



NASHPA Gas Processing and LPG Recovery Plant

PROC-FC-CB/NASHPA/PROJ-1247 /2015

PROJECT NO.: NASHPA 1247



DOCUMENT NO.:
NGP-000-SCW-15.03-0001-00

SPECIFICATION

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Specification for Plain and Reinforced Concrete Works

REVISION DETAILS

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1.0 GENERAL

1.1 Introduction

OIL & GAS Development Company Ltd. (OGDCL) is operating NASHPA Oil & Gas fields in Khyber Pakhtunkhwa of Islamic Republic of Pakistan. OGDCL intends to install LPG Recovery Plant, Compressors & Allied Facilities at this field.

1.2 Scope

This specification covers the supply of materials, proportioning, mixing and placing of plain and reinforced concrete, including requirements for concrete materials, storage of materials, design of concrete mix, sampling and testing, batching, forms and form work, construction joints, expansion joints, preparation, placement of concrete including mixing, conveying, depositing and curing, finishing, grouting, inspection and clean-up.

All information pertaining to plain and reinforced concrete shown and noted on the construction drawings shall be considered part of this specification

1.3 Definitions

Within this document the following definitions apply:

| | |
|-------------------------------------|--|
| Project | NASHPA Gas Processing and LPG Recovery Plant PROC-FC-CB/NASHPA/PROJ-1247 /2015 |
| Company/Owner | Oil & Gas Development Company Ltd.(OGDCL) |
| Consultant | Zishan Engineers (Pvt.) Ltd. |
| Contractor | Hong Kong Huihua Global Technology Limited Wholly owned Subsidiary of China OIL HBP Science and Technology Corporation Ltd |
| Manufacturer/Supplier/Vendor | Party(ies), which manufactures and/or supplies material, equipment and service to perform the duties as specified by CONTRACTOR in the scope of supply |
| Shall | Indicates a mandatory requirement |
| Should | Indicates a strong recommendation to comply with the requirement of this document |

2.0 REFERENCES AND ABBREVIATIONS

2.1 Codes and Standards

| Doc. No. | Description |
|------------|--|
| ACI 201.2R | Guide To Durable Concrete |
| ACI 211.1 | Standard Practice for Selecting Proportions for Normal, Heavyweight & Mass Concrete |



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| Doc. No. | Description |
|-------------------|--|
| ACI 214.3 R 88 | Recommended Practice for Evaluation of Strength Test Results of Concrete |
| ACI 301 | Specifications for Structural Concrete |
| ACI 302 - I R | Guide for Concrete Floor & Slab Construction |
| ACI 304 R | Guide for Measuring, Mixing, Transporting, & Placing Concrete |
| ACI 304 2R | Placing of Concrete by Pumping Methods |
| ACI 305 R | Guide to Hot Weather Concreting |
| ACI 306 R | Guide to Cold Weather Concreting |
| ACI 308 R01 | Recommended Practice for Curing Concrete |
| ACI 309 | Recommended Practice for Consolidation of Concrete |
| ACI 318-08 | Building Code Requirements for Structural Concrete |
| ACI 347 | Recommended Practices for Concrete Formwork |
| ACI 350 | Environmental Engineering Concrete Structures |
| ASTM A36 | Standard Specification for Carbon Structural Steel |
| ASTM A185 | Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement |
| ASTM A496 | Standard Specification for Steel Wire, deformed, for Concrete Reinforcement |
| ASTM A497 | Standard Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement |
| ASTM A615 | Standard Specification for Deformed and Plain Billet Bars for Concrete Reinforcement |
| ASTM-C31/C31M | Standard Method of Making and Curing Concrete Test Specimens in the Field. |
| ASTM-C33 /C33M | Standard Specification for Concrete Aggregates. |
| ASTM C39 | Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C94/ /C94M | Standard Specification for Ready- Mixed Concrete |
| ASTM C-1107 | Specification for Packaged Dry, Hydraulic- Cement Grout |
| ASTM C1017/C1017M | Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| ASTM-C109 | Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2" or 50 mm Cube Specimens) |
| ASTM-C125 | Standard Definition of Terms Relating to Concrete and Concrete Aggregates |
| ASTM C143/C143M | Standard Test Method for Slump of Hydraulic Concrete |
| ASTM-C150 | Standard Specification for Portland Cement |
| ASTM C172 | Standard Method of Sampling Fresh Concrete |
| ASTM C183 | Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement |
| ASTM C192/C192M | Standard Practice for Making & Curing Concrete Test Specimens in the Laboratory |



