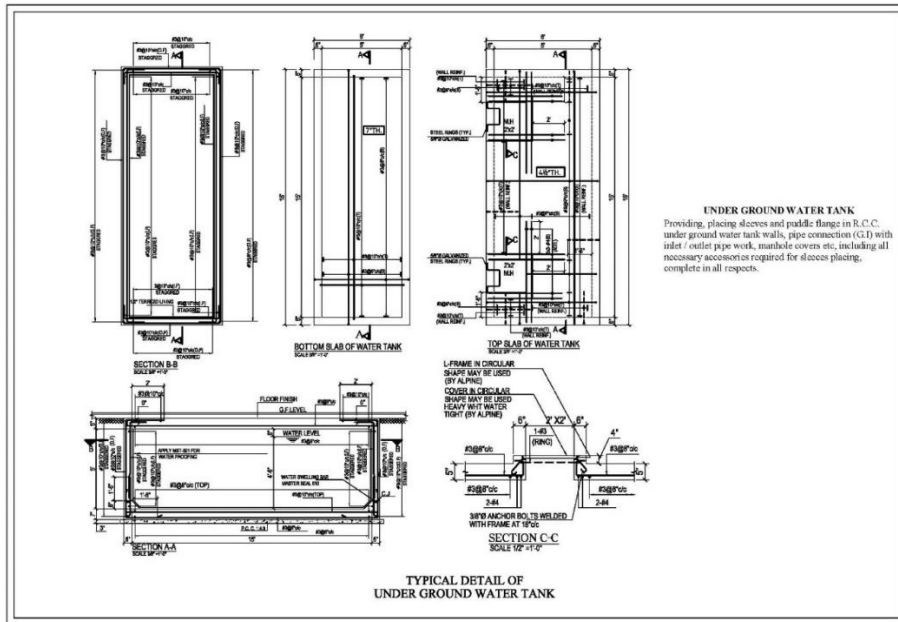


Figure 16-3 Typical Drawing for UnderGround Tank

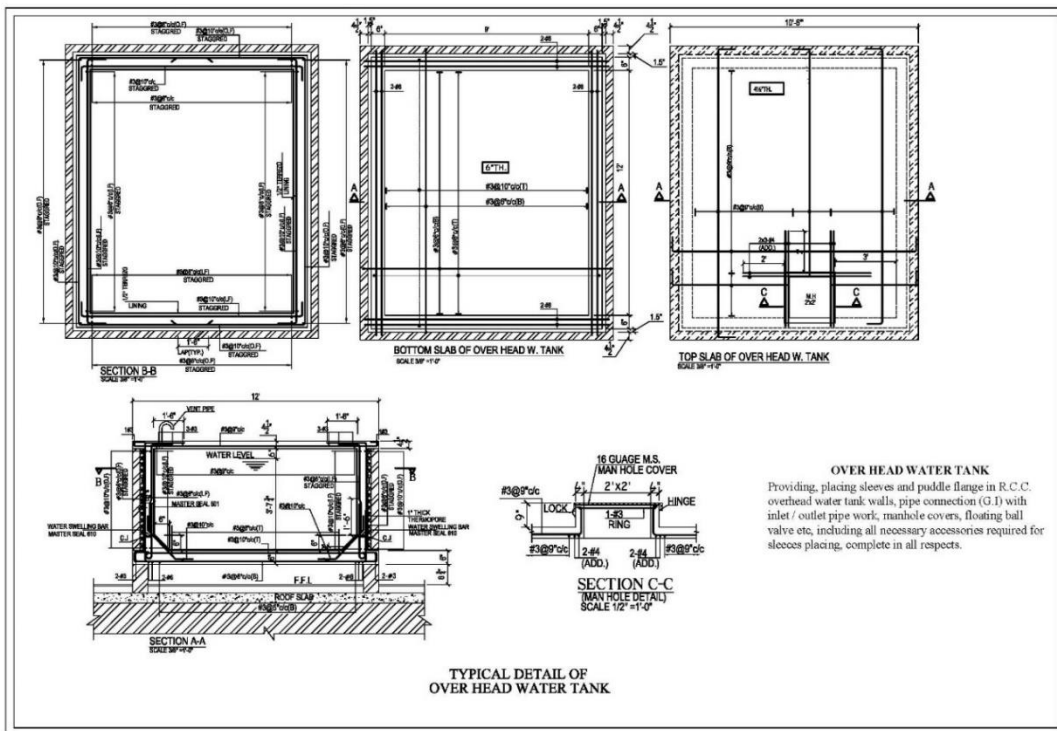


Figure 16-4 Typical Drawing for Overhead Tank

SECTION 17 - ELECTRICAL WORKS

17.1 Section 1 - Technical Provisions

17.1.1 General

The general instructions are given to the tenderers elsewhere in this contract document. The additional instructions in the following paragraphs are given in order to invite the tenderer's attention towards some major points pertaining to electrical work only and to assist them in preparing tenders. These instructions shall be deemed as Technical provisions of the Contract. For the purpose of low cost, the power distribution network scope work may be assigned to concerned distribution company or overhead distribution network may be used instead of underground distribution as cost of underground network will be high as compared to overhead distribution network.

17.1.2 Scope of Work.

The work consists of furnishing all tools, plants, labour, materials and equipment and performing the internal and external electrical works comprising of the following or as specified in B.O.Q.

SECTION - Main Panel Board and DB's.

SECTION - Internal Wiring Concealed with PVC Conduit.

SECTION - CFitting & Fixtures.

SECTION - Cables, Conduits, Cable Trays & Rising Mains.

SECTION - Earthing System

SECTION - Miscellaneous Items.

The work shall be carried out in strict accordance with the conditions of contract, special conditions, Drawings, Technical Specifications, in coordination with other contractors on this project and as per items of Bill of Quantities and including the responsibility of all related works necessary for their proper functioning, testing, commissioning and satisfactory operation and performance including maintenance for the period specified elsewhere. The contractor shall provide for all required technical non-technical personnel, skilled and non-skilled labour, construction equipment, transportation etc., as required for the completion of works in strict accordance with the Technical specifications laid here-in after.

17.1.3 Contractor's Qualification

The Electrification work shall be carried out only by a licensed Contractor authorized to undertake such work under the provisions of the Electricity Act, 1910, and the Electricity Rules, 1937, as adopted and modified by the Government of Pakistan.

17.1.4 Llicensed Electrical Contractor

Shall have the following qualifications.

- a. Must have in his employment a competent graduate Electrical Engineer registered with Pakistan Engineering Council, Islamabad.
- b. Must possess a valid Electrical licence issued by the Electrical Inspector of Islamabad region.
- c. Must have in its employment an Electrical Supervisor having certificate of competency who will exclusively look after this work.
- d. Must have necessary tools, plant and instruments.
- e. Must have adequate experience of similar works.

17.1.5 Rules and Regulations

The installation in general shall be carried out in conformity with the Electricity Rules, 1937, and the latest edition of the Regulations for the electrical equipment of buildings issued by the Institution of Electrical Engineers London (I.E.E.) However, in case of conflict between these specifications and the I.E.E. Regulations, these specifications supersede IEE regulation.

17.1.6 Standards

The latest relevant British specifications and codes, Pakistan Standard Specifications, VDE, I.E.C. and I.E.E. recommendations shall be applicable and be followed for the equipment specified herein.

17.1.7 Climatic Conditions

All equipment supplied shall withstand, without developing any defect, the following climatic conditions.

- a. Maximum Ambient Temperature=120°F or 49°C
- b. Minimum Ambient Temperature=28°F or (-) 2.2°C
- c. Maximum Humidity=90 %

17.1.8 Specifications

The contractor shall furnish all material and equipment at site, conforming fully to the specifications given herein and to the accepted standards as laid down by British Standards, the Institution of Electrical Engineers, London, and the Pakistan Standard Institution. It is not the intent of these specifications to include all details of design and construction of various material and equipment to be supplied under this contract. The Contractor shall supply and install all material and equipment specified herein and also all installation and small material such as nuts, bolts, washers, shims, angles, leveling material, installation as covered by the specifications.

All material and equipment supplied by the Contractor shall be new and in all respects conform to the high standard of engineering design and workmanship, perform and function as herein specified and fully meet the quality level and ruggedness requirement of the specifications. All material and equipment which have to be supplied and installed by the Contractor shall be passed / approved by the Engineer; even if the same is exactly in accordance with the Bill of Quantities and drawings

17.1.9 Submittal

The contractor, after the award of work, shall submit for approval of the Engineer all drawings and Catalogues of equipment, appliances, fixtures and accessories that are to be furnished under the contract. After final approval of a sufficient number of copies as desired shall be furnished for distribution. Catalogues and drawings shall be clearly marked to indicate, the items furnished. Catalogues of all fixtures, and not a few, shall be submitted.

17.1.10 Approval of Drawings and Data

The Contractor shall provide detailed electrical drawings, wiring diagrams, foundation details, etc., for all electrical switchgear, fuse gear and all other systems etc., for the Engineer's review for obtaining approval.

The manufacturing of electrical equipment shall be started only after the above mentioned drawings and data are approved.

The time required for review and approval shall be considered included in the total time of completion of job.

17.1.11 Drawings and Data

Three sets of drawings and data for each equipment shall be furnished by the Contractor for the Engineer's approval before commencement of fabrication and manufacture which would start only after that approval. The drawings to be supplied by the Contractor shall be as follows:-

- a. -Arrangements.
- b. -Dimensional Plans, elevations and front view.
- c. -Foundation Plan, anchors and configuration.
- d. -Incoming and outgoing cable termination positions.
- e. -Earthing arrangement.
- f. Electrical Drawings showing.
- g. -One-Line diagram.
- h. -Detailed wiring diagram.
- i. -All interconnections.
- j. -Instrument transformers.
- k. -Relays, their locations and internal wiring diagrams.
- l. -Other electrical devices including meters instruments and their wiring diagram.
- m. -Signal and alarm circuit.

17.1.12 Shop Drawings

The design drawings show approximate conduit routes and depict only the position of various fixtures and outlets. All the actual planning for the conduit routes shall be carried out, well in advance of the actual execution of work, by the Contractor to the satisfaction of the Engineer. For this purpose the Contractor shall prepare shop drawings and obtain prior approval of the Engineer. Three prints of each shop drawings shall be submitted for obtaining approval.

No piece of work shall be allowed to be executed at site without the availability of these approved shop drawings. These shop drawings shall clearly depict the load balancing

chart of each distribution board. Time required for the preparation and approval of shop drawings shall be considered to have been included in the total time allowed for the completion of the work.

17.1.13 Setting Out of Work

The Contractor shall set out the work himself and if any discrepancy is found, he shall report the matter to the Engineer and shall act as directed. If any defective or modified setting out is carried out by the Contractor on his own, he shall rectify or make it good at his own cost.

17.1.14 Programming

The contractor shall keep pace with the work of the Civil Contractor and any other specialist contractor. The engineer shall be kept informed about the programme and the progress of work so that there is no hindrance in the execution of work at site.

17.1.15 Protection

The contractor shall take care not to damage the structure , material, equipment and property belonging to and/or installed by other contractors during execution of work and shall repair and make-good all losses at his own cost, if found damaged in the opinion of the Engineer.

17.1.16 Change of Specifications.

No change in specification of the equipment / material will be allowed at any stage, except with the prior approval of the Engineer before the opening of Tenders.

17.1.17 Purchase of Equipment / Material.

All the equipment and material e.g. transformers, switchgear, cables, conduits, light fixtures and fans etc. will be purchased direct from the manufacturer. Certificate and copies of delivery challans for all such material will be produced as and when desired.

17.1.18 Manufacturers and Brands.

Where brands and names of Sub-Station equipment or any other system are specified by name, alternative can be offered provided these are equal in quality to those specified. Satisfaction of the Engineer in this respect shall be essential and prior approval for such deviation shall have to be obtained before submission of Tenderers. However all equipment for substation or system shall be from one manufacturer only.

17.1.19 Factory Tests

All routine and type tests on HT LT switchgear (ACBs, MCCBs , Relays , Magnetic Contactors , PFI Equipment and Enclosures), HT & LT cables , Emergency Diesel Generating Sets and other equipment shall be performed at the manufactures facility or at a recognized independent test laboratory in the presence of the “Engineer” as per applicable international standards .The term “Engineer” henceforth in the rest of the technical specification of electrical works shall mean an assigned, qualified electrical engineer of Client and Consultant. The presence of both engineers shall be ensured at all

times during factory tests and inspection. The contractor shall be allowed to supply equipment to site only after successful and satisfactory testing and inspection at factory / laboratory with 3 copies each of test reports duly issued to be maintained in client's and consultant's record. The contractor shall inform the engineer about the date and time of tests on each equipment at least two weeks in advance. The witnessing of tests by the engineer shall not absolve the contractor of his responsibility for proper functioning of the equipment, and for furnishing the guarantee. Contractor shall at its own expense make all arrangement of transportation loading etc. for the engineer, without any claim of addition charge or cost to the client for tests and inspection.

17.1.20 Owner's Supplied Material.

Material and equipment if supplied by the Owner shall be made available at site store to the contractor for installation. Any lead and lift upto and within the site of work shall be at the cost and responsibility of the Contractor. The contractor shall ensure safe handling and proper protection after the material and equipment are issued to him at site store and shall provide and maintain required plant and equipment for handling, proper protection and installation at his own cost.

17.1.21 Spare Parts List

A list of spare parts required for one year's operation of each equipment where deemed necessary "except OFM" together with unit price of each part, shall be supplied by the contractor.

17.1.22 Guarantee

The contractor shall furnish written guarantee, in triplicate, of the manufacturer for successful performance of each equipment. Such guarantee shall be of material and / or workmanship. The guarantee shall cover a minimum period of 12 months effective from the date of completion certificate.

17.1.23 As-Built Drawings.

The contractor shall, during the progress of work keep a careful record of all changes and revisions where the actual installation differs from that shown on shop drawings. These changes and revisions shall be accurately carried out on the shop drawings and submitted to the Engineer for approval. After approval these drawings shall become the property of the Owner. These updated and approved shop drawings depicting clearly As-Built drawings shall be submitted to the Engineer. Reproducible tracings of all these As-Built drawings shall be handed over to the Engineer. Final payment will be withheld until the receipt of the approved As-Built Drawings.

17.1.24 Test Reports.

The contractor shall be responsible for submitting the test reports/ certificates and get the installation inspected / passed by the Regional Electric Inspector at his own cost.

17.1.25 DISCOS Requirement.

The contractor shall assist the Owner in sponsoring application for Electrical Connection, with respective DISCO and carry out necessary formalities. Any special requirement of

DISCO shall be complied with by the contractor. The Owner shall arrange to deposit all amounts, on demand, to relevant DISCO for providing service connection and security deposits thereof.

17.1.26 T & T Requirement.

For the supply, installation and regularization of Telephone system, the contractor shall obtain N.O.C. from Director General, T&T Department, Ministry of Communications, Govt. of Pakistan, Islamabad if required. Any special requirement of the T&T Department shall be complied with by the Contractor. The Owner shall arrange to deposit all amounts on demand from T&T Department for obtaining telephone connections to public Exchange and security deposits etc.

17.2 Section 2 - PVC Conduits and Accessories

17.2.1 Scope

This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

17.2.2 Submittals

Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:

17.2.3 Materials

17.2.2.1 Conduit Pipe

The conduit for wiring of circuits, lights, socket outlets and other systems shall be made of PVC manufactured under the trade names of "Polo" or "Popular" conforming to BS6099.

Steel conduit shall conform to BSS 31/latest and shall be 'International', Hilal and/or Premier "brands. The conduit shall be enameled with good quality non-cracking and non-flaking black paint.

17.2.2.2 Flexible Pipe

Flexible conduit shall be furnished and installed where necessary for convenient dismantling and/or avoiding vibrations to be transmitted. Flexible conduit shall be spiral interlocked type made of steel strip construction and coated with zinc or chromium plated.

17.2.2.3 Conduit Accessories

Factory made round PVC junction boxes shall be installed with non-pressure type PVC conduits. Junction boxes shall be of 2-1/4" dia and 3" long to receive Pvc conduit and shall be concealed in RCC of slab. The wall type junction box shall also be factory made round PVC boxes having minimum dimensions of 2-1/4" dia and not less than 1-1/4" long. Each junction box shall be provided with one piece cover which shall be fitted on the box with chromium plated screws.

- 17.2.2.3.1** Conduit accessories such as switch boxes, socket outlet boxes, pull boxes and inspection boxes shall be made of 16 SWG sheet steel having dust tight covers. All boxes shall have required number of conduit entry holes and earth terminals for connecting E.C.P. All the rectangular or square shaped boxes shall have nipples to receive PVC conduit with force fit. All these boxes shall be painted inside and outside with black enamel, over a base coat of red oxide antirust paint. Shapes and sizes of these boxes shall be determined on each application.
- 17.2.2.3.2** Manufactured smooth bends shall be used where conduit changes direction. Bending of conduit by heating or otherwise shall be allowed only at special situations with the permission of the Engineer. Use of shape 90 degree bends and Tees is prohibited. Bends shall have enlarged ends to receive the conduit without any deduction in the internal diameter of the PVC pipe.
- 17.2.2.3.3** All accessories e.g. boxes, couplings, bends, solid plugs, bushes, reducers, checkouts etc. shall be equal in quality to the specified conduit.
- 17.2.2.3.4** Where inspection boxes occur in floor slabs a special cover on the box shall be installed to the satisfaction of the Engineer.
- 17.2.2.3.5** The use of looping in box shall be allowed in places where floor slab thickness permits 90 degree bends in conduit.

17.2.4 Execution

The contractor shall furnish all labour and material for the installation of conduit as required.

- 17.2.4.1** Conduit shall be installed concealed in RCC ceiling slabs, columns, walls and floors etc., Recessed conduit shall be laid over the first tier of reinforcement and under the second tier of reinforcement before pouring of concrete. All conduit outlet boxes to be concealed shall be laid firmly flush with the soffit of the slab or beam. The conduit should be tied to the reinforcement firmly so that the alignment is not disturbed by vibrators. All the outlet boxes installed shall be stuffed and their cover plates fixed so as to prevent concrete entering the outlet boxes.
- 17.2.4.2** Under no circumstances shall chassis be made for recessing conduit in the RCC structure after it has been cast without the permission of the Engineer. Where conduits have to be concealed in cement concrete or brick masonry, chassis shall be made with appropriate tools not deeper than required. The conduit shall then be fixed in the chassis with iron hooks before covering it up with at least 20mm thick plaster. Conduit ends pointing upward shall be properly sealed to avoid entry of foreign material.
- 17.2.4.3** The drawings show conduit routes but planning for proper arranging conduit routes shall be carried out by the contractor to the satisfaction of the Engineer.
- 17.2.4.4** The entire conduit system shall be essentially completed before the wire pulling is taken in hand. Each conduit run shall be tested for continuity and obstructions. All obstructions shall be cleared in an approved manner. Water and moisture that has entered any section of the conduit installation must be dried with suitable swabs to the satisfaction of the Engineer.

SECTION 17– ELECTRICAL WORKS

- 17.2.4.5** Adequate expansion joints shall be provided in all conduit runs passing across the expansion joints in the concrete slabs of the buildings. A typical arrangement is shown on drawing.
- 17.2.4.6** Pull boxes shall be installed in conduit runs at intervals mentioned below to facilities the pulling length of wires:-
- i) Straight runs.-20 meter.
 - ii) Runs with one 90 degrees bends.-15 meter.
 - iii) Runs with two 90 degrees bends.- 10 meter.
- 17.2.4.7** Conduit runs between two outlets shall not contain more than two quarter bends or one 90 degree bend.
- 17.2.4.8** All the free ends of conduit shall be solidly plugged till such time as final and proper terminations are made.
- 17.2.4.9** All conduits of a system shall be run at least 6" away from the other systems and services where conduit of one system crosses the other it shall be done so at right angle i.e. 90 degree.
- 17.2.4.10** All multiple runs of conduit shall be arranged symmetrically.
- 17.2.4.11** Exposed runs of conduit where required shall be firmly held by means of G.I. saddles, clamps and brackets etc., to the surfaces of walls, columns and ceiling. Rawal plugs or phil plugs may be used for fixing saddles, clamps and brackets etc. The spacing between two saddles may not be more than 30". The straight runs on walls may be 18" to 24" below the ceiling and in the event of any obstruction due to beams the runs may be routed them. The conduit shall have a minimum clearance of 6 mm from the surface supporting it. Purpose made special clips and brackets may be required at some situations to support the conduit.
- 17.2.4.12** No conduit less than 20mm dia. shall be used for point wiring and 25mm dia. for power wiring. The size of conduit shall however be determined from the number of wires required in the conduit run according to number of wires allowed as per IEE Regulations.
- 17.2.4.13** Use appropriate size sleeves for crossing of beams lentils retarding walls etc. for providing conduits / cables at later stage.
- 17.2.4.14** Use exposed PVC conduit wiring on ceiling side and concealed for open area side or wall and floors.

17.2.5 Application - Outdoors – General

Exposed:	PVC
Concealed:	PVC
Underground	PVC SCHEDULE 80
Boxes and Enclosures	NEMA 250, Type 3R.

17.2.6 Job Conditions

Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

17.3 Section -3 Wires, Cables and Cords

17.3.1 Scope

The wires & cords for conduit wiring shall be single core, made of stranded copper conductors, PVC insulated, tested to B.S. 6004, 1975. The voltage grade shall be 300/500 volts or 450/750 V unless otherwise specified on drawings and Bill of Quantities. Three phase wiring is being suggested for 5 marla and 10 marla, single/double story house. The cables shall be certified and approved. The main panel board and all types of boxes should be concealed on wall. The ceiling fan box should be concealed on ceiling and would not be fixed with rawl bolt.

17.3.2 Materials

In order of preference as approved by the Engineer. The size of the wire shall be as follows:

- i. for light or fan point wiring with 1.5MM square (or 3./029) or as specified in the B.O.Q.
- ii. for light circuit wiring with 2.5MM square (or 7/0.29) or as specified in the B.O.Q.
- iii. for power plug 15A wiring with 4 MM square (or 7/.036) or as specified in the B.O.Q.
- iv. the sizes of cables from Main Panel Board to Sub-Main Panel board to distribution boards shall be as shown on drawings or as specified in BOQ.

17.3.3 Execution

17.3.3.1 The contractor shall furnish all material and labour to pull in and install wires and cables as required. The contractor shall also supply, without extra cost, wire accessories e.g. plugs, solder, clamps, supports, bushes, fixing pins, adhesive tapes, connectors, identification tags, straps, filling compound and earthing clips etc. as are required to be furnished for complete wiring installation in accordance with standard practice. The pulling of wires shall be taken in hand only when all conduit system is complete. All termination shall be mechanically strain free and electrically sound.

17.3.3.2 The wiring of the installation shall be strictly in accordance with the scheme, cable sizes and circuit details as shown on drawings and specified in WCC.1

17.3.3.3 All wiring shall be continuous between terminations and use of connectors or joints disallowed. Spur and Tee connections are strictly prohibited. Looping in system shall be followed throughout.

SECTION 17– ELECTRICAL WORKS

- 17.3.3.4** Manufacturers recommended lubricant shall be allowed to facilitate pulling of wires, use of all other kind of oil and soap is prohibited.
- 17.3.3.5** All wires occupying the same conduit shall be pulled together. Wires and cords at the time of pulling shall not be subjected to a bending radius more than 10 times the overall diameter of cables. Cable manufacturer’s recommendation of pulling speed and pulling tension on cables shall govern the pulling operation.
- 17.3.3.6** Not more than 2 circuit wires shall be bunched in the same conduit. Wires of two different phase, however, shall not be run or terminated in the same outlet box for single phase wiring of lights, switches and sockets.
- 17.3.3.7** Porcelain or molded plastic connectors shall be provided for a joint between light point wiring and light fixture wiring and housed in the outlet box provided for this purpose. The contactor after terminations are made shall be wrapped in PVC insulation tape.
- 17.3.3.8** The quantity and the size of the wire contained in any one conduit shall not be in excess of the numbers permitted by I.E.E. regulations.
- 17.3.3.9** All point and circuits wiring shall be solidly earthed by 14SWG (2.5mm square) PVC insulated wire of color Green, Yellow to serve as CPC which shall be run inside the conduit.
- 17.3.3.10** All 5A & 15A socket shall be wired separately direct from D.B. without any claim of circuit and distinctly from light point wiring, or as specified in B.O.Q. However 5 Amps socket shall be controlled by D.B, or as specified in B.O.Q.

17.4 Section -4 Wiring Accessories

17.4.1 Scope

This Section includes the following:

- a. Single and duplex receptacles, and ground-fault circuit interrupters.
- b. Single- and double-pole switches and dimmer switches.
- c. Device wall plates.
- d. Floor service outlets and multi outlet assemblies.

17.4.2 Submittals

Product Data	For each type of product indicated.
Shop Drawings	List of legends and description of materials and process used for pre marking wall plates
Reports	Field quality-control test reports

17.4.3 Materials

17.4.3.1 Switches

1. Indoor switches controlling lights and fans shall be single pole, 10A, one or two way, suitable for 250V, 50Hz. The body of the switches shall be made of molded plastic, one, two, three, four or six gang with integral built in molded

plastic face plate suitable for fixing on a sheet steel outlet box. The switch contacts shall be silver alloy tipped and these shall operate with snap action. The switches shall be piano type, ivory white in color. The switches shall conform to BSS 800.

2. Weather proof switches on external lighting circuits shall be rotary type with quick make quick break action rated 5/10 Amps, 250 V, 50 Hz.

17.4.3.2 Switch Socket Outlet Units

1. Switch and socket units shall be single pole, 3 pin rated 13A or 15A, 250V, 50 Hz. These shall be molded plastic type with ivory white integral built-in face plate. Each socket shall have its control switch by the side of it on a common face plate. Thus the complete unit specified in BOQ shall be as switch and a socket outlet unit. The switch socket outlet unit shall comply with BSS 546 and BSS 5733 or BSS 3052. Bells / chimes/Buzzers and bell pushes shall be suitable for operation on 230 Volts
2. Weather proof switch units shall have a cast iron outlet box with threaded conduit entry holes or nipples, rubber gasket and a spring loaded sheet steel cover.
3. Ceiling roses shall conform to BSS 67/1969. Lamp batten holders shall conform to BSS 5042 Part-I.

17.4.3.3 Execution

1. All the switches and switch socket outlet units shall be installed on 16 SWG thick sheet steel outlet boxes of appropriate sizes All sheet steel boxes shall have conduit entry and terminals for connecting 14 SWG or 2.5mm (sq) PVC insulated circuit protective conductors.(CPC)
2. Install devices and assemblies level, plumb, and square with building lines.
3. Install equipment in accordance with manufacturer's installation instructions.
4. Define each dimmer's load type, assign each load to a zone, and set control functions.
5. Provide equipment at locations and in quantities indicated on drawings. Provide any additional equipment required to provide control intent.
6. Perform full-function testing on all completed assemblies. Statistical sampling is not acceptable.
7. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.
8. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.
9. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multipage wall plates where possible.
10. Remove wall plates and protect devices and assemblies during painting.
11. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

17.4.4 Dandification

1. **Receptacles:** Identify panel board and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
2. **Switches:** Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.

17.4.5 Quality Assurance

1. **Source Limitations:** Obtain each type of wiring device through one source from a single manufacturer.
2. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.

17.5 Section -5 Point Wiring, Circuit Wiring and Socket Outlet Wiring

17.5.1 Scope

The work included under this Section consists of furnishing all labor, material, services and skilled supervision necessary for the construction, erection, installation and connection of all circuits and equipment specified herein or shown on the drawings and / or normally required for an installation of this type including but not limited to testing of the installation and its handing over to the Owners. The extent of work specified herein and/or shown on the drawing represent the minimum requirements. The installation on the whole should conform to the best form of workmanship and shall be accomplished by workmen, licensed and skilled in this type of work.

17.5.2 Materials

17.5.2.1 Point Wiring

For the purpose of measurement of light / fan point wiring the following work shall be deemed to constitute the work of a point wiring:-

- a. Providing and fixing conduit from a switch to wall / column / ceiling outlet, or fan / fixture excluding final sub-circuit conduit from distribution board to the switch as described in section 2 or as specified in B.O.Q.
- b. Providing and pulling of wires from switch to fan / fixture outlet excluding providing and pulling of final sub-circuit wiring in the conduit laid as in (a) above and as described in Section 3 or as specified in B.O.Q.

17.5.2.2 Socket Outlet Wiring

- a. For 5A socket on the light switch board and also away from the board the basis of the measurement shall be the same as in section 2.1.
- b. For 13A/15A socket outlets the work shall comprise as under:-
 - i. Providing and fixing conduit from distribution board to the socket outlet as described in section 2
 - ii. Providing and pulling of wires in the conduit as in (a) above as described in section 3

17.5.2.3 Call Bell Point Wiring

This shall be identical to section W.1 i.e. wiring for light point or as specified in B.O.Q.

17.6 Section -6 Light Fixtures

17.6.1 Scope

Light fixture schedule is provided in the drawings along with catalogue numbers of the manufacturers which are meant to serve as illustrations of the types of fixtures required for various applications.

The contractor shall be required to submit samples of each and every light fixture for the approval of the Engineer, before commencing with mass production of the fixtures. The contractor should be prepared to carry out any number of modifications and improvements in the submitted sample free of cost until a finally acceptable sample is produced. Mass production shall be taken in hand only after a finished and modified sample has been produced and approved in writing by the Engineer. For low cost houses, fire alarm system should be used without the panel and it may have smoke detector with alarm. AC to DC circuit with manual switch 5A, which is fixed in switch board will be installed as a separate system for each area. The contractor has the option to offer acceptable equivalent of the specified light fixtures but to be installed with prior approval from Engineer.

This Section includes the following:

- a. Interior lighting fixtures with lamps and ballasts.
- b. Lighting fixtures mounted on exterior building surfaces.
- c. Emergency lighting units.
- d. Exit signs.
- e. Accessories, including occupancy sensors.

17.6.2 Submittals

Product Data: For each type of lighting fixtures, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

- a. Physical description of lighting fixture including dimensions.
- b. Emergency lighting units including battery and charger.
- c. Ballast type and ballast factor.
- d. Energy-efficiency data.
- e. Sound Performance Data
- f. Life, initial lumen rating, CRI, CCT, mercury content, and energy-efficiency data for lamps and ballast system.
- g. Photometric data,
- h. Shop Drawings: Show details of nonstandard or custom lighting fixture. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
- i. Wiring Diagrams: Power and control wiring.
- j. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

- k. Lighting fixtures.
- l. Suspended ceiling components.
- m. Structural members to which suspension systems for lighting fixtures will be attached [including seismic strengthening].
- n. Other items in finished ceiling including the following:
 - o. Air outlets and inlets. .
 - p. Smoke and fire detectors.
 - q. Occupancy sensors.
 - r. Photo sensors
 - s. Access panels.
 - t. Perimeter moldings.
- u. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture/Luminaire Schedule. Each sample shall include the following:
 - v. Lamps and Ballasts: Specified units installed.
 - w. Accessories: Cords and plugs.
 - x. Product Certificates: For each type of ballast for bi-level and dimmer-controlled lighting fixture, signed by product manufacturer.
 - y. Qualification Data: For agencies providing photometric data for lighting fixture.
 - z. Field quality-control test reports.
- aa. Operation and Maintenance Data: For lighting equipment, controls and fixtures, including emergency, operation, and maintenance manuals.

17.6.3 Materials

The LED lights fixtures shall be down lighters/light panels/floods lights as shown in drawings and given in BOQ. These will be surface mounted or recessed in false ceiling as per requirement of the project. The light fittings shall be CE/IEC & ROHS approved according to ambient temperature comprising of LED's of having life span of 50,000 hours. All the light fixtures shall be certified by 3rd party having following certificates

- a. Lumen Maintenance of LED Source: IES LM-80-08
- b. Luminaire Fixtures Type Test: IEC 60598
- c. Photo biological Safety: IEC 62471
- d. EMC Test Report EN 56100-3-2, EN 61000-3-3

17.6.3.1 LF.3 Led & Driver

LED shall be class-I having at least 100 lumens/Watt and make of CREE/EPISTAR/BRIDGLUX/LG/NICHIA or approved equivalent having color shifting SDCM Level of ≤ 5 for indoor light & ≤ 7 for outdoor light. The Driver unit having tolerance range of 110V to 277V with surge protection device & Power Factor PF of >0.9 , total harmonic distortion should be less than 15%. The driver should be MEANWELL or approved equivalent.

