

ADNOC GROUP PROJECTS AND ENGINEERING

CONCRETE SUPPLY AND CONSTRUCTION SPECIFICATION

Specification

AGES-SP-01-001

GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE

CUSTODIAN	Group Projects & Engineering / PT&CS
ADNOC	Specification applicable to ADNOC & ADNOC Group Companies

Group Projects & Engineering is the owner of this Specification and responsible for its custody, maintenance and periodic update.

In addition, Group Projects & Engineering is responsible for communication and distribution of any changes to this Specification and its version control.

This specification will be reviewed and updated in case of any changes affecting the activities described in this document.

INTER-RELATIONSHIPS AND STAKEHOLDERS

- a) The following are inter-relationships for implementation of this Specification:
- ADNOC Upstream and ADNOC Downstream Directorates and
 - ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOC Gas Processing, ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat
- b) The following are stakeholders for the purpose of this Specification:
- ADNOC PT&CS Directorate.
- c) This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance
- d) Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

DEFINED TERMS / ABBREVIATIONS / REFERENCES

“**ADNOC**” means Abu Dhabi National Oil Company.

“**ADNOC Group**” means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

“**Approving Authority**” means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

“**Business Line Directorates**” or “**BLD**” means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

“**Business Support Directorates and Functions**” or “**Non- BLD**” means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

“**CEO**” means chief executive officer.

“**Group Company**” means any company within the ADNOC Group other than ADNOC.

“**Specification**” means this Concrete Supply and Construction Specification.

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GENERAL

1.0 INTRODUCTION

This specification stipulates the minimum technical requirements for CONTRACTOR's services related to the concrete supply and construction of plain and reinforced concrete works.

1.1 Purpose

This specification defines the minimum requirements for materials, concrete supply, concrete mix design, placing, testing, curing, protection and finishing of both cast in-situ and precast concrete works.

1.2 Definitions

Where used in this specification, the following terms shall have the meanings indicated below unless otherwise clearly indicated by context of their use.

COMPANY	Abu Dhabi National Oil Company or any of its group companies. It may also include an agent or consultant authorized to act for, and on behalf of the COMPANY.
CONTRACTOR	The parties that carry out all or part of the design, engineering, procurement, construction, commissioning or management of the PROJECT. CONTRACTOR includes its approved MANUFACTURER(s), VENDOR(s), SUPPLIER(s) and SUBCONTRACTOR(s).
DESIGNER	The Engineering Division of the CONTRACTOR or the Consultant which performs the design of the element in question.
ITP	Inspection & Test Plan prepared by the CONTRACTOR/MANUFACTURER, reviewed and approved by COMPANY, highlighting the principal hold and witnessing points during and after the process of the product realization (i.e.: manufacturing, fabrication, construction, installation), to ensure that the quality level of the product is within the acceptable design standards and requirements.
MANUFACTURER/ VENDOR/SUPPLIER	The parties which manufactures and/or supplies the material/equipment and provides technical documents/drawings and services to perform the duties specified by COMPANY/CONTRACTOR.
MAY	Indicates a permitted option.
PROJECT	To be identified

PROJECT MANAGEMENT CONSULTANT (PMC)	Persons, firms, companies, or partnerships appointed by COMPANY to perform PROJECT Management services for the PROJECT, on behalf of the COMPANY.
PROJECT MANAGEMENTTEAM (PMT)	The COMPANY authorized party responsible for the overall day-to-day execution of the Project. The PMT is to serve as the liaison between the COMPANY and the CONTRACTOR(S) on the Project.
SHALL	Indicates a mandatory requirement.
SHOULD	Indicates a recommendation
SUBCONTRACTOR/ SUBVENDOR/SUBSUPPLIER	The party(s) which carry(s) out all or part of the design, procurement, installation and testing of the system(s) as specified by the CONTRACTOR/VENDOR.
TECHNICAL DEVIATION	A deviation requested by the CONTRACTOR, usually after receiving the Contract Package or Purchase Order.
TPA	COMPANY contracted to undertake the third-party inspection & verification tasks (TPA) on behalf of ADNOC.
WORKS	CONTRACTOR's scope of work

1.3 Abbreviations

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BSI	British Standards Institute
DFT	Dry Film Thickness
GGBS	Ground Granulated Blast Furnace Slag
HRWRA	High Range Water Reducing Agent
HSE	Health, Safety & Environment
ISO	International Organization for Standardization
QA	Quality Assurance
QC	Quality Control
UNO	Unless Noted Otherwise

SECTION A

2.0 REFERENCE DOCUMENTS

The following Codes and Standards shall form a part of this Specification. When an edition date is not indicated for a Code or Standard, the latest edition at the time of contract award shall apply.