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| Doc. No. | Description |
|------------------------|--|
| ASTM C231 | Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C260 | Specification of Air-Entraining Admixtures for Concrete |
| ASTM C421 | Standard Method of Obtaining and Testing Drilled Core and Sawed Beam of Concrete |
| ASTM C494 | Specification of Chemical Admixtures for Concrete |
| ASTM C531 | Standard Test Method for Shrinkage and Coefficient of Thermal Extension of Chemical-Resistant Mortars Grouts and Monolithic Surfacing. |
| ASTM C579 | Standard Test Method for Compressive Strength Surfacing. |
| ASTM C827 | Standard Test Method for Early Volume Change of Cementitious Mixtures |
| ASTM C588 | Specification for Non-shrink Grout (Corps of Engineers) |
| AASHTO-T26 | Quality of Water to be Used in Concrete |
| ANSI A10.9 | Safety Requirements for Concrete Construction and Masonry Work. |
| BS EN 1992-1-1 | Euro code 2 – Design of Concrete Structures |
| BS EN 196 Parts 1 to 6 | Methods of Testing Cement |
| BS EN 196 Parts 7 | Method of Taking and Preparing Samples Of Cement |
| BS EN 196 Parts 21 | Determination of the Chloride, Carbon Dioxide and Alkali Content of Cement |
| BS EN 197-1 | Cement. Composition, Specifications and Conformity Criteria for Common Cements |
| BS EN 206-1 | Concrete. Specification, Performance, Production and Conformity |
| BS 476-4 | Fire Tests on Building Materials and Structures Combustibility Test for Materials |
| BS EN 480-1 to 12 | Admixtures for Concrete, Mortar and Grout |
| BS EN 771-3 | Specification for Masonry Units. Aggregate Concrete Masonry Units (Dense And Light-Weight Aggregates) |
| BS EN 934-2 | Admixtures for Concrete, Mortar and Grout. Concrete Admixtures. Definitions, Requirements, Conformity, Marking and Labelling. |
| BS EN 934-6 | Admixtures for Concrete, Mortar and grout. Sampling, Conformity Control and Evaluation of Conformity |
| BS EN 1008 | Mixing Water for Concrete. Specification for Sampling, Testing and Assessing the Suitability of Water, Including Water Recovered from Processes in the Concrete Industry, as Mixing Water for Concrete |
| BS EN 12620 | Specification for Aggregates from Natural Sources For Concrete |
| BS EN 13043 | Aggregates for Bituminous Mixtures and Surface Treatments for Roads |
| BS EN 13242 | Aggregates for Unbound and Hydraulically Bound Materials for Use in Civil Engineering Work and Road Construction |
| BS 1199 & 1200 | Specifications for Building Sands from Natural Sources |
| BS EN 1744-1 | Tests for Chemical Properties of Aggregates Chemical Analysis |
| BS 812 | Testing Aggregate |
| BS 1199 and 1200 | Specification for Building Sands from Natural Sources. |
| BS 1305 | Batch Type Concrete Mixers |



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| Doc. No. | Description |
|-------------|--|
| BS 1881 | Methods of Testing Concrete. (Including non -destruction test methods) |
| BS 2571 | Specification for General-Purpose Flexible PVC Compounds for Moulding and Extrusion |
| BS 3148 | Methods of Test for Water for Making Concrete (including notes on the suitability of the water) |
| BS 4550 | Methods of Testing Cements |
| BS 4251 | Specification for Truck Type Concrete Mixers |
| BS 5628-1 | Code Of Practice For The Use Of Masonry - Part 1: Structural Use of Unreinforced Masonry |
| BS 5628-2 | Code Of Practice For The Use Of Masonry - Part 2: Structural Use of Reinforced and Prestressed Masonry |
| BS 5628-3 | Code Of Practice For The Use Of Masonry - Part 3: Materials and Components, Design and Workmanship |
| BS 5975 | Code of Practice for False work. |
| BS 6213 | Selection Of Construction Sealants - Guide |
| BS 8000-2.1 | Workmanship on Building Sites - Code Of Practice for Concrete Work - Mixing and Transporting Concrete |
| BS 8000-2.2 | Workmanship on Building Sites - Code of Practice for Concrete Work - Sitework With in Situ and Precast Concrete |
| BS 8000-3 | Workmanship on Building Sites - Part 3: Code of Practice for Masonry |
| BS 8000-4 | Workmanship on Building Sites - Code of Practice for Waterproofing |
| BS 8000-9 | Workmanship on Building Sites - Part 9: Cementitious Levelling Screeds and Wearing Screeds -Practice |
| BS 8000-10 | Workmanship on Building Sites - Code of Practice for Plastering and Rendering |
| BS 8000-16 | Workmanship on Building Sites - Part 16: Code of Practice for Sealing Joints in Buildings Using Sealants |
| BS 8007 | Code of Practice for Design of Concrete Structure for Retaining Aqueous Liquids. |
| BS 8110-1 | Structural Use of Concrete and All Referenced Publications. |
| BS 8204-1 | Screeds, Bases And In Situ Floorings - Part 1: Concrete Bases and Cementitious Levelling Screeds to Receive Floorings - Code of Practice |
| BS 8666 | Specification for Bending dimension and scheduling of reinforcement for concrete. |