17.6.3.2 LF.4 Emergency Lighting

Emergency light fixtures shall be of the self-contained 3-hour maintained/non-maintained type, as specified, with 8 watt high efficiency fluorescent lamp and prismatic

diffuser, with maintenance-free NiCad batteries, separate baseplate, plug-in luminaires with locking screw. The emergency output shall typically be 180 lumens.

Exit sign and other legends, which shall be chosen and approved by the Engineer, shall be to BS formats, 180mm or 90mm high, as required.

Converter systems shall be of the type suitable for mounting within luminaires, to convert an ordinary fluorescent luminaires into a self-contained battery-powered emergency luminaires. The emergency output shall typically be 600 lumens minimum.

17.6.4 Execution

The light fittings shall be installed according to manufacturer's recommendations or as approved by the Engineer including the following items:

- a. Flexible connecting wires from outlet box to the fixture shall be provided by the Contractor; connector made of porcelain or thermoplastic material shall be provided and installed in the outlet boxes for connecting flexible wires to the point wires.
- b. Outlet boxes or any openings in the ceilings or walls shall be covered with appropriately fabricated accessories to provide an architectural entity to conceal them.
- c. Rawal plugs or nylon plugs with good screws shall be used for fixing purposes.
- d. Completely connect and securely mount lighting fixtures. Provide additional supports and hangers as necessary to securely fasten and support lighting fixtures to ceiling or structure.
- e. Install lighting fixtures plumb and true, and square with ceilings and walls. Install continuous rows of fixtures such that rows appear as continuous system without visible vertical or horizontal undulation.
- f. Hang pendant fixtures plumb, and with no "kinks" in pendants or cable.
- g. Install lamps in each fixture.

17.6.5 Quality Assurance

Quality insurance include the following items:

- a. Mockups: Provide lighting fixtures for room or module mockups. Install fixtures for mockups with power and control connections.
- b. Obtain Project Director/COR's approval of fixture for mockups before starting installations.
- c. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
- d. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- e. Inspect each installed fixture for damage. Replace damaged fixtures and components
- f. Verify normal operation of each fixture after installation
- g. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal. Prepare a written report of tests, inspections, observations, and

verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

17.6.6 Extra Materials

Extra materials include the items described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- a. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
- b. Plastic Diffusers and Lenses: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
- c. Battery and Charger Data: One for each emergency lighting unit.
- d. Ballasts: 5 for every 100 of each type and rating installed. Furnish at least one of each type.
- e. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.
- f. Control Devices: 1 for every 10 of each type and rating installed. Furnish at least one of each type.

17.7 Section -7 Power Cable

17.7.1 Scope

This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and above

17.7.2 Submittals

Product Data - General: For each type of product indicated.

Qualification Data: For testing agency.

Field quality-control test reports.

17.7.3 Materials

17.7.3.1 Kv Power Cables

All XLPE cables shall be manufactured to I.E.S. standard 502 or BSS-5467.

The XLPE cables shall be provided with extruded semiconducting conductor screen over stranded circular copper conductors before XLPE insulation is provided. On each core of conductor another layer of extruded semi-conducting core screen and copper tape screen are provided. The number of cores required then shall be put together and the anti-spaces filled with non-hygroscopic fiber filler and binding tape. The core is extruded with another PVC bedding.

Galvanized steel armor is provided underneath an overall PVC sheath.

17.7.3.2 L.T. Cables

The low tension cables shall be manufactured to the requirements of B.S 2004, **B.S. 6004**, and rated at 250/400 and 600/1000 Volts as the case may be including the following items

- a. The conductors shall be annealed copper conductors, single or standard circular or shaped as the case may be, to B.S.S. 6360/69.
- b. The conductors specified for use in the cables shall be of at least 98% IASC conductivity.
- c. The reference temperature for the purpose of determining the standard resistance of the conductors shall be 20 degree centigrade.
- d. The conductors shall be insulated with poly-vinyl chloride insulation. The minimum thickness of the insulation shall be in conformity with the specifications to which it is manufactured.
- e. Power cables shall be multicore cables, insulated and sheathed, armored or unarmored as required.
- f. 3.6 Various conductors forming the cables shall be laid together and voids shall be filled with soft plastic or fibers materials so as to give a circular shape to the cable.
- g. A tough PVC shall be extruded over the cable so as to cover the insulated conductors and fillers.
- h. Where armoring is required, a soft PVC jacket shall be provided over the laid up cable. Steel wire armoring shall be applied on a tough PVC sheathed extruded over the cable so as to cover the insulated conductors, fillers, jacket and armoring.
- i. Complete identification of the cable together with Owner's identification markings if required shall be embossed on the final over sheath of the cable at every meter length.

17.7.3.3 Cables Terminations

All PVC power cables shall be terminated with suitable brass cable glands for securing the armor wires and incorporating a packing ring for excursion of water and moisture. The cables shall be secured at required spacing by means of cleats fixed to walls or roofs or hangers and where multiple runs occur perforated metal tray made of heavy gauge galvanized steel shall be used.

17.7.3.4 Cable Markers

For underground installation cable position markers shall be sited in the ground where cables change direction and at 30 meter intervals along straight runs of the cables. Markers shall also be provided to locate the position of joints. Cable markers shall be made of cast iron. Any one of the following words shall be embossed / engraved for the identification of cable routes.

11000V. Cable.

440V. Cable.

The markers shall comprise of a cast iron circular disc of 115 mm dia. and 10 mm thick to which an angle iron 25x3 mm bar 710 mm long shall be riveted at one end. The end of the bar shall be frock-opened up to a length of 75mm. this end shall be embedded in a

cement concrete block of ratio 1:3:6 to a length, of 180mm. The concrete block shall have a shape of truncated pyramid with base 152x152 mm and a vertical height of 200 mm. The cable marker shall be buried in the ground such that its total height above ground level is 267 mm.

17.7.3.5 Cable Joints

The contractor shall be in possession of cable jointing kit and all termination shall be made by a bonafide and experienced cable joiner. All cable termination boxes kits and glands shall be of recognized makes and complete with claw clamps, ferrules, lugs, tapes, solders and jointing compounds.

17.7.3.6 Wires & Cords

The wires & cords for conduit wiring shall be single core, made of stranded copper conductors, PVC insulated, tested to B.S. 6004, 1975. The voltage grade shall be 300/500 volts or 450/750 V unless otherwise specified on drawings and Bill of Quantities.

In order of preference as approved by the Engineer. The size of the wire shall be as follows:

- a. for light or fan point wiring with 1.5MM square (or 3/029) or as specified in the B.O.Q.
- b. For light circuit wiring with 2.5MM square (or 7/0.29) or as specified in the B.O.Q.
- c. For power plug 15A wiring with 4 MM square (or 7/.036) or as specified in the B.O.Q.
- d. the sizes of cables from Main Panel Board to Sub-Main Panel board to distribution boards shall be as shown on drawings or as specified in BOQ.

17.7.4 Delivery, Storage and Handling

The cables shall be delivered wound over strong drums of suitable dimensions. The cables ends shall be fastened to the drums and completely protected in suitable manner to protect any injury to the cables during transportation and handling. The direction of rolling shall be clearly marked with bold arrows on both faces of the drums.

17.7.5 Execution

The contractor shall be under obligations to provide all labor, material and accessories for the installation of cables shown on drawings and listed in the BOQ conforming to the specifications in this section including the following items:

- a. The contractor shall provide, without any extra cost, all material for termination of cables such as lugs, solders, clamps, supports, ferrules, bushes, fluxes, taps, fixing pins, identification tags, , earthing clips, straps for a complete terminal jointing operation in accordance with the best modern practice.
- b. For underground cable installation the depth of digging the trench shall be such that the top surface of the cable shall not be less than 900mm and more than 1100 mm from the finished ground level. It will be contractor's responsibility to obtain true trench levels.

- c. Cable routes indicated on the drawings shall be followed unless otherwise specified or agreed to by the Engineer. Where change in direction of the cable is necessitated, the bending radius of the cable shall not be less than the diameter of the cable drum or 12 times the diameter of the cable whichever is greater.
- d. At all road crossing the cables shall pass through 100/150mm dia. core thickness minimum 1-1/2" RCC pipes with A class specifications sleeve shrouded in cast concrete , the mouths of which shall be sealed with cable bitumen compound of approved quality after drawing the cable. The road cuts shall be first filled with mud and 50mm size ballast upto 182mm level below the road surface and after ramming it properly 1500mm thick layer of cement concrete 1:3:6 shall be laid over it.
- e. The cushion of sand to be provided in the trench before laying the cable shall not be less than 75mm and after laying the cable 150mm. The total depth of cushion of sand shall be not less than 225mm. Over the final layer of sand, tiles/bricks or concrete masonry blocks of adequate strength 2" thick and 300mx200mm in size shall be provided to the satisfaction of the Engineer. The rest of the trench shall be backfilled with earth, in 150mm layers and rammed properly before dressing.
- f. All trenches and holes dug for laying the cables shall not be left open and unprotected for any length of time without completing the job and backfilling it to the satisfaction of Engineer. Where trenches are left open due to some unavoidable reasons the contractor shall exhibit suitable danger signals such as banners, red flags and red lamps etc.
- g. All cables shall always be lead out or lead into the ground through 2.5 meter long G.I. pipes of 75mm dia. or suitable size with 40% clearance as approved by the Engineer. The length of the pipe in the ground shall be 600mm. The pipe should be attached to the poles with approved clamps.
- h. Markers of approved design and inscription shall be installed as specified.
- i. For installation of cable in perforated metal trays, the cable shall be tied or bunched properly in an approved manner. Similarly for installation of cables on cleats or raceway approval of the Engineer shall be obtained.
- j. The contractor shall furnish all material and labor to pull in and install wires and cables as required. The contractor shall also supply, without extra cost, wire accessories e.g. plugs, solder, clamps, supports, bushes, fixing pins, adhesive tapes, connectors, identification tags, straps, filling compound and earthing clips etc. as are required to be furnished for complete wiring installation in accordance with standard practice. The pulling of wires shall be taken in hand only when all conduit system is complete. All termination shall be mechanically strain free and electrically sound.
- k. The wiring of the installation shall be strictly in accordance with the scheme, cable sizes and circuit details as shown on drawings
- l. All wiring shall be continuous between terminations and use of connectors or joints disallowed. Spur and Tee connections are strictly prohibited. Looping in system shall be followed throughout.
- m. Manufacturers recommended lubricant shall be allowed to facilitate pulling of wires, use of all other kind of oil and soap is prohibited.

- n. All wires occupying the same conduit shall be pulled together. Wires and cords at the time of pulling shall not be subjected to a bending radius more than 10 times the overall diameter of cables. Cable manufacturer's recommendation of pulling speed and pulling tension on cables shall govern the pulling operation.
- o. Not more than 2 circuit wires shall be bunched in the same conduit. Wires of two different phase, however, shall not be run or terminated in the same outlet box for single phase wiring of lights, switches and sockets.
- p. Porcelain or molded plastic connectors shall be provided for a joint between light point wiring and light fixture wiring and housed in the outlet box provided for this purpose. The contactor after terminations are made shall be wrapped in PVC insulation tape.
- q. The quantity and the size of the wire contained in any one conduit shall not be in excess of the numbers permitted by I.E.E. regulations.
- r. All point and circuits wiring shall be solidly earthed by 14SWG (2.5mm square) PVC insulated wire of color Green, Yellow to serve as CPC which shall be run inside the conduit.
- s. All 5A & 15A socket shall be wired separately direct from D.B. without any claim of circuit and distinctly from light point wiring, or as specified in B.O.Q. However 5 Amps socket shall be controlled by D.B, or as specified in B.O.Q.

17.7.6 Quality Assurance

The cables should be tested according to BS 6004. The following tests shall be carried out at least

- a. Dielectric Strength Test.
- b. Instantaneous and longtime break down strength test.
- c. Temperature rise test.
- d. High voltage test.

Test certificates covering all these tests shall accompany the cables supplied by the Contractor. After carrying out the tests as laid down in these specifications both ends of the cables shall be sealed at the manufacturer's works.

The owner may require the Engineer to witness the tests as specified herein and the contractor shall make necessary arrangements for the presence of the Engineer on such tests and obtain their signatures in testimony thereof without any cost to the Owner.

17.8 Section -8 Main L.T. Switch Board

17.8.1 Scope

This Section includes metal-enclosed, low-voltage, power circuit-breaker switchgear rated 1000 V and less for use in AC systems.

The L.T. switchboard shall be indoor type, free standing, free supporting, floor mounted, totally enclosed, sheet steel clad, dust and vermin proof, completely wired, factory assembled and suitable for installation back to the wall and capable of front attendance. The switchboard shall comprise of multi panels suitable for housing, air circuit breakers, molded case breakers or load break switches as shown on the drawings and as listed in the schedule of quantities. The switch board shall be designed to suit services conditions and

ensure security and safety during operation, inspection, operation, cleaning and maintenance. The switch board shall be designed and tested to IEC recommendations. Each panel shall withstand strain of 2000 Volts insulation level for one minute power frequency test. The switchboard shall comprise of the following main components and each removable component of the same rating shall be physically and electrically interchangeable. Switchboard to British Electrically Standard 41-5 are also acceptable.

17.8.2 Submittals

The submittals should include:

- a. **Product Data:** For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- b. **Shop Drawings:** For each type of switchgear and related equipment.
- c. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
- d. Tabulation of installed devices with features and ratings.
- e. Enclosure types and details.
- f. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
- g. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
- h. Current rating of buses.
- i. Short-time and short-circuit current rating of switchgear assembly.
- j. Nameplate legends.
- k. Mimic-bus diagram.
- l. Utility company's metering provisions with indication of approval by utility company.
- m. Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.

17.8.3 Wiring Diagrams: Power, signal, and control wiring.

Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

Field quality-control test reports.

Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals

Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

SECTION 17- ELECTRICAL WORKS

Time-current curves, including selectable ranges for each type of overcurrent protective device.

17.8.4 Materials

17.8.4.1 Submain Panel Boards

The Sub-Main panel board shall be similar to the Main L.T. board and the components in its fabrication may differ and shall comprise of the components as shown on drawings and as described or listed in the Schedule of quantities. The rupturing capacity of the each component for sub-main boards shall be as under:-

- a. Air circuit breakers.-35 KA (or as specified)
- b. Molded case circuit breaker.-25 KA

All the other details and specification as in Section 17.9 shall be applicable to this section.

17.8.5 Delivery, Storage, and Handling

Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

17.8.6 Execution

All labor, equipment, tools and plant required to complete the installation shall be provided by the Contractor. The switchboard shall be fixed firmly on the floor in perfect line, plumb and level position. All incoming and outgoing cable connections shall be made including earth connections.

17.8.7 Examination

Examine elements and surfaces to receive switchgear for compliance with installation tolerances and other conditions affecting performance.

Proceed with installation only after unsatisfactory conditions have been corrected.

17.8.8 Project Conditions

Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

Existing Utilities: Do not interrupt utilities serving facilities occupied by Government or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

Notify Project Director/COR not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.

Indicate method of providing temporary utilities.

Do not proceed with utility interruptions without Project Director/COR's written permission.

17.8.9 Quality Assurance

Prepare for acceptance tests as follows:

- a. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
- b. Test continuity of each circuit.
- c. Manufacturer's Field Service: Engage factory-authorized service representative to perform the following:
- d. Inspect switchgear installation, including wiring, components, connections, and equipment.
- e. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.
- f. Complete installation and startup checks according to manufacturer's written instructions.
- g. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
- h. Report results in writing.

17.9.3.1 Testing Agency

Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports. Travelling, Boarding/Lodging, Food of the Testing Agency to Be Borne By the Contractor

Perform the following field tests and inspections and prepare test reports:

- a. Type Tests**
 - i. Temperature rise test.
 - ii. Mechanical endurance test.
 - iii. Making / breaking capacity test.

- b. Routine Test**
 - i. High Voltage tests.

- c. Visual and Mechanical**

Perform each visual and mechanical inspection and electrical test

- i. Switchgear.
- ii. Circuit breakers.
- iii. Protective relays.
- iv. Instrument transformers.
- v. Metering and instrumentation.
- vi. Ground-fault systems.
- vii. Battery systems.
- viii. Surge arresters.
- ix. Capacitors.

Remove and replace malfunctioning units and retest as specified above.

17.8.10 Adjusting

Set field-adjustable, protective-relay trip characteristics

17.8.11 Protection

Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturers stipulated service conditions.

17.9 Section -9 Distribution Boards

17.9.1 Scope

This Section includes load centers and panel boards, over current protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

- a. Lighting and appliance branch-circuit panel boards.
- b. Distribution panel boards.
- c. Transient voltage surge suppressor panel boards.

The distribution boards shall be either free standing, cubical type or wall mounting type suitable for surface and/or recessed mounting. Each distribution boards (D.B.) shall be tropical in design, fully dust and vermin proof and liquid repellent. The cabinet housing the main components shall be fabricated from mild steel sheets 16 SWG thick and reinforced with structural steel members welded to it. Front access, mechanically locked and hinged doors, fully gasketed, having one or two leafs depending upon the size of the cabinet shall be provided on each cabinet. All operable parts shall be provided with gaskets or lining and screwed to the main body with chromium plated screws.

The cabinets after fabrication shall be thoroughly cleaned completely derusted and degreased before applying one coat of zinc or lead based primer and then two coats of top quality synthetic emulsion or stove enamel paint in battleship gray color. All exposed parts of the D.B's shall be covered with 5mm thick bake lite sheet. A load distribution chart shall be provided in each D.B showing the areas fed by each circuit and a suitably sized pocket inside the front door shall be provided for the purpose. Each D.B. shall be delivered complete with all instruments accessories, rating plates, designations, as approved by the Engineer.

Suitable cable entry glands shall be provided as required for floor mounted boards on the incoming cables but for outgoing cables and/or wall mounted boards exact number of conduit entry holes as are required shall be provided with male brass bushes. The bushes shall be tin plated and fully shrouded or housed in gasketed compartments.

17.9.2 Submittals

The submittal shall include:

- a. Product Data - General: For each type of panel board, over current protective device, transient voltage suppression device, accessory, and component

- indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- b. Shop Drawings for each panel board and related equipment.
 - c. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - d. Enclosure types and details
 - e. Bus configuration, current, and voltage ratings.
 - f. Short-circuit current rating of panel boards and over current protective devices.
 - g. Features, characteristics, ratings, and factory settings of individual over current protective devices and auxiliary components.
 - h. Wiring Diagrams: Power, signal, and control wiring.
 - i. Qualification Data: For testing agency.
 - j. Field quality-control test reports including the following:
 - k. Test procedures used.
 - l. Test results that comply with requirements.
 - m. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
 - n. Panel board Schedules: For installation in panel boards. Submit final versions after load balancing.
 - o. Operation and Maintenance Data: For panel boards and components to include in emergency, operation, and maintenance manuals. Include:
 - p. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - q. Time-current curves, including selectable ranges for each type of overcurrent protective device.

17.9.3 Materials

17.9.4.1 Components

The main components e.g. earth leakage circuit breakers (ELCB / RCCB), molded case circuit breakers, **load break switches**, HRC fuses and instrument as shown on the drawings and as described in schedule of quantities shall be the same as described in section 9. However miniature circuit breakers (MCBs) used in D.B's are briefly described hereunder:

17.9.4.2 MCBs

The incoming shall have triple pole mcb's suitable for use on 415V 50Hz, AC and the outgoing mcbs shall be single pole or single phase for use on 220V, 50Hz, AC. The ratings are as shown in drawings and/or described in the schedule of quantities.

The mcbs shall be molded case type having hydraulic magnetic short circuit releases, contacts, operating mechanism and arcing chambers.

The mcbs shall be manufactured and tested to BSS 3871/1966, and shall have a rupturing capacity of 7.5 KA or as specification B.O.Q. The final circuit mcb's on the outgoing, shall however be rated 5KA.

17.9.4.3 Fabrication and Features

The fabrication should include following:

- a. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- b. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
- c. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
- d. Directory Card: With transparent protective cover, mounted inside metal frame, inside panel board door.
- e. Bus: Hard-drawn copper, 98 percent conductivity.
- f. Bus Bars of Power Distribution and Branch Circuit Panel boards: Provide hard drawn copper. The neutral bus shall be isolated from both the ground bus and the cabinet, except at the service entrance or at the output of separately derived systems and shall be grounded in accordance with the NEC.
- g. Main and Neutral Lugs: Compression or mechanical type suitable for use with conductor material.
- h. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- i. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- j. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
- k. Split Bus: Vertical buses divided into individual vertical sections.
- l. Skirt for Surface-Mounted Panel boards: Same gage and finish as panel board front with flanges for attachment to panel board, wall, and ceiling or floor.
- m. Feed-through Lugs: Compression or mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- n. Provide 10 percent spare circuit breakers, 20 percent spaces for future breakers, and 20 percent overall spare current carrying capacity for future expansion.

17.9.4 Execution

All labour, equipment, tools, plant and accessories required to complete the installation shall be provided by the Contractor. The distribution board shall be fixed as required in perfect line and plumb. All earth terminations shall be made on the neutral block.

17.9.4.1 Testing

All D.B's shall be tested at manufacturer's works and tests shall be witnessed by the Engineer without incurring any additional expense to the Owner.

17.10 Section -10 Earthing

17.10.1 Scope

The contractor shall be under obligation to supply all material and labor for the completion of the Earthing system as shown on drawings, listed in the schedule / Bill of Quantities and conforming to specifications laid down, hereinafter. The completed installation shall, in general, conform to British Code of Practice CP 1013/1965 and regulations of Pakistan Electricity Act. In the case of any conflict, specifications laid

down hereinafter shall be followed. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

17.10.2 Submittals

The submittals shall include:

- a. Product Data: For each type of product indicated.
- b. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features
- c. Test wells.
- d. Ground rods.
- e. Ground rings.
- f. Grounding arrangements and connections for separately derived systems.
- g. Grounding for sensitive electronic equipment.
- h. Qualification Data: For testing agency and testing agency's field supervisor.
- i. Field quality-control test reports.

17.10.3 Materials

17.10.3.1 Circuit Protective Conductor

The Circuit Protective Conductors and earthing leads shall be solid hard drawn, insulated electrolytic copper wires of sizes given on the drawings and Bill of Quantities. All fixing accessories such as saddles, copper bolts, nuts, and washers shall be provided. The size of conductor above 19/.083 shall be of 1-1/8" flat copper strip or as specified.

17.10.3.2 Earth Point

It shall comprised of 1" dia & 10 ft long steel rod with 1mm copper conductor sleeve of 99.97% imported copper as earth electrode 100ft below ground level including cost of boring and lowering the rod 100ft down, complete with clamp and appropriate size of stranded copper conductor from rod to ground surface in 1½" dia G.I. pipe (length 20' only) with tee on top having watering cap, earth access hole comprising of 8" dia, 12" deep 16-SWG M.S. cylinder with 12-SWG M.S. cover, both hot dipped galvanized, as per detail shown in drawings.

17.10.3.3 Earth Connecting Point

The earth connecting point in switch room or sub-station shall comprise 300mmx50mmx5mm (1'x2"x1/4") electrolytic copper bar having as many terminals of 3/8" dia. copper bolts, nuts, and washers as are required. The earth bar shall be fixed on bus bar insulators of appropriate size. The fixing bolts shall be galvanized and provided for fixing the bar on the wall. The bar shall be tinned for protection against corrosion. Copper tapes from various equipment and earth point shall be terminated on this bar.

17.10.3.4 Earth Electrode

For the earthing of poles or any devices or equipment rates less than 15 KW, earth assembly as shown on the drawing shall be installed.

17.10.3.5 Manhole

Cast concrete inspection manhole covers shall be provided on each earth point, as shown on drawings.

17.10.4 Execution

The execution shall include the following:

- a. The circuit protective conductor (CPC) shall be run, inside, all along the conduit installation. The CPC shall be insulated as specified elsewhere.
- b. The C.P.C. or copper strip shall be laid all along the length of perforated metal tray or walls of masonry ducts, fixed at 3' intervals. At terminations the CPC or traps shall be bolted firmly to the equipment as per standard practice. Copper tape at straight through joints shall be brazed or cad welded. Joints between standard CPC shall be avoided or cad welded.

17.10.5 Quality Control

For Testing, engage a qualified testing agency to perform the following field quality-control testing. The following field quality-control testing shall be performed.

- a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
- b. Test completed grounding system at each building electric service entrance, electric/telecom rooms, generator system, buildings and lightning protection system where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Tests at each ground rod before any conductors are connected are not required if a clamp-on ground tester is used. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
- c. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results. Maximum value of acceptable system ground resistance is 1 ohms.
- d. Excessive Ground Resistance: If resistance to ground exceeds specified values, drive additional ground rods until resistance meets specified values.
- e. Water pumping motor (if recommended and installed) will be switched automatically.

17.11 Section -11 Testing and Commissioning

17.11.1 Scope

Upon completion of the installation the contractor shall perform field tests on all equipment, material and systems. All tests shall be conducted in the presence of the

Engineer for the purpose of demonstration equipment or system compliance with specifications.

The contractor shall furnish, install and maintain all tools, instruments, test equipment, material, connections, etc., and furnish all personnel including supervision and 'Stand by' labour required for the testing, setting and adjustment of all electrical facilities and their component parts, including putting the same into operation.

All tests shall be made with the proper regard for the protection of the equipment, and the contractor shall be responsible for adequate protection to all personnel during such tests.

The contractor shall record all test values of the tests made by him on all equipment, giving both "as found" and 'as left" conditions. Three (3) copies of all test data shall be given to the Engineer for record purposes.

The witnessing of any test by the Engineer do not relieve the contractor of his guarantees for materials, equipment and workmanship as specified in the Conditions of Contract.

The contractor shall provide proper date and time schedules for testing.

Earth pit filling material will be used to achieve the earthing resistance less than 1 (one) ohm.

This Section includes general requirements for field testing and inspection of electrical systems. More detailed requirements are specified in each Section listed in the "Related Sections" paragraph.

General requirements include the following:

- a. Qualifications of testing agencies and their personnel.
- b. Suitability of test equipment.
- c. Calibration of test instruments.
- d. Coordination requirements for testing and inspecting.
- e. Reporting requirements for testing and inspecting.

17.11.2 Type of Tests

17.11.2.1 T.2 Insulation Tests

Insulation resistance tests shall be made on all electrical equipment, using a self-contained instrument such as the direct indicating ohm-meter of the generator type direct current potentials shall be used in these tests shall be as follows :-

Circuit under 230 volts - 500 volts test.

Circuit 230 volts to 400 volts-1000 volts test.

The minimum acceptable insulation resistance value will be 5 Mega ohms.

The test equipment for insulation testing will be furnished by the contractor.

Before making connections at the ends of each cable run, the insulation resistance test of each cable shall be made. Each conductor of a multicore cable shall be tested individually to each other conductor of the group and also to earth. If insulation resistance test readings are found to be less than the specified minimum in any conductor, the entire cable shall be replaced and the new cable tested.

All transformers, switchgear shall be given an insulation resistance measurement test to ground after installation but before any wiring is energized. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

If the insulation resistance of the circuit under test is less than that specified above, the cause of the low reading shall be determined and removed. Corrective measure shall include dry out procedure by means of heaters if equipment is found to contain moisture. Where corrective measures have been necessary and the insulation resistance reading taken after the correction has been made it should satisfy the requirements specified herein. Repeated insulation resistance maintenance test shall be made twice and at least 12 hours apart. The maximum range for each reading on the 3 successive tests shall not exceed 20% of the average value. After all tests have been made successfully, the equipment shall be reconnected.

17.11.2.2 T.3 Earth Resistance Tests

Earth resistance tests shall be made by the contractor on the earthing system, separating and re-connecting each earth connection as may be required by the Engineer. If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The electrical resistance of the ECP together with the resistance of the earthing lead measured from the connection with earth electrode to any other position in the completed installation shall not exceed **one ohm**.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earthing sets are installed, the earth resistance test between two sets shall be measured by means of resistance bridge instrument. The earth resistance between two sets shall not exceed one ohm.

17.11.2.3 T.4 Transformer & Switchgear.

In addition to the insulation resistance tests on the transformer, a polarity or phase rotation test shall also be made. Auxiliary devices, breather, bucholz relay etc. shall be tested for satisfactory operation.

Each air circuit breaker shall be operated electrically and mechanically, ascertaining that handle mechanisms are operating. All interlock control circuit shall be checked out for proper connections in accordance with the wiring diagrams given by the manufacturer.

The contractor shall identify the phase of all switchgear and power cables by stenciling the switchgear and tagging the cables so that the phases can be identified for connections to give proper phase sequence.

Series overcurrent trip elements shall be checked against rating of equipment served. Also to checked for correct size, function of fuses disconnect switches, number of interlocks indicating lights, alarms and remote control devices. Name plates shall be checked for proper designation of equipment served.

17.11.2.4 T.5 Operating Tests

Current load measurement shall be made on equipment and on all power and lighting feeders.

The current reading shall be taken in each phase wire and in each neutral wire while the circuit or equipment is operating under actual load conditions. Clip-on ammeters may be used to take current readings. All light fittings shall be tested electrically and mechanically to check whether they comply with the standard of specifications. Fluorescent light fittings shall be tested so that when functioning properly no flickering is observed or choke noise is heard.

The lightning protection system shall be tested for earth resistance and for electrical and mechanical joints. The combined resistance to earth to the whole lightning protection system shall not exceed 5 ohms.

The alarm system, telephone system, sound distribution system shall be checked and tested as per manufacturer's instructions and in the presence of the Engineer or his representative.

After any equipment has been tested, checked for operation etc., and is accepted by the Owner's representative the contractor shall be responsible for the proper protection of such equipment for assurance that subsequent testing of other equipment of system do not disturb the completed work.

17.11.2.5 General Tests and Inspections

Testing Preparation

Prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for Independent Testing Agency testing. Include the following minimum preparations as appropriate:

Perform insulation-resistance tests.

Perform continuity tests.

Perform rotation test (for motors to be tested).

Provide a stable source of electrical power for test instrumentation at each test location.

Field Test and Inspection Reporting: In addition to requirements specified in Related Sections, ensure that each test and inspection report includes the following:

Manufacturer's written testing and inspecting instructions.

Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.

Tabulation of expected measurement results made before measurements.

Tabulation of "as-found" and "as-left" measurement and observation results.

SECTION 18 - STEEL WORKS

18.1 Scope of Work

The work covered under this section of Specifications, consists of providing all material, labour, plant, equipment, appliances and performing all operations connected with the fabricating and erection of all metal work, millwork, construction, assembly, surface finish treatment of all type of doors, windows, railing, grating, grills, embedded metal work, fences, gates, shutters etc., and incidentals, associated works appurtenances, procuring and applying preservatives, installation of “Finish Hard Ware” in connection with finish metal work as per details shown on the drawings or as directed by the Engineer. The scope of this section is covered with detailed specifications as laid down herein.

18.2 Submittals

18.2.1 Shop Drawings

Contractor shall submit Shop Drawings which shall show full construction details, quantities and locations, with metal gauges, reinforcing, cut-outs, hold-fast and attachment to adjacent construction and materials. Shop Drawings shall be submitted well in time to allow for checking, revisions, agreement, manufacturer, delivery and installation to suit the building programme.

18.2.2 Samples

Contractor shall submit representative samples of a typical metal door, hardware, accessories and any other product required for the approval of the Engineer.

For metal shutters the Contractor shall similarly submit cross-sections of typical welded jointed or assembled frame, in specified thickness showing reinforcing, welding and prime paint coat.