2.1 International Codes and Standards

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 207.1R-05	Guide to Mass Concrete. Reported by ACI Committee 207
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 212-3R	Report on Chemical Admixtures for Concrete
ACI 214.4R-10	Guide for Obtaining Cores and Interpreting Compressive Strength Results
ACI 301	Specification for Structural Concrete
ACI 302.1R	Guide for Concrete Floor and Slab Construction
ACI 304R	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI 304.2R	Guide to Placing Concrete by Pumping Methods
ACI 305.1	Specification for Hot Weather Concreting
ACI 308R	Guide to External Curing of Concrete. Reported by ACI Committee 308
ACI 318/ACI 318R/ ACI 318M	Building Code Requirements for Structural Concrete and Commentary
ACI 347R-14	Guide to Formwork for Concrete
ACI 350.1-10	Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures & Commentary
ACI 550.2R	Design Guide for Connections in Precast Jointed Systems
ACI SP-66	ACI Detailing Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A36/A36M	Standard specification for carbon structural steel
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ASTM A123/A123M	Standard specification for zinc (hot dip galvanized) coatings on iron & steel products
ASTM A615/A615M	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31/C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	Standard Specification for Concrete Aggregates
ASTM C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C40/C40M	Standard Test Method of Organic Impurities in Fine Aggregates for Concrete
ASTM C42/C42M	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C87/C87M	Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C88/C88M	Test Method for Soundness of Aggregates by use of Sodium Sulphate or Magnesium Sulphate
ASTM C94/C94M	Standard Specification for Ready-Mixed Concrete
ASTM C127	Standard Test Method for Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C131/C131M	Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregates by Abrasion and Impact in the Los Angeles machine
ASTM C138/C138M	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	Standard Test Method for Clay Lumps and friable Particles in Aggregates
ASTM C143/C143M	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C150/C150M	Standard Specification for Portland cement
ASTM C227	Cement-Potential Alkali Reactivity- Expansion test
ASTM C232/C232M	Standard Test Methods for Bleeding Concrete

ASTM C260/C260M	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C289	Standard Test Method for Potential Alkali-silica Reactivity of Aggregates (Chemical Method)
ASTM C295/C295M	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C309-19	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C330/C330M	Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C490/C490M	Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
ASTM C494/C494M	Standard Specification for Chemical Admixtures for Concrete
ASTM C535	Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C586	Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)
ASTM C642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C836/C836M	Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
ASTM C944/C944M	Standard Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method
ASTM C979/C979M	Standard Specification for Pigments for Integrally Colored Concrete
ASTM C989/C989M	Standard Specification for Slag Cement for Use in Concrete and mortars
ASTM C1012/C1012M	Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to Sulphate Solution
ASTM C1017/C1017M	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C1105	Standard Test Method for Length Change of Concrete Due to Alkali-Carbonate Rock Reaction
ASTM C1116	Standard Specification for Fiber-Reinforced Concrete and Shotcrete
ASTM C1202	Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1582/C1582M	Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete
ASTM C1602/C1602M	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D36/D36M	Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
ASTM D412	Standard Test Methods for vulcanized rubber and thermos plastic elastomer- tension
ASTM D570-98	Standard Test Method for Water Absorption of Plastics
ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D638-14	Standard Test Method for Tensile Properties of Plastics
ASTM D994/D994M	Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ASTM D1000-17	Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
ASTM D1004-13	Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
ASTM D4060	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D4541-17	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D4551-17	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM D7234	Standard Test Method for pull-off strength of coating on concrete using portable pull-off adhesion tests

ASTM E96/E96M	Standard Test Methods for Water Vapor Transmission of Materials
ASTM E154/E154M	Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover

BRITISH STANDARDS INSTITUTE (BSI)