2.2 Project Specifications, Procedures and drawings

Particular reference is made to the following project specifications:

| | |
|---|---------------------------|
| Design Basis for civil and Structure works | NGP-000-SCW-15.05-0001-00 |
| General Notes for Reinforced Concrete Works | NGP-000-SCW-15.01-0001-00 |

2.3 Abbreviations



The following abbreviations are used in this document:

| | |
|------|--|
| ACI | American Concrete Institute |
| AISC | American Institute of Steel Construction |
| API | American Petroleum Institute |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| AWS | American Welding Society |
| BS | British Standards |
| EN | European Standard |
| ISO | International Organization for Standardization |

3.0 MATERIAL

3.1 Cement

3.1.1 Grey Portland cement shall be normal setting cement of the specific gravity, fineness and chemical composition fully conforming to American Society for Testing and Materials (ASTM) or British Standard Specifications and shall be capable of satisfying all tests such as the tensile strength tests contained therein. Standard test briquettes prepared with 1:3 cement sand mortar shall give the following tensile strengths:

At 3 days not less than 2.1 N/mm²

At 7 days not less than 2.8 N/mm²

3.1.2 Sulphate Resistant Cement where required shall be sulphate resistant cement type in accordance with ASTM C150 or 'A' fully conforming to British Standard Specification BS4027 and satisfying the requirements for fineness, chemical composition, strength, setting time and soundness, etc.

3.1.3 Portland Blast Furnace Slag Cement shall comply with BS146 or equivalent.

3.1.4 The supply of cement must be so programmed by the contractor that at no time the quantity of cement stock shall be less than that required for an average consumption of four weeks. Lorry or truck or other means of transportation, for the conveyance of cement to the site of works, shall be clean, dry, metalled lined and covered from top with water proof sheets, so that cement is sufficiently protected from any deterioration during transit.

3.1.5 The Contractor shall provide at his own cost, on the site, all necessary sheds which shall be perfectly dry and water tight for the storing of cement to be delivered to the works, to ensure adequate supplies being available at site of work.

3.1.6 If at any time the Engineer considers that any batch of cement may have deteriorated on the site during storage for any reason, he will direct that tests shall be made and the batch of cement on the site which may be in question shall not be used until it has been shown by test at laboratory, approved or appointed



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by the Engineer to be satisfactory. Contractor shall bear all costs of such testing. Any rejected cement shall be removed from the site by the Contractor without delay. Cement reclaimed from cleaning bags or leaking containers shall not be used.

3.2 Aggregates

- 3.2.1 All fine and coarse aggregates to be used shall be supplied from approved source, which shall not be changed without permission in writing from the Engineer. Aggregates shall conform to the test requirements of ASTM C33 or British Standard 882 or as per local regulations.
- 3.2.2 Coarse aggregate shall be confirming to ASTM C33, grading requirement of size number 67, nominal size 19 mm to 4.75 mm. for beams, slabs, columns and foundations. Normal weight of coarse aggregate shall conform to ASTM C33.
- 3.2.3 Size of fine aggregate shall conform to ASTM C33, Table 1. Fine and coarse aggregate shall be considered as separate ingredients.
- 3.2.4 All aggregates shall be stored on properly constructed paving and in bins and there shall be a physical partition between the stock piles of coarse and fine aggregate. No mixed-up aggregates shall be used in any concrete. Under no circumstances aggregates shall be allowed to be in contact with ground.
- 3.2.5 If required, aggregates shall be washed and screened to the satisfaction of the Engineer before use by processing through proper screening and washing plant. Adequate time is to be allowed therefore, for the moisture content to become substantially uniform before use in works.
- 3.2.6 Sieve analysis and other necessary tests of all aggregates shall be carried out as and when required by the Engineer. Samples for such tests shall be taken in the presence of the Engineer. All costs in connection with the test shall be borne by the Contractor.
- 3.2.7 All aggregates shall be subject to the approval of the Engineer. Any aggregates not found to the required standard shall be rejected by the Engineer and shall have to be removed from site without delay. Concrete structures executed with rejected aggregate shall be disbanded and rebuilt at the Contractor's expenses.

3.3 Water

Unless otherwise authorized in writing, only water from potable supply system will be used for mixing concrete. Similarly only potable water shall be used for curing of concrete.

The source of water for construction purposes shall be approved by the Engineer, based on the satisfactory results of test for portability of water. Sampling and testing of water shall be the responsibility of Contractor; all cost thereof shall be deemed to have been included in the quoted rates for concrete works.

4.0 PROPORTIONING OF CONCRETE MIXES

All concrete shall be proportioned by weight for concrete mixes, unless specifically directed by Engineer to proportion them by volume. The Contractor shall submit to the Engineer proposed mix designs for concrete to be used. The proportion of cement aggregates and water in the concrete shall be determined based on preliminary laboratory tests. However, the amount of cement for any class of concrete shall not be less than that indicated in related codes and standard listed above. Preliminary test results of at least three different



mixes of each class of concrete with varied water cement ratios shall be submitted. The results of 7 days and 28 days tests shall be used to establish the ratio between 7 days and 20 days strengths. The Engineer may make adjustments in the ratio of fine to coarse aggregate in the mix for a certain work. Preliminary design of mixes and testing shall be the responsibility of the Contractor. The proportion of voids in the coarse aggregate shall be controlled and if it exceeds 45% than sand and consequently the cement content shall be increased by the Contractor without any charge. If the proportion is less than 40%, sand shall be decreased but not the cement.