18.2.3 Methodology

Methodology for fabrication, installation, erection and fixing.

18.3 Applicable Standards

Latest additions of following ASTM, Pakistan, and British standards are relevant to these specification wherever applicable.

ASTMA 36-81 Structural steel specifications

ASTMA307-80 Carbon steel externally and Internally Threaded Standard Fasteners Specifications.

BS729-71 Hot dip galvanized coating on iron and steel articles.

AWSD 12 Recommended Practice for welding steel.

AASHTO Standard Specifications for Corrugated Sheet Steel

FF-W-92 Washers, Metal, Flat (Plain)

FF-W-84 Washers, Lock (Spring)

QQ-F-46 Floor Plate, Steel Rolled

RR-G-661 Grating, Metal, Floor

RR-T-650 Treads, Metallic and Non-Metallic, Non-Skid

RR-C-271 Chain and Attachments, Welded, Weld less and Roller Chain.

18.4 Quality Assurance

18.4.1 Finishing

After erection, all proposed surfaces shall be checked and unpainted areas adjacent to field connections and damaged areas shall be given a finishing coat according to the same standards as required for the shop coat and the same primer as used in the shop coat.

18.4.2 Tolerances

A variation of 1 mm is permissible in the overall length of members with both ends finished for contact bearing. The bearing surface is to be prepared to a common plane by milling.

Members without end finish for contact bearing which are to be framed to other steel parts of the structure shall have a variation from detailed length not greater than 3 mm.

Rolling tolerance of all shapes and profile according to AISC shall be in accordance with the provisions of the ASTM A.6. These shall be checked by the Contractor before being worked upon and shall be rejected if found not within limits.

18.5 Materials

18.5.1 General Requirements

All contours and arises in metal door shall be true and sharp as can be produced in the thickness of metal required.

Construction joint of steel work welded to full depth and width or equivalent splice plates shall be welded on unexposed faces of frames. Exposed surface of welded joints shall be dressed and ground smooth to produce invisible connections.

Reinforcement and stiffeners shall be welded to the inside of the frame surfaces.

Weather baffles shall be integrally rolled shall provide contact on all the four sides of the operating ventilators.

Weep holes and drips shall be provided for drainage in accordance with drawings or instructions of Engineer.

18.5.2 Sheet Steel

Sheet steel for structures where no welding is required shall conform to the requirements of ASTM A-366 (for Cold Rolled Carbon Steel Sheets, Commercial quality) or ASTM A-569 (Standard Specifications for Cold Rolled Carbon Steel Sheet, commercial quality). For Structures where welding is required sheet steel shall conform to the requirements of ASTM A-569.

18.5.3 Welding Rods

Except as otherwise shown on the Drawings, welding rod shall conform to the following requirements;

18.5.4 Structural Welding Rod

Welding rod for manual welding of structural carbon and low alloy steels shall conform to the applicable requirements of American Welding Society. For structural, Carbon steel E-60 or E-70 series, low-hydrogen electrodes shall be used.

18.5.5 Corrosion Resisting Welding Rod

Welding rod for corrosion-resisting welds shall conform to the applicable requirements of American Welding Society for Corrosion-Resisting Chromium and Chromium series, low-hydrogen electrodes shall be used.

For type 304 Corrosion-Resistant Steel, E-306 series shall be used for welds to type 304 steel whereas E-309 series shall be used for welds to structural carbon steel.

For Type 347 Corrosion-Resistant Steel or Corrosion-Resistant Clad Steel, E-347 series shall be used for shop welds to Type 347 steel or clad steel;

E-309 Cb series shall be used for field welds to Type 347 steel or clad steel whereas E-309 Cb series shall be used for welds to structural carbon steel.

18.5.6 Aluminium Welding Rod

Welding rod for aluminium welding shall conform to the applicable requirements of American Welding Society for Aluminium and Aluminium Alloy Metal Arc-Welding Electrodes and Alloy Welding Rods and Bare Electrodes, as applicable, to meet the requirements of sub-section 5.3 Welding Rods.

18.5.7 Bolts, Nuts and Washers

Except as otherwise indicated on the Drawings or specified herein, bolts and nuts shall conform to the requirements of ASTM-A 307, Standard Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners. Bolts shall be grade A for general application, with square or hexagon heads. Turned bolts shall conform to the requirements of ASTM A 307, Standard Specifications for Low-Carbon Steel Externally and Internally Threaded Fasteners, for regular semi-finished type, except that tolerance of the unthreaded portion of the body shall be 0.0 mm over the nominal diameter to 0.1542 mm under the nominal diameter. Where bolts of material, type, dimensions and tolerance other than those specified as standard in ASTM-A 307 are indicated they shall conform to the applicable requirements of ANSI B 18.2 square and Hexagon Bolts and Nuts, for bolts and nuts of the types dimensions and tolerances indicated. Where bolt threading differs from that specified as standard in ASTM-A 307, threading shall conform to the requirements of ANSI B1.1, Unified Screw Threads, as applicable to the bolts indicated. Nuts shall be of similar material, finish, class of fit and thread series as their companion bolts and shall be washer-faced except as otherwise indicated or specified.

18.5.8 Washers

Cut Washers. Cut washers, unless otherwise indicated shall be of structural grade steel and shall conform to dimensions of the manufacturer's regular standard for plain washers for the size of bolts used. They shall conform to the applicable provisions of Federal Specification FF-W-92, Washers, Metal, Flat (Plain), for Type A, Grade 1 washer of class as shown on the drawing.

Lock Washers. Except as otherwise specified lock washers shall conform to the requirements of Federal Specification FF-W-84 for Washers, Lock (Spring). Unless otherwise indicated or specified, washers shall be Class A Carbon Steel, Style 3, heavy.

18.5.9 Steel Floor Plating (Raised Pattern)

Steel floor plates shall conform to the requirements of Federal Specification QQ-F-461b(I). Floor Plate, Steel, Rolled, Class I floor plate of an approved raised pattern.

18.5.10 Steel Gratings

Steel grating shall conform to the applicable requirements of Federal Specification RR-G-661b, Grating, Metal, Floor (except for Naval Vessels) Type 1. All panels shall be banded on all edges.

18.5.11 Safety Treads

Safety treads shall conform to the requirements of Federal Specification RR-T-650, Treads, Metallic and Nonmetallic Nonskid, for type as shown on the Drawings.

18.5.12 Chain and Attachments

Chain and attachments shall conform to the requirements of Federal Specification RR-C-271a(I), Chain and Attachments, Welded, Weld less, and Roller Chain. Chain shall be of type, grade and class as shown on the Drawings. Types and classes of attachments and accessories shall be as indicated on the drawings or as required for the intended purposes.

18.5.13 Turnbuckles

Turnbuckles shall conform to the requirements of Federal Specifications FF-T-791a(3), Turnbuckle, for turnbuckles of the type and class shown on the Drawings.

18.5.14 Wire Rope

Wire rope shall conform to the requirements of Federal Specifications RR-W-410a (2), Wire Rope and Strand, for wire rope of the type, class, construction, size and style shown on the Drawings.

18.5.15 Metal Pipe, Tubing and Fittings

Metal pipe, tubing, fittings and valves required for the installation of piping required to be furnished and installed by the Contractor, shall conform to the applicable requirements of Section 2F-Piped Utility Services for the type and class of piping indicated.

18.5.16 Metal Guard Rail

Metal guard roll of the highway type shall conform to the requirements of AASHTO-M180-60, Standard specifications for corrugated Sheet Steel Beams for Highway Guard Roll.

18.5.17 Anchors

Rods, Nuts and Washers, Embedded rods, nuts and washers shall conform to the requirements of ASTM-A 307, Specification for Low Carbon Steel Externally and Internally Threaded Standard Fasteners. Anchor plates shall conform to the requirements of ASTM-A 36, Specification for Structural Steel. Unless otherwise noted, anchor bolts shall conform to the requirements of ASTM A-307.

Welded Concrete Anchor Studs. Steel for studs shall conform to ASTM-A 108, Specification for Cold-Finished Carbon Steel Bars and Shafting. Grades 1015-1020; having a minimum yield strength of 345 MPa an ultimate tensile strength of 415 MPa and minimum elongation of 20 percent in 50 mm.

18.6 Execution

18.7.1 Fabrication

Prior to Fabrication, the Contractor shall notify the Engineer about any problem or doubt/error discovered in the drawings for clarification / rectification well in time to prevent any fabrication error. Fabrication shall not be commenced until approval has been obtained from the Engineer.

The Fabrication works includes the following:

a. **Straightening Material**

Rolled material, before being worked upon, must be straightening within tolerances by ASTM specifications A6. Straightening necessarily shall be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 590 Deg. C for A 514 steel or 650 Deg. C for other steels.

b. **Cutting**

As far as possible cutting must be done by shearing. Oxygen cutting shall be done where sheet cutting is not possible and shall preferably be done by a machine. All edges shall be free from gauges, notches or burs. If necessary the same shall be removed by grinding.

c. **Holes Punching and Drilling**

Holes shall be punched where thickness of the material is not greater than the diameter of bolt or rivet or + 3 mm whichever is bigger.

Where the thickness of the material is greater than 3 mm the holes shall either be drilled or sub-punched and then reamed to size. The die for all sub-punched holes and the drill of all subdrilled holes shall be at least 2 mm smaller than the nominal diameter of the rivet or bolt. Holes for A514 steel plates over 12 mm thick shall be drilled.

Holes shall be drilled or punched at right angles to the surface of the metal, not more than 2 mm larger than the connector diameter. Holes shall not be made or enlarged by burning. Material having a thickness in excess of the connector diameter and material thicker than 22 mm shall be drilled. Holes shall be clean-cut without torn or ragged edges or outside burrs resulting from drilling operations.

d. **Holes, Slots and Openings**

Holes, slots, and openings required by other work shall be provided together with necessary reinforcing as shown and by using suitable templates for proper location of these openings. Steel requiring adjustment shall be provided with slotted holes as shown. No change in location of openings shall be permitted without prior approval.

e. **Welding Requirement**

Structural welding shall not begin until joint elements are bolted or tacked in intimate contact and adjusted to dimensions shown with allowance for any weld shrinkage that is expected. Heavy sections and those having a high degree of restraint shall be welded with low hydrogen type electrodes. No members shall be spliced without approval.

The processes listed in AWS D 1.1 are permitted, subject to the restrictions of article 3-2 “Welding process Restrictions”.

f. **Workmanship**

Unless otherwise authorized or specified, welding shall be by the electric arc welding process, using a method which excludes the atmosphere from the molten metal. Welding, unless specified otherwise shall conform to the applicable requirements of the American Welding Society’s D1.0, Code for Welding in Building Construction as applicable to the work required to be done. Important joints and connections which will be heavily stressed in service, such as connections and all field splices shall be made with special precautions to ensure that such joints are sound and without flaws. The Contractor shall assign to such work, the welders best qualified to perform such welding operation. Welding operators, including tack welders and machine welders shall be qualified, and as necessary requalified, for the particular type or work to be done in accordance with American Welding Society’s B3.0 Standard Qualification Procedures.

g. **Welding Equipment**

Manual and automatic arc-welding machines and equipment may be of either the alternating current or direct current type and shall conform to the requirement for arc-welding equipment as set forth in the American Welding Society’s D2.0, Specifications for Welded Highway and Railway, Bridges. When the use of gas welding equipment is specifically authorized by the Engineer, such equipment shall also conform to this specification.

h. **Filler Metal**

Unless otherwise specified or authorized, all deposited weld metal shall have elastic limits and ultimate tensile strengths not less than those specified for the respective base metals welded; shall have an elongation in 50 m, using annealed

samples, of at least ninety-five percent of the value specified for the base metal or at least seventy-five percent using unannealed samples; shall have chemical composition similar to that of the base metal; and when subjected to approved tests shall have corrosion resistance at least equivalent to that of the base metal. These properties shall be determined by testing in accordance with the applicable provisions of the American Welding Society Specifications, or as otherwise approved by the Engineer.

Except as otherwise specified in this Clause, welding electrodes and rods shall be as specified in sub-section 5A-2.02 Welding Rod, and shall be of a type and grade approved by the Engineer; of such chemical composition and physical properties as will produce the characteristics specified above; and so adapted to the base, metal and thickness of parts to be welded as will ensure effective penetration and an intimate uniform fusion of the filler and base metals, in all welding positions and under all conditions to be encountered, without undercutting or overlapping. The electrodes shall conform to the applicable requirements of the American Society for Testing and Materials. The use of mild steel electrodes for welding corrosion-resistant steel will not be permitted.

Welding electrodes to be used for making welds on the clad side of corrosion-resisting, steel clad plate shall conform to the applicable requirements of American Welding Society Specifications for Corrosion resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes, Classification No. E309 or E310, to cover the exposed carbon steel. After cover of the carbon steel has been made, electrodes of Classification E308 may be used in lieu of Classification E309 or E310.

i. **Riveting**

Punching, drilling, reaming and riveting shall be in accordance with the best commercial practice for the type of work concerned and as approved by the Engineer.

j. **Bolted Connections**

Bolt Holes

Holes for unfinished bolts shall be not more than 1.6 mm larger than the nominal diameter of the bolts. Unless otherwise specified or shown on the Drawings, holes for turned bolts shall be not more than 0.5 mm larger than the nominal diameter of the bolt, holes for unfinished bolts shall be sub-punched and reamed or sub-drilled and reamed or drilled from the solid. Holes for turned bolts shall be truly cylindrical throughout and drilling or reaming shall be done after the parts to be connected are assembled. Poor matching of holes shall be the cause for rejection.

High Strength Bolted Connections

High strength bolts shall be installed in accordance with the applicable requirements of the specifications for Structural Joints using ASTM-A 325 High-Strength Bolts for Structural Steel Joints, including Suitable Nuts and Plain Hardened Washers, or A490 Quenched and Tempered Alloy Bolts for Structural Steel Joints. Burrs shall be removed from around bolt holes.

k. **Painting and Galvanizing- Surface Preparation**

All structural steel material i.e. rolled steel section, plates, flat bards, chequered plates shall be cleaned free from loose scale, rust, burrs, slag etc., by sand blasting.

The sand used for this purpose shall be free from earth, dust, clay and moisture.

The size of sand particles, air pressure and size of the hose nozzle shall be correlated to give proper and acceptable surface.

Material which is to be used for fabrication of components to be galvanized later on shall not be cleaned.

l. **Painting**

Immediately after surface preparation all material should be given a prime coat of rust preventive paint.

After fabrication and test assembly all shop assemblies shall be given one shop coat of Prime paint and then one coat of enamel paint.

One final coat of enamel paint shall be applied after erection of all components.

The type of primer and enamel paint to be applied shall be specified on the drawings.

The thickness of each coat of paint shall be in accordance with the paint manufacturer's specifications / recommendations.

All other requirements for the specified paint system shall be in accordance with the paint manufacturer's specifications / recommendations.

The Contractor shall use the best quality of the type of paint specified and shall get the same approved by the Engineer.

Steel Work / Surfaces not to be Painted include Steel work to be encased / embedded in concrete or surface in contact with concrete or grout shall be given a cement wash after sand blasting.

Machine finished surfaces shall not be painted but shall be coated with rust preventive compound approved by the Engineer immediately after finishing. Such surfaces shall also be protected with wooden pads or other suitable means for transportation. Unassembled pins, keys and bolt thread shall be greased and wrapped with moisture resistant paper.

Contact surfaces of connections using high strength bolts in friction type connection shall not be painted. Such surfaces of all components, after fabrication, shall be cleaned free of paint, grease, burrs, slag by means of sand blasting. No coating whatsoever shall then be applied to such surfaces. The surface roughness for high strength friction grip bolts is a very important factor and therefore components shall not be erected unless duly approved by the Engineer.

m. **Zinc Coating (Galvanizing)**

Components should be galvanized after complete fabrication i.e., welding, drilling etc. The process should consist of removal of rust and mill scale by picking in hydrochloric acid or sulphuric acid followed by water wash and preflushing in tanks containing zinc ammonium chloride and then flushing with ammonium

chloride. The flushed components should then be passed through a drying oven prior to immersion in a bath of virtually pure molten zinc.

Wherever specified by the Engineer zinc coating shall be applied in a manner and of a thickness and quality specified for zinc (hot galvanized) coating on products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.

18.7.2 Installation

The Contractor shall be responsible for proper protection and installation of all items furnished. Should the prime coat be damaged, or rust scale appears, he shall at this own expense and at the Engineer's direction, have all exposed surfaces cleaned to bare bright and re-primed with an approved priming coat before finish painting.

All items shall be installed plumb and square and shall be solidly anchored in a good workman-like manner in accordance with the approved Shop Drawings. The Contractor shall be responsible for the protection of installed items from damages by trades. All items shall be left in operating neat and clean condition free from dirt, finger marks etc. The Contractor shall be responsible for final cleaning before final acceptance.

18.7 Delivery and Storage

18.7.1 Handling

Structural steel shall not be handled until the paint has thoroughly dried. Care shall be exercised to avoid abrasions and other damages.

18.7.2 Protection

Material shall be stacked out of mud and dirt and proper drainage be provided. Protection measures from damages or soiling by adjacent construction operations shall be provided.

18.7.3 Storage

Storage of fabricated steel at the job Site shall be the responsibility of the Contractor. Material at the Job site shall be stored in all manner which does not exceed design loads of existing or newly constructed structure. Material shall be protected against Corrosion or deterioration.

18.8 Measurement and Payment

18.8.1 General

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

Nuts, Bolts, Screw, rivets, beads, fillets, welds and welding rods.

Painting, galvanizing and anti-corrosion prime coating.

Notches, holes and slots and no allowance shall be made for rolling margin or weld metal.

SECTION 18– STEEL WORKS

Cutting, bending, fabricating.

All embedded metal parts, metal fittings and fixtures required for the operational process.

Cleaning with sand blasting.

Hinges, hold-fasts, latches, aldrops, stopper handles.

18.8.2 Measurement

Measurement of acceptably completed works of steel doors, windows, rolling shutters etc. will be made on the basis of net actual area in square feet of steel fabricated and installed in position as shown on the drawings or as directed by the Engineer.

18.8.3 Payment

Payment will be made for acceptable measured quantity on the basis of Contract unit rate per Square feet and shall constitute full compensation for all the works related to the item.

SECTION 19 - ENVIRONMENTAL IMPACT ASSESSMENT

19.1 General

EIA is a process whereby an assessment is made of the environmental impacts which may result from a proposed project and its alternatives. It is a planning tool providing an aid to decision makers, policy makers, developers, industrialists and the public.

According to Principle 17 of Rio Conference (1992),” Environmental Impact Assessment as a national instrument shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent authority”.

Following are the Objectives of Conducting an Environmental Impact Assessment

- a. To identify and evaluate all potentially significant environmental impacts of proposed undertakings, at a stage when alternative solutions, including remedial measures and the alternative of not proceeding, are available to decision makers
- b. To ensure that the proponent of an undertaking and government agencies required to approve the undertaking has given due consideration to the means of avoiding or mitigating adverse environmental impacts prior to granting approval to proceed with an undertaking

19.2 The EIA Process

The Environmental Impact Assessment process vary from country to country and even between state to state in several countries. The major objective is to determine whether or not the proposed activity have the potential to adversely affect the existing environment of the area. Whilst, it is impossible to have a development with zero damage to the environment, yet, it is far more beneficial to attend to the likely impacts and plan on elimination or minimization of potentially adverse impacts through alternatives, technological measures, administrative measures, trainings, and legislative bounds.

In Pakistan, requirement of an Environmental Statement was initiated in 1994. Later, Section 12 of Pakistan Environmental Protection Act (1997) required that an EIA or IEE was to be submitted for approval of a project having potential for damaging the environment. IEE/EIA Review Regulations (2000) further elaborated on whether EIA or IEE (Initial Environmental Examination) or none was required for a list of project categories. The requirement of IEE and EIA was based either upon the cost of the project or potential environmental impacts of a project.

Before the 18th Amendment, Environment was a federal subject and EIA was conducted under Section 12 of the Pakistan Environmental Protection Act (1997). Although, the spirit is same and a standard process is followed to conduct EIA, it is now a provincial subject and carried out under provincial acts.

19.3 Conducting an EIA

Following are the steps involved in conducting an EIA

Step-1: Screening – What is needed for the project, IEE or EIA?

Step-2: Scoping

- a. Identify the SCOPE of investigation within well-defined technical and physical boundaries of the project.
- b. Define Team, role of each team member.
- c. Determine the potentially significant environmental impacts and their level of significance
- d. Define which areas to be investigated and the extent of investigation.
- e. Explore what alternative are available? Which one is the best alternative and why?

Step-3: Conduct Detailed Environmental Assessment as defined in the SCOPING

- a. Get Lab tests done for air, water, noise, and soil.
- b. Determine the quantity and quality of the expected wastewater and define how the wastewater will be treated and its likely impacts on the quality of the receiving water-body.
- c. Where will the project get the drinking or process water and its impacts on ground water table or surface water?
- d. What will be the impacts of the project on the existing fauna and flora?
- e. How will the traffic within the project area as well as in the surroundings be affected and how will that impact be minimized during construction and operation of the project.
- f. How will be the air, water and noise pollution be kept at its minimum during all the phases of the project.
- g. What will be the socio-economic impacts of the project and working labor on the surrounding communities?
- h. How will be natural slopes and storm water drainage pattern be affected?
- i. How many trees be removed and how many new planted?
- j. Where will be the material stored and labor camp installed?
- k. What Safety measures will be adopted and how safety training will be imparted?

Step-4: Draft report preparation and submission along with appropriate fee, Schedule-IV form, 11 Hard and 2 Soft copies of the document to the relevant EPA Office.

Step-5: Arrangements for Public Hearing (in case of EIA only)

Step-6: If draft submitted by the proponents meets the fundamental requirements of EIA, EPA would ask the proponent to advertise for public hearing.

Step-7: Conduct of public hearing and incorporation of public concerns as well as concerns raised by EPA before re-submission of EIA.

Step-8: Review by EPA (45 Days for IEE and 90 Days for EIA).

Step-9: Decision by EPA along with terms and conditions of project operation during construction and operation of the project or to re-produce the EIA after resolving the outstanding issues.

Low Cost (Affordable) Housing Project falls under Schedule I of the IEE/EIA Review Regulation (2000) of the Pakistan Environmental Protection Act (1997). Subsection I requires that an IEE (Initial Environmental Examination) be carried out for Projects under “Urban Development and Tourism”.

Major environmental impacts of such project will include but not limited to:

- a. Changes in land use patterns (from agricultural to residential)
- b. Changes in natural storm water drainage pattern
- c. Changes and flora and fauna population and wildlife habitat
- d. Utilization of natural resources partly recoverable
- e. Solid waste and wastewater generation
- f. Changes in traffic patterns resulting in rise of air and noise pollution

All of the above impacts are manageable with committed environmental management.

In principal the above guidelines will be followed for assessing the Environmental Impact Assessment for all the projects undertaken by NAPHDA, however EIA being a provincial subject regulatory requirements of concerned Environmental Protection Agencies will be followed.

Ensuring sanctity of protected areas/Biodiversity by not targeting such areas for housing must also be enlisted the measures of Adaptation of Climate resilient infrastructure must be encouraged

A sub-section under section 19 may be added as that of “Environmental Management Plan for Schemes/projects under NAPHDA” primarily for contractors, that incorporate potential impacts and mitigation measures from different activities involved e.g., construction, operation, general environment issues and Health & Safety considerations. A sample/template in this regard is shared in the Table below:

Table - Environmental Management Plan

Housing Scheme Activities	Potential Impacts	Mitigation Measures
Construction/ Rehabilitation/ Phase		
Excavation	Loss of material into surroundings in case of improper disposal Contamination of ground water if hazardous materials percolate in the ground	Excavated material should be appropriately disposed off Concrete mixing on the ground should not be allowed Deep ditching should be consulted with Assistant/Deputy Director Environment if required Structural insulated panels with concrete mixture should be used to make foundation waterproof and avoid seepage Foundation stabilizing materials should be used Safety of labor must be ensured
Demolition, Construction and renovation activities	Air and noise pollution disrupt nearby also lead to eye / ear infection & respiratory related complications to workers Debris from demolition of the buildings would lead to aesthetic damage and environmental degradation.	Activities with intensive noise and air pollution to be undertaken during least disruptive times and holidays Provide workers with protective gears e.g masks, helmets, gloves, and gumboots Provide construction workers with First Aids Kits, proper protective equipment Collection of all debris from demolition activities for disposal to a designated waste disposal site with knowledge of local authorities Giving out unwanted materials from demolished structures such as iron sheets and timbers to local communities for reuse
Repairing Activities (Floor, Roof, Doors)	Humidification of building due to uncontrolled measures Injuries due to slippery floor surfaces Health hazard (Asbestosis) Energy efficient design of building Safety of labor	Floor surface should not be slippery to avoid injuries No asbestos material should be used during construction work. Rooms should be designed as properly ventilated and naturally lighted to reduce energy cost Rain chutes should be constructed on roofs to properly drain rainwater Resilient plastic—both vinyl sheet and tile are suitable for floor Scaffoldings should be used during construction activities (when Working at Height) Labor should be equipped with proper PPEs
Electric Installations	Injuries/Incidents due to unsafe electric installations. Short circuits due to quality compromised electric equipment/installations. Fire accidents due to electric installations	The labor should be provided with safety shoes, gloves, Safety goggle as per nature of job of worker Quality of electric installations should not be compromised Wiring should be underground Fire retardant plastic wires should be used Fire extinguishers should be installed at appropriate places
Sanitary Fittings	Ground water contamination due to lack of sewage treatment facility	Construction of soakage pit required for treatment of sewage waste

SECTION 19– ENVIRONMENTAL IMPACT ASSESSEMENT

Material and resources	Depletion of resources Environmental footprint Damage to infrastructure	Regionally produced and sustainable materials should be given preference for usage in construction and repair activities Project activities shall not use any hazardous materials such as asbestos, lead and PCBs Good engineering and construction practices must be applied Good housekeeping practices should be observed at site
Fire Safety Equipment Installation	Incidents due to fire	Smoke alarms and fire extinguishers should be installed at appropriate places Safety signage, including emergency exits, should be pasted at appropriate places
Operation Phase		
Indicators	Potential Impacts	Mitigation Measures
Plantation/ Greening		Aesthetically pleasing and contributing to Carbon reduction
Waste Bins installation	Aesthetically unappealing solid waste sprawl	Waste bins should be installed at appropriate places for effective management of solid waste
General Environmental Issues		
indicators	potential impacts	mitigation measures
Air Quality	Dust emission may be generated during construction Air emissions may be generated due to fuel burning from machinery/equipment and vehicles Complaints from community nearby	Air quality analysis should be carried out before and during construction All equipment and vehicles being used during the project activities should be ensured to be in good working condition Wherever possible, carry out major dust causing activities in spring / autumn
Water Resources	Accidental spillage of contaminants	Apply best engineering practices in storage and handling of lubricants, fuels and solvents
Soil pollution/ Land Contamination	Soil contamination from improper storage, handling of materials Soil pollution from improper disposal of waste	Apply best engineering practices in storage and handling of lubricants, fuels and solvents Immediately transport the accumulated construction waste to a site identified by the implementing authorities Cleaning of sites upon completion of schemes
Noise & Vibration	Noise/Vibration due to construction activities	Communities should be informed prior to starting work Workforce should be provided with earmuff/ear plugs Contractor should use well maintained machinery to reduce the impact. College/school timings should be considered, and work activities should be limited during working hours of nearby educational and health facilities

SECTION 19– ENVIRONMENTAL IMPACT ASSESSEMENT

Solid waste	Scattered solid waste may affect visuals /aesthetics and provide breeding place to mosquitoes	Immediately transport the accumulated construction waste to a site identified by the implementing authority or other concerned authority Scattered solid waste should be properly managed in order to avoid contamination and disturbance
Health & Safety		
Health & Safety Issues	Risk may occur from: Inadequate use of Personal Protective Equipment (PPEs) Accidentals risks Dust particles Air and Noise pollution fire hazards chemical spillages Falls Communicable diseases Other construction activities	Providing basic medical service and supplies to workers on-site such as First Aid Box and Fire Extinguisher and the workers should be trained in using them Consecutive sessions to be organized to create awareness among labor and contractors regarding Health, Safety and Environment Work safety measures and good workmanship practices are to be followed by the contractor to ensure no health risks for laborers Protection devices (ear muffs) will be provided to the workers operating in the vicinity of high noise generating machines Provision of adequate sanitation, washing, cooking and dormitory facilities including lighting Provision of protective clothing for laborers handling hazardous materials, e.g., helmet, adequate footwear for bituminous pavement works, protective goggles, gloves etc. Ensure strict use of wearing these protective clothing during work activities Elaboration of a contingency planning in case of major accidents Close consultation with local communities to identify optimal solutions for diversions to maintain community integrity & social links Provision of proper safety signage at sensitive/ accident-prone spots; and Cordon-off the constructed area
Social/Gender issues	Nearby community may be disturbed	Workers would be trained to address privacy issues and ethically behaved Labor would be strictly asked to cater for privacy issues

SECTION 20 - QUALITY ASSURANCE CRITERIA AND GUIDELINES FOR PREFABRICATED UNITS

20.1 General

The integrated performance of prefabricated units can be evaluated using several on-site as well as laboratory tests. Several international guidelines and standards are available to identify various aspects of performance to be examined in order to satisfy the minimum requirements. These requirements can be summarized under the following performance criterion.

- a) Mechanical resistance and stability
- b) Safety against natural hazards
 - i) Safety against strong winds and storms
 - ii) Seismic safety, resilience and other aspects of earthquake hazard
 - iii) Safety against floods and tsunamis
- c) Safety in case of fire
 - i) Reaction to fire
 - ii) Resistance to fire
 - iii) External fire performance of the roof covering
- d) Hygiene, health and environment
 - i) Vapour permeability and moisture resistance
 - ii) Water tightness
- e) Release of dangerous substances
- f) Safety in use
 - i) Slipperiness of floor finishes
 - ii) Falling due to changes in level or sudden drops
 - iii) Resistance to eccentric loads, including impact resistance
- g) Protection against noise
 - i) Airborne sound insulation
 - ii) Impact sound insulation
 - iii) Sound absorption
- h) Energy economy and heat retention
 - i) Thermal resistance
 - ii) Air permeability
 - iii) Thermal inertia

A list of laboratory and on-site tests generally used to assess the component- and structural-level performance of prefabricated units is given in subsequent section.

20.2 Component and Structural-Level Tests for Prefabricated Units

It is essential to ensure structural strength and stability of any prefabricated design submitted to NAPHDA. In order to ensure structural strength and stability, structural design calculations along with architectural, structural, electrical, and plumbing drawings to vetting. Enlisted renowned structural engineer shall review the structural design to ensure

compliance with building code provision. The overall structural performance under various load conditions can be assessed using the following tests.

A. Structural Integrity and Strength

- a) The direct compression testing of prefabricated panels.
- b) The flexure testing of prefabricated panels (under centre-point or two-point) loading (subjected to in- plane and out- of- plane bending).
- c) On-site non-destructive testing for qualitative assessment of individual components of prefabricated units.
 - i) Ultrasonic pulse velocity (UPV) testing.
 - ii) Electrical resistivity tests for corrosion under different exposure conditions.
 - iii) Cracks measurements at different loading and exposure conditions.
 - iv) Rebound hammer tests to qualitatively assess the surface toughness and strength.

B. Energy Efficiency

- a) Thermal performance testing of prefabricated units and their envelope for assessing the indoor thermal environment vs. the thermal comfort requirements.
- b) Energy economy and heat retention tests.
- c) Thermal resistance and air permeability tests.

C. Seismic Resilience

- a) Monotonic lateral static load testing of the prefabricated units.
- b) Reversed-cyclic lateral static load testing of the prefabricated units.
- c) Reversed-cyclic lateral static load testing of the connections between components of prefabricated units.
- d) Shake table dynamic testing of prefabricated and low-cost units.
- e) Ambient and forced vibration testing of prefabricated and low-cost units using eccentric mass vibrator (EMV) and accelerometers to determine their modal properties (mode shapes and natural frequencies).