BS 476-20	Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)
BS 812-111	Testing aggregates. Methods for determination of Ten per cent Fines Value (TFV)
BS 812-121	Testing aggregates. Method for determination of soundness
BS 812-123	Testing aggregates. Method for determinations of Alkali-Silica Reactivity. Concrete Prism Method
BS 1881-122	Testing concrete. Method for determination of water absorption
BS 1881-124	Testing concrete. Methods for analysis of hardened concrete
BS 1881-204	Testing concrete. Recommendations on the use of electro magnetic
BS 2571	Specification for general purpose flexible PVC compounds for molding and extrusion
BS 4449	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, Coil and decoiled product. Specification
BS 4482	Steel wire for the reinforcement of concrete products. Specification
BS 4483	Steel fabric for the reinforcement of concrete. Specification
BS 6349-1-4	Maritime works. General. Code of practice for materials.
BS 8102	Code of practice for protection of below ground structures against water from the ground
BS 8443	Specification for establishing the suitability of special purpose concrete admixtures
BS 8476:2007	Code of Practice for the Safe Use of Concrete Pumps
BS 8500-1:2015+A2	Concrete. Complementary British Standard to BS EN 206 Part-1: Method of specifying and guidance for the specifier

BS 8500-2:2015+A2	Concrete. Complementary British Standard to BS EN 206 Part-2: Specification for constituent materials and concrete
BS 8539	Code of practice for the selection & installation of post-installed anchors in concrete.

EUROCODES (BS EN)

BS EN 197-1	Cement. Composition, specifications and conformity criteria for common cements
BS EN 206:2013+A1	Concrete Specification, performance, production and conformity
BS EN 480-4	Admixtures for concrete, mortar and grout. Test methods. Determination of bleeding of concrete
BS EN 932-1	Tests for general properties of aggregates. Methods for sampling
BS EN 932-3	Tests for general properties of aggregates. Procedure and terminology for simplified petrographic description
BS EN 933	Tests for geometrical properties of aggregates
BS EN 934-2:2009 +A1	Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labeling
BS EN 934-6	Admixtures for concrete, mortar and grout. Sampling, assessment and verification of the constancy of performance
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 1062-3	Paints and varnishes. Coating materials and coating systems for exterior masonry and concrete. Determination of liquid water permeability
BS EN 1062-6	Paints and varnishes. Coating materials and coating systems for exterior masonry and concrete. Determination of carbon dioxide permeability
BS EN 1097-3	Tests for mechanical and physical properties of aggregates. Determination of loose bulk density and voids
BS EN 1367-2	Tests for thermal and weathering properties of aggregates. Magnesium sulfate test
BS EN 1367-4	Tests for thermal and weathering properties of aggregates. Determination of drying shrinkage

BS EN 1504-9	A guide to the concrete repair
BS EN 1542	Products and systems for the protection and repair of concrete structures. Test methods. Measurement of bond strength by pull-off
BS EN 1744-1	Tests for chemical properties of aggregates. Chemical analysis
BS EN 1881-124	Testing concrete. Methods for analysis of hardened concrete
BS EN 1992-1-1	Design of Concrete Structures
BS EN 1992-3	Design of Concrete Structures. Liquid retaining and containing structures
BS EN 10025-3	Hot rolled products of structural steels
BS EN 12350-1	Testing fresh concrete. Sampling and common apparatus
BS EN 12350-2	Testing fresh concrete. Slump test
BS EN 12350-7	Testing fresh concrete. Air content. Pressure methods
BS EN 12390-1	Testing hardened concrete. Shape, dimensions and other requirements for test specimens and molds
BS EN 12390-2	Testing hardened concrete. Making and curing specimens for strength tests
BS EN 12390-3	Testing hardened concrete. Compressive strength of test specimens
BS EN 12390-7	Testing hardened concrete. Density of hardened concrete
BS EN 12390-8	Testing hardened concrete. Depth of penetration of water under pressure
BS EN 12504-1	Testing concrete in structures. Cored specimens. Taking, examining and testing in compression
BS EN 12620	Aggregate for concrete
BS EN 12878	Pigments for the coloring of building materials based on cement and/or lime. Specifications and methods of test
BS EN 13055	Lightweight aggregates
BS EN 15167-1	Ground granulated blast furnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria
BS EN 15167-2	Ground granulated blast furnace slag for use in concrete, mortar and grout. Conformity evaluation
BS EN 16236	Assessment and verification of the constancy of performance (AVCP) of aggregates. Type testing and factory production control