5.0 MAXIMUM ALLOWABLE WATER CONTENT

All concrete specimens shall be made, cured and tested in accordance with British Standard or ASTM Standard. A curve representing the relation between the water content and the average 28 days Crushing Strength or earlier strength at which the concrete is to receive its full working load shall be established for a range of values, including all the crushing strengths shown on the plans. The curve shall be established by at least four points each point representing average values for at least four specimens. The maximum allowable water content for the concrete shall be as determined from this curve and shall correspond to strength 15% greater than indicated on the plans. No substitution shall be made in the materials used in the work without additional tests in accordance with this procedure to indicate that the quality of the concrete is satisfactory.

The maximum allowable water cement ratio shall be 0.4 unless otherwise by Engineer In charge

6.0 SLUMP TESTS

The slump for concrete, determined in accordance with ASTM C143 or BS 1880, shall be a minimum of 25mm and a maximum of 75mm provided the requisite strength is obtained. Corrective additions to remedy deficiencies in aggregate gradations shall be used only with the written approval of the Engineer. When such additions are permitted, the materials shall be measured separately for each batch of concrete.

7.0 BATCHING & MIXING

7.1 General

Concrete shall be mixed by a mechanical batch type mixing plant with adequate facilities for accurate measurements and control of each material entering the mixer and for changing the proportions to conform to varying conditions of the work. If approved by the Engineer, volumetric batching can be adopted using cement by weight. Water shall be measured for every batch with due allowance made for water already present in aggregates. The mixing plant assembly, if used by the Contractor, shall permit ready inspection of operations at all times. The plant and its location shall be subject to approval of the Engineer In charge.

7.2 Batching

Units where used shall be supplied with the following items:

7.2.1 Weighing unit shall be provided for each type of material to indicate the scale load at convenient stages of the weighing operations. Weighing units shall be checked at times directed by and in the presence of the Engineer and required adjustments shall be made before further use.

7.2.2 Water mechanism shall be tight with the valve interlocked so that the discharge valve cannot be opened before the filling valve is fully closed and shall be fitted with graduated gauge.



- 7.2.3 Discharge gate shall control the mix to produce a rib boning and mixing of cement with aggregates. Delivery of materials from the batching equipment to the mixer shall be accurate within the following limits:

| MATERIAL | PERCENTAGE BY WEIGHT |
|------------------|----------------------|
| Cement | $\frac{1}{2}$ |
| Water | $\frac{1}{4}$ |
| Fine Aggregate | 1 |
| Coarse Aggregate | 2 |

7.3 Mixing Unit

- 7.3.1 Mixers shall not be charged in excess of noted capacity nor be operated in excess of noted speed. In general not more than 20 revolutions per minute are necessary for adequate mixing. Excessive mixing requiring addition of water to preserve required consistency shall not be permitted. The entire batch shall be discharged before recharging.
- 7.3.2 Mixing time shall be measured from the instant water is introduced into the mixer drum containing before one fourth of the mixing time has elapsed. Mixing time for mixers of one cubic yard or less shall be between 1 minute and 1½ minute; for larger than one cubic yard capacity mixers time shall be increased 15 seconds for each additional cubic yard or fraction thereof. If an air-entraining agent is used, additional mixing time shall be allowed such as to provide the specified air content.
- 7.3.3 On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean mixing water. If old concrete deposits remain in the mixer drum, it shall be rotated with clean aggregate and water prior to production of new concrete.
- 7.3.4 Unless waived by the Engineer, device to lock the discharge mechanism, until the required mixing time has elapsed, shall be provided on each mixer.
- 7.3.5 No hand mixing under any circumstances even with extra cement shall be permitted. If during concreting, the mixing plant fails, the concrete already poured shall be removed, unless directed otherwise by the Engineer.

7.4 Batching Aggregate by Volume

- 7.4.1 When batching aggregates by volume is allowed, as and when required, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in metallic containers. The containers shall be of such shape that their volume can be easily checked by measurement.
- 7.4.2 Concrete shall be mixed in a (Full Load) batch mixer of an approved type and in good condition having a drum rotating about a horizontal or inclined axis.

Continuous mixers shall not be used. Each mixer is to be fitted with a water measuring device having accuracy within one per cent of the quantity of water required for the batch. The water measuring device shall be such that its accuracy is not affected by variations in the water supply pressure.