D. Specifications for Component- and Structural-Level Tests of Prefabricated Units

The following international standards cover various aspects of individual component- and structural-level tests of prefabricated units.

- a) ASTM C901 – 18: Standard Specification for Prefabricated Masonry Panels.
- b) ETAG 023 – 2006: Guideline for European Technical Approval of Prefabricated Building Units.

SECTION 20 – QUALITY ASSURANCE CRITERIA AND GUIDELINES FOR PREFABRICATED UNITS

- c) CSA A277-2016: Procedure For Certification Of Prefabricated Buildings, Modules, And Panels
- d) CAN/UL 2600: Standard for Relocatable Structures.
- e) TS ENV1998-1: Eurocode 8: Projecting Buildings Resistance to Earthquake –Volume 1: General rules, rules for seismic effects and buildings.
- f) TS 3611 EN 20898-2: Mechanical specifications of connection elements – Part 2: Test Load Values Determined Nuts—Normal Step.

SECTION 21 - GUIDELINES FOR SOLAR PV SYSTEM

21.1 General

The following are the steps for the insatallation of Solar PV System

- I. Before installation of any Solar PV system, survey and assessment should be conducted for available space at roof top, injection point, PV Cable routing from PV modules to Inverters, delivery of components to roof top, roof top load bearing capacity, availability of south facing, shading during the day, consumption profile and monthly average energy (KWh) requirement etc.
- II. After complete survey, the solar PV system should be designed as per the load, energy requirement (KWh) and back up time for battery based solar systems and Energy (KWh) requirement for battery less Solar PV systems as per space availability. System must be designed by Qualified PEC Registered Engineer.
- III. After system design the solar PV procurement should be done. Solar PV system should be procured from legally registered Solar Company having valid Income Tax and GST registration and valid registration from PEC in solar category. Solar Company must have minimum three years' experience of installation of solar PV system on Turnkey basis. For Net Metered Solar System, AEDB registration for net metering is mandatory.
- IV. Regarding Solar PV components Specifications, Quality and standards, following guidelines should be followed:
 - a. Solar PV Modules should be Tier-1 as per Bloomberg New Energy Finance (BNEF) Tier-1 List. PV module must have serial Number under the Glass and Logo engraved on back junction box. Solar PV Module Conversion Efficiency should be the highest available in the market and current best conversion Efficiency is 20%. Solar PV modules must comply with the IES standard 61215 (Latest Edition) and IEC 61370 (Latest Edition) and must have been tested as per these two standards from any accredited laboratory certified as per IEC 17025 standard. The product warranty should not be less than 10 years and performance warranty should not be less than 25 years.
 - b. Solar PV Inverters should be of high quality not having efficiency less than 98% and having Total Harmonic Distortion (THD) of less than or equal to 3%. Output of Solar PV inverters must be fully clean sinewave. The Inverters must comply with IEC standards 61683, 62116 & 61727 (Latest Editions). The warranty should not be less than five years.
 - c. The cable from PV modules to Inverters must be single core, double insulated, halogen free, Fire and UV resistant and tested at continuous temperature of 120 Degree C and must withstand 1500V. Cable insulation must be of XLPE/XLPO.
 - d. Solar PV Mounting structure must be Hot Dip Galvanized not less than 12 SWG with stainless SS304 nut bolts having capability to withstand 120 KM per hour of wind speed. Material must be rust free and durable.
 - e. Battery based systems should have Lead Acid or Lithium Battery designed as per requirement of Back up when solar and Grid is not present. Locally manufactured batteries should be preferred.

- f. Switchgears panels components must be of high quality and locally manufactured switch gears should be preferred. Switch Gear cabinets and Power distribution Boards must include Circuit Breakers of High quality, Surge Protection Devices (SPDs), Bus Bars, manual ON/OFF switch and separation of DC and AC circuit breakers should be maintained.
- g. Solar PV Systems must have capability through web-based applications to monitor remotely at mobile or Laptop or PC the Solar PV performance parameters such as Load, Energy, Energy export and import, daily trends.
- h. Accessories like Ducts, Pipes, Thimbles, Connectors, Channels, brackets, shrouds etc should be of high quality.
- i. The warranty (Free Labor, material and troubleshooting) of the whole system should not be less than three years in addition to warranty of individual components.
- j. Proper RFP or RFQ should be generated for solicitation of proposals from Vendors and suppliers and Proposals must mention brand and manufacturer of each Component with warranties.
- k. For net metering, Solar PV system must comply with relevant DISCO SOPs for net metering and NEPRA SRO 892/2015 for Net Metering.
- l. One common earth pit earthing system for DC and AC both is required for non-net metering system and two earth pits separate for DC and AC are required in case of Net Metered Systems as per NEPRA Net Metering SRO and DISCO SOPs.
- m. System installation should be done by trained and qualified persons.

21.2 Typical System Designs For Guidance Purposes – Not Mandatory

Less than 3 KVA solar system of any kind is not feasible in terms of cost and quality. There are two types of solar systems used where Grid supply is available. One is Solar Grid Hybrid System and other is On-Grid system.

Solar Grid Hybrid PV system is built with battery and on-grid solar PV system is without battery used for export of extra energy through net meter and these systems are mostly useful for three phase Utility connections. Solar Grid Hybrid systems are expressed in KVA of INVERTER with average Energy Generation per day.

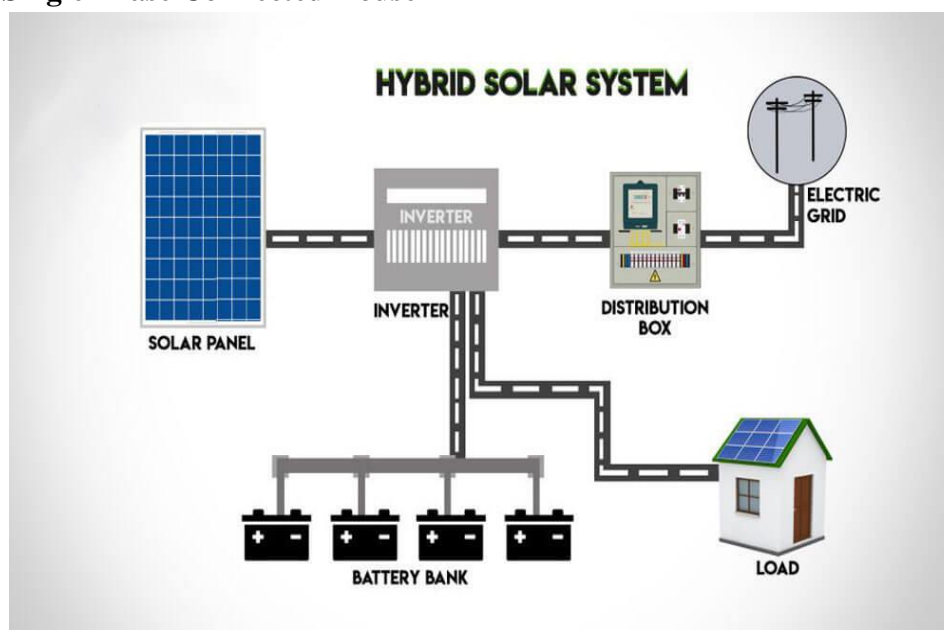
On-grid solar PV systems are defined with the total size of PV Modules in Wp at STC (Standard Testing Conditions).

Typical System Designs are provided for Guidance purposes only and are not Manadotory. The designs include

- Solar PV System for Single Story House – Suitable for 05Marla and 10 Marla Single Phase Connected House
- KWP Rooftop Solar PV On-Grid without Battery with Net Metering for 10 Marla Single or Double Story Three Phase Connection House

For Both the above designs typical BOQ are also provided.

21.2.1 Solar PV System for Single Story House – Suitable for 05 Marla and 10 Marla Single Phase Connected House



Rooftop Solar PV Grid Hybrid System for Running 2500 W Load

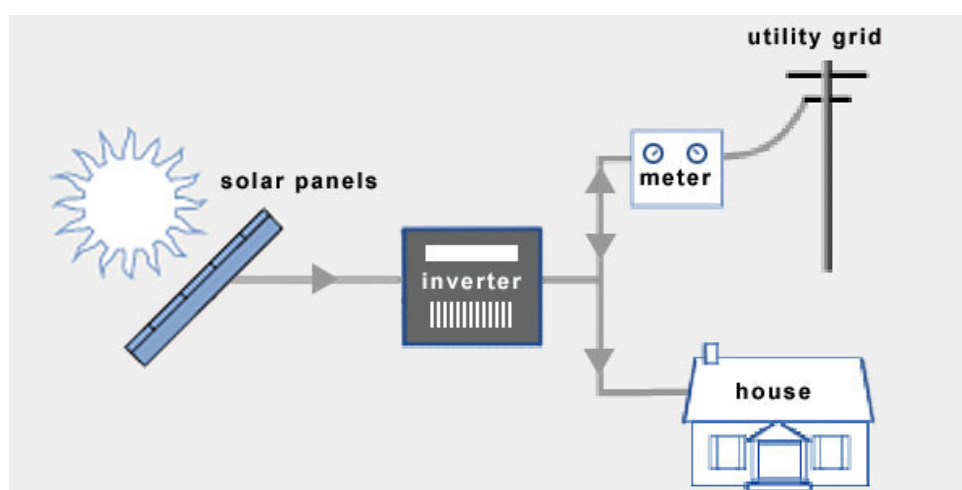
This solar system will be Grid Hybrid system providing average energy of 12 KWh/Day (Annual Energy generation divided by 365 days) and monthly average of 360 KWh per month. The system will provide battery backup of two hours if the battery is fully charged. The total space required is 422 SQF for PV modules installation and this system is suitable for Five Marla and 10 Marla single story house.

Typical BOQ for 3 KVA Grid Hybrid System

ITEM	ITEM units	Total Size/QTY	Remarks
Tier-1 Solar PV PERC Half Cut Module having conversion efficiency of 20% tested as per IEC 61215 and 61730 with 10 years product warranty and 25 years performance warranty	Watts at STC	3200	Eight Modules if 400W PV Module is used. In case of higher watt module, number will change needing matching with inverter.
Single Solar PV Hybrid Inverter having efficiency of minimum 95% (five years warranty minimum).	KVA	3 KVA	Will not export electricity to Grid
Solar PV Mounting Frame 12 Gauge Hot Dip MS Galvanized with stainless Nut Bolts	Number	04	04 frames each of two modules if 400W module is selected. In case of higher watt module, this needs to be adjusted accordingly.
Solar PV cable from PV modules to Inverter tested as per IEC standard 62930:2017	meter	90	

Power Distribution Box containing Bus-bars, DC and AC circuit breakers. SPDS, Volt and Current meters display with rotary change over switch disconnecting solar from GRID.	QTY	01	
Tubular 12 Volts Battery having three years warranty. Pakistan Origin	Ampere-Hour	800	There will be 04 batteries if 200AH battery is selected.
Angle iron Battery Rack painted	SET	01	As per Battery Numbers.
Electrical and mechanical accessories set (MC- 4 connectors, PVC pipe, Slotted ducts and channels, Tape, Heat, Shrinks for Battery terminals, Thimbles etc	SET	01	
16 mm DC Cable from Inverter to Battery	Meter	30	
25 mm AC Cable from Inverter to Power Distribution Board	Meter	30	
Transportation and Handling	Job	01	
Installation and commissioning	Job	01	

21.2.2 5 KWP Rooftop Solar PV On-Grid without Battery with Net Metering for 10 Marla Single or Double Story Three Phase Connection House



This solar system will be On-Grid system without battery. This On-grid system will provide average 20 KWh/Day (Annual Energy generation divided by 365 days) and monthly average of 600 KWh per month. The system will stop production when the Grid will be off. Such systems are synchronized with Grid and are called Energy Sharing Systems and

SECTION 21 – GUIDELINES FOR SOLAR PV SYSTEMS

are feasible only with Net Meter installed and therefore suitable for three phase Utility connections only.

The space required for this system is 660 SQFT for PV modules installation and this system is suitable for 10 Marla Single or Double Story house.

Typical BOQ FOR 5 KVA Grid Hybrid System,

ITEM	ITEM units	Total Size/QTY	Remarks
Tier-1 Solar PV PERC Half Cut Module having conversion efficiency of 20% tested as per IEC 61215 and 61730 with 10 years product warranty and 25 years performance warranty	Watts at STC	5340 Wp	PV Modules will be 12 if 445W of PV module is used. In case of higher watt module, the number of modules will reduce and matching with Inverter will be required.
Single Solar PV On-Grid Inverter with Export Manager and Wifi Stick having efficiency of minimum 98% with five years warranty.	KVA	5 KVA	Will export energy in case of net metering
Solar PV Mounting Frame 12 Gauge Hot Dip MS Galvanized with stainless Nut Bolts	Number of frames as per selection of Module size.		
4 mm Solar PV cable from PV modules to Inverter tested as per IEC standard 62030:2017	meter	180	
Power Distribution Box containing Bus-bars, DC and AC circuit breakers. Volt and Current meters display with rotary change over switch disconnecting solar from GRID.	QTY	01	
Tubular 12 Volts Battery having three years warranty. Pakistan Origin	Ampere-Hour	800 AH	
Angel iron Battery Rack painted	SET	01	As per Battery Numbers
Electrical and mechanical accessories set (MC- 4 connectors, PVC pipe, Slotted ducts and channels, Tape, Thimbles etc.	SET	01	
10 mm AC Cable from Inverter to Power Distribution Board	Meter	60	

Earthing at DC and AC sides with earthing cables and earthing material and labour.	job	01	
Main Outdoor DC Disconnect 100A/1000V	Nr	01	
Net metering fee and processing charges	Job	01	
Transportation and Handling	Job	01	
Installation and commissioning	Job	01	

21.2.3 Multiple Story Flats and Apartments

As there is common roof for multiple story flats and apartments and big solar hybrid system as per roof size can be installed to share energy with Grid and provide also back up when grid is not available and this system should run the common loads of building like Outdoor lighting, Lifts and Pumps. Such systems should be Hybrid On-grid which means that when Grid will be off the system will act as Off-grid and when Grid is On, it will act as On-Grid and start export of extra energy if not used and residents should pay monthly fixed charges for such solar systems to Facility Management and should be part of maintenance charges. 50KW solar Hybrid system with batteries can run the lifts, outdoor lighting and one emergency Pump of the Building but system size depends upon the actual load calculation of lifts, outdoor lighting and pumps. Space required for 50KW solar On-grid and hybrid system will be 7920 SQF.

Provision of such system should be made by having a separate circuit of Outdoor lighting, Lifts and Pumps and one DB should be made available at roof top to connect solar system along with one room at roof-top as control room of 20x20 ft for inverters and batteries. System will be under the control of Facility Management.

21.2.4 Prepaid Metering for Houses and Flats of 3 Marla or Less

As poor households always have problem of over use of electricity and they always remain out of budget and face problems and if each household unit is provided with one pre-paid meter, they can manage the Utility bill in better manner and can use electricity within their resources and budgets.

Every month they get token from the facility management and consume that energy on monthly basis as per limit. This will provide poor household good control of electricity consumption and provide ease in life.

APPENDIX-A

STRUCTURAL PRECAST CONCRETE

A-1 General

This Specification is intended to be used for the preparation of specifications for a particular project. Coordinate the specifications with the information shown on the contract drawings to avoid duplication or conflicts.

- a. The specifications cover the performance requirements, materials, design, production, and erection of structural precast and precast, pre-stressed concrete for the entire project. The work performed under this Section includes all labor, material, equipment, related services, and supervision required for the manufacture and erection of the structural precast and precast, pre-stressed concrete work shown on the Contract Drawings. The following headings are included.
- Performance requirements
 - Action Submittals
 - Informational Submittals
 - Quality Assurance
 - Delivery, Storage and Handling
 - Sequencing
 - Fabricators
 - Form Materials
 - Reinforcing Materials
 - Prestressing Materials
 - Concrete Materials
 - Steel Connection Materials
 - Stainless Steel Connection Materials
 - Bearing Pads and Other Accessories
 - Grout Materials
 - Insulated Panel Accessories
 - Concrete Mixtures
 - Form Fabrication
 - Fabrication
 - Insulated Panel Casting
 - Fabrication Tolerances
 - Finishes
 - Source Quality Control
 - Site Preparation for Execution
 - Examination
 - Erection
 - Erection Tolerances
 - Field Quality Control
 - Repairs
 - Cleaning

- b. This specification covers the different components of the precast construction including the following:
1. Hollow-core slab units.
 2. Beams, columns, double tees.
 3. Walls, spandrels.
 4. Insulated, precast concrete units.
 5. If needed, <Insert other applicable members> if specified by LDP.

A-1.1 Industry Codes and Standards

ACI 318 (ACI 318M).

ASTM C 1077

ASTM E 329

PCI MNL 120, “PCI Design Handbook – Precast and Pre-stressed Concrete,”

PCI MNL 116, “Manual for Quality Control for Plants and Production of Structural Concrete Products.”

ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

ASTM A 706/A 706M, deformed.

ASTM A 775/A 775M]

ASTM A 934/A 934M]

ASTM A 184/A 184M,

ASTM A 185/A 185M,

ASTM A 1064/A 1064M

ASTM A 497/A 497M, or ASTM A 1064/A 1064M

ASTM A 884/A 884M,

ASTM A 416/A 416M,

ASTM A 886/A 886M,

ACI 423.7

ASTM A 910/A 910M

ASTM A 722/A 722M

CONCRETE MATERIALS

ASTM C 150, Type I or III.

ASTM C 618

ASTM C 618, Class N.

ASTM C 1240

ASTM C 989

ASTM C 33

ASTM C 330

ASTM C 979

ASTM C 260

ASTM C 494/C 494M

ASTM C 1017/C 1017M

ASTM C 1582/C 1582M

STEEL CONNECTION MATERIALS

ASTM A 36/A 36M

ASTM A 108

AWS D1.1/D1.1M

ASTM A 283/A 283M

ASTM A 47/A 47M.

ASTM A 27/A 27M
ASTM A 572/A 572M
ASTM A 500/A 500M
ASTM A 675/A 675M
ASTM A 496
ASTM A 706/A 706M.
ASTM A 307
ASTM F 568M
ASTM A 563/A 563M
ASTM F 844
ASTM A193/A193M
ASTM A 325/ A 325M
ASTM A 490/ A 490M
A 563/A 563M
ASTM F 436/F 436M
ASTM A 123/A 123M
ASTM A 153/A 153M
ASTM F 2329
ASTM B 633

STAINLESS-STEEL CONNECTION MATERIALS

ASTM A 666
ASTM F 593
ASTM A 276

BEARING PADS AND OTHER ACCESSORIES

AASHTO M 251
ASTM D 2240
ASTM D 412

A-1.2 Definitions

Constructor or Contractor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of concrete materials in accordance with contract documents. The term constructor shall apply also to constructor's subcontractor(s) and vendor(s).

Contract documents: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and constructor.

Engineer of record (The Engineer): Purchaser's authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, structure, foundations, materials, and appurtenances described in contract documents. Engineer of record shall be licensed as defined by laws of the locality in which the work is to be constructed, and be qualified to practice in the specialty discipline required for the work described in contract documents.

Environmental engineering concrete structures: Concrete structures intended for conveying, storing, or treating water, wastewater, or other nonhazardous liquids, and for secondary containment of hazardous materials.

Licensed Design Professional: An engineer or architect who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of a state or jurisdiction

Manufacturer: Party who produces and warrants performance of products, materials, and/or items provided in accordance with contract documents. Products, materials, and/or items are manufactured in a controlled process using standard codes, specifications, tests and possibly include shop drawings to assist in proper application, installation and/or use. The term manufacturer shall apply also to manufacturer's subcontractor(s) and/or vendor(s).

Mass concrete: Any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.

Owner: Party who has authority through ownership, lease, or other legal agreement over site, facility, structure or project wherein concrete materials will be used.

Purchaser: Party who awards contract to constructor. Purchaser may be owner or owner's authorized agent.

Self-consolidating concrete: Fresh concrete that can flow around reinforcement and consolidate within formwork under its own weight without vibration.

Supplier: Party responsible for supplying concrete materials in accordance with contract documents.

A-2 Performance Requirements

a. Structural Performance:

Provide structural precast concrete members and connections capable of withstanding design loads indicated within limits and under conditions indicated on Structural Drawings.

Or

b. Structural Performance:

Provide structural precast concrete members and connections capable of withstanding the following design loads within limits and under conditions indicated below or as specified by the LDP.

No.	Loads	
1	Dead Loads	
2	Live Loads	
3	Roof Loads	
4	Basic Ground Snow Load:	
5	Rain Loads:	
6	Concrete Topping Thickness:	
7	Wind Loads: as required by applicable building code or ASCE/SEI 7, including basic wind speed, importance factor, exposure category, and pressure coefficient.	
8	Seismic Loads: as required by applicable building code including seismic performance category, importance factor, use group, seismic design category, seismic zone, site classification, site coefficient and drift criteria.	
9	Blast Loads	

- c. Licensed Design Professional (LDP) shall design structural precast concrete framing system and connections to maintain clearances at openings, to allow for fabrication and construction tolerances, to accommodate live-load deflection, shrinkage and creep of primary building structure, and other building movements. Maintain structural precast concrete deflections within limits of ACI 318 (ACI 318M).
- d. Licensed Design Professional (LDP) shall provide locations on Drawings if different movements are anticipated for different building elements. If deflection limits stricter than ACI 318 (ACI 318M) are required, the limits must be specified.
 - 1. Thermal Movements: Provide for thermal movements noted.
 - a. The precast system design shall consider the maximum seasonal climatic temperature change.
 - b. In plane thermal movements of individual members directly exposed to the sun shall consider a temperature range as specified by the LDP.
 - c. Member connection design shall consider through thickness thermal gradients as appropriate.
- e. When required, fire-rated products shall be clearly identified on the design drawings.
- f. For Fire Resistance Rating, Provide the information in the Table below as specified by LDP.

Member	Fire rating
Roof:	
Floors	
Columns	
Exterior Walls	

- g. For Parking Structures, provide information on the Vehicular Impact Loads:
- h. Design spandrel beams acting as vehicular barriers for passenger cars to resist a single load of **(6,000 lb [26.7 kN])** or as specified by the LDP service load applied horizontally in any direction to the spandrel beam, with anchorages or attachments capable of transferring this load to the structure. Design spandrel beams, assuming the load to act at a height of 18 in (457 mm) and 27 in (686 mm) above the floor or ramp surface on an area not to exceed 1 ft² (0.093 m²).

A-3 Action Submittals

- a. Product Data: For each type of product indicated. Retain quality control records and certificates of compliance for 5 years after completion of structure.
- b. Design Mixtures: For each precast concrete mixture. Include compressive strength.
- c. Shop (Erection) Drawings:
 - 1. Detail fabrication and installation of structural precast concrete units including connections at member ends and to each adjoining member.
 - 2. Indicate locations, plan views, elevations, dimensions, shapes, and cross sections of each unit, openings, support conditions and types of reinforcement, including special reinforcement.
 - 3. Indicate aesthetic intent including joints, rustications or reveals, and extent and location of each surface finish.
 - i. Indicate welded connections by AWS standard symbols. Show size, length, and type of each weld.
 - ii. Detail loose and cast-in hardware, lifting and erection inserts, connections, and joints.
 - iii. Indicate locations, tolerances and details of anchorage devices to be embedded in or attached to structure or other construction.
 - iv. Include and locate openings larger than 10 in (250 mm). Where additional structural support is required for openings include header design.
 - v. Coordinate and indicate openings and inserts required by other trades.
 - vi. Indicate location of each structural precast concrete member by same identification mark placed on unit.
 - vii. Indicate relationship of structural precast concrete members to adjacent materials.
 - viii. Indicate locations and details of joint treatment.
 - ix. Indicate areas receiving toppings and magnitude of topping thickness.
 - x. Indicate estimated cambers for floor slabs receiving cast-in-place topping.
 - xi. Indicate multiple Wythe connection devices.
 - xii. Indicate shim sizes and grouting sequence.
 - xiii. Design Modifications: If design modifications are proposed to meet performance requirements and field conditions, notify the Licensed Design Professional (LDP) and submit design calculations and Shop Drawings. Do not affect the appearance, durability or strength of members when modifying details or materials. Maintain the general design concept when altering size of members and alignment.
- d. Provide handling procedures, erection sequences, and for special conditions provide temporary bracing and shoring plan.

- e. Comprehensive engineering design shall be signed and sealed by a qualified Licensed Design Professional (LDP) responsible for its preparation licensed in the jurisdiction in which the project is located.

A-4 Informational Submittals

The following are included in the Submittals.

- a. Qualification Data: The installer, fabricator, testing agency and persons specified in "Quality Assurance" Article shall demonstrate their capabilities and experience. Include list of completed projects with project names and addresses, names and addresses of Licensed Design Professionals and owners, and other information specified.
- b. Welding Certificates: Copies of certificates for welding procedure specifications (WPS) and personnel certification.
- c. Material Test Reports for aggregates: From an accredited testing agency, indicating and interpreting test results for compliance with requirements indicated.
- d. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements.
 - 1. Cementations materials.
 - 2. Reinforcing materials and pre-stressing tendons.
 - 3. Admixtures.
 - 4. Bearing pads.
 - 5. Structural-steel shapes and hollow structural sections.
 - 6. Insulation.
 - 7. Other components specified in Contract Documents with applicable standards.
- e. Field quality-control test and special inspections reports.

A-5 Quality Assurance

- a. Erector Qualifications: A precast concrete erector shall have a minimum of 2 years of experience in structural precast concrete work [including Category S1 (Simple Structural Systems) for horizontal decking members and single-lift wall panels, Category S2 (Complex Structural Systems) for load-bearing members]. Erectors with more than 03 precast work projects completed projects will be preferred.
- b. Erector Certification: Certificate of successful completion of the project (if available) should be submitted.
- c. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in producing structural precast concrete units similar to those indicated for this Project and with a record of successful in-service performance.
 - i. Assumes responsibility for engineering structural precast concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
 - ii. Professional Engineer Qualifications: A professional engineer licensed in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of structural precast concrete that are similar to those indicated for this Project in material, design, and extent.
 - iii. Has sufficient production capacity to produce required members without delaying the Work.

- iv. Certification shall be maintained throughout the production of the precast concrete units. Production shall immediately stop if at any time the fabricator's certification is revoked, regardless of the status of completion of contracted work. Production will not be allowed to re-start until the necessary corrections are made and certification has been re-established.
- v. Is registered with and approved by authorities having jurisdiction.
- d. Testing Agency Qualifications: An independent accredited testing agency, [acceptable to Authorities having jurisdiction] qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated.
- e. Design Standards: Comply with ACI 318 (ACI 318M) and the design recommendations of PCI MNL 120, "PCI Design Handbook – Precast and Pre-stressed Concrete," applicable to types of structural precast concrete members indicated.
- f. Quality-Control Standard: For manufacturing procedures and testing requirements and quality control recommendations for types of members required, comply with PCI MNL 116, "Manual for Quality Control for Plants and Production of Structural Concrete Products."
 - 1. Comply with camber and dimensional tolerances of PCI MNL 135, "Tolerance Manual for Precast and Pre-stressed Concrete Construction."

A-6 Delivery, Storage, And Handling

- a. Deliver all structural precast concrete members in such quantities and at such times to assure compliance with the agreed upon project schedule and setting sequence to ensure continuity of installation.
- b. Handle and transport members in a manner to avoid excessive stresses that could cause cracking or other damage.
- c. Store units with adequate dunnage and bracing, and protect units to prevent contact with soil, staining, and to control cracking, distortion, warping or other physical damage.
- d. Unless otherwise specified or shown on Shop Drawings, store members with dunnage across full width of each bearing point.
- e. Place stored members so identification marks are clearly visible, and units can be inspected.
- f. Place dunnage of even thickness between each member.
- g. Lift and support members only at designated points indicated on the Shop Drawings.

A-7 Sequencing

- a. Coordination and responsibility for supply of items to be placed on or in the structure to allow placement of precast concrete members depends on type of structure and varies with local practice.
- b. Clearly specify responsibility for supply and installation of hardware. If not supplied by precast concrete fabricator, supplier should be listed and requirements included in related trade sections. Ensure that type and quantity of hardware items to be cast into precast concrete members for use by other trades are specified or detailed in Contract Drawings and furnished to fabricator, with instructions, in a timely manner in order not to delay the Work.
- c. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction without delaying the Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

A-8 Products -Fabricators

- a. **Fabricators:** The fabricators shall provide one of the following
- Fabricators names
 - Product designations from acceptable manufacturers.

A-9 Form Materials

- a. **Forms:** The material shall be Rigid, dimensionally stable, no absorptive material, warp and buckle free that will provide precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required surface finishes.
1. **Form-Release Agent:** Commercially produced form-release agent that will not bond with, stain or affect hardening of precast concrete surfaces and will not impair subsequent surface or joint treatments of precast concrete.

A-10 Reinforcing Materials

- a. **Recycled Content of Steel Products:** Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of pre-consumer recycled content is not less than **25** percent.
- b. **Reinforcing Bars:** ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- c. **Low-Alloy-Steel Reinforcing Bars:** ASTM A 706/A 706M, deformed.
- d. **Galvanized Reinforcing Bars:** [ASTM A 615/A 615M, Grade 60 (Grade 420)] [ASTM A 706/A 706M], deformed bars, ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized and chromate wash treated after fabrication and bending.
- e. **Epoxy-Coated Reinforcing Bars:** [ASTM A 615/A 615M, Grade 60 (Grade 420)] [ASTM A 706/A 706M], deformed bars, [ASTM A 775/A 775M] or [ASTM A 934/A 934M] epoxy coated.
- f. **Steel Bar Mats:** ASTM A 184/A 184M, fabricated from [ASTM A 615/A 615M, Grade 60 (Grade 420)] [ASTM A 706/A 706M], deformed bars, assembled with clips.
- g. **Plain-Steel Welded Wire Reinforcement:** ASTM A 185/A 185M, or ASTM A 1064/A 1064M, fabricated from galvanized and chromate wash treated steel wire into flat sheets.
- h. **Deformed-Steel Welded Wire Reinforcement:** ASTM A 497/A 497M, or ASTM A 1064/A 1064M, flat sheet.
- i. **Epoxy-Coated-Steel Welded Wire Reinforcement:** ASTM A 884/A 884M, Class A coated, [plain] [deformed], flat sheet, Type (1 bendable coating) (2 non-bendable coating).
- j. **Supports:** Use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.

A-10.10.1 Prestressing Tendons

- a. **Prestressing Strand:** ASTM A 416/A 416M, Grade 250 (Grade 1720) or Grade 270 (Grade 1860), uncoated, 7-wire, low-relaxation strand or ASTM A 886/A 886M, Grade 270 (Grade 1860), indented, 7-wire, low-relaxation strand (including supplement).
- b. **Unbonded Post-Tensioning Strand:** ASTM A 416/A 416M, Grade 270 (Grade 1860), 7-wire, low-relaxation strand with corrosion inhibitor conforming to ACI 423.7, with polypropylene tendon sheathing. Include anchorage devices.

- c. Prestressing Strand: ASTM A 910/A 910M, Grade 270 (Grade 1860), uncoated, weldless, 2-and 3-wire, low relaxation strand.
- d. Post-Tensioning Bars: ASTM A 722/A 722M, uncoated high strength steel bar.