BS EN ISO 527-1	Plastics. Determination of tensile properties. General principles
BS EN ISO 1461	Hot-dip galvanized coatings on fabricated iron & steel articles. Specifications and test methods.
BS EN ISO 3310-2	Test Sieves – Technical requirements and Testing. Test sieves of perforated plate
BS EN ISO 3766	Construction drawings. Simplified representation of concrete reinforcement
BS EN ISO 5470-1	Rubber- or plastics-coated fabrics. Determination of abrasion resistance. Taber abrader
BS EN ISO 7783	Paints and varnishes. Determination of water-vapor transmission properties. Cup method
BS EN ISO 8501-3	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Preparation grades of welds, edges and other areas with surface imperfections
BS EN ISO 9001	Quality Management Systems – Requirements
BS EN ISO 9004	Quality Management – Quality of an organization – Guidance to achieve sustained success
BS EN ISO 11600	Building construction. Jointing products. Classification and requirements for sealants.

OTHER CODES AND STANDARDS

AASHTO T259	Standard Method of Test for Resistance of Concrete to Chloride Ion Penetration
AWS D1.4/D1.4M	Structural Welding Code – Reinforcing Steel
CIRIA C577 Pub	Guide to the Construction of Reinforced Concrete in Arabian Peninsula
CPMB100M-00	Concrete Plant Standards of the Concrete Plant Manufacturers Bureau
RILEM CPC 11.1	Absorption of Water by Concrete by Immersion

2.2 ADNOC Specifications

The following ADNOC general specifications, as available with respective Group Company and as applicable to the Project, shall form a part of this specification. When an edition date is not indicated for a document, the latest edition in force at the time of contract award shall apply.

Structural Steel Supply, Fabrication and Erection Specification AGES-SP-01-002

Structural Design Basis – Onshore Specification AGES-SP-01-003

Anchor Bolts & Grouting

Painting

Galvanizing

Onsite Material Sampling and Testing

Design, Installation, Commissioning and Monitoring of Cathodic Protection for Plant Facilities

2.3 ADNOC Drawings

The following ADNOC standard drawings, as available with respective Group Company and as applicable to the Project, shall form a part of this specification. When an edition date is not indicated for a document, the latest edition in force at the time of contract award shall apply.

Concrete Works – General Notes

Anchor Bolts Material-Fabrication-Marking

Anchor Bolt Details

Membrane Protection to Concrete Foundation and Pedestal

Fireproofing Details

3.0 DOCUMENT PRECEDENCE

It shall be the CONTRACTOR'S responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein. Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

In the event of a conflict between documents, the following hierarchy of adherence shall be followed:

- 1) UAE Statutory Legislation and Regulations

- 2) ADNOC Code of Practices
- 3) Purchase Order or Contract documents including Project drawings and Specifications
- 4) COMPANY General Specifications and Standards
- 5) International Codes and Standards

In case of conflict between documents in the same level of hierarchy, the most stringent requirement shall apply. Such interpretation of the most stringent requirement shall be subject to COMPANY's approval utilizing a technical query sheet. In all such cases of conflict, COMPANY's decision shall be final.

4.0 TECHNICAL DEVIATION CONTROL

Any technical deviations to the Purchase Order and its attachments including, but not limited to, the COMPANY's General Specifications shall be sought by the CONTRACTOR only through technical deviation request format. Technical deviation requests require COMPANY'S review/approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

5.0 QUALITY PLANS

5.1 General

Quality plans shall address all aspects related to local conditions, such as climatic conditions, back up facilities, spare parts, transport possibilities, storage facilities, quarries, local Manufacturer/Suppliers, test facilities (field laboratory).

Quality Management Systems shall comply with the applicable requirements of BS EN ISO 9001 "Quality Management Systems- Requirements" and BS EN ISO 9004, "Quality management – Quality of an organization – Guidance to achieve sustained success". Written quality plans and procedures shall be submitted to the COMPANY for review and approval.

Materials should be obtained from the same source(s) throughout the work (including both trial and production mixes).