7.4.3 The batch shall be so charged into the mixer that some water (about 10 percent) enters the drum in advance of the cement and aggregates. Water shall then be added gradually while the drum is in motion such that all required water shall be in the drum by the end of the first quarter of the mixing time. The concrete shall be mixed until a mixture of uniform colour and consistency is obtained.

7.4.4 The amount of concrete mixed in any batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enters the drum.

7.5 Transporting & Placing Concrete

7.5.1 Concrete shall be conveyed and deposited as quickly as possible after mixing and shall proceed so that, as far as possible a complete section of the work is done in one operation.

7.5.2 Transport of concrete shall be in a manner approved by the Engineer and shall be so as to avoid segregation or loss of ingredients of concrete.

7.5.3 All foundations and portions of work to be concreted shall be approved by the Engineer before concrete is poured.

7.5.4 All forms and reinforcement shall be completed, cleared inspected and approved before pouring of concrete. No concrete is to be deposited till the Engineer has inspected and approved in writing all reinforcement, foundations, forms, details, positioning of all fixture and materials to be embedded in concrete, control levels and screeds, etc., and is satisfied with the arrangements the Contractors has made to efficiently proceed with the work such as sufficient labour, materials, plants, etc. Such an approval will not relieve the Contractor from any of his obligations under this Contract. Water shall be removed from excavations before concrete is deposited.

7.5.5 Placing of concrete shall not be permitted when, in the opinion of the Engineer, the sun heat wind cold snow or limitations or facilities furnished by the Contractor prevent proper placing finishing and curing of concrete.

7.5.6 All concrete shall be thoroughly compacted and consolidated by means of pneumatic or mechanical vibrators or other approved compacting method. Care shall be taken to avoid segregation due to excessive vibration. The Contractor shall maintain on site at all times one or more standby vibrators. Tapping or other external vibration of forms shall not be allowed, unless so directed by the Engineer. Compaction shall be done until the whole mass assumes a jelly like appearance and consistency with the water just appearing on the surface.

Concrete shall be sufficiently tamped and consolidated around the steel rods, care taken that the vibrator does not touch steel or formwork and into all parts of the moulds in order that no voids or cavities are left. Steel shall not be disturbed during operations of concreting. Concrete shall be brought up in even layers not more than 150mm thickness and worked against side of forms to give a smooth and uniform surface. No excessive water shall be allowed to come out and lie on the surface of concrete.

The concrete must be of such a consistency that after ramming, consolidating and tamping is completed, a thin film of water is just appearing on the surface.

7.5.7 Hardened concrete, debris and foreign material shall be removed from interior of forms and from inner surface of mixing and conveying equipment.



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7.5.8 Concrete shall not be dropped freely from a height of more than 2.0 meters. In cases where an excessive drop is inevitable the Contractor shall provide spouts, down pipes, chutes, or side parts to forms with pockets which will protect concrete from segregation. The discharge of the spouts, down pipes or chutes shall be controlled so that the concrete may be effectively compacted into horizontal layers not more than 200 mm thick.

7.5.9 Concrete is to be deposited as quickly as possible after mixing and to proceed continuously. Concrete which has attained its initial set or has contained its mixing water for more than 20 minutes shall not be allowed to be placed in the work.

7.5.10 When concrete is laid on hard core, such as sub grade for floor slabs, or other absorbed material, the surface shall be watered, consolidated and blinded before the concrete is deposited.

7.5.11 Fresh concrete shall not be placed on previously laid concrete or on old concrete surfaces until the later has been cleaned of dirt, scum and laitance by wire brushes. The clean surface shall then be thoroughly wetted and grouted with cement slurry as approved by the Engineer.

7.5.12 Care shall be taken not to disturb newly placed concrete by vibrator, indirect loading or otherwise. No traffic or loading shall be allowed on the concrete until it has thoroughly set and hardened.

7.5.13 Construction joints in concrete shall only be given at locations indicated on the drawings or as approved by the Engineer. At the end of the day's work the concrete shall be finished off against a temporary shutter stop which shall be vertical and securely fixed. Such stops shall be removed within 24 hours of placing of concrete.

Construction joints not shown on the drawings shall be reinforced with steel bars or dowels, if deemed necessary by the Engineer and shall be furnished by the Contractor without any additional payment. Surface shall be wetted and coated with neat cement grout immediately before placing new concrete.

7.5.14 No concrete shall be placed during rains or in inclement weather and all fresh concrete shall be suitably protected from rainfall and excessive heat or cold.

7.5.15 Should any part of the exposed surface present a rough uneven or imperfect appearance when the shuttering is removed, it shall be picked out to honeycomb depth and refilled and properly re-surfaced or entirely redone as per directions of Engineer at the cost of the Contractor.

7.5.16 On removal of the forms and before the skin has had time to harden, all faces of the concrete inside or outside, to be kept exposed shall be rubbed over with carborundum stone, and washed with cement to remove all marks, projections, hollows or any other defect. No extra payment shall be made for this work.