A-10.10.2 Concrete Materials

- a. Portland cement: ASTM C 150, Type I or III. For surfaces exposed to view in finished structure, use same type, brand, and mill source throughout the precast concrete production.
 - 1. Supplementary Cementitious Materials
 - Fly Ash: ASTM C 618, Class C or F with maximum loss on ignition of 3%.
 - 2. Metakaolin: ASTM C 618, Class N.
 - 3. Silica Fume: ASTM C 1240 with optional chemical and physical requirements.
 - 4. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- b. Normal weight Aggregates: ASTM C 33, with coarse, non-reactive aggregates complying with Class [4S] [4M]. Stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for Project.
- c. Lightweight Aggregates: ASTM C 330 with absorption less than 11 percent.
- d. Coloring Admixture: ASTM C 979, synthetic or natural mineral-oxide pigments or liquid coloring admixtures, temperature stable and nonfading.
- e. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete.
- f. Air Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- g. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15 percent chloride ions or other salts by weight of admixture.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - 4. Water-Reducing and Accelerating Admixture ASTM C494/C 494M, Type E.
 - 5. High Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - 6. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - 7. Plasticizing Admixture for Flowable Concrete: ASTM C 1017/C 1017M.
 - 8. Corrosion Inhibiting Admixture: ASTM C 1582/C 1582M

A-10.10.3 Steel Connection Materials

- a. Carbon-Steel Shapes and Plates: ASTM A 36/A 36M
- b. Carbon-Steel Headed Studs: ASTM A 108, Grades 1010 through 1020, cold finished, AWS D1.1/D1.1M, Type A or B, with arc shields and with the minimum mechanical properties of PCI MNL 116, Table 3.2.3.
- c. Carbon-Steel Plate: ASTM A 283/A 283M, Grade C.
- d. Malleable Iron Castings: ASTM A 47/A 47M. Grade 32510 or 35028.
- e. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 60-30 (Grade 415-205).
- f. High-Strength, Low-Alloy Structural Steel: ASTM A 572/A 572M
- g. Carbon-Steel Structural Tubing: ASTM A 500/A 500M, Grade B or C.
- h. Wrought Carbon-Steel Bars: ASTM A 675/A 675M, Grade 65 (Grade 450).
- i. Deformed-Steel Wire or Bar Anchors: ASTM A 496 or ASTM A 706/A 706M.

- j. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A or C (ASTM F 568M, Property Class 4.6) carbon-steel, hex-head bolts and studs; carbon-steel nuts (ASTM A 563/A 563M, Grade A); and flat, unhardened steel washers (ASTM F 844).
- k. High-Strength Bolts and Nuts: ASTM A193/A193M, Grade B5 or B7, ASTM A 325/A 325M, or ASTM A 490/ A 490M, Type 1, heavy hex steel structural bolts, heavy hex carbon-steel nuts, (ASTM A 563/A 563M) and hardened carbon-steel washers (ASTM F 436/F 436M).
- l. Shop-Primed Finish: Prepare surfaces of non galvanized steel items, except those surfaces to be embedded in concrete.
- m. Zinc-Coated Finish: For exterior steel items and items indicated for galvanizing, apply zinc coating by [hot-dip process according to ASTM A 123/A 123M, after fabrication, ASTM A 153/A 153M, or ASTM F 2329 as applicable] [electrode position according to ASTM B 633, SC 3, Type 1 or 2 and for bolts F 1941 and F 1941M].
 - 1. For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03 percent or to between 0.15 and 0.25 percent or limit sum of silicon content and 2.5 times phosphorous content to 0.09 percent.
 - 2. Galvanizing Repair Paint: Zinc paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035B or SSPC-Paint 20.
- n. Galvanizing Paint: Zinc paint with dry film containing not less than 94 percent zinc dust by weight. Comply with manufacturer’s requirements for surface preparation.

A-10.10.4 Stainless-Steel Connection Materials

- a. Stainless-Steel Plate: ASTM A 666, Type 304, Type 316, or Type 201, of grade suitable for application.
- b. Stainless-Steel Bolts and Studs: ASTM F 593, alloy 304 or 316, hex-head bolts and studs; stainless-steel nuts; and flat, stainless-steel washers.
 - 1. Lubricate threaded parts of stainless steel bolts with an anti-seize thread lubricant during assembly.
- c. Stainless-Steel Headed Studs: ASTM A 276, with minimum mechanical properties for studs as indicated under MNL 116, Table 3.2.3.

A-10.10.5 Bearing Pads And Other Accessories

Provide one of the following bearing pads for structural precast concrete members [as recommended by precast fabricator for application]:

- 1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D 2240, minimum tensile strength 2250 psi (15.5 MPa) per ASTM D 412.
- 2. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer according to ASTM D2240. Capable of supporting a compressive stress of 3000 psi (20.7 Mpa) with no cracking, splitting or delaminating in the internal portions of the pad.
- 3. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer. Surface hardness of 80 to 100 Shore A durometer according to ASTM D 2240. Conforming to Division II, Section 18.10.2 of AASHTO LRFD Bridge Design Specifications or Military Specification, MIL-C-882E.

4. Frictionless Pads: Polytetrafluoroethylene (PTFE), glass-fiber reinforced, bonded to stainless or mild-steel plates, or random-oriented, fiber-reinforced elastomeric pads, of type required for in-service stress.
5. High-Density Plastic: Multimonomer, nonleaching, plastic strip capable of supporting loads with no visible overall expansion.
6. Hardboard: AHA A135.4, Class 1, tempered hardboard strips, smooth on both sides.
7. Reglets: A Reglet is found on the exterior of a building along a masonry wall, chimney or parapet that meets the roof. It is a groove cut within a mortar joint that receives counter-flashing meant to cover surface flashing used to deflect water infiltration. Reglet should be of PVC extrusions or Stainless steel, Type 304, or copper felt or fiber filled face opening of slots covered.
8. Erection Accessories: Provide clips, hangers, high density plastic or steel shims, and other accessories required to install structural precast concrete members.
9. Welding Electrodes: Comply with AWS standards for steel type and/or alloy being welded.

A-10.10.6 Grout Materials

- a. Sand-Cement Grout: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144, or ASTM C 404. Mix at ratio of 1 part cement to 2 ½ to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content of grout less than 0.06 percent chloride ion by weight of cement when tested in accordance with ASTM C 1218/C 1218M.
- b. Nonshrink Grout: If required should be Premixed, prepackaged ferrous and non-ferrous aggregate shrink-resistant grout containing selected silica sands, portland cement, shrinkage-compensating agents, plasticizing and water-reducing agents, complying with ASTM C 1107, Grade A for drypack and Grades B and C for flowable grout and of consistency suitable for application with a 30-minute working time. Water-soluble chloride ion content of grout less than 0.06 percent chloride ion by weight of cement when tested in accordance with ATM C1218/C1218M.
- c. Epoxy-resin grout: Two-component mineral-filled epoxy-resin: ASTM C 881/C 881M of type, grade, and class to suit requirements.

A-10.10.7 Insulated Panel Accessories

- a. Expanded-Polystyrene Board Insulation: ASTM C 578, Type [XI, 0.70 lb/ft³(12kg/m³)], [I, 0.90 lb/ft³ (15kg/m³)][VIII, 1.15 lb/ft³(18kg/m³)][II, 1.35 lb/ft³(22kg/m³)][IX, 1.80 lb/ft³(29 kg/m³)]; [square][ship-lap] edges; with thickness of <Insert dimension> as approved by the Engineer.
- b. Extruded-Polystyrene Board Insulation: ASTM C 578, Type [X, 1.30 lb/ft³(21kg/m³)][IV, 1.55 lb/ft³(25 kg/m³)][VI, 1.80 lb/ft³(29 kg/m³)][VII, 2.20 lb/ft³(35 kg/m³)][V, 3.00 lb/ft³(48 kg/m³)]; [square][ship-lap] edges; with thickness of <Insert dimension> as approved by the Engineer.
- c. Polyisocyanurate Board Insulation: Rigid, cellular polyisocyanurate thermal insulation complying with ASTM C 591; Grade 1, or ASTM C 1289 Type [I, 1.8 lb/ft³(29kg/m³)][II, 2.5 lb/ft³ (40kg/m³)][III, 3.0 lb/ft³(48kg/m³)]; square edged; unfaced; with thickness as specified by the LDP and approved by the Engineer.
- d. Wythe Connectors: [Glass-fiber in vinyl-ester polymer], [Polypropylene pin], [Stainless-steel pin], [Bent galvanized reinforcing bars] [Galvanized welded wire trusses], [Galvanized bent wire connectors] [Epoxy coated carbon fiber grid], [Fiberglass truss] manufactured to connect wythes of precast concrete panels.

- e. Provide holes in insulation for connector placement at least 4 in. (100 mm) and no more than 12 in. (0.30m) from edges of member or openings.

A-10.10.8 Concrete Mixtures

- a. Prepare design mixtures for each type of precast concrete required.
 - 1. Limit use of fly ash to 35 percent replacement of Portland cement by weight; granulated blast-furnace slag to 50 percent of Portland cement by weight; and metakaolin and silica fume to 10 percent of Portland cement by weight.
- b. Design mixtures may be prepared by a qualified independent testing agency or by qualified precast plant personnel at structural precast concrete fabricator's option.
- c. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 (ACI 318M) or PCI MNL 116 when tested in accordance with ASTM C 1218/C 1218M.
- d. Normal weight Concrete Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normal weight concrete with the following properties:
 - 1. Compressive Strength (28 Days): 6000 psi (34.5 Mpa) minimum. Higher-strength mixtures may be available; verify with fabricators.
 - 2. Release Strength: as required by design.
 - 3. Maximum Water-Cementitious Materials Ratio: 0.45. A maximum water-cementitious materials ratio of 0.40 to 0.45 is usual for structural precast concrete. Lower ratios may be possible with use of high-range water reducing admixtures.
- e. Lightweight Concrete Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.2, with materials to be used on Project, to provide lightweight concrete with the following properties:
 - 1. Minimum Compressive Strength (28 Days): 6000 psi (34.5 Mpa). Higher-strength mixtures may be available; verify with fabricators.
 - 2. Release Strength: as required by design.
 - 3. Density (Unit Weight): Calculated equilibrium density of 115 lb/ft.³ (1842 kg/m³), plus or minus 5 lb/ft.³ (80 kg/m³) adjusted to plus or minus 3 lb/ft.³ (48 kg/m³), when tested in accordance with ASTM C 567. Coordinate with lightweight-aggregate supplier and structural precast concrete fabricator. Lightweight concretes with combinations of lightweight and normal weight aggregate in mixture will usually be heavier than unit weight mentioned above.
- f. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content complying with PCI MNL 116.
- g. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.
- h. Concrete Mixture Adjustments: Concrete mixture design adjustments may be proposed if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.

A-11 Form Fabrication

- a. Form: Accurately construct forms, mortar tight, of sufficient strength to withstand pressures due to concrete placement and vibration operations and temperature changes, and for prestressing and detensioning operations. Coat contact surfaces of forms with release agent before reinforcement is placed. Avoid contamination of reinforcement and prestressing tendons by release agent. Maintain forms to provide completed structural

precast concrete members of shapes, lines, and dimensions indicated in Contract Documents, within fabrication tolerances specified.

1. Edge and Corner Treatment: Uniformly chamfered or as built-in on standard forms.

A-12 Fabrication

- a. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement. Do not relocate bearing plates in members unless approved by Licensed design professional
 1. Weld headed studs and deformed bar anchors used for anchorage according to AWS D1.1/D1.1M and AWS C5.4, “Recommended Practices for Stud Welding.”
- b. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, hangers, and other hardware shapes for securing precast concrete members to supporting and adjacent construction.
- c. Cast-in reglets, slots, and other accessories in structural precast concrete members as indicated on Contract Drawings.
- d. Cast-in openings larger than 10 inches (250 mm) in any dimension. Do not drill or cut openings or prestressing strand without Engineer’s approval.
- e. Reinforcement: Comply with recommendations in PCI MNL 116 for fabricating, placing, and supporting reinforcement.
 1. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete. When damage to epoxy coated reinforcing exceeds limits specified in ASTM A 775/A 775M, repair with patching material compatible with coating material and epoxy coat bar ends after cutting.
 2. Accurately position, support, and secure reinforcement against displacement during concrete-placement and consolidation operations. Locate and support reinforcement by plastic tipped or corrosion resistant metal or plastic chairs, runners, bolsters, spacers, hangers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.
 3. Place reinforcing steel and prestressing tendons to maintain at least $\frac{3}{4}$ in. (19 mm) minimum concrete cover. Provide cover requirements in accordance with ACI 318 (ACI 318M) when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.
 4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces in accordance with ACI 318 (ACI 318M) and wire tie laps, where required by design. Offset laps of adjoining widths to prevent continuous laps in either direction.
- f. Reinforce structural precast concrete members to resist handling, transportation, and erection stresses, and specified in-place loads, whichever governs.
- g. Prestressing tendons for structural precast concrete members by either pretensioning or post-tensioning methods. Comply with PCI MNL 116.
 1. Delay detensioning or post-tensioning of precast prestressed concrete members until concrete has reached its indicated minimum design release compressive strength as established by test cylinders cured under the same conditions as concrete member.

2. Detension pretensioned tendons either by gradually releasing tensioning jacks or by heat-cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.
 3. If concrete has been heat cured, detension while concrete is still warm and moist to avoid dimensional changes that may cause cracking or undesirable stresses.
 4. Recess strand ends and anchorages exposed to view a minimum of 1 inch (25 mm), fill with non-metallic, non-shrink mortar and sack rub surface. Coat or spray the inside pocket surfaces with a bonding agent before installing mortar.
 5. Protect strand ends and anchorage not exposed to view with bitumastic, zinc-rich or epoxy paint.
- h. Comply with requirements in PCI MNL 116 and in this Section for measuring, mixing, transporting, and placing concrete. After concrete batching, no additional water may be added.
 - i. Place concrete in a continuous operation to prevent cold joints or planes of weakness from forming in precast concrete members.
 - j. Place backup concrete to ensure bond with face-mixture concrete.
 - k. Thoroughly consolidate placed concrete by vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing or entrapped air voids on surfaces. Use equipment and procedures complying with PCI MNL 116.
 - l. Place self-consolidating concrete without vibration in accordance with PCI TR-6 “Interim Guidelines for the Use of Self-Consolidating Concrete.” If face and backup concrete is used, ensure adequate bond between concrete mixtures.
 - m. Comply with PCI MNL 116 procedures for hot and cold-weather concrete placement.
 - n. Identify pickup points of precast concrete members and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark casting date on each precast concrete member on a surface that will not show in finished structure.
 - o. Cure concrete, according to requirements in PCI MNL 116, by moisture retention without heat or by accelerated heat curing using live steam or radiant heat and moisture. Cure members until compressive strength is high enough to ensure that stripping does not have an effect on the performance or appearance of final product.

A-13 Insulated Panel Casting

- a. Cast, screed and consolidate bottom concrete Wythe supported by form.
- b. Place insulation boards, abutting edges and ends of adjacent boards. Stagger end joints between rows to minimize cold joints. Stagger joints of insulation layers one-half board apart. Insert Wythe connectors through insulation, and consolidate concrete around connectors according to connector manufacturer’s written instructions.
- c. Cast and screed top Wythe and apply required finish.
- d. Maintain temperature below 150 deg. F (65 deg. C) in bottom cast concrete Wythe.

A-14 Fabrication Tolerances

Fabricate structural precast concrete members of shapes, lines and dimensions indicated, so each finished member complies with PCI MNL 135 product tolerances as well as position tolerances for cast-in items.

A-15 Finishes

- A. Commercial (Structural) Finishes
1. Commercial Grade: Remove fins and protrusions larger than 1/8 inch (3 mm) and fill holes with a diameter larger than 1/2 inch (13 mm). Rub or grind ragged edges. Faces shall be true, well-defined surfaces. Air holes, water marks, and color variations are acceptable. Allowable form joint offsets are limited to 3/16 in. (5mm).
 2. Standard Grade: Normal plant-run finish produced in forms that impart a smooth finish to concrete. Surface holes smaller than 1/2 inch (13mm) caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are acceptable. Fill air holes greater than 1/4 inch (6 mm) in width that occur in high concentration (more than one per 2 in.² [1300 mm²]). Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Allowable joint offset limited to 1/8 inch (3 mm).
 3. Grade B Finish: Fill air pockets and holes larger than 1/4 inch (6 mm) in diameter with sand-cement paste matching color of adjacent surfaces. Fill air holes greater than 1/8 inch (3 mm) in width that occur in high concentration (more than one per 2 in.² [1300 mm²]). Grind smooth form offsets or fins larger than 1/8 inch (3 mm). Repair surface blemishes due to dents in forms. Discoloration is permitted at form joints.
 4. Grade A Finish: Repair all surface blemishes and fill all air holes with the exception of air holes 1/16 inch (2 mm) in width or smaller and form marks where the surface deviation is less than 1/16 inch (2 mm). Float-apply a neat cement-paste coating to exposed surfaces. Rub dried paste coat with burlap to remove loose particles. Discoloration is permitted at form joints. Grind smooth all form joints.
- B. Screed or float finish unformed surfaces. Strike off and consolidate concrete with vibrating screeds to a uniform finish, float finish, if required. Hand screed at projections. Normal color variations, minor indentations, minor chips, and spalls are permitted. No major imperfections, honeycombing, or defects are permitted.
- C. Smooth steel-trowel finish unformed surfaces. Consolidate concrete, bring to proper level with straightedge, float and trowel to a smooth, uniform finish.
- D. Apply roughened surface finish in accordance with ACI 318 (ACI 318M) to precast concrete members that will receive concrete topping after installation.

A-16 Source Quality Control

- a. **Quality-Control Testing:** Test and inspect precast concrete according to PCI MNL 116 requirements. If using self-consolidating concrete also test and inspect according to PCI TR-6 “Interim Guidelines for the Use of Self-Consolidating Concrete” and ASTM C 1611/C 1611M, ASTM C 1712, ASTM 1610/1610M, and ASTM C 1621/C 1621M.
- b. **In addition to PCI Certification,** Owner will employ an accredited independent testing agency to evaluate structural precast concrete fabricator’s quality-control and testing methods.
 1. Allow Owner’s testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with Owner’s testing agency and provide samples of materials and concrete mixtures as may be requested for additional testing and evaluation.
- c. **Strength of precast concrete members** will be considered deficient if units fail to comply with ACI 318 (ACI 318M) concrete strength requirements.
- d. **Testing:** If there is evidence that strength of precast concrete members may be deficient or may not comply with ACI 318 (ACI 318M) requirements, fabricator shall employ an

independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42/C 42M and ACI 318/ACI 318M.

1. Test results shall be reported in writing on the same day that tests are performed, with copies to Licensed Design Professional, Contractor, and precast concrete fabricator. Test reports shall include the following:
 - a. Project identification name and number.
 - b. Date when tests were performed.
 - c. Name of precast concrete fabricator.
 - d. Name of concrete testing agency.
 - e. Identification letter, name, and type of precast concrete member(s) represented by core tests; design compressive strength; type of failure; actual compressive strength at breaks, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.
- e. **Patching:** If core test results are satisfactory and precast concrete members comply with requirements, clean and dampen core holes and solidly fill with precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- f. **Acceptability.** Structural precast concrete members that do not comply with acceptability requirements in PCI MNL 116, including concrete strength, and manufacturing tolerances, are unacceptable. Chipped, spalled or cracked members may be repaired. Replace unacceptable units with precast concrete members that comply with requirements.

A-17 Site Preparation For Execution

- a. Furnish loose connection hardware and anchorage devices for precast concrete members to be embedded in or attached to the building structural frame or foundation before starting that Work. Provide locations, setting diagrams, templates and instructions for the proper installation of each anchorage device.

A-18 Examination

- a. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surface tolerances, and other conditions affecting precast concrete performance.
- b. Proceed with precast concrete installation only after unsatisfactory conditions have been corrected.
- c. Contractor shall notify precast concrete erector that supporting cast-in-place concrete foundation and building structural framing has attained minimum allowable design compressive strength or supporting steel or other structure is structurally ready to receive loads from precast concrete members prior to proceeding with installation.

A-19 Erection

- a. Install loose clips, hangers, bearing pads, and other accessories required for connecting structural precast concrete members to supporting members and backup materials.
- b. Erect structural precast concrete level, plumb and square within the specified allowable erection tolerances. Provide temporary structural framing, shoring and bracing as required to maintain position, stability, and alignment of members until permanent connections are completed.

1. Install temporary steel or plastic spacing shims or bearing pads as precast concrete members are being erected. Surface weld steel shims to each other to prevent shims from separating.
 2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.
 3. Remove projecting lifting devices and use plastic patchcaps or sand-cement grout to fill voids within recessed lifting devices flush with surface of adjacent precast concrete surfaces when recess is exposed.
 4. Unless otherwise indicated provide uniform joint widths of $\frac{3}{4}$ in. (19 mm).
 5. For hollow-core slab voids used as electrical raceways or mechanical ducts, align voids between units and tape butt joint at end of slabs.
 6. Provide and install headers of structural-steel shapes for openings larger than one slab width according to hollow-core slab fabricator's written recommendations.
- c. Connect structural precast concrete members in position by bolting, welding, grouting, or as otherwise indicated on approved Shop (Erection) Drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and/or grouting are completed.
1. Disruption of roof flashing continuity by connections is not permitted; concealment within roof insulation is acceptable.
- d. Welding: Comply with applicable AWS D1.1/D1.1M, AWS D1.4/D1.4M and AWS D1.6/D1.6M requirements for welding, welding electrodes, appearance of welds, quality of welds, and methods used in correcting welding work.
1. Protect structural precast concrete members and bearing pads from damage during field welding or cutting operations and provide noncombustible shields as required.
 2. Welds not specified shall be continuous fillet welds, using not less than the minimum fillet as specified by AWS D1.1/D1.1M, D1.4/D1.4M or D1.6/D1.6M.
 3. Clean-weld-affected metal surfaces with chipping hammer followed by brushing or power tool cleaning and then reprime damaged painted surfaces in accordance with manufacturer's recommendations.
 4. For galvanized metal, clean weld affected metal surfaces with chipping hammer followed by brushing or power tool cleaning, and apply a minimum 0.004 inch (4 mil) thick coat of galvanized repair paint to galvanized surfaces in conformance with ASTM A 780/A 780M.
 5. Visually inspect all welds critical to precast concrete connections. Visually check all welds for completion and remove, reweld or repair all defective welds, if services of AWS-certified welding inspector are not furnished by Owner.
- e. At bolted connections, use upset threads, thread locking compound or other approved means to prevent loosening of nuts after final adjustment.
1. Where slotted connections are used, verify bolt position and tightness at installation. For sliding connections, properly secure bolt but allow bolt to move within connection slot.
 2. For slip critical connections, one of the following methods shall be used to assure proper bolt pretension:
 - a. Turn-of-Nut – in accordance with AISC.
 - b. Calibrated Wrench – in accordance with AISC.
 - c. Twist-off Tension Control Bolt – meeting ASTM F 1852.
 - d. Direct-Tension Control Bolt – meeting ASTM F 1852.
 3. For slip critical connections, the method to be used and the inspection procedure to be used shall be approved by the Licensed Design Professional and coordinated with the inspection agency.

- f. Grouting or Dry-Packing Connections and Joints: Indicate joints to be grouted and any critical grouting sequences on Shop (Erection) Drawings. Grout open spaces at keyways, connections and joints where required or indicated. Provide reinforcing steel where indicated. Retain flowable grout in place until it gains sufficient strength to support itself. Fill joints completely without seepage to other surfaces. Alternatively, pack spaces with stiff dry pack grout material, tamping until voids are completely filled. Place grout and finish smooth, level, and plumb with adjacent concrete surfaces. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Keep grouted joints damp for at least 24 hours after initial set.
 - 1. Trowel top of grout joints on roofs smooth to prevent any unevenness that might interfere with placing of, or cause damage, to insulation and roofing. Finish transitions due to different surface levels not steeper than 1 to 12.
 - 2. At Hollow-Core Slab Ends (where shown on Drawings): Provide suitable end cap or dam in voids as required.
- g. Field cutting of precast, prestressed concrete members is not permitted without approval of the Engineer.
- h. Fasteners: Do not use drilled or power-actuated fasteners for attaching accessory items to precast, prestressed concrete members unless approved by Precast Engineer and Engineer of Record.

A-19.1 Erection Tolerances

Erect structural precast concrete members level, plumb, square, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 135. Level out variations between adjacent members by jacking, loading, or any other feasible method as recommended by the fabricator and acceptable to the Licensed Design Professional (LDP).

A-20 Field Quality Control

- a. Special Inspections: Owner or Contractor will engage a qualified special inspector to perform the following special inspections and prepare reports:
 - 1. Erection of loadbearing precast concrete members.
 - 2. **<Insert special inspections>** if specified by LDP.
- b. Testing: Owner will engage accredited independent testing and inspecting agency to perform field tests and inspections and prepare reports.
 - 1. Field welds will be subject to visual inspections and dye penetrant or magnetic particle testing in accordance with ASTM E 165 or ASTM E 1444. Testing agency shall be qualified in accordance with ASTM E543.
 - 2. Testing agency will report test results promptly and in writing to Contractor and Licensed design professional
- c. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.
- d. Additional testing and inspecting, at Erector's expense, will be performed to determine compliance of corrected work with specified requirements.

A-21 Repairs

- a. Repairs will be permitted provided structural adequacy, serviceability and durability of members and appearance are not impaired.

- b. Prepare and repair damaged galvanized coatings with galvanizing repair paint according to ASTM A 780/A 780M.
- c. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
- d. Remove and replace damaged structural precast concrete members when repairs do not comply with specified requirements.

A-22 Cleaning

- a. Clean mortar, plaster, fireproofing, weld slag, and any other deleterious material from concrete surfaces and adjacent materials immediately.
- b. Clean exposed surfaces of precast concrete members after erection and completion of joint treatment to remove weld marks, other markings, dirt, and stains.
 - 1. Perform cleaning procedures, if necessary, according to precast concrete fabricator's recommendations. Protect adjacent work from staining or damage due to cleaning operations.
 - 2. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

APPENDIX B

HOLLOW & LIGHT GAUGE STEEL SECTIONS (HSS & LGS)

B-1 General

This specifications covers the Cold formed Hollow Steel Sections (HSS) and Cold formed Light Gauge Steel sections (LGS) for construction. All materials and workmanship shall comply with the relevant AISI, North American Specification for the Design of Cold-Formed Steel Structural Members.

B-2 Industry Codes And Standards

- **American Iron And Steel Institute (AISI) Specifications**
 - AISI S240-15, North American Standard for Cold-Formed Steel Structural Framing
 - AISI S310-16, North American Standard for the Design of Profiled Steel Diaphragm Panels
 - AISI S400-15, North American Standard for Seismic Design of Cold-Formed Steel Structural Systems
 - AISI S901-13, Rotational-Lateral Stiffness Test Method for Beam-to-Panel Assemblies
 - AISI S902-13, Stub-Column Test Method for Effective Area of Cold-Formed Steel Columns
 - AISI S903-13, Standard Method for Determination of Uniform and Local Ductility
 - AISI S904-13, Standard Test Methods for Determining the Tensile and Shear Strength of Screws
 - AISI S905-13, Test Standard for Cold-Formed Steel Connections
 - AISI S906-13, Standard Procedures for Panel and Anchor Structural Tests
 - AISI S907-13, Test Standard for Cantilever Test Method for Cold-Formed Steel Diaphragms
 - AISI S909-13, Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams
 - AISI S910-13, Test Method for Distortional Buckling of Cold-Formed Steel Hat-Shaped Compression Members
 - AISI S911-13, Method for Flexural Testing Cold-Formed Steel Hat-Shaped Beams
 - AISI S912-13, Test Procedure for Determining a Strength Value for a Roof Panel-to-Purlin-to-Anchorage Device Connection
 - AISI S913-13, Test Standard for Hold-Downs Attached to Cold-Formed Steel Structural Framing
 - AISI S914-15, Test Standard for Joist Connectors Attached to Cold-Formed Steel Structural Framing
 - AISI S915-15, Test Standard for Through-the-Web Punch-out Cold-Formed Steel Wall Stud Bridging Connectors
 - AISI S916-15, Test Standard for Cold-Formed Steel Framing—Nonstructural Interior Partition Walls With Gypsum Board
- **American Society of Testing & Materials (ASTM) Specifications**
 - ASTM A194/A194M-15a, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
 - ASTM A242/A242M-13, Standard Specification for High-Strength Low-Alloy Structural Steel

- ASTM A283/A283M-13, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
- ASTM A307-14, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
- ASTM A354-11, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
- ASTM A370-15, Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- ASTM A449-14, Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
- ASTM A500/A500M-13, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A529/A529M-14, Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality
- ASTM A563-15, Standard Specification for Carbon and Alloy Steel Nuts
- ASTM A563M-07(2013), Standard Specification for Carbon and Alloy Steel Nuts (Metric)
- ASTM A572/A572M-15, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A588/A588M-15, Standard Specification for High-Strength Low-Alloy Structural Steel, Up to 50 ksi [345 MPa] Minimum Yield Point, With Atmospheric Corrosion Resistance
- ASTM A606/A606M-15, Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, With Improved Atmospheric Corrosion Resistance
- ASTM A653/A653M-15, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM A792/A792M-10(2015), Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
- ASTM A847/A847M-14, Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing With Improved Atmospheric Corrosion Resistance
- ASTM A875/A875M-13, Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process
- ASTM A1003/A1003M-15, Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members
- ASTM A1008/A1008M-15, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy With Improved Formability, Solution Hardened, and Bake Hardenable
- ASTM A1011/A1011M-15, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy With Improved Formability, and Ultra-High Strength
- ASTM A1039/A1039M-13, Standard Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial, Structural, and High-Strength Low-Alloy, Produced by the Twin-Roll Casting Process
- ASTM A1058-14, Standard Test Methods for Mechanical Testing of Steel Products—Metric
- ASTM A1063/A1063M-11a, Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process
- ASTM E1592-05(2012), Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference

- ASTM F436-11, Standard Specification for Hardened Steel Washers
- ASTM F436M-11, Standard Specification for Hardened Steel Washers (Metric)
- ASTM F844-07a(2013), Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
- ASTM F959-15, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use With Structural Fasteners
- ASTM F959M-13, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use With Structural Fasteners (Metric)
- ASTM F3125-15, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

User Note:

ASTM F3125 is an umbrella standard including Grades A325, A325M, A490, and A490M, which were previously separate standards

• **Connections**

- AWS. 2010. “Structural Welding Code – Steel”, AWS D1.1/D1.1M:2010, 22nd. Edition, American Welding Society, Miami, FL.
- G40.20-13/G40.21-13, General requirements for rolled or welded structural quality steel/Structural quality steel, CSA Group, 178 Rexdale Boulevard, Toronto, Ontario, Canada, M9W 1R3:

• **OTHER SPECIFICATIONS**

CONCRETE FOUNDATION:

- ACI 318-14, Building Code Requirements for Structural Concrete, American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331:

ROOFS/METAL DECKS

- Approval Standard for Class 1 Metal Roofs, 201, Factory Mutual, Corporate Offices, 270 Central Avenue, Johnston, RI 02919-4949: FM 4471,
- Standard for Composite Steel Floor Deck—Slabs, Steel Deck Institute, P.O. Box 25, Fox River Grove, IL 60021-0025 ANSI/SDI C-2011,

DESIGN SPECIFICATIONS

- AISC Specifications for Structural Steel Buildings.
- **Pakistan Standards and Quality Control Authority (PSQCA)**
 - P.S. 2321983 Ordinary Portland cement (4th Revision). 2008 (R) Specific composition and manufacture, fineness, chemical composition, strength, consistence of standard cement paste, setting, time, soundness, sampling and test method. 2015 (4th R)
 - P.S. 6121989 Sulphate resisting Portland Cement Type A (1st Revision)

For specific situation, only if provisions in the relevant AISI, AISC, ACI, ASTM, and PSQCA documents

are not available, BS standard may be used. Use of other sources shall be approved by the Engineer.