5.2 Inspection, Testing and Reporting

- a) Inspection and Test Plans (ITPs) identifying the tests, frequencies, acceptance criteria, and responsibilities shall be prepared as part of the quality plan.
 - 1) Tests for approval and acceptance of materials used for concrete production as well as tests on reinforcement shall be performed by a certified testing laboratory approved by the COMPANY.
- b) A reporting system of Quality Control Records (QCRs) shall be part of the quality plan.
- c) The reporting system shall record all results obtained during the following:
 - 1) Concrete production

- 2) Concrete supplying and transporting
 - 3) Material and concrete testing
 - 4) Concrete placing/pouring
 - 5) Concrete finishing
 - 6) Concrete curing
 - 7) Formwork striking
 - 8) Inspection of concrete members
- d) Weather conditions shall be recorded in the quality records.
- e) The proposed ITPs and QCRs shall be included in the Quality Plan and cover the following:
- 1) Setting out
 - 2) Anchor bolts
 - 3) Rebar and cover
 - 4) Concrete strength
 - 5) Pre-stressing strands
 - 6) Inserts and other embedments
 - 7) Formwork (including loading capacity, if required)
 - 8) Concrete placing
 - 9) Field concrete workability
 - 10) Curing
 - 11) Removal of formwork (take loading capacity into account)
 - 12) Joint preparations- defects
- f) Standard forms of inspection and test plans shall be used as a basis for the development of the ITPs and QCRs supplemented by the requirements of the specifications for the work to be executed.
- g) After completion, if there is any doubt about the concrete member integrity based on the inspection records, rebound or ultrasonic measurements shall be taken to control and verify the concrete quality against the compliance tests and required concrete quality.
- 1) Any deviation shall be reported, including the measurements to be taken
- h) The COMPANY reserves the right to make inspections of the following at any time:
- 1) At the source of supply of materials
 - 2) At the place of preparation of materials
 - 3) At the mixing plant if ready mixed concrete is used
 - 4) During execution of all concrete work

- i) Prior to supply of any material to site the CONTRACTOR shall obtain COMPANY approval by submitting necessary documentation such as test certificates, source of supply, date of manufacture, etc.

5.3 Quality Control and Assurance

CONTRACTOR shall submit the material handling procedure, quality control program and inspection procedures documents to COMPANY for approval. CONTRACTOR's Quality Management Systems shall comply with all the requirements of ISO 9001 "Quality Management Systems – Requirements" and ISO 9004 "Quality Management – Quality of an organization – Guidance to achieve sustained success".

CONTRACTOR shall be solely responsible for quality control of all materials and workmanship. The quality system shall provide for the planned and systematic control of all quality-related activities performed during design, fabrication and erection of steel structures. Implementation of the quality system shall be in accordance with the Project Agreement, CONTRACTOR's approved Quality Manual and Project Specific Quality plan.

The CONTRACTOR shall ensure that the FABRICATOR/VENDOR/MANUFACTURER shall always have in effect, a QA/QC program, which clearly establishes the authority and responsibilities of those responsible for the quality system. Persons performing quality functions shall have sufficient and well-defined authority to enforce quality requirements that they initiate or identify and to recommend and provide solutions for quality problems and thereafter verify the effectiveness of the corrective action.

Quality System and Quality Control requirements shall be identified and included in the CONTRACTOR's Purchase documentation. Based on these requirements, the FABRICATOR or VENDOR/MANUFACTURER will develop a QA/QC program, which shall be submitted to the COMPANY/CONTRACTOR for review and concurrence. The FABRICATOR or MANUFACTURER/VENDOR's QA/QC program shall extend to SUBCONTRACTOR'S or SUBVENDOR's.

The CONTRACTOR shall submit certified reports of all tests as soon as the tests are completed satisfactorily.

COMPANY/CONTRACTOR reserves the right to inspect or to conduct a quality audit of materials, installation and workmanship standards and shall have unrestricted entry to the shop of the fabricator at all stages of manufacture and to witness any or all tests. The FABRICATOR or VENDOR/MANUFACTURER, 30 days after award but prior to the pre-inspection meeting, shall provide the COMPANY/CONTRACTOR with a copy of its Manufacturing and Inspection Plan for review and inclusion of any mandatory COMPANY/CONTRACTOR witness or hold points.