All exposed surfaces and lines of the concrete work are to be true and fair without cracks, bends, windings and distortions of all kinds, and if accruing, shall be removed without any extra charges by the Contractor. All un-plastered concrete works is to be fair face, smooth, pleasing and to the entire satisfaction of the Engineer.

7.5.17 A float or screed is to be worked over the exposed surfaces of all concrete work on the flat or curve, so as to render the surfaces perfectly smooth, clear, and to the necessary slopes or falls or as required to receive the floor or roof finishes, according to the drawings, and as directed by the Engineer without any extra charges by the Contractor.



7.6 Finished Concrete to Tolerance

- Plumbness of columns, walls, and piers
 - In a 3m of vertical distance $\pm 6\text{mm}$
 - Maximum for entire vertical distance $\pm 25\text{mm}$
- Elevation
 - In any 3m of horizontal distance $\pm 6\text{mm}$
 - In any bay or in any 6m of horizontal distance $\pm 10\text{mm}$
 - Maximum for entire horizontal distance $\pm 20\text{mm}$
- Distance between wall, columns, and beams $\pm 10\text{mm}$
- Cross-sectional dimensions of columns and beams. - 6mm to +10mm
- Thickness of slabs and walls - 6mm to +10mm
- Plan dimension of footing - 6mm to +20mm

8.0 FORMWORK

8.1 General

The formwork shall be inclusive of all labour, material, workmanship and alike. All formwork and supports thereto shall be designed by the Contractor and relevant drawings for approval before the work are put in hand. Such an approval shall not relieve the Contractor from all the obligations of the Contract or give rise to any claims.

8.2 Making Forms

8.2.1 The formwork for columns, beams, slabs and all other works whether to be precast or cast in situ shall be made-up of M.S plates or other materials as approved by the Engineer for obtaining industrial finishing and shall be rigidly formed and designed by the Contractor to the shapes and forms as per drawings in accordance with the best of the existing practices so as to be able to withstand, without displacement, deflection or deformation movements of any kind, the pressure of the moist concrete and all other loads. The exposed surfaces of all beams, columns, walls, slabs, etc., shall be Homogenous, perfectly even and smooth in appearance.

8.2.2 Scaffolding pipes shall be used for supporting the formwork of walls, beams, columns and slabs etc.

8.3 Rigid with allowance for camber and bulges

It shall be fabricated and erected in position, perfect in alignment, levels and true to plumb and shape and securely braced so as to enable it to stand all weights, live and vibrating to be endured during placing of concrete and its subsequent hardening till the formwork is struck. It shall be so sufficiently rigid as not to loose its form and shall be so made for bulging, and deflection as to give the finished concrete the required lines, plumb, size and shape.



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8.4 Exposed surfaces left un-plastered

For concrete work, where concrete surface is to be exposed for Industrial finish and left un-plastered, the formwork shall be made up of M.S. plates or other materials as approved by the Engineer, so as to make a perfectly smooth surface of the finished concrete.

Where any surface defects on the exposed concrete surfaces occur and which do not impair the structural performance, being in excess of the designed surfaces, and the architectural appearance of the work in the opinion of Engineer, such defects may be removed by granting and grinding with carborundum stone or in any other approved manner, at the cost of the Contractor, otherwise the whole or part of the work may have to be removed and remade good by the Contractor at his own cost. For precast concrete members the forms shall be rigid, exact, smooth and made of steel.

8.5 Injury or Damage

The Contractor shall be responsible for any injury to the work and any consequential damages caused by or arising from the removal and striking of forms, centering and supports, due to striking too soon, and any advice, permission or approval given by the Engineer, relative to the removal and striking of forms, centering and supports shall not relieve the Contractor from the responsibilities herein defined.

8.6 Treatment after removal of Forms

Any minor surface honey combing or other irregularities are to be properly made good immediately upon the removal of the formwork and the surface made good to the satisfaction of the Engineer. Any small voids shall be neatly stopped with cement mortar consisting of one part of cement to two parts of sand and the whole surface rubbed over with carborundum stone and cement wash and bring the whole to a smooth a pleasing finish and uniform color.

9.0 PROTECTION & CURING

All exposed concrete shall be cured. Curing shall be accomplished by preventing loss of moisture, rapid temperature change and mechanical injury or injury from rain or flowing water for a period of at least 7 days. Curing shall be started as soon as the concrete has hardened sufficiently for the surface not to be marked. Curing shall be done either by continuous sprinkling of water on the surface or by covering with sand, hessian, canvas or other approved fabrics mats, which shall be kept continually wet. If required and so directed by the Engineer, formed surfaces with forms in position shall also be cured by keeping all forms continually wet. As an alternative, curing of concrete, on all exposed surfaces which could not be kept covered, such as sides of the beams, under side of the slabs, may also be done by sealing concrete surfaces with curing compounds like "PACCACURE" or equal so as to arrest loss of moisture from concrete, with approval of Engineer. The Contractor shall take special care that curing of concrete is satisfactorily carried out and in accordance with methods specified herein and/or as instructed by the Engineer. Any negligence in this regard may result in total rejection of such concrete works, which in the opinion of the Engineer have not been adequately cured.