B-2.1 Referenced Specifications, Codes, And Standards For United States And Mexico

1. ANSI/AISC 360-10, Specification for Structural Steel Buildings, American Institute of Steel Construction (AISC)
2. AISI S908-13, Base Test Method for Purlins Supporting a Standing Seam Roof System, American Iron and Steel Institute (AISI)
3. ASCE/SEI 7-10 including Supplement No. 1, Minimum Design Loads in Buildings and Other Structures. American Society of Civil Engineers (ASCE)
4. American Welding Society (AWS)
 - AWS D1.1/D1.1M-2010, Structural Welding Code–Steel
 - AWS D1.3-2008, Structural Welding Code–Sheet Steel
 - AWS C1.1/C1.1M-2012, Recommended Practices for Resistance Welding
5. ASTM A924/A924M-14, Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot Dip Process, ASTM International (ASTM)

B-2.2 Referenced Specifications, Codes, And Standards For Canada

1. CSA Group, Canada, M9W 1R3:
 - CAN/CSA A23.3-14, *Design of Concrete Structures*
 - S16-14, *Design of steel structures*
 - W47.1-09 (R2014), *Certification of companies for fusion welding of steel*
 - W55.3-08 (R2013), *Certification of companies for resistance welding of steel and aluminum* W59-13, *Welded steel construction (metal arc welding)*
2. *National Building Code of Canada (NBCC)*, 201, National Research Council of Canada (NRC), 1200 Montreal Road, Bldg. M-58, Ottawa, Ontario, Canada, K1A 0R6.

B-3 Definitions

Constructor or Contractor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of concrete materials for foundation and steel framing and decking in accordance with contract documents. The term constructor shall apply also to constructor's subcontractor(s) and vendor(s).

Contract documents: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and constructor.

Engineer of record (The Engineer): Purchaser's authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, foundations, materials, appurtenances, steel framing and decking and their connections described in contract documents. Engineer of record shall be licensed as defined by laws of the locality in

which the work is to be constructed, and be qualified to practice in the specialty discipline required for the work described in contract documents.

Environmental engineering concrete structures: Steel is environment friendly whereas the effect of concrete works either for foundations on environment must be taken in account. Concrete structures intended for conveying, storing, or treating water, wastewater, or other nonhazardous liquids, and for secondary containment of hazardous materials.

Manufacturer: Party who produces and warrants performance of products, materials, and/or items provided in accordance with contract documents. Products, materials, and/or items are manufactured in a controlled process using standard codes, specifications, tests and possibly include shop drawings to assist in proper application, installation and/or use. The term manufacturer shall apply also to manufacturer's subcontractor(s) and/or vendor(s).

Mass Concrete: Any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.

Owner: Party who has authority through ownership, lease, or other legal agreement over site, facility, structure or project wherein construction materials will be used.

Purchaser: Party who awards contract to constructor. Purchaser may be owner or owner's authorized agent.

Supplier: Party responsible for supplying construction materials in accordance with contract documents.

B-4 Requirements

1. Concrete supply and construction shall be in accordance with all requirements of *ACI 301-16 / ACI 301M-16*, except as modified or supplemented in this Practice or by contract documents.
2. Steel supply and construction shall be in accordance with all requirements of *ASTM A500/A500M-13*, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
3. Requirements of federal, state or local agencies that have jurisdiction where concrete and steel is to be placed shall apply.
4. Any conflicts or inconsistencies between this Practice, design drawings, and other contract documents shall be brought to the attention of purchaser for resolution.
5. For applications designated as environmental engineering concrete structures in contract documents, concrete supply and construction shall also be in accordance with *ACI 350.5 / ACI 350.5M and ASTM A500/A500M-13*.

B-5 Materials

B-5.1 General

B-5.1.1 Materials shall be in accordance with this Practice and contract documents unless otherwise approved in writing by The Engineer.

B-5.1.2 Materials and application thereof shall be in accordance with applicable federal, state and local regulations.

This Specification requires the use of steels intended for structural applications as defined in general by the specifications of ASTM International listed in this section. The term SS designates structural steels and the terms HSLAS and HSLAS-F designate high-strength low alloy steels.

B-5.2 Reinforced Concrete

For RC Components of construction, use American Concrete Institute (ACI) -ACI 318-14, Building Code Requirements for Structural Concrete or refer to RC Specifications in Section 3.

B-5.3 Applicable Steels

This section shall apply to steels that are based on specifications providing mandatory mechanical properties and requiring test reports to confirm those properties.

Steels used in *structural members*, decks, and *connections* shall follow uses and restrictions outlined in this section and sub-sections, as applicable. Exception: For steels used in composite slabs, the requirements of ANSI/SDI C shall be followed exclusively.

Applicable steels have been grouped by their minimum elongation requirements over a two-inch (50-mm) gage length.

B-5.3.1 Steels with a Specified Minimum Elongation of Ten Percent or Greater (Elongation \geq 10%)

Steel grades listed below, as well as any other steel for structural applications, are permitted to be used without restriction under the provisions of this *Specification* provided:

- (a) Ratio of *tensile strength* to *yield stress* is not less than 1.08; and
- (b) The minimum elongation is greater than or equal to either 10 percent in a two-inch (50mm) gage length or 7 percent in an eight-inch (200-mm) gage length standard specimen tested in accordance with ASTM A370 or ASTM A1058

The following steel grades and standards fall within this range of permitted elongations:

- ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*
- ASTM A242/A242M, *Standard Specification for High-Strength Low-Alloy Structural Steel*
- ASTM A283/A283M, *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*
- ASTM A500, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*
- ASTM A529/A529M, *Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality*

- ASTM A572/A572M, *Standard Specification for High-Strength Low-Alloy Columbium Vanadium Structural Steel*
- ASTM A588/A588M, *Standard Specification for High-Strength Low-Alloy Structural Steel With up to 50 ksi [345 MPa] Minimum Yield Point, With Atmospheric Corrosion Resistance*
- ASTM A606, *Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, With Improved Atmospheric Corrosion Resistance*
- ASTM A653/A653M (SS Grades 33 (230), 37 (255), 40 (275), 50 (340) Class 1, Class 3 and Class 4, 55 (380) and 60 (410); HSLAS and HSLAS-F, Grades 40 (275), 50 (340), 55 (380) Class 1 and 2, 60 (410), 70 (480), and 80 (550)), *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Gal annealed) by the Hot-Dip Process*
- Exception: SS Grade 60 (410) with *thicknesses* less than or equal to 0.028 in. (0.71 mm) is excluded from this elongation group.
- ASTM A792/A792M (Grades 33 (230), 37 (255), 40 (275), 50 (340) Class 1 and Class 4, and 60 (410)), *Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process*, Exception: Grade 60 (410) with *thicknesses* less than or equal to 0.028 in. (0.71 mm) is excluded from this elongation group.
- ASTM A847/A847M, *Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low-Alloy Structural Tubing With Improved Atmospheric Corrosion Resistance*
- ASTM A875/A875M (SS Grades 33 (230), 37 (255), 40 (275), and 50 (340) Class 1 and Class 3; HSLAS and HSLAS-F, Grades 50 (340), 60 (410), 70 (480), and 80 (550)), *Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process*
- ASTM A1003/A1003M (ST Grades 50 (340) H, 40 (275) H, 37 (255) H, 33 (230) H), *Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members*
- ASTM A1008/A1008M (SS Grades 25 (170), 30 (205), 33 (230) Types 1 and 2, and 40 (275) Types 1 and 2; HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), 65 (450), and 70 (480); HSLAS-F Grades 50 (340), 60 (410), 70 (480), and 80 (550)), *Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable*
- ASTM A1011/A1011M (SS Grades 30 (205), 33 (230), 36 (250) Types 1 and 2, 40 (275), 45 (310), 50 (340), and 55 (380); HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), 65 (450), and 70 (480); HSLAS-F Grades 50 (340), 60 (410), 70 (480), and 80(550)), *Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy With Improved Formability*
- ASTM A1039/A1039M (SS Grades 40 (275), 50 (340), 55 (380), 60 (410), 70 (480), and 80 (550); HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), and 65 (450)), *Standard Specification for Steel, Sheet, Hot-Rolled, Carbon, Commercial and Structural, Produced by the Twin-Roll Casting Process*
- Exception: SS Grades 55 (380), 60 (410), 70 (480), and 80 (550) with *thicknesses* outside the range of 0.064 in. (1.6 mm) to 0.078 in. (2.0 mm) are excluded from this elongation group.
- ASTM A1063/A1063M (SS Grades 40 (275), 50 (340); HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), and 65 (450)), *Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process*

-
- CSA G40.20-13/G40.21-13, *General requirements for rolled or welded structural quality steel/Structural quality steel*

B-5.3.2 Steels with a Specified Minimum Elongation from Three Percent to Less than Ten Percent ($3\% \leq \text{Elongation} < 10\%$)

Steel grades listed below, as well as any other steel for structural applications that has a minimum elongation of 3 percent in a two-inch (50-mm) gage length standard specimen tested in accordance with ASTM A370 or ASTM A1058, are permitted to be used provided that the *available strengths [factored resistances] of structural members and connections* are calculated. For the purposes of these calculations, a reduced *yield stress* $0.9 F_{sy}$ shall be used in place of F_{sy} , and a reduced *tensile strength* of $0.9 F_u$ shall be used in place of F_u .

The following steel grades and standards fall within this range of permitted elongations:

- ASTM A653/A653M (SS Grades 60 (410), 70 (480), and 80 (550) Class 3), *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*, Exception: SS Grade 60 (410) with *thicknesses* greater than 0.028 in. (0.71 mm) is excluded from this elongation group.
- ASTM A792/A792M (Grades 60 (410), 70 (480), and 80 (550) Class 3), *Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process*
 - Exception: Grade 60 (410) with *thicknesses* greater than 0.028 in. (0.71 mm) is excluded from this elongation group.
- ASTM A1039/A1039M (SS Grades 55 (380), 60 (410), 70 (480), and 80 (550); HSLAS Classes 1 and 2, Grades 70 (480) and 80 (550)), *Standard Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial and Structural, Produced by the Twin-Roll Casting Process*
 - Exception: SS grades with *thicknesses* greater than or equal to 0.064 in. (1.6 mm) are excluded from this elongation group.
- ASTM A1063/A1063M (SS Grades 55 (380), 60 (410), 70 (480), Grade 80 (550) Class 1); (HSLAS Grade 70 (480) Classes 1 and 2, Grade 80 (550) Classes 1 and 2), *Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process*.

B-5.3.3 Steels with a Specified Minimum Elongation of Less than Three Percent (Elongation < 3%)

Steel grades listed below, as well as other steel grades that do not meet the requirements of 5.2.3.1. or 5.2.3.2, are permitted to be used only for multiple *web* configurations such as roofing, siding, and floor decking provided the following adjustments are made to the design parameters:

A reduced *specified minimum yield stress*, $R_b F_{sy}$, is used for determining the *nominal flexural strength [resistance]* in Chapter F, for which the reduction factor, R_b , is determined in accordance with (1) or (2): as shown in **Table A-1**.

Table A-1 – Determination of Rb

(1) For stiffened and partially stiffened compression flanges	
For $w/t \leq 0.067E/F_{sy}$	
Rb = 1.0	
For $0.067E/F_{sy} < w/t < 0.974E/F_{sy}$	
$R_b = 1 - 0.26[wF_{sy}/(tE) - 0.067]0.4$	(Eq. A3.1.3-1)
For $0.974E/F_{sy} \leq w/t \leq 500$	
Rb = 0.75	
(2) For unstiffened compression flanges	
For $w/t \leq 0.0173E/F_{sy}$	
Rb = 1.0	
For $0.0173E/F_{sy} < w/t \leq 60$	
$R_b = 1.079 - 0.6 wF_{sy}/\sqrt{tE}$	(Eq. A3.1.3-2)

Where

w= Flat width of compression flange

t= Thickness of section

E= Modulus of elasticity of steel

F_{sy}= Specified minimum yield stress determined ≤ 80 ksi (550 MPa, or 5620 kg/cm²)

- The yield stress, F_{sy}, used for determining nominal strength [resistance] in Appendix 1 and Chapters C to J exclusive of Section F2.4 is taken as 75 percent of the specified minimum yield stress or 60 ksi (414 MPa or 4220 kg/cm²), whichever is less, and
- The tensile strength, F_u, used for determining nominal strength [resistance] in Chapter J is taken as 75 percent of the specified minimum tensile strength or 62 ksi (427 MPa or 4360 kg/cm²), whichever is less.

The following steel grades and standards fall within this range of permitted elongations:

- ASTM A653/A653M (SS Grade 80 (550) Classes 1 and 2), *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*
- ASTM A792/A792M (Grade 80 (550) Classes 1 and 2), *Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process*
- ASTM A875/A875M (SS Grade 80 (550)), *Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process*
- ASTM A1008/A1008M (SS Grade 80 (550)), *Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.*
- ASTM A1063/A1063M (SS Grade 80 (550) Class 2), *Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process*

B-6 Material Specifications

All structural framing components shall conform to ASTM A 635 or equivalent hot dipped galvanized (G90 coating, complying with ASTM A 653/653M, C 955 or equivalent) with thickness and grade as required by structural design calculations (min. yield strength 550/350 MPa).

X Drive @ screw shall be used for assembling of the structure.

B-6.1 Exterior Wall System



Option 1: Using 10 to 12mm Cement fiber board

Option 2: Using Steel Cladding System (Cost effective).

Option 3: Using brick masonry attached with HSS/LGS wall system.

Option 4: Light concrete using form work up to 4 feet. Remaining wall cladded with Cement Fiber or steel profile sheet

Figure A-1 and A-2 shows the pictures of typical exterior wall system.

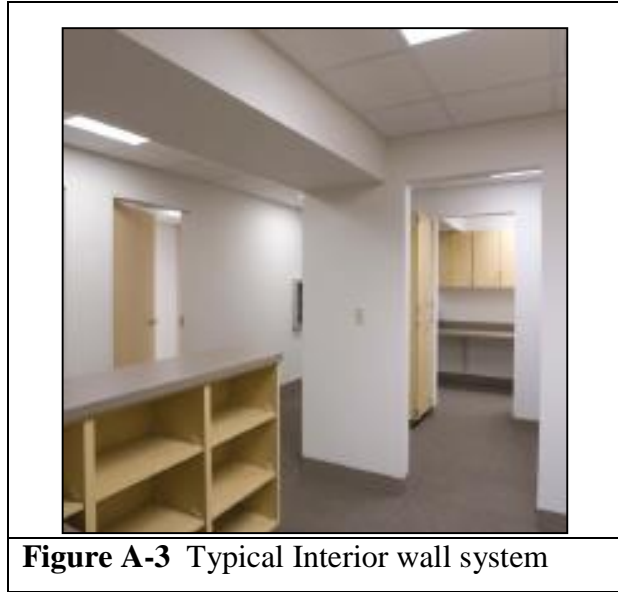
	
<p>Figure A-1 Typical exterior wall system using Cement Board</p>	<p>Figure A-2 Typical exterior wall system using brick attached with LGS wall system</p>

B-6.2 Interior Wall System

Option 1: Using 8 to 10 mm Cement fiber board.

Option 2: Using 12 mm Gypsum board (cost Effective).

Option 3: Concrete using form work up to sill level. Remaining with 12mm Gypsum /CF.
Typical Interior wall system is shown in **Figure A-3**.



B-6.3 Wall Structure

Cold Formed Galvanized Structure with C-Section spaced at 300-610mm of 89S41 & 150S41 with thickness of 0.55- 1.55mm of Grade G-350/G-550 with zinc coating of Z-180/275 g/m². Wall thickness of structure is 89 & 150mm.

B-6.4 Floor Joist

Cold Formed Galvanized Open Web Joist with C-Section spaced at 300-610mm of 89S41 & 150S41 with thickness of 0.75-1.55mm of Grade G-350/G-550 with zinc coating of Z-180/275 g/m². Depth varies from 250-600mm.

B-6.5 Roof Truss

Cold Formed Galvanized Truss with C-Section spaced at 600- 1800mm of 89S41 & 150S41 with thickness of 0.75-1.55mm of Grade G-350/G-550 with zinc coating of Z-180/275 g/m². Truss system is available with Single Side Slope, Gable Slope & Hip Slope.

B-6.6 Composite Decking System

Option 1: 24mm Cement Fiber board Decking sheeting on HSS/LGS Joist or 12mm board with 50mm cement screed with tiles.

Option 2: Steel decking sheets with 50mm Cement screed and with tiles.

B-6.7 First Floor Roofing

- HSS/LGS Trusses
- Roof Panels
- 50 mm Glass Wool Insulation
- 0.6mm Pre-Painted Galvanized Steel Profiled Sheeting.

B-6.8 Insulations

All interior and exterior walls shall be filled with mineral wool insulation. Glass wool insulation Blanket shall be used on first floor roof.

B-6.9 Cladding System

Cement Fiber Board cladding for Infill works For Dry wall cement fiber board, Gypsum Board & MDF will be used.

B-6.10 Infill For Walls

EPS Foam concrete for Infill walls with density 300-700 kg/m³ for wet solution which gives solid wall and highly thermal resistant properties in comparison to conventional For Dry Walls Glass wool with density of 12 kg/m³ and EPS insulation with density of 20 kg/m³.

B-6.11 Finishes

High end finishes with water based paint.

B-6.12 Fire Resistance

Fire Resistance up to 3-4 hrs.

B-6.13 Sound Insulation

Sound Insulation up to 39-60db.

B-6.14 Weight Of Wall

90 kg/m² which saves structural cost in case of partition.

B-6.15 Weight Of Floor

75-200 kg/m², M & E Works Concealed within wall.

B-6.16 Surface Flatness

Flatness due to laser survey of cement fiber board.

B-6.17 Site Management

Easily worked, faster with few workers and tools

B-7 Workmanship

B-7.1 Reinforcing Steel

- a. Dirt, rust, concrete, scale, paint, oil, grease, salts etc. shall be removed from the reinforcement by grit blasting or other approved technique.
- b. Reinforcement shall be bent when cold by hand or by using an approved hand or power operated bending machine. When bending the reinforcement should be subjected to a constant even load and not an impact load.
- c. Welding of reinforcement will be allowed only when required by the drawings and with specific written permission by the Engineer.

- d. Bar types, sizes and placement with bending dimensions shall be on the drawings.

B-7.2 Foundation

- a. Reinforcement must be tied and fixed accordingly and bar bending schedules must be prepared, refer to Reinforced Concrete Specifications 3.4.2 and 3.4.3 for details.

B-7.3 Anchor Bolts

- a. Anchor bolts must be designed by Engineer with reference to the code according to requirement for erection of steel columns.
- b. Dirt, rust, concrete, scale, paint, oil, grease, salts etc. shall be removed from the bolts by approved techniques.
- c. Welding of bolt connection will be allowed only when required by the drawings and with specific written permission by the Engineer.
- d. Anchor bolt types, sizes and placement with dimensions shall be on the drawings.

B-7.4 Framing Elements

- a. The design of beams and columns must be done by Engineer according to the requirement of structure with reference to the code.
- b. Detailed drawings of beams and columns with all the required specifications, section details must be developed by Engineer or his/her consultancy.
- c. The beams and columns are to be assembled on site on the responsibility of contractor according to the drawings.

B-7.5 Connections-Workmanship

- a. The connections are to be designed by the Engineer. Detailed drawings with connection details, its type, thickness. Dimensions etc. must be developed under supervision of Engineer.
- b. Contractor is required to connect the framing elements according to the connection drawings.
- c. Connections must be free of dirt, rust, concrete, scale, paint, oil, grease, salts etc. and if present shall be removed from the connections by approved techniques.

B-7.6 Connections

Connections are to be designed in such a way that it does not fail or fracture before structural elements i.e., beam-columns. Connections are classified into following three categories:

B-7.7 Welded Connections

The design of welded connections used for cold-formed steel structural members in which the thickness of the thinnest connected part is 3/16 in. (4.76 mm) or less shall be based on the following sub-sections. Additionally, the following specifications or standards shall apply:

For the United States and Mexico:

- (a) AWS D1.3, and
- (b) AWS C1.1 or AWS C1.3 for resistance welds.

For Canada:

- (a) CSA W59, and

(b) CSA W55.3 for resistance welds.

For the design of welded connections in which the thickness of the thinnest connected part is greater than 3/16 in. (4.76 mm), the following specifications or standards shall apply:

- (a) ANSI/AISC 360 for the United States and Mexico, and
- (b) CSA S16 for Canada.

B-7.8 Bolted Connections

The following design criteria shall apply to steel-to-steel bolted connections used for cold formed steel structural members in which the thickness of the thinnest connected part is 3/16 in. (4.76 mm) or less. For bolted connections in which the thickness of the thinnest connected part is greater than 3/16 in. (4.76 mm), the following specifications and standards shall apply:

- (a) ANSI/AISC 360 for the United States and Mexico, and
- (b) CSA S16 for Canada.

Bolts, nuts, and washers conforming to one of the following ASTM specifications are approved for use under this Specification:

- ASTM A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service, or Both
 - ASTM A307 (Type A), Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
 - ASTM A354 (Grade BD), Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners (for diameter of bolt smaller than 1/2 in.)
 - ASTM A449, Standard Specification for Hex Cap Screws, Bolts and Studs, Steel Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
 - ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts
 - ASTM A563M, Standard Specification for Carbon and Alloy Steel Nuts [Metric]
 - ASTM F436, Standard Specification for Hardened Steel Washers
 - ASTM F436M, Standard Specification for Hardened Steel Washers [Metric]
 - ASTM F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
 - ASTM F959, Standard Specification for Compressible Washer-Type Direct Tension Indicators for Use With Structural Fasteners
 - ASTM F959M, Standard Specification for Compressible Washer-Type Direct Tension Indicators for Use With Structural Fasteners [Metric]
 - ASTM F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions (for Grades A325, A325M, A490, and A490M only)
- When bolts, nuts, and washers other than the above are used, drawings shall clearly indicate the type and size of fasteners to be employed and the nominal strength [resistance] assumed in design.

B-7.9 Screw Connections

The provisions of this section shall apply to steel-to-steel screw connections within specified limitations used for cold-formed steel structural members. All provisions in Section J4 shall apply to screws with $0.08 \text{ in. (2.03 mm)} \leq d \leq 0.25 \text{ in. (6.35 mm)}$. The screws shall be thread-forming or

thread-cutting, with or without a self-drilling point. Screws shall be installed and tightened in accordance with the manufacturer's recommendations.

For further details of connections, their further details along with specifications refer to "AISI STANDARD North American Specification for the Design of Cold-Formed Steel Structural Members" Chapter J.

B-8 Available Soft Wares

For the design of Hollow Steel Sections (HSS) and Light Gauge Steel (LGS), following are some of the licensed software available:

- a. ETABS
- b. Scottsdale
- c. AGACAD
- d. RFEM and RSTAB
- e. Frame CAD etc.

B-9 Available Manufacturers

- a. International Industries Limited for HSS
- b. International Steel Limited for LGS

APPENDIX-C

PAKISTAN STANDARDS AND QUALITY CONTROL **AUTHORITY (PSQCA) STANDARDS**

PS 1421961 Wooden doors. Specific material, construction, dimension, type of doors and tests

PS 1731962 Wooden windows. Specifies the quality, construction and sizes of wooden windows for exterior – interior use in buildings.

PS 26841989 Doors terminology

PS 26851989 Door leave – Test of behavior under humidity variations. (Successive uniform climates). Specifies a method of testing the behavior under humidity variations of door leaves placed in successive uniform climates. ISO:6444

PS 26861989 Windows and door height windows wind resistance tests. Defines method of testing for assessing structural performance, under positive / negative static air-pressure of windows to be fitted in the form of completely assembled and finished units

PS 26871989 Windows and door height windows air permeability test. Defines the method used for air permeability, testing of windows to be fitted in exterior walls and supplied in the form of completely assembled and finished units.

PS 26881989 Partitions made of components test for resistance to wind (static pressure and slamming doors). This standard is one of the series of standards relating to performance of building elements and gives method of testing the resistance to positive and negative static air pressure of complete partitions made of components, i.e. of the assembly consisting of partition components over panels and doors, their connection and device fixing them to the structure. It also specifies the method for assessing the effect of slamming doors.

PS 26891989 Facades made of components – Test for resistance to positive and negative static pressure generated by wind. ISO:7894. This Standard is one of the series of standards relating to performance of building elements-specifies method for testing resistance to positive and negative static air pressure of complete facades made of components, i.e. glazed component, fixed or opening.

PS 26901989 Window and door height windows mechanical test. ISO:8248. This standards specifies the methods to be used for the mechanical testing of windows and door height windows, supplied in the form of finished products in their normal condition of use.

PS 26911989 Door sets – Static loading tests. ISO:8269. Specifies a method of testing the behavior of doorsteps under static loading. It applies to doorsteps with one pivoting leaf, without fixed parts.

PS 26921989 Door sets – Soft heavy body impact test. ISO:8270. Specifies a soft heavy body impact test for door sets-applies to door sets with one or two leaves as supplied ready for installation and including the leaf, door frame, associated hardware (closing, pivoting mechanism)

PS 26931989 Door leaves – Hard body impact test. ISO:8271. Specifies a hard body (steel ball) impact test for door leaves applies to all flat and rigid doors

P.S. 29311990 Doors leaves – Measurement of dimension and of effects of squareness. Specifies a method of measuring the dimensions and defects of squareness of door leaves.

P.S. 29321990 Doors leaves – Measurement of defects of general flatness. Specifies the method for measuring the defects of general flatness of door leaves.

P.S. 29331990 Doors sets – Static torsion test. Specifies the method to be used to determine the residual deformation of door set and its hardware.

P.S. 30391991 Door sets – Test of behavior between two different climates. Specifies the method for the behavior testing of doors and door sets placed between two different climates

P.S. 30401991 Door sets – Repeated opening and closing test. Specifies the method to be used when determining the effect on door set of repeated opening and closing the door under normal conditions.

P.S. 30411991 Symbol designation of direction of closing and faces of doors windows and shutters. This standard fixes. The convention. a) To identify by symbol for direction operating. b) To specify the arrangement of the frame of door, windows, shutters in relation to premises.

P.S. 32031992 Match board wooden door leaves for external use. This standard specifies size limitation, materials, workman shop and construction for ledged and braced doors, framed and ledged doors and framed, ledged and braced doors, all with tongued and grooved match boarded facings for external use.

P.S. 32041992 Metal door frames (steel). This standard specifies sizes and general requirements for door frames fabricated from mild steel sheet and protective coatings suitable for internal or external use.

PS: 34431993 Modular coordination – coordinating sizes for door sets external and internal. This Standard specifies the coordinating sizes for door sets of all materials to be used in buildings, and which will fill coordinating spaces in dimensionally coordinated buildings.

P.S. 34441993 Door-sets-Repeated torsion test. This standard specifies the method to be used to determine the effect or repeated torsion on door sets and their hardware. It applies to all door sets made of any materials with vertically hinged door leaves in their normal operating conditions.

P.S. 35591994 Internal and external wood door sets, door leaves and frames. This Pakistan standard specified the metric sizes for dimension coordinated internal and external wood door sets, door leaves frames

P.S. 38581996 Door closers-specification for mechanical performance of crank and rack overhead door closers. This standard covers requirements for the mechanical performance of single action overhead door closers (with or without back check), including their arms and arm linkage, not forming the pivotal or hinged arrangement of the door.

PS 40311997 Test methods of bending and impact for building boards. (JIS-A:1408). This standard describes a test method for bending test for boards of building.

P.S. 40321997 Wooden flush door shutters, cellular and hollow core type part-1: plywood face panels. This standard lays down requirements regarding types, sizes, materials, construction, workmanship and finish, and tests of cellular and hollow core wooden flush door shutters with face panels of plywood or cross band and face veneers.

PS 4032-11997 Wooden flush door shutters, cellular and hollow core type. Part 1: Plywood face panels. This standard lays down requirements regarding types, sizes, materials, construction, workmanship and finish, and tests of cellular and hollow core wooden flush door shutters with face panels of plywood or cross band and face veneers.

PS 43471998 Test methods for wet tensile breaking strength of paper and paper products

P.S. 42761999 Wooden flushed doors shutter, (cellular and hollow type) particle board and hard face panels. This standard lays down the requirements regarding material grade, types, size, construction, finishes and tests for wooden flush door shutters of cellular and hollow core type with particle board face panels (both veneered and unveneered and hard board face panels).

P.S. 45191999 Polyvinyl chloride (PVC) prime windows-sliding glass doors. This standard specifies the polyvinyl chloride (PVC) prime windows – sliding glass doors.

P.S. 47762001 Wood windows specification for factory assembled windows of various types. This part of PS specifies requirements for materials (including preservation), profile design, workmanship, glazing, construction, security and safety, weather tightness performance and operation and strength performance of factory assembled wood framed windows of various types. The windows are designed to be finished with either opaque or non-opaque finish.

P.S. 47562000 Locks and latches for doors in buildings. This standard specifies tests and levels of performance for locks and latches for doors used in buildings. For locks and latches for doors used in housing it also specifies dimensions. Locks and latches for fire doors are not included.

P.S. 2301962 Glossary of terms applicable to timber plywood and joinery. Define characteristics and explanatory terms, seasoning, defects, plywood air board terms and joinery terms.

P.S. 5511985 Shear test for timber, (Revised). Specifies a method for determining the ultimate shearing stress of wood by compressive loading parallel to grain either along the radial or along the tangential surface.

PS 5521982 Determination of moisture content of wood. (1st Revision)

P.S. 5531965 Cleavage test for wood. Specifies test materials, preparation of specimens, size of specimens, rate of loading and moisture content.

P.S. 5541965 Determination of specification gravity & weight per cubic centimeter for timber. Specifies test materials, preparation of specimens, procedure, calculation and moisture contents.

P.S. 5551985 (R) Wood – Determination of ultimate strength in static bending. (1st Revision). Specifies a method for determining the ultimate strength of wood in static bending.

P.S. 5561985 Impact bending test for timber Specifies test materials, preparation of specimen, size of specimen and procedure of testing, calculation and procedure of testing, calculations and moisture contents.

P.S. 8441991 (R) Plywood – classification (Revised) Specifies classifications.

P.S. 8451990 (R) Plywood – Measurement of dimension of panels, (1st Revised). Specifies sampling moisture content, apparatus, procedure, expression of results and test report.

P.S. 8461990 (R) Plywood – Veneer plywood for general use – General requirements. (1st Revised). Specifies construction of panels, moisture content, workmanship, characteristics of outer and inner plies and gluing.

P.S. 9651990 (R) Fiber building boards – Definition classification (1st Revised) Gives a definition and established a classification of fibers building boards.

P.S. 9661990 (R) Particle boards – Definition classification (1st Revised).Covers definitions and classification.

P.S. 9841974 Plywood vocabulary. Specifies composition and preparation of elements, grain, plywood panel's defects, repair, state of surface (non-finished) and transformation).

P.S. 15451982 Wood – sampling methods and general requirements for physical and mechanical tests. It specifies methods for the selective and mechanical sampling of wood for the conditioning of selected material and for the preparation of test pieces. In addition, it specifies general requirements for physical and mechanical tests on small, clear test pieces free from visible effects.

P.S. 16731985 Fiber building boards – Hard and medium boards for general purposes quality specification – water absorption and swelling in thickness. Specifies the maximum values of water absorption and of swelling in thickness after immersion in water of hard and medium fibre building board.

P.S. 17291985 Fiber building boards – Hard medium boards, determination of water absorption, swelling in thickness after immersion.

P.S. 17301985 Wood test method, determination of ultimate stress in compression parallel to grain. Specifies a method for determination the ultimate stress wood in compression parallel to grain.

P.S. 17311985 Wood – Determination of ultimate tensile stress, parallel to grain. Specifies a method for determining the ultimate tensile stress of wood parallel to grain.

P.S. 17321985 Wood – Determination of ultimate tensile stress, perpendicular to grain. Specifies a method for determining the ultimate tensile stress if wood perpendicular to grain radial and tangential directions.

P.S. 17331985 Wood – Determination of modular of Elasticity in static bending. Specifies a method of determining the modules of elasticity of wood in static bending by measuring the deflections in the net bending area.

P.S. 17341985 Wood – Testing in compression perpendicular to grain. Specifies a method of testing wood in compression perpendicular to the grain to determine proportional limit (conventional ultimate strength) the load being applied to the whole surface (radial or tangential) of the test piece.