Minimum period of curing for concrete using Blast Furnace Slag Cement shall be 10 days or more as directed by the Engineer. All concrete components of concreted structures shall be clearly marked with non-washable paints to indicate the date of placing concrete. During hot weather, curing shall be done even at night.

10.0 CONSTRUCTION JOINTS



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Construction joints shall be located within the middle third of spans of slabs, beams and girders or as indicated on the drawings or as approved or directed by the Engineer. Joints in columns shall be made at the under-side of the deepest beam framing thereto. Beam stems shall be poured monolithically unless directed otherwise by the Engineer. Joints not specified or shown on the drawings shall be so located as to least impair the strength and appearance of the work. Except where indicated on the drawings no joint shall be made in footings or foundations without written approval of the Engineer.

Construction jointing shall be at angles to the member and shall be formed against firm stop boards, the stop boards shall be removed as soon as possible after placing the concrete but without the risk of movement of the concrete and the concrete surface shall be well brushed with a hard brush and washed-off with a spray of water, two (2) to four (4) hours after casing, to expose the aggregates and provide a key for the next pour. In all liquid retaining structures and other sub-structures pits and trenches, etc. PVC or any other approved water stops shall be provided at the construction joint in the manner shown on the drawings and/or approved by the Engineer.

Whenever a section of concrete is left unfinished, for any reasons with the approval of Engineer, leaving a surface which will be hard set before additional concrete can be joined to it, dovetails, grooves or other bond with the new work shall be provided at cost of the Contractor. Before depositing fresh concrete upon or against any concrete which has already set, the surface of the set concrete shall be roughened with a cutting tool, any laitance removed, thoroughly cleaned of all foreign matter, well watered and covered with cement grout, and special care shall be taken to ram the fresh concrete thoroughly up and against the set concrete; and, if deemed necessary by the Engineer, the joints shall be reinforced with steel bars or dowels to be all furnished and done by the Contractor without any additional payment.

11.0 ANCHOR BOLTS & BASE PLATE/EMBEDDED PARTS

All sleeves, inserts, anchor bolts, stainless steel drains and other embedded items shall be positioned accurately and supported against displacement by template wherever required or as directed.

For detail of anchor bolts and capacities and other specifications refer Standard Drawing of Anchor Bolts

Material for Base Plates, Embedded plates/template shall be ASTM A-36.

Anchor bolts shall be positioned inside vertical reinforcement by means of temporary template 5mm thick.

The Contractor shall fabricate template as per bolt circle Diameter at no extra cost to the Owner.

Special anchor bolts for machinery engines pumps, compressors shall be in accordance with equipment manufacturer recommendations.

Plates and sections shall be true to form. Stiffeners, plates and the like shall be ground to fit the profile of the member. Sections to be cut to 'exact' lengths shall be accurately cold sawn or machined. Preparation of edges by flame-cutting shall, wherever practicable, be done by machine. Cold sawn, machine-cut and flame-cut edges shall be cleaned free of burrs and slag and left as smooth and regular as those produced by edge planning. All holes shall be drilled.

12.0 SAMPLES & TESTING

12.1 General



Test of concrete shall be prepared and stored by the Contractor, in accordance with ASTM C-31 or BS 560, or BS1881 as directed by the Engineer. Concrete Test must be tested in approved laboratory and the contractor shall bear the charges for the same. Aggregates shall be tested as prescribed.

12.2 Cement

Cement shall be tested as prescribed in the following ASTM Standards or equivalent British Standards.

12.3 Aggregates

Aggregates shall be tested as prescribed in relevant Pakistan Standard or ASTM or equal British Standard. In addition fine aggregates shall be tested for organic impurities in conformity with equal ASTM Standard or British Standard or Pakistan standard.

12.4 Reinforcement

All Reinforcing bars shall be deformed steel, tested as per ASTM A615 or equivalent British Standard..

The Contractor shall furnish copies of manufacturer certificates of tests for steel reinforcement to be supplied to prove yield, ductility, (elongation) and tensile strength.

The cost of the tests is a Contractor charge. In any case, materials not according to requirements, shall be rejected.

12.5 Testing of Concrete

12.5.1 The Contractor shall prepare for test purposes one set of mix specimen taken for each class of concrete poured on each day or specified elsewhere. The Engineer, however, may order for more cube tests if any irregularity is found in the concrete.

12.5.2 Size of test specimen shall be 150 × 150 × 150mm cubes as per British Standard or 150 × 300mm cylinder as per ASTM.

12.5.3 All test specimens of the same set shall be made from the same batch of concrete.

12.5.4 Three test specimens of the set shall be tested at 7 days and three shall be tested at 28 days or at a date as directed by the Engineer.

12.5.5 All test specimens shall be made and cured in accordance with Pakistan Standard PS 560:1965 or British Standard BS 1881 or ASTM C-31.