P.S. 19061987 Wood preservation by means of water – borne copper – chrome – arsenic comparison. Specifies requirements for the treatment of timber with water borne wood preservative consisting essentially of copper sulphate, sodium dichromate and hydrated arsenic pent oxide etc. requirement for the composition of preservative and method of application are specified.

P.S. 26681989 Fiber building boards hard and medium boards for general purposes quality specification appearance shape and dimension tolerance. This standard establishes quality specifications for appearance, shape and dimensional tolerances of fibre building boards for general purpose.

P.S. 26691989 Coniferous sawn timber size permissible deviation and shrinkage. Specifies permissible deviations due to inaccuracies in sawing, form nominal thicknesses, widths and lengths, for coniferous sawn timber.

P.S. 26701989 Coniferous, sawn timber sizes method of measurement. Defines method of measurements of thickness, width, length and volume of coniferous sawn timber. Covers unplanned, square edge and un-edge coniferous sawn timber.

P.S. 26711989 Wood – Determination of static hardness. Specifies a method for the determination of the static hardness of wood.

P.S. 26721989 Wood – Determination of resistance to impact indentation. Specifies a method of the determination of resistance of wood to impact indentation.

P.S. 26731989 Copper – Chrome water-born wood preservation and their application. Specifies requirements for wood preservation consisting essentially of mixtures of copper sulphates and sodium dichromate of potassium dichromate and for the method of application of such preservative.

P.S. 29341990 Wood based panels – Determination of dimension of test pieces. Specifies a method for measuring the thickness length and width of test pieces of wood based panels such as fibre building boards defined in PS: 965 – 1990, particle boards, plywood etc.

P.S. 29351990 Wood based panels – Determination of moisture content. Specifies a method for determining the moisture content of wood based panels such as fibre building boards, particle boards, plywood etc.

P.S. 30421991 Coniferous sawn timber – Sizes terms and definition. This standard establishes a first series of terms and definitions for correct and adequate understanding of terms relating to square edged and edged sawn Timber its geometrical elements and sizes

P.S. 30431991 Coniferous sawn timber – Defects classification. Specifies the national and international classification of defects of coniferous sawn timber for which the terms and definitions are specified in PS: 3042.

P.S. 30441991 Medium density fiber board for interior use. This standard covers definitions, dimensional tolerances, property requirements, test methods and methods of identification.

P.S. 32051992 Plywood-veneer plywood with rotary cut veneer for general use rules for classification by appearance. This standard established general rules for the classification by appearance of veneer plywood defined in PS: 984, plywood vocabulary.

P.S. 32061992 Wood based panels – Determination of dimensions. This standard specifies methods for measuring the thickness, width and length

P.S. 32071992 Wood based panels – determination of density. This standard specifies a method of determining the density of wood based panels such as fibre building boards, defined in PS: 965, particle, boards, defined in PS: 966, as well as plywood, defined in PS : 984.

P.S. 32081992 Coniferous sawn timber-defect measurement. This standard specified international methods of measurement of defects of coniferous sawn timber, classified in PS: 3043, coniferous sawn timber-defects-classification.

P.S. 35601999 Grading rules for sawn timber. The rules are intended for use in grading of sawn and hewn timbers produced in Pakistan and will be terms as “The grading rules” for sawn timbers.

P.S. 35611994 Wood for manufacture of wood flooring-symbols for marking according to species. This standard specified a masking system for wood, according to the species, utilized in the manufacturer of wood flooring.

P.S. 35621994 Sound absorbing expanded pure agglomerated cork in tiles. This standard specifies certain characteristics of sound absorbing expended pure agglomerated cork in tiles.

P.S. 35631994 Sound reducing composition cork in tiles. This standard specifies certain characteristics of sound-reducing composition cork in tiles.

PS: 35811994 Sawn timber of broad leaved species-defects, classification

PS: 35821994 Sawn timber of broad leaves species – Defects, terms and definition

PS: 35831994 Sawn timber of broad leaved species defects measurement

PS: 35841994 Coniferous sawn timber – nominal dimension

PS: 35851994 Coniferous and broad leaved tree saw logs, visible defects-terms and definitions

PS: 35861994 Coniferous and broad leaved tree saw logs visible effects measurement

PS: 35871994 Broad leaved sawn timber – Sizes method of measurements

PS: 35881994 Sawn timber test methods determination of ultimate strength in shearing parallel to grain

PS: 35891994 Sawn timber test methods determination of resistance to local transverse compression

PS: 35901994 Timber structures-testing of unilateral punched metal plate fasteners and joints

PS: 35911994 Timber structures-testing of joints made with mechanical fasteners – requirements for wood density

PS: 35921994 Fibre building boards – Determination of bending strength

PS: 35931994 Floor tiles of agglomerated cork method of test

PS: 35941994 Agglomerated cork material of expansions joint for construction and building-test methods

P.S. 37061995 Coniferous and broad leaved sawn timber frames transportation packages. This standard specifies requirement for packages and multi packages of square-edged and nudged, planned and unplanned coniferous and broadleaved sawn timber.

P.S. 37071995 Plywood-veneer plywood with rotary out veneer for general use classification by appearances of panels with outer veneers of poplar. This standard establishes the permissible defects for the classification by appearance of surfaces of general purpose, veneer plywood with rotary cut outer veneers of poplar.

P.S. 38591996 Expanded pure agglomerated cork for thermal insulation characteristics, sampling and package. Expanded pure agglomerated cork for thermal insulation – characteristics, sampling and packaging.

P.S. 38601996 Mosaic parquet panels-general characteristics. This standard covers the general manufacturing characteristics (dimension, permissible deviations, etc.), the inspection and delivery conditions and the marking of mosaic parquet panel for any species of wood.

38801996 Cork and cork products-determination of thermal conductivity-hot plate method.

PS 43561998 Test methods for rubber property effect of liquids.

PS 43651998 Rubber vulcanized or thermoplastic determination of tension set at normal and high temperature.

P.S. 45201999 Timber in joinery general classification of timber quality. This standard specifies the method to be used to determine the characteristics and classify the appearance quality of timber to joinery.

P.S. 47552000 Standard grading rules for logs. This standard specify grading rules for all timber species produced in Pakistan.

52132012 Specification for Computing Reference Resistance of Wood-Based Materials and Structural Connections for Load and Resistance Factor Design. This specification covers procedures for computing the reference resistance of wood-based materials and structural connections for use in load and resistance factor design

5214201225/8-In. and 4-In. Diameter Metal Shear Plates for Use in Wood Constructions. This specification covers standardizing the dimensions and materials for the manufacture of 25/8 and 4-in. diameter metal or cast iron shear plates used in the fabrication of connections in wood constructions.

P.S. 2311962 Mild steel bars for structural uses. Specifies steel making process, quality of finished steel margin over and under dimension and weights, Pieces, tensile properties and tests.

P.S. 2401963 Plain cold drawn steel wire for pre-stressed concrete. Specifies process of manufacture, quality of finished wire, chemical composition, tolerances, tensile strength, selection of test pieces, tests and size of coil

P.S. 2421963 Tensile testing of steel wire. Specifies symbols and designation, test pieces, determination of cross-sectional area of test piece determination of elongation, rate of testing determination of proof limit and proving tests.

P.S. 3851988 (R) Steel-charpy impact test (V-notch). (Revised). Specifies principle of test, symbol and designations, test pieces, testing machine and test requirements.

P.S. 4231964 Cold drawn steel wire for concrete reinforcement. Specifies process of manufacture, quality of finished wire, tensile test pieces, cold bend test pieces, selection of test pieces, tests, margin over and under specified dimensions, identification of wire calculation of weight and test at work.

P.S. 4241964 Load calibration of testing machine for tensile testing of steel. Specifies calibration by means of: i) weight (mass), ii) elastic devices (dynamometers), iii) proving levers and assessment of calibration.

P.S. 4251964 Calibration of Vickers hardness testing machines. Covers calibration of testing machines for determining Vickers hardness.

P.S. 4271988 Charpy impact test (u-notch for steel. (Revised). Covers principle of test, symbols and designations, test pieces, testing machines and test requirements.

P.S. 6071991 Steel and steel products- general technical delivery requirements, (2nd Revision). Covers ordering, manufacturing processes, documents, carrying out acceptance tests, mechanical test, chemical composition, defects and dimensional tolerances and authorization for dispatch.

P.S. 6101967 Tables of brinell hardness (HB) for use in test made on flat surfaces. Specifies table of brinell hardness values for steel.

P.S. 6111991 Specifies table of brinell hardness values for steel. Metallic materials: Hardness test-Tables of Vickers hardness values (HV) for use in test made on flat surface, Part 2: HV 0.2 to HV S (Revised)

P.S. 6361967 Galvanized Steel Wire. Specifies terminology, materials, manufacture, ductility weight, reeling and marking.

P.S. 6801968 Steel nails for building purposes. Specifies materials, workmanship, finish, dimensions and tolerances, inspection, certificate of compliance, weights and designation of ordering.

P.S. 6811968 Hot rolled, steel strips (baling). Specifies materials, chemical composition, mechanical properties, tolerances, supplier's guarantee, inspection & testing facilities and test.

P.S. 7201991 Metallic material – Hardness test – verification of brinesll hardness testing machine (Revised). Verification of brinesll hardness testing machines.

PS 7431969 Dimension of hot rolled steel sections equal leg- angles metric series –dimension and sectional properties.

P.S. 7451994(R) Steel and cast iron – determination of sulphur content combustion titrimetric. (1st Revision). Specification principle of method, reagents, apparatus procedure, expression of results and test report.

P.S. 8471971 Selections & preparation of samples and test pieces prim wrought steel. Covers selection and preparation of samples and test pieces for mechanical tests and selection and preparation of samples for chemical analysis.

P.S. 9081994 (R) Method for chemical analysis of steel determination of Manganese volumetric. (1st Revision). Covers principal of method, apparatus reagents, sampling procedure standardization and circulation.

P.S. 9101987 (R) Hot-Rolled steel bars- Tolerances (1st Revision). Specifies dimensions

P.S. 9811994 (R) Steel wire Ropes for general purposes- characteristics. (1st Revision). Specifies types of construction and diameter ranges-round strand, material and rope characteristics.

P.S. 9821974 Drawn wire for general purposes non alloy steel wire ropes. Specifies quality of coating, diameters, breaking strength, simple torsion test, reverse bend test temple test on knotted wire, galvanized wire inspection on zinc coating and accepted conditions.

P.S. 16122007 (R) Steel for the reinforcement of concrete-Weld able reinforcing 2014 (2nd R) Steel-Bar, coil and decoiled product-Specification

PS 18501987 Zinc coating testing zinc coating on steel wire and quality requirements. It specifies the methods of testing zinc coated steel wires and products fabricated, determine the nominal mass of the zinc coatings.

P.S. 18561987 Hot rolled steel bars dimensions of round bars. This standard specifies dimensions of metric series hot rolled steel round bars.

P.S. 18571987 Hot rolled steel bars dimensions of square bars. Specifies dimensions of metric series hot rolled steel square bars.

P.S. 18581987 Hot rolled steel bars tolerances. This standard specifies metric dimensional tolerances applicable to hot rolled steel bars supplied in straight length in the following product forms i.e. round, square hexagonal, octagonal and flat bars

P.S. 18791987 Deformed & plain Billets – Steel Bars for the Concrete re-enforcement (metric). 2009 (1st R) Specification covers deformed and plain billet hot-rolled steel concrete reinforcement bars. Sizes and dimensions of deformed bars and their designated number are given in table. Bars of two minimum yield levels namely 300 Mpa and 400 Mpa, designated as grade-300 and Grade-400 are specified. 2014 (2nd R).

P.S. 19181987 Steel and cast iron-determination of total silicon gravimetric method. Specifies a gravimetric method for the determination of total silicon in steel and case iron.

P.S. 19191987 Metallic materials – Hardness test – Brinell test specifies the method for the brinells hardness test for metallic materials.

P.S. 19201987 Metallic Material Wrapping Test. Specifies the method for determining the ability of metallic wire of diameter or thickness 0.1 to 10 mm inclusive, to undergo plastic deformation during single torsion in one direction.

P.S. 19211987 Metallic Material Wire simple torsion test. Specifies the method of determining the ability of metallic wire of dia. or thickness 0.3 to 10 mm inclusive to undergo plastic deformation during single torsion in one direction.

P.S. 19221987 Steel and cast iron- Determination of total carbon content combustion gravimetric method. Specifies a gravimetric method for determining the total carbon content of steel and cast iron after combustion of the test portion in current of oxygen.

P.S. 20311988 Metallic materials – Bend test. Specifies the method for determination the ability of metallic wire of diameter or thickness of 0.3 to 10 mm to undergo plastic deformation during reserve bending.

P.S. 20321988 Metallic Material Reverse Bend Test. Specifies the method for determining the ability of metallic wire of diameter or thickness of 0.3 to 10 mm to undergo plastic deformation during reverse bending.

P.S. 26741989 Metallic materials – Tensile Testing at ambient temperature. Describes the method of tensile testing of metals at room temperature to determine the following properties, yield strength, proof strength, tensile strength elongation, reduction area etc.

P.S. 28691990 Metallic materials – Tube (in full section) – Bend test. It specifies a method for determining the ability of full-section metallic tube of circular cross-section with an outside diameter not greater than 65 mm to undergo plastic deformation in bending.

P.S. 28701990 Metallic materials – Tube – Flattening test. It specifies a method for determining the ability of metallic tubes of circular cross-section having an outside diameter not greater than 400.

P.S. 30451991 Rail steel deformed & plain bars for concrete reinforcement. This specification covers deformed and plain rail steel concrete reinforcement bars. Bars are of two minimum yield levels 50,000 PSI (350 Mpa) and 60,000 PSI (400 Mpa) designated as Grade-50 (350) and Grade-60 (400) respectively are specified.

P.S. 30461991 Axle-steel deformed and plain bars for concrete reinforcement. This specification covers deformed and plain axle steel concrete reinforcement bars are of two minimum yield levels, namely 40,000 PSI (300 Mpa) and 600 000 PSI (420 Mpa) designated as Grade-40 (300) and Grade-60 (400) respectively are defined.

P.S. 32091992 Steel for the prestressing and concrete-General requirements. Specifies requirements for high tensile strength steel to be used in pre stressed concrete. It applies only to material in the requirements for materials and anchorage devices used in conjunction with the pre stressing steel in structural components.

P.S. 34451993 Steel bars for reinforcement of concrete-bend re bend test. This specification specifies procedures for bend and rebends testing of reinforcing steel bars. The purpose of the rebend test is to determine the ageing properties of bars exposed to plastic deformation

P.S. 34461993 Steel for the pre stressing of concrete- cold drawn wire. This standard specifies requirements for round, cold drawn, high tensile steel wire, either plain, intended, ribbed or crimped. The product is supplied mill coil wire or straight ended and stress relieved wire in coils or cut lengths.

P.S. 34471993 Steel for the pre stressing – strand. It specifies requirements for high tensile steel strand which has been given a stress relieving heat treatment according to the general requirements specified in PS: 3209-1992. The strand may contain either 2, 3, 7 or 19 individual wire.

P.S. 34481993 Certification scheme for steel bars and wire for the reinforcement of concrete structures. It specifies rules for a certification scheme for continuous production of steel bars and wires for ordinary reinforcement of concrete structures in order to verify the conformity with requirements specified in product standards such as PS: 1612 and PS: 1879.

P.S. 35641994 Fabricated deformed steel bar mats for concrete reinforcement. This standard covers materials in mat (or sheet) from fabricated from hot rolled deformed steel bars to be used for the reinforcement of concrete.

P.S. 35651994 Zinc coated steel wire for fencing. This standard specifies requirements for drawn steel wire zinc coated by the hot dip process, and intended for use in general purpose wire bending, barbed wire bending field fencing and chain link fencing.

P.S. 35661994 Carbon steel Girder Rails of plain grooved and guard types. This standard covers carbon steel girder rails of three classes based on type or type and weight, and chemistry.

P.S. 35671994 Zinc coatings for steel wire. This standard covers the requirements for the mass quality and testing of zinc coatings and steel wire of circular cross section.

P.S. 37081995 Steel wire hard drawn for prestressing concrete redrawing. This specification covers uncoated, high-strength hard-drawn steel wire for use in the manufacture of Prestressed concrete tanks and similar structures. In application, the wire is continuously wrapped on the structure maintaining tension by a device employing a wire drawing dia. for back tension.

P.S. 37091995 Zinc coated (Galvanized) steel bars for concrete reinforcement. This standard covers concrete reinforcing bars with protective zinc coating applied by dipping the properly prepared reinforcing bars into a molten bath of zinc.

P.S. 38611996 Steel for the pre-stressing of concrete quenched and tempered wire. This standard specifies requirements for round wire made of quenched and tempered high tensile steel, with a surface which is either plain, ribbed, grooved for indented.

P.S. 40331997 Hot rolled steel with or without subsequent processing. This standard specifies requirements for round high tensile steel bars. The bars may be supplied either hot rolled or in a hot rolled and processed condition.

P.S. 40341997 Epoxy coated reinforcing steel bars. This standard covers deformed and plain steel reinforcing bars with protective epoxy coating applied by the electrostatic spray method.

P.S. 42771998 Cold reduced steel wire for the reinforcement of concrete and the manufacturing of welded fabric. This standard specifies technical requirements for cold reduced steel wire designed for the reinforcement of concrete or for use in welded fabric.

P.S. 42781998 Steel for the reinforcement of concrete welded fabric. This standard covered technical requirements for factory made sheets or rolls of welded fabric, manufactured from steel wires or bars with diameters from 4 mm to 16 mm and designed for the reinforcement present

PS 43571998 Test method for rubber deterioration in air oven

PS 47982002 Carbon structural steel

PS 49942009 Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement 2014 (1st R)

PS 50232009 Low-alloy steel deformed and plain bars for concrete reinforcement. Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

PS 50242009 Practice for using significant Digits in Test Data to Determine Conformance with Specifications

PS 51352009 Deformed and plain carbon-steel bars for reinforcement. Test Methods and Definitions for Mechanical Testing of Steel Products

PS 51362009 Practices for packaging, marking and loading methods for steel products for shipment

P.S. 2321983 Ordinary Portland cement (4th Revision). 2008 (R), Specific composition and manufacture, fineness, chemical composition, strength, consistence of standard cement paste, setting, time, soundness, sampling and test method. 2015 (4th R)

P.S. 6121989 Sulphate resisting Portland Cement Type A (1st Revision)

METRICATION CONVERSION GUIDE

Note:

Based on IEEE/ASTM SI 10-2002 document

The values stated in either inch-pound or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

1a. LENGTH

$$1 \text{ in.} = 25.40 \text{ mm}$$

Rules:

1. Convert **in.** to **mm** using the factor **25.40** and round to two significant digits.
2. Orange shading: equivalence number for ACI 318M document.
3. Change to **m**, when conversion reaches **1000 mm**.

Example 1: $1/2 \text{ in.} = 0.5 \times 25.40 = 12.70 \rightarrow$ use 13 mm

in.-lb Units [in.]	Conversion to SI Units [mm]	Equivalent SI Units [mm]	ACI 318M Units [mm]
1/4	6.35	6.4	6
3/8	9.53	9.5	10
1/2	12.70	13	13
5/8	15.88	16	16
3/4	19.05	19	20
7/8	22.23	22	22
1	25.40	25	25
1 1/4	31.75	32	30
1 1/2	38.10	38	40
1 3/4	44.45	44	45
2	50.80	51	50
2 1/2	63.50	64	65

APPENDIX – D - METRICATION CONVERSION GUIDE

3	76.20	76	75
3 1/2	88.90	89	90
4	101.60	100	100
5	127.00	130	125
5 1/2	139.70	140	140
6	152.40	150	150
7	177.80	180	175
7 1/2	190.50	190	190
8	203.20	200	200
9	228.60	230	230
9 3/4	247.65	250	245
10	254.00	250	250
11	279.40	280	280
12	304.80	300	300
12.5	317.50	320	315
14	355.60	360	350
16	406.40	410	400
18	457.20	460	450
20	508.00	510	500
24	609.60	610	600
25	635.00	640	635
30	762.00	760	750
36	914.40	910	900

1a. LENGTH CONTINUED

in.-lb Units [in.]	Conversion to SI Units [m]	Equivalent SI Units [m]	ACI 318M Units [m]
48	1.22	1.2	1.2
50	1.27	1.3	1.3
54	1.37	1.4	1.4
60	1.52	1.5	1.5
72	1.83	1.8	1.8
120	3.05	3.0	3.0

APPENDIX – D - METRICATION CONVERSION GUIDE

144	3.66	3.7	3.7
1,200	30.48	30	30
1,800	45.72	46	46

1b. CRACK WIDTH

1 in. = 25.40 mm

Rule:

Convert **in.** to **mm** using the factor **25.40** and round to 2 significant digits.

Example : 0.013 in. = 0.013 x 25.40 = 0.3302 → use 0.33 mm

in.-lb Units [in.]	Conversion to SI Units [mm]	Equivalent SI Units [mm]	ACI 318M Units [mm]
0.012	0.3048	0.30	0.30
0.016	0.4064	0.41	0.41

1c. AGGREGATE SIZE

ASTM E 11			ACI 318M Units [mm]
Approx. Size in.-lb Units [in.]	Nomenclature in.-lb Units	Size and Nomenclature are the Same SI Units	
4	4 in.	100 mm	100 mm
3.5	3-1/2 in.	90 mm	90 mm
3	3 in.	75 mm	75 mm
2.5	2-1/2 in.	63 mm	63 mm
2	2 in.	50 mm	50 mm
1.5	1-1/2 in.	37.5 mm	37.5 mm
1	1 in.	25.0 mm	25.0 mm
0.875	7/8 in.	22.4 mm	22.4 mm
0.750	3/4 in.	19.0 mm	19.0 mm
0.625	5/8 in.	16.0 mm	16.0 mm
0.500	1/2 in.	12.5 mm	12.5 mm
0.375	3/8 in.	9.5 mm	9.5 mm

APPENDIX – D - METRICATION CONVERSION GUIDE

0.250	1/4 in.	6.3 mm	6.3 mm
0.187	No. 4	4.75 mm	4.75 mm
0.132	No. 6	3.35 mm	3.35 mm
0.0937	No. 8	2.36 mm	2.36 mm
0.0787	No. 10	2.00 mm	2.00 mm
0.0469	No. 16	1.18 mm	1.18 mm
0.0331	No. 20	850 μμ	850 μμ
0.0234	No. 30	600 μμ	600 μμ
0.0165	No. 40	425 μμ	425 μμ
0.0117	No. 50	300 μμ	300 μμ
0.0070	No. 80	180 μμ	180 μμ
0.0059	No. 100	150 μμ	150 μμ
0.0029	No. 200	75 μμ	75 μμ

1d. AREA

$$1 \text{ ft}^2 = 0.09290 \text{ m}^2$$

Rule:

Convert **ft²** to **m²** using the factor **0.09290** and round to 2 significant digits.
 Therefore 5,000 ft² = 5,000 x 0.09290 = 464.5 → use 460 m²

in.-lb Units [ft ²]	Conversion to SI Units [m ²]	Equivalent SI Units [m ²]	ACI 318M Units [m ²]
5,000	464.50	460	460

1e. AREA PER UNIT LENGTH

$$1 \text{ in.}^2 / \text{ft} = 2117 \text{ mm}^2 / \text{m}$$

Rule:

Convert **in²/ft** to **mm²/m** using the factor **2117** and round to 2 significant digits.
 Therefore : 0.10 in.²/ft = 0.10 x 2117 = 211.7 → use 210 mm²/m

in.-lb Units [in. ² /ft]	Conversion to SI Units [mm ² /m]	Equivalent SI Units [mm ² /m]	ACI 318M Units [mm ² /m]
0.10	211.70	210	210

1f. VOLUME

1 yd³ = 0.7646 m³

Rule:

Convert **yd³** to **m³** using the factor **0.7646** and round to 2 significant digits.

Example : 50 yd³ = 50 x 0.7646 = 38.23 → use 38 m³

in.-lb Units [yd ³]	Conversion to SI Units [m ³]	Equivalent in SI Units [m ³]	ACI 318M Units [m ³]
50	38.23	38	38
150	114.69	110	110

1g. LOADS

1 lb = 0.004448 kN

Rule:

Convert **lb** to **kN** using the factor **0.004448** and round to 2 significant digits.

Example : 16,000 lb = 16,000 x 0.004448 = 71.17 → use 71 kN

in.-lb Units [lb]	Conversion to SI Units [kN]	Equivalent SI Units [kN]	ACI 318M Units [kN]
3,000	13.34	13	13
9,000	40.03	40	40
10,000	44.48	44	44
16,000	71.17	71	71

1h. LOADS PER UNIT LENGTH

1 lb / ft = 0.01459 kN / m

Rule:

Convert **lb/ft** to **kN/m** using the factor **0.01459** and round to 2 significant digits.

Example : 1,500 lb/ft = 1,500 x 0.01459 = 21.89 → use 22 kN/m

in.-lb Units [lb/ft]	Conversion to SI Units [kN/m]	Equivalent SI Units [kN/m]	ACI 318M Units [kN/m]
200	2.918	2.9	3.0
300	4.377	4.4	4.4
1,500	21.885	22	22
3,000	43.770	44	44

1i. AREA LOADS

$$1 \text{ psf} = 0.04788 \text{ kN/m}^2$$

Rule: Convert **psf** to **kN/m²** using the factor **0.04788** and round to 2 significant digits. Therefore : 100 psf = 100 x 0.04788 = 4.788 → use 4.8 kN/m²

in.-lb Units [psf]	Conversion to SI Units [kN/m ²]	Equivalent SI Units [kN/m ²]	ACI 318M Units [kN/m ²]
100	4.7880	4.8	4.8

2. TEMPERATURE

$$\text{Degree F} = (F-32)/1.8 = \text{Degree C}$$

Rule: To convert °F to °C use the conversion above and round to the nearest degree. Except for temperatures above 212 deg F, for which the conversion is rounded to 2 significant figures).

Example: 35 °F = (35 – 32)/1.8 = 1.67 → use 2 °C

According to ACI style manual, the degree symbol should be used with temperature, °F and °C.

in.-lb Units [°F]	Conversion to SI Units [°C]	Equivalent SI Units [°C]	ACI 318M Units [°C]
35	1.6667	2	2
40	4.4444	4	4
50	10.0000	10	10

60	15.5556	16	16
90	32.2222	32	32
95	35.0000	35	35
100	37.7778	38	38
200	93.3333	93	93
300	148.8889	150	150
400	204.4444	200	200
600	315.5556	320	320
1,500	815.5556	820	820

3. CONCRETE UNIT WEIGHT

1 lb/ft³ = 16.02 kg/m³

Rule:

Convert the unit weight in **lb/ft³** to **kg/m³** using the factor **16.02** and round to three (3) significant digits. (Show to the nearest 5 kg/m³ for values in the 'ones' digit.)

Example: 144 x 16.02 = 2307 → use 2310 kg/m³

in.-lb Units [pcf]	Conversion to SI Units [kg/m ³]	Equivalent SI Units [kg/m ³]	ACI 318M Units [kg/m ³]
70	1121.40	1120	1120
90	1441.80	1440	1440
105	1682.10	1680	1680
110	1762.20	1760	1760
115	1842.30	1840	1840
120	1922.40	1920	1920
140	2242.80	2240	2240
144	2306.88	2310	2310
145	2322.90	2320	2320
150	2403.00	2400	2400
155	2483.10	2480	2480

NOTE:

In SI Units the kg is a unit of mass therefore the term "unit weight" in a SI document should be "unit density."

4a. CONCRETE STRESS

1000 psi = 6.895 MPa

Rule:

Convert **psi** to **MPa** using the factor **0.006895** and round to two (2) significant digits (except for concrete stress levels 5000 psi and above round to the nearest 5 MPa - see shaded equivalents below).

Example 1: 4440 psi = 4.44 x 6.894757 = 30.61 → use 31 MPa

Example 2: 12,000 psi = 12 x 6.894757 = 82.737 → use 85 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
50	0.3448	0.34	0.35
70	0.4827	0.48	0.5
80	0.5516	0.55	0.55
100	0.6895	0.69	0.7
125	0.8619	0.86	0.9
150	1.0343	1.0	1.0
200	1.3790	1.4	1.4
225	1.5514	1.6	1.6
250	1.7238	1.7	1.7
260	1.7927	1.8	1.8
300	2.0685	2.1	2.1
400	2.7580	2.8	2.8
500	3.4475	3.4	3.5
700	4.8265	4.8	5.0
800	5.5160	5.5	5.5
1,000	6.8950	6.9	7.0
1,200	8.2740	8.3	8.3
2,000	13.7900	14	14
2,500	17.2375	17	17
3,000	20.6850	21	21
3,500	24.1325	24	24
4,000	27.5800	28	28

4,440	30.6138	31	31
4,500	31.0275	31	31
5,000	34.4750	35	35
6,000	41.3700	40	40
8,000	55.1600	55	55
10,000	68.9500	70	70
11,000	75.8450	75	75
12,000	82.7400	85	85
15,000	103.4250	105	105

4b. MODULUS OF ELASTICITY

1000 psi = 6.895 MPa

Rule:

Convert **psi** to **MPa** using the factor **0.006895** and round to 2 significant digits.

Therefore : 29,000,000 psi = 29,000,000 x 6.895 / 1000 = 199,995 → use 200,000 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
29,000,000	199955	200000	200 000

5. EMPIRICAL EQUATIONS FOR CONCRETE WITH MULTIPLIERS OF

1/12.043 or 0.08304

$$\sqrt{f'_c}$$

Rule:

To convert the multipliers of $\sqrt{f'_c}$ use the factor **1/12.043** (or **0.08304**) and round to two (2) significant digits. Show constants or multipliers in front of equation.