12.5.6 Specimens shall be cured under laboratory conditions except that the Engineer may require curing under field conditions.

12.5.7 All sample moulds shall be steel moulds perfectly true having all internal and the meeting faces machined to a smooth surface.

12.5.8 If the strength tests of the laboratory controlled specimens for any portion of the work falls below the minimum allowable compressive strength at 28 days required for the class of concrete used in that portion, the Engineer shall have the right to order replacement of the effected work.



12.5.9 All test specimens cast at site shall bear distinguishing mark showing serial number, date of casting, quality of concrete and place from where sample was taken and where that batch of concrete was placed in the structure. A proper daily record of test specimen made, best results obtained shall be maintained by the Contractor and weekly test results shall be submitted to the Engineer.

12.5.10 The Engineer may require load tests for the part of the structure from where test specimens have shown unsatisfactory results at the cost of the Contractor.

12.5.11 In the event that load test indicate bad quality of concrete, measures as prescribed by the Engineer shall be taken to correct the deficiency at no additional cost to the Owner. The nature, descriptions and details of load test shall be determined by the Engineer and shall be binding on the Contractor.

13.0 REINFORCEMENT STEEL

13.1 Scope of Work

The work covered in this section of the specifications consists of furnishing all materials, tools, labors and in performing all operations in connection with providing, straightening, cutting, bending, binding, fixing, including binding wire, chairs, pins, spacer block complete in strict accordance with this section of the specifications, the applicable drawings, approved bar bending schedule, and the terms and conditions of the Contract.

13.2 Materials

13.2.1 Reinforcing steel to be new billet stock of mild steel (plain bar), and hard grade (deformed bar) steel as specified on the drawings and shall confirm to British Standard Specifications or equivalent ASTM or Pakistan Standard.

13.2.2 The Contractor shall purchase the steel from Consultant approved factory of steel manufacturing. The Contractor shall furnish to Engineer, Manufacturer's mill certificate to guarantee that steel meets the standard, specification requirement and minimum certified yield stresses as specified on the drawings.

13.2.3 All steel to be true to the Standard Specifications with regard to bend ability specially the hard grade deformed bars under Ø19mm shall be capable of being bent cold through 90 degrees round a bar of four times its own diameter without fractures or injury of any kind. In case of deformed bars over Ø19mm and under Ø28mm round a bar of 6 times its own diameter shall be capable of being bent cold.

13.2.4 20 gauge galvanized wire shall be used for binding the steel reinforcement.

13.3 Testing

Samples shall be tested for above specification in an approved laboratory when required by the Engineer and all costs of such tests shall be borne by the Contractor.

13.4 Storage

Reinforcing bars shall be stored on platforms above surface of ground and be free from scale, oil, structural defects prior to placement in works. Rusty or dirty steel bars shall not be used in the works unless brushed and cleaned by proper steel wire brushes and after being approved for use by the Engineer.

13.5 Reinforcement Cutting & Placing



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13.5.1 All reinforcement steel shall be cut and bent cold in strict accordance with approved bar bending schedules and drawings supplied by Engineer. The Contractor shall prepare bar bending schedule from approved structural working drawings and instructions to be provided to him by the Engineer. The bending schedules shall be drawn on approved forms and submitted to the Engineer for checking and approval. The steel reinforcement shall be cut and bent to sizes as per drawings and approved bending schedules. In case any bars, cut, bent or even fixed in position are found incorrect in dimension size or shape according to the requirements of the drawings and instructions of the Engineer, the Contractor shall replace such steel bars cut bent or fixed in position by correct sized bars at his own cost and no extra payment shall be made to the Contractor on such account.

The system of holding bars in place shall ensure that all steel in top section will support weight of workmen without displacement or distortion. Suitable spacers/ chairs as approved by the Engineer shall be used for supporting and spacing of bars. In case any bars are bent or displaced they shall be straightened on the limit of a day's pour and shall be in place and firmly tied with 20 gauge G.I. wires. Bars with kinks or bends not shown on drawings shall not be used.

13.5.1 Where indicated in the drawings, mesh shall be of the sizes as shown on drawings. Mesh reinforcement when used in slabs shall be supported at proper elevations by standard accessories. In slabs on ground, precast concrete blocks may be substituted for chairs.

13.6 Laps & Splices

13.6.1 Lap splices in reinforcements shall be made at design locations shown on the drawings. Lap lengths for splices shall be in accordance with ACI-318-08. Chairs made of reinforcements shall be used to support top grids of slab reinforcement and shall be so dimensioned as to be stable during concreting operations. Splices of adjacent bars shall be staggered or as directed by the Engineer.

13.6.2 All reinforcing steel fixed in position shall be inspected by the Engineer and no concrete shall be poured until steel placement has been approved by the Engineer. For inspection purposes the Contractor shall give to the Engineer reasonable notice before the scheduled pouring time. Clear concrete cover to reinforcement steel shall be as indicated on the drawings/specified..