Conversion of commonly used multipliers of : $\sqrt{f'_c}$

in.-lb Units	Conversion to SI Units	Equivalent SI Units	ACI 318M Units
0.1	0.0083	0.0083	0.0083
0.6	0.0498	0.050	0.050

APPENDIX – D - METRICATION CONVERSION GUIDE

0.75	0.0623	0.062	0.062
1	0.0830	0.083	0.083
1.25	0.1038	0.10	0.10
1.33	0.1104	0.11	0.11
1.7	0.1412	0.14	0.14
1.9	0.1578	0.16	0.16
2	0.1661	0.17	0.17
2.66	0.2209	0.22	0.22
3	0.2491	0.25	0.25
3.3	0.2740	0.27	0.27
3.5	0.2906	0.29	0.29
4	0.3322	0.33	0.33
5	0.4152	0.42	0.42
6	0.4982	0.50	0.50
6.7	0.5564	0.56	0.56
7	0.5813	0.58	0.58
7.5	0.6228	0.62	0.62
8	0.6643	0.66	0.66
10	0.8304	0.83	0.83
12	0.9965	1.0	1.0
15	1.2456	1.2	1.2
16	1.3286	1.3	1.3
20	1.6608	1.7	1.7
25	2.0760	2.1	2.1
33	2.7403	2.7	2.7
40	3.3216	3.3	3.3
50	4.1520	4.2	4.2
65	5.3976	5.4	5.4
100	8.3040	8.3	8.3
160	13.2864	13	13
57000	4733.2800	4700	4700

6a. STEEL GRADES IN REFERENCED ASTMs FOR REINFORCING BARS, WELDED WIRE REINFORCEMENT, STEEL STRANDS, AND STRUCTURAL STEEL PLATES & SHAPES

APPENDIX – D - METRICATION CONVERSION GUIDE

Conversion of reinforcing steel grades per **ASTMs listed in the 318:** (Minimum yield strengths)

Not included: A 53 - 02, A 307 - 04, A 500 - 03, A 501 - 01

A 185 - 02 and A 497 - 02 refer to A 82

A 185 - 02 and A 497 - 02 refer to A 82

A 775 - 01 and A 934 - 03 refer to A 615, A 706, and A 996

A 884 - 02 refers to A 82, A 185, A 496, and A 497

in.-lb Units [ksi]	SI Units [MPa]	
ASTM A 36/ A 36M - 03		Plate, Bar and Shapes
36	250	
ASTM A 82 - 02		WWR
56	385	
65	450	
70	485	
ASTM A 242/ A 242M - 03		Plate, Bar and Shapes
42	290	
46	315	
50	345 ⁴	
ASTM A 416/ A 416M - 02		Strand
250	1725	
270	1860	
ASTM A 421/ A 421M - 02		Strand
235	1620	
240	1655	
250	1725	
ASTM A 496 - 02		WWR
70	485	
ASTM A 572/ A 572M - 03		Plate, Bar and Shapes
42	290	

in.-lb Units [ksi]	SI Units [MPa]	ACI 318M Units [MPa]
Summary		Nearest 5 MPa
36	250	250
40	280(300) ¹	280
42	290	290
46	315	315
50	350(345) ²	350
55	380	380
56	385	385
60	420(415) ³	420
70	485	485
75	520	520
150	1035	1035
235	1620	1620
240	1655	1655
250	1725	1725
270	1860	1860

1. ASTM is in the process of changing to 280.

2. Steel plate uses 345 and concrete reinforcement uses 350: Use 350.

APPENDIX – D - METRICATION CONVERSION GUIDE

50	345 ⁴	
55	380	
60	415 ⁴	
65	450	
ASTM A 588/ A 588M - 03		Plate, Bar and Shapes
42	290	
46	315	
50	345 ⁴	
ASTM A 615/ A 615M - 03		Rebar
40	280	
60	420	
75	520	
ASTM A 706/ A 706M - 03		Rebar
60	420	
ASTM A 722/ A 722M - 98		Rebar
150	1035	
ASTM A 767/ A 767M - 00		Rebar
40	300 ⁴	
50	350	
60	420	
75	520	
ASTM A 992/ A 992M - 03		Plate, Bar and Shapes
50	345 ⁴	
65	450	
ASTM A 996/ A 996M - 03		Rebar
40	280	
50	350	
60	420	

3. Steel plate uses 415 and concrete reinforcement uses 420: Use 420.

4. Red values shall not be used.

6b. STEEL STRESSES NOT REFERENCED IN ASTMs

$$1000 \text{ psi} = 6.895 \text{ MPa}$$

Rule: Convert **psi** to **MPa** using the factor **0.006895**; round to 2

APPENDIX – D - METRICATION CONVERSION GUIDE

significant digits (except for 5000 psi and above round up to the nearest 5 MPa)

Example: 80,000 psi = 80000 x 0.006895 = 551.6 → use 550 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
3,000	20.69	21	21
10,000	68.95	70	70
18,000	124.11	125	125
20,000	137.90	140	140
30,000	206.85	205	210
52,000	358.54	360	360
80,000	551.60	550	550
100,000	689.50	690	700
125,000	861.88	860	860
275,000	1896.13	1895	1900

7a. REINFORCING BAR SIZE

Conversion of reinforcing steel bar sizes per **ASTM**:

in.-lbs Units	(SI) Units	ACI 318M
ASTM A 615/ A 615M-03		
No. 3	No. 10	No. 10
No. 4	No. 13	No. 13
No. 5	No. 16	No. 16
No. 6	No. 19	No. 19
No. 7	No. 22	No. 22
No. 8	No. 25	No. 25
No. 9	No. 29	No. 29
No. 10	No. 32	No. 32

No. 11	No. 36	No. 36
No. 14	No. 43	No. 43
No. 18	No. 57	No. 57

7b. STEEL STRAND SIZE*

Conversion of steel strand sizes per **ASTM**:

in.-lbs Units [in.]	SI Units [mm]	ASTM Designated Strand No.	ACI 318M
ASTM A 416/ A 416M-02			
0.250	6.4	6	6
0.313	7.9	8	8
0.375	9.5	9	9
0.438	11.1	11	11
0.500	12.7	13	13
0.600	15.2	15	15

7c. REINFORCING BAR SIZE* (HIGH-STRENGTH)

Conversion of steel strand sizes per **ASTM**:

in.-lbs Units [in.]	SI Units [mm]	ACI 318M
ASTM A 722/ A 722M – 98 Type I (Plain) Bar		
---	---	---
3/4	19	19
7/8	22	22

in.-lbs Units [in.]	SI Units [mm]	ACI 318M
ASTM A 722/ A 722M – 98 Type II (Deformed) Bar		
5/8	15	15
3/4	20	20
---	---	---

APPENDIX – D - METRICATION CONVERSION GUIDE

1	25	25
1-1/8	29	29
1-1/4	32	32
1-3/8	35	35

1	26	26
---	---	---
1-1/4	32	32
1-3/8	36	36
1-3/4	46	46
2-1/2	65	65

*Where ACI 318 gives limits on general 'Tendon' sizes, an exact conversion of shall be made.
 (Example; 5/8" tendon will be converted to 16 mm)

8. STEEL WIRE REINFORCEMENT

ASTM does not have a direct SI equivalent (ASTM sizes and dimensions not shaded); Table below shows in.-lb unit sizes with calculated SI dimensions and suggested SI sizes (shaded). Use the nearest SI size as appropriate.

in.-lb Units			SI Units			
ASTM A 82-02 (W, MW) and ASTM A 496-02 (D, MD)						
Size	Diameter [in.]	Area [in. ²]	Size	Calculated	Calculated	ACI 318 M - Suggested Size
				Diameter [mm]	Area [mm ²]	
W 0.5	0.080	0.005		2.03	3.23	MW 5
			MW 5	2.50	5.00	
D 1	0.113	0.01		2.87	6.45	
W 1.2	0.124	0.012		3.15	7.74	MW 5
W 1.4	0.134	0.014		3.40	9.08	MW 10
			MW 10	3.60	10.00	
W 2 or D 2	0.160 : 0.159	0.02		4.06	12.90	MW 15
			MW 15	4.40	15.00	
W 2.5	0.178	0.025		4.52	16.13	MW 15
W 2.9	0.192	0.029		4.88	18.70	MW 20
D 3	0.195	0.03		4.95	19.35	
			MW 20	5.00	20.00	
W 3.5	0.211	0.035		5.36	22.58	MW 25
			MW 25 or MD 25	5.60	25	
W 4 or D 4	0.226 : 0.225	0.04		5.74	25.81	MW25 or MD25
W 4.5	0.239	0.045		6.07	29.03	MW 30
			MW 30 or MD 30	6.20	30	

APPENDIX – D - METRICATION CONVERSION GUIDE

W 5 or D 5	0.252 : 0.250	0.05		6.40	32.26	MW 30 or MD 30
			MW 35 or MD 35	6.70	35	
W 5.5	0.265	0.055		6.73	35.48	MW 35
W 6 or D 6	0.276	0.06		7.01	38.71	MW 40 or MD 40
			MW 40 or MD 40	7.10	40	
D 7	0.299	0.07		7.60	45	MD 45
			MW 50 or MD 50	8.00	50	
W 8 or D 8	0.319	0.08		8.10	51.61	MW 50 or MD 50
			MW 55 or MD 55	8.40	55	
D 9	0.338	0.09		8.59	58.96	MD 60
			MW 60 or MD 60	8.70	60	
W 10 or D 10	0.357 : 0.356	0.10		9.07	64.52	MW 65 or MD 65
			MW 65 or MD 65	9.10	65	
			MW 70 or MD 70	9.40	70	
D 11	0.374	0.11		9.50	70.97	MD 70
W 12 or D 12	0.391 : 0.390	0.12		9.93	77.42	MW 80 or MD 80
			MW 80 or MD 80	10.10	80	
D 13	0.406	0.13		10.31	83.87	MD 80
			MW 90 or MD 90	10.70	90	
W 14 or D 14	0.422	0.14		10.72	90.32	MW 90 or MD 90
D 15	0.437	0.15		11.10	96.77	MD 100
			MW 100 or MD 100	11.30	100	
W 16 or D 16	0.451	0.16		11.46	103.25	MW 100 or MD 100
D 17	0.465	0.17		11.81	109.68	MD 100
W 18 or D 18	0.479 : 0.478	0.18		12.17	116.13	MW 120 or MD 120
			MW 120 or MD 120	12.40	120	
D 19	0.491	0.19		12.47	122.58	MD 120
W 20 or D 20	0.505 : 0.504	0.20		12.83	129.03	MW 130 or MD 130
			MW 130 or MD 130	12.90	130	
D 21	0.517	0.21		13.13	135.48	MD 130
W 22 or D 22	0.529	0.22		13.44	141.90	
D 23	0.541	0.23		13.74	148.39	

APPENDIX – D - METRICATION CONVERSION GUIDE

W 24 or D 24	0.533 : 0.553	0.24		14.05	154.80	
D 25	0.564	0.25		14.33	161.29	
W 26 or D 26	0.575	0.26		14.61	167.70	
D 27	0.586	0.27		14.88	174.19	
W 28 or D 28	0.597	0.28		15.16	180.60	
D 29	0.608	0.29		15.44	187.10	
W 30 or D 30	0.618	0.3		15.70	193.50	
W 31 or D 31	0.628	0.31	MW 200 or MD 200	15.95	200	MW 200 or MD 200
W 45 or D 45	0.757	0.45	MW 290 or MD 290	19.22	290	MW 290 or MD 290

Metrication Conversion Guide

Note:

Based on IEEE/ASTM SI 10-2002 document

The values stated in either inch-pound or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

1a. LENGTH

$$1 \text{ in.} = 25.40 \text{ mm}$$

Rules:

1. Convert **in.** to **mm** using the factor **25.40** and round to two significant digits.
2. Orange shading: equivalence number for ACI 318M document.
3. Change to **m**, when conversion reaches **1000 mm**.

Example 1: 1/2 in. = 0.5 x 25.40 = 12.70 → use 13 mm

in.-lb Units [in.]	Conversion to SI Units [mm]	Equivalent SI Units [mm]	ACI 318M Units [mm]
1/4	6.35	6.4	6

APPENDIX – D - METRICATION CONVERSION GUIDE

3/8	9.53	9.5	10
1/2	12.70	13	13
5/8	15.88	16	16
3/4	19.05	19	20
7/8	22.23	22	22
1	25.40	25	25
1 1/4	31.75	32	30
1 1/2	38.10	38	40
1 3/4	44.45	44	45
2	50.80	51	50
2 1/2	63.50	64	65
3	76.20	76	75
3 1/2	88.90	89	90
4	101.60	100	100
5	127.00	130	125
5 1/2	139.70	140	140
6	152.40	150	150
7	177.80	180	175
7 1/2	190.50	190	190
8	203.20	200	200
9	228.60	230	230
9 3/4	247.65	250	245
10	254.00	250	250
11	279.40	280	280
12	304.80	300	300
12.5	317.50	320	315
14	355.60	360	350
16	406.40	410	400
18	457.20	460	450
20	508.00	510	500
24	609.60	610	600
25	635.00	640	635
30	762.00	760	750
36	914.40	910	900

1a. LENGTH CONTINUED

in.-lb Units [in.]	Conversion to SI Units [m]	Equivalent SI Units [m]	ACI 318M Units [m]
48	1.22	1.2	1.2
50	1.27	1.3	1.3
54	1.37	1.4	1.4
60	1.52	1.5	1.5
72	1.83	1.8	1.8
120	3.05	3.0	3.0
144	3.66	3.7	3.7
1,200	30.48	30	30
1,800	45.72	46	46

1b. CRACK WIDTH

1 in. = 25.40 mm

Rule:

Convert **in.** to **mm** using the factor **25.40** and round to 2 significant digits.

Example : 0.013 in. = 0.013 x 25.40 = 0.3302 → use 0.33 mm

in.-lb Units [in.]	Conversion to SI Units [mm]	Equivalent SI Units [mm]	ACI 318M Units [mm]
0.012	0.3048	0.30	0.30
0.016	0.4064	0.41	0.41

1c. AGGREGATE SIZE

ASTM E 11			ACI 318M Units [mm]
Approx. Size in.-lb Units [in.]	Nomenclature in.-lb Units	Size and Nomenclature are the Same SI Units	
4	4 in.	100 mm	100 mm

APPENDIX – D - METRICATION CONVERSION GUIDE

3.5	3-1/2 in.	90 mm	90 mm
3	3 in.	75 mm	75 mm
2.5	2-1/2 in.	63 mm	63 mm
2	2 in.	50 mm	50 mm
1.5	1-1/2 in.	37.5 mm	37.5 mm
1	1 in.	25.0 mm	25.0 mm
0.875	7/8 in.	22.4 mm	22.4 mm
0.750	3/4 in.	19.0 mm	19.0 mm
0.625	5/8 in.	16.0 mm	16.0 mm
0.500	1/2 in.	12.5 mm	12.5 mm
0.375	3/8 in.	9.5 mm	9.5 mm
0.250	1/4 in.	6.3 mm	6.3 mm
0.187	No. 4	4.75 mm	4.75 mm
0.132	No. 6	3.35 mm	3.35 mm
0.0937	No. 8	2.36 mm	2.36 mm
0.0787	No. 10	2.00 mm	2.00 mm
0.0469	No. 16	1.18 mm	1.18 mm
0.0331	No. 20	850 μm	850 μm
0.0234	No. 30	600 μm	600 μm
0.0165	No. 40	425 μm	425 μm
0.0117	No. 50	300 μm	300 μm
0.0070	No. 80	180 μm	180 μm
0.0059	No. 100	150 μm	150 μm
0.0029	No. 200	75 μm	75 μm

1d. AREA

$$1 \text{ ft}^2 = 0.09290 \text{ m}^2$$

Rule:

Convert **ft²** to **m²** using the factor **0.09290** and round to 2 significant digits.
 Therefore $5,000 \text{ ft}^2 = 5,000 \times 0.09290 = 464.5 \rightarrow$ use 460 **m²**

in.-lb Units [ft ²]	Conversion to SI Units [m ²]	Equivalent SI Units [m ²]	ACI 318M Units [m ²]
5,000	464.50	460	460

1e. AREA PER UNIT LENGTH

$$1 \text{ in.}^2 / \text{ft} = 2117 \text{ mm}^2 / \text{m}$$

Rule: Convert **in²/ft** to **mm²/m** using the factor **2117** and round to 2 significant digits.
 Therefore : 0.10 in.²/ft = 0.10 x 2117 = 211.7 → use 210 mm²/m

in.-lb Units [in. ² /ft]	Conversion to SI Units [mm ² /m]	Equivalent SI Units [mm ² /m]	ACI 318M Units [mm ² /m]
0.10	211.70	210	210

1f. VOLUME

$$1 \text{ yd}^3 = 0.7646 \text{ m}^3$$

Rule: Convert **yd³** to **m³** using the factor **0.7646** and round to 2 significant digits.
 Example : 50 yd³ = 50 x 0.7646 = 38.23 → use 38 m³

in.-lb Units [yd ³]	Conversion to SI Units [m ³]	Equivalent in SI Units [m ³]	ACI 318M Units [m ³]
50	38.23	38	38
150	114.69	110	110

1g. LOADS

$$1 \text{ lb} = 0.004448 \text{ kN}$$

Rule: Convert **lb** to **kN** using the factor **0.004448** and round to 2 significant digits.
 Example : 16,000 lb = 16,000 x 0.004448 = 71.17 → use 71 kN

in.-lb Units [lb]	Conversion to SI Units [kN]	Equivalent SI Units [kN]	ACI 318M Units [kN]
-------------------	-----------------------------	--------------------------	---------------------

3,000	13.34	13	13
9,000	40.03	40	40
10,000	44.48	44	44
16,000	71.17	71	71

1h. LOADS PER UNIT LENGTH

1 lb / ft = 0.01459 kN / m

Rule:

Convert **lb/ft** to **kN/m** using the factor **0.01459** and round to 2 significant digits.

Example : 1,500 lb/ft = 1,500 x 0.01459 = 21.89 → use 22 kN/m

in.-lb Units [lb/ft]	Conversion to SI Units [kN/m]	Equivalent SI Units [kN/m]	ACI 318M Units [kN/m]
200	2.918	2.9	3.0
300	4.377	4.4	4.4
1,500	21.885	22	22
3,000	43.770	44	44

1i. AREA LOADS

1 psf = 0.04788 kN/m²

Rule:

Convert **psf** to **kN/m²** using the factor **0.04788** and round to 2 significant digits.

Therefore : 100 psf = 100 x 0.04788 = 4.788 → use 4.8 kN/m²

in.-lb Units [psf]	Conversion to SI Units [kN/m ²]	Equivalent SI Units [kN/m ²]	ACI 318M Units [kN/m ²]
100	4.7880	4.8	4.8

2. TEMPERATURE

Degree F = (F-32)/1.8 = Degree C

Rule: To convert °F to °C use the conversion above and round to the nearest degree. Except for temperatures above 212 deg F, for which the conversion is rounded to 2 significant figures).

Example: $35\text{ °F} = (35 - 32)/1.8 = 1.67 \rightarrow \text{use } 2\text{ °C}$

According to ACI style manual, the degree symbol should be used with temperature, °F and °C.

in.-lb Units [°F]	Conversion to SI Units [°C]	Equivalent SI Units [°C]	ACI 318M Units [°C]
35	1.6667	2	2
40	4.4444	4	4
50	10.0000	10	10
60	15.5556	16	16
90	32.2222	32	32
95	35.0000	35	35
100	37.7778	38	38
200	93.3333	93	93
300	148.8889	150	150
400	204.4444	200	200
600	315.5556	320	320
1,500	815.5556	820	820

3. CONCRETE UNIT WEIGHT

$$1 \text{ lb/ft}^3 = 16.02 \text{ kg/m}^3$$

Rule: Convert the unit weight in **lb/ft³** to **kg/m³** using the factor **16.02** and round to three (3) significant digits. (Show to the nearest 5 kg/m³ for values in the 'ones' digit.)

Example: $144 \times 16.02 = 2307 \rightarrow \text{use } 2310 \text{ kg/m}^3$

in.-lb Units [pcf]	Conversion to SI Units [kg/m ³]	Equivalent SI Units [kg/m ³]	ACI 318M Units [kg/m ³]
70	1121.40	1120	1120
90	1441.80	1440	1440

105	1682.10	1680	1680
110	1762.20	1760	1760
115	1842.30	1840	1840
120	1922.40	1920	1920
140	2242.80	2240	2240
144	2306.88	2310	2310
145	2322.90	2320	2320
150	2403.00	2400	2400
155	2483.10	2480	2480

NOTE:

In SI Units the kg is a unit of mass therefore the term "unit weight" in a SI document should be "unit density."

4a. CONCRETE STRESS

1000 psi = 6.895 MPa

Rule:

Convert **psi** to **MPa** using the factor **0.006895** and round to two (2) significant digits (except for concrete stress levels 5000 psi and above round to the nearest 5 MPa - see shaded equivalents below).

Example 1: 4440 psi = 4.44 x 6.894757 = 30.61 → use 31 MPa

Example 2: 12,000 psi = 12 x 6.894757 = 82.737 → use 85 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
50	0.3448	0.34	0.35
70	0.4827	0.48	0.5
80	0.5516	0.55	0.55
100	0.6895	0.69	0.7
125	0.8619	0.86	0.9
150	1.0343	1.0	1.0
200	1.3790	1.4	1.4
225	1.5514	1.6	1.6
250	1.7238	1.7	1.7

APPENDIX – D - METRICATION CONVERSION GUIDE

260	1.7927	1.8	1.8
300	2.0685	2.1	2.1
400	2.7580	2.8	2.8
500	3.4475	3.4	3.5
700	4.8265	4.8	5.0
800	5.5160	5.5	5.5
1,000	6.8950	6.9	7.0
1,200	8.2740	8.3	8.3
2,000	13.7900	14	14
2,500	17.2375	17	17
3,000	20.6850	21	21
3,500	24.1325	24	24
4,000	27.5800	28	28
4,440	30.6138	31	31
4,500	31.0275	31	31
5,000	34.4750	35	35
6,000	41.3700	40	40
8,000	55.1600	55	55
10,000	68.9500	70	70
11,000	75.8450	75	75
12,000	82.7400	85	85
15,000	103.4250	105	105

4b. MODULUS OF ELASTICITY

1000 psi = 6.895 MPa

Rule:

Convert **psi** to **MPa** using the factor **0.006895** and round to 2 significant digits.

Therefore : 29,000,000 psi = 29,000,000 x 6.895 / 1000 = 199,995 → use 200,000 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
29,000,000	199955	200000	200 000

5. EMPIRICAL EQUATIONS FOR CONCRETE WITH MULTIPLIERS OF

$$\sqrt{f'_c}$$

APPENDIX – D - METRICATION CONVERSION GUIDE

1/12.043 or 0.08304

Rule:

To convert the multipliers of $\sqrt{f'_c}$ use the factor **1/12.043** (or **0.08304**) and round to two (2) significant digits. Show constants or multipliers in front of equation.

Conversion of commonly used multipliers of $\sqrt{f'_c}$:

in.-lb Units	Conversion to SI Units	Equivalent SI Units	ACI 318M Units
0.1	0.0083	0.0083	0.0083
0.6	0.0498	0.050	0.050
0.75	0.0623	0.062	0.062
1	0.0830	0.083	0.083
1.25	0.1038	0.10	0.10
1.33	0.1104	0.11	0.11
1.7	0.1412	0.14	0.14
1.9	0.1578	0.16	0.16
2	0.1661	0.17	0.17
2.66	0.2209	0.22	0.22
3	0.2491	0.25	0.25
3.3	0.2740	0.27	0.27
3.5	0.2906	0.29	0.29
4	0.3322	0.33	0.33
5	0.4152	0.42	0.42
6	0.4982	0.50	0.50
6.7	0.5564	0.56	0.56
7	0.5813	0.58	0.58
7.5	0.6228	0.62	0.62
8	0.6643	0.66	0.66
10	0.8304	0.83	0.83
12	0.9965	1.0	1.0
15	1.2456	1.2	1.2

16	1.3286	1.3	1.3
20	1.6608	1.7	1.7
25	2.0760	2.1	2.1
33	2.7403	2.7	2.7
40	3.3216	3.3	3.3
50	4.1520	4.2	4.2
65	5.3976	5.4	5.4
100	8.3040	8.3	8.3
160	13.2864	13	13
57000	4733.2800	4700	4700

6a. STEEL GRADES IN REFERENCED ASTMs FOR REINFORCING BARS, WELDED WIRE REINFORCEMENT, STEEL STRANDS, AND STRUCTURAL STEEL PLATES & SHAPES

Conversion of reinforcing steel grades per **ASTMs listed in the 318:** (Minimum yield strengths)

Not included: A 53 - 02, A 307 - 04, A 500 - 03, A 501 - 01

A 185 - 02 and A 497 - 02 refer to A 82

A 185 - 02 and A 497 - 02 refer to A 82

A 775 - 01 and A 934 - 03 refer to A 615, A 706, and A 996

A 884 - 02 refers to A 82, A 185, A 496, and A 497

in.-lb Units [ksi]	SI Units [MPa]	
ASTM A 36/ A 36M - 03		Plate, Bar and Shapes
36	250	
ASTM A 82 - 02		WWR
56	385	
65	450	
70	485	
ASTM A 242/ A 242M - 03		Plate, Bar and Shapes
42	290	
46	315	

in.-lb Units [ksi]	SI Units [MPa]	ACI 318M Units [MPa]
Summary		Nearest 5 MPa
36	250	250
40	280(300) ¹	280
42	290	290
46	315	315
50	350(345) ²	350
55	380	380
56	385	385
60	420(415) ³	420

APPENDIX – D - METRICATION CONVERSION GUIDE

50	345 ⁴	Strand
ASTM A 416/ A 416M - 02		
250	1725	Strand
270	1860	
ASTM A 421/ A 421M - 02		
235	1620	
240	1655	WWR
250	1725	
ASTM A 496 - 02		
70	485	Plate, Bar and Shapes
ASTM A 572/ A 572M - 03		
42	290	
50	345 ⁴	
55	380	
60	415 ⁴	
65	450	
ASTM A 588/ A 588M - 03		
42	290	Plate, Bar and Shapes
46	315	
50	345 ⁴	
ASTM A 615/ A 615M - 03		Rebar
40	280	
60	420	
75	520	
ASTM A 706/ A 706M - 03		Rebar
60	420	Rebar
ASTM A 722/ A 722M - 98		
150	1035	Rebar
ASTM A 767/ A 767M - 00		
40	300 ⁴	
50	350	

70	485	485
75	520	520
150	1035	1035
235	1620	1620
240	1655	1655
250	1725	1725
270	1860	1860

1. ASTM is in the process of changing to 280.
2. Steel plate uses 345 and concrete reinforcement uses 350: Use 350.
3. Steel plate uses 415 and concrete reinforcement uses 420: Use 420.
4. Red values shall not be used.

APPENDIX – D - METRICATION CONVERSION GUIDE

60	420	Plate, Bar and Shapes
75	520	
ASTM A 992/ A 992M - 03		
50	345 ⁴	Rebar
65	450	
ASTM A 996/ A 996M - 03		
40	280	
50	350	
60	420	

6b. STEEL STRESSES NOT REFERENCED IN ASTMs

$$1000 \text{ psi} = 6.895 \text{ MPa}$$

Rule: Convert **psi** to **MPa** using the factor **0.006895**; round to 2 significant digits (except for 5000 psi and above round up to the nearest 5 MPa)

Example: 80,000 psi = 80000 x 0.006895 = 551.6 → use 550 MPa

in.-lb Units [psi]	Conversion to SI Units [MPa]	Equivalent SI Units [MPa]	ACI 318M Units [MPa]
3,000	20.69	21	21
10,000	68.95	70	70
18,000	124.11	125	125
20,000	137.90	140	140
30,000	206.85	205	210
52,000	358.54	360	360
80,000	551.60	550	550
100,000	689.50	690	700
125,000	861.88	860	860
275,000	1896.13	1895	1900

7a. REINFORCING BAR SIZE

Conversion of reinforcing steel bar sizes per **ASTM:**

in.-lbs Units	(SI) Units	ACI 318M
ASTM A 615/ A 615M-03		
No. 3	No. 10	No. 10
No. 4	No. 13	No. 13
No. 5	No. 16	No. 16
No. 6	No. 19	No. 19
No. 7	No. 22	No. 22
No. 8	No. 25	No. 25
No. 9	No. 29	No. 29
No. 10	No. 32	No. 32
No. 11	No. 36	No. 36
No. 14	No. 43	No. 43
No. 18	No. 57	No. 57

7b. STEEL STRAND SIZE*

Conversion of steel strand sizes per **ASTM:**

in.-lbs Units [in.]	SI Units [mm]	ASTM Designated Strand No.	ACI 318M
ASTM A 416/ A 416M-02			
0.250	6.4	6	6
0.313	7.9	8	8
0.375	9.5	9	9
0.438	11.1	11	11
0.500	12.7	13	13
0.600	15.2	15	15

7c. REINFORCING BAR SIZE* (HIGH-STRENGTH)

Conversion of steel strand sizes per **ASTM**:

in.-lbs Units [in.]	SI Units [mm]	ACI 318M
ASTM A 722/ A 722M – 98 Type I (Plain) Bar		
---	---	---
3/4	19	19
7/8	22	22
1	25	25
1-1/8	29	29
1-1/4	32	32
1-3/8	35	35

in.-lbs Units [in.]	SI Units [mm]	ACI 318M
ASTM A 722/ A 722M – 98 Type II (Deformed) Bar		
5/8	15	15
3/4	20	20
---	---	---
1	26	26
---	---	---
1-1/4	32	32
1-3/8	36	36
1-3/4	46	46
2-1/2	65	65

*Where ACI 318 gives limits on general 'Tendon' sizes, an exact conversion of shall be made.
(Example; 5/8" tendon will be converted to 16 mm)

8. STEEL WIRE REINFORCEMENT

ASTM does not have a direct SI equivalent (ASTM sizes and dimensions not shaded); Table below shows in.-lb unit sizes with calculated SI dimensions and suggested SI sizes (shaded). Use the nearest SI size as appropriate.

in.-lb Units			SI Units			
ASTM A 82-02 (W, MW) and ASTM A 496-02 (D, MD)						
Size	Diameter [in.]	Area [in. ²]	Size	Calculated	Calculated	ACI 318 M - Suggested Size
				Diameter [mm]	Area [mm ²]	
W 0.5	0.080	0.005		2.03	3.23	MW 5
			MW 5	2.50	5.00	
D 1	0.113	0.01		2.87	6.45	

APPENDIX – D - METRICATION CONVERSION GUIDE

W 1.2	0.124	0.012		3.15	7.74	MW 5
W 1.4	0.134	0.014		3.40	9.08	MW 10
			MW 10	3.60	10.00	
W 2 or D 2	0.160 : 0.159	0.02		4.06	12.90	MW 15
			MW 15	4.40	15.00	
W 2.5	0.178	0.025		4.52	16.13	MW 15
W 2.9	0.192	0.029		4.88	18.70	MW 20
D 3	0.195	0.03		4.95	19.35	
			MW 20	5.00	20.00	
W 3.5	0.211	0.035		5.36	22.58	MW 25
			MW 25 or MD 25	5.60	25	
W 4 or D 4	0.226 : 0.225	0.04		5.74	25.81	MW25 or MD25
W 4.5	0.239	0.045		6.07	29.03	MW 30
			MW 30 or MD 30	6.20	30	
W 5 or D 5	0.252 : 0.250	0.05		6.40	32.26	MW 30 or MD 30
			MW 35 or MD 35	6.70	35	
W 5.5	0.265	0.055		6.73	35.48	MW 35
W 6 or D 6	0.276	0.06		7.01	38.71	MW 40 or MD 40
			MW 40 or MD 40	7.10	40	
D 7	0.299	0.07		7.60	45	MD 45
			MW 50 or MD 50	8.00	50	
W 8 or D 8	0.319	0.08		8.10	51.61	MW 50 or MD 50
			MW 55 or MD 55	8.40	55	
D 9	0.338	0.09		8.59	58.96	MD 60
			MW 60 or MD 60	8.70	60	
W 10 or D 10	0.357 : 0.356	0.10		9.07	64.52	MW 65 or MD 65
			MW 65 or MD 65	9.10	65	
			MW 70 or MD 70	9.40	70	
D 11	0.374	0.11		9.50	70.97	MD 70
W 12 or D 12	0.391 : 0.390	0.12		9.93	77.42	MW 80 or MD 80
			MW 80 or MD 80	10.10	80	
D 13	0.406	0.13		10.31	83.87	MD 80
			MW 90 or MD 90	10.70	90	
W 14 or D 14	0.422	0.14		10.72	90.32	MW 90 or MD 90
D 15	0.437	0.15		11.10	96.77	MD 100

APPENDIX – D - METRICATION CONVERSION GUIDE

			MW 100 or MD 100	11.30	100	
W 16 or D 16	0.451	0.16		11.46	103.25	MW 100 or MD 100
D 17	0.465	0.17		11.81	109.68	MD 100
W 18 or D 18	0.479 : 0.478	0.18		12.17	116.13	MW 120 or MD 120
			MW 120 or MD 120	12.40	120	
D 19	0.491	0.19		12.47	122.58	MD 120
W 20 or D 20	0.505 : 0.504	0.20		12.83	129.03	MW 130 or MD 130
			MW 130 or MD 130	12.90	130	
D 21	0.517	0.21		13.13	135.48	MD 130
W 22 or D 22	0.529	0.22		13.44	141.90	
D 23	0.541	0.23		13.74	148.39	
W 24 or D 24	0.533 : 0.553	0.24		14.05	154.80	
D 25	0.564	0.25		14.33	161.29	
W 26 or D 26	0.575	0.26		14.61	167.70	
D 27	0.586	0.27		14.88	174.19	
W 28 or D 28	0.597	0.28		15.16	180.60	
D 29	0.608	0.29		15.44	187.10	
W 30 or D 30	0.618	0.3		15.70	193.50	
W 31 or D 31	0.628	0.31	MW 200 or MD 200	15.95	200	MW 200 or MD 200
W 45 or D 45	0.757	0.45	MW 290 or MD 290	19.22	290	MW 290 or MD 290