The COMPANY/CONTRACTOR may reject improper, inferior, defective, or unsuitable materials, installation and workmanship. All materials and workmanship rejected shall be repaired or replaced by the FABRICATOR as directed by the COMPANY.

CONTRACTOR to develop the Criticality Rating (CR) System the design checking levels and minimum requirements for shop inspection, testing and material certification. CONTRACTOR shall develop a list of Criticality ratings for all equipment items. Regardless of the Criticality Rating COMPANY/CONTRACTOR shall review the FABRICATOR'S/VENDOR'S documentation to ensure compliance with the requirements of the AGREEMENT.

SECTION B

6.0 TECHNICAL REQUIREMENTS

Not Applicable.

7.0 ADDITIONAL SPECIFIC REQUIREMENTS

Not Applicable.

SECTION C

8.0 MATERIALS

8.1 Cement

8.1.1 Cement shall be of the following types

- a) For mass concrete and concrete exposed to seawater (for definition of mass concrete see clause 8.1.6):

[Blast furnace cement Type CEM III/B 42.5L per BS EN 197-1] / [Combination Type CIIIB 42.5L per BS 8500-2], with minimum clinker content of 30%

OR

[30% CEM I 42.5N cement to BS EN 197-1 with 70% ggbs per BS EN 15167-1]

OR

[30% Type I cement per ASTM C150/C150M with 70% ggbs to ASTM C989/C989M, Grade 100 or 120].

- b) For general use concrete below and above ground:

[Blast furnace cement Type CEM III/A 42.5L per BS EN 197-1] / [Combination Type CIIIA 42.5L per BS 8500-2], with minimum clinker content of 45%

OR

[45% CEM I 42.5N cement to BS EN 197-1 with 55%ggbs per BS EN 15167-1]

OR

[45% Type I cement per ASTM C150/C150M with 55% ggbs to ASTM C989/C989M, Grade 100 or 120].

- 8.1.2 Ground granulated blast furnace slag (ggbs) alumina content shall not exceed 14%. If it exceeds, it shall be used only with Portland cement having a tricalcium aluminate (C3A) content not exceeding 10%.

- 8.1.3 The source of blast furnace cement or ground granulated blast furnace slag (ggbs) and Portland cement shall be subject to approval of COMPANY. Once a source is approved, an alternative source shall not be used without further approval of the COMPANY. One cement type shall be used for the entire project unless noted otherwise on the Engineering drawings approved by the COMPANY.

- 8.1.4 For blinding and unreinforced Mass Concrete, it is permissible to use Type I Cement to ASTM C150/C150M or CEM I 42.5N cement to BS EN 197-1.

- 8.1.5 For Sulphur pits, the cement combination shall be comprised of 45% cement, 50% ggbs and 5% micro silica.
- 8.1.6 Mass concrete is defined as concrete placements (concrete pours) where the least dimension (length, width or thickness) is greater than 1000mm.
- 8.1.7 Slag cement shall be supplied from a source that has a well-established proven record for consistent supply of quality material (minimum of two years production). Necessary references shall be submitted.
- 8.1.8 Cement shall be of recent manufacture and shall be used within a period of 3 months from production. Blast Furnace Slag age from granulation to blending shall not be more than six (6) months.
- 8.1.9 Blast furnace slag cement shall either have its two components ground separately and then blended at the mill or have its two components be inter-ground where consistent control of particle size distribution can be demonstrated.
- 8.1.10 In no case it is allowable to blend the two components at any location other than the mill.
- 8.1.11 Before or after delivery COMPANY shall have the right to check any cement and/or associated documentation. COMPANY may reject the cement if it does not comply with this specification.
- 8.1.12 COMPANY reserves the right to take samples and order any additional tests. The CONTRACTOR shall remove all rejected cement from the site immediately.
- 8.1.13 Storage of Cement
- a) Cement storage shall afford easy access for inspection and identification of each shipment in accordance with test reports. It shall be used in the order in which it is delivered to the site.
 - b) Cement in bulk shall be used and stored in approved purpose made silos (white coloured insulated silos) large enough to allow continuity of work. Cement stored in bulk silos shall not exceed 75° C.
 - c) Bagged cement shall be delivered to site in the MANUFACTURER's original sealed bags or containers and shall be stored in a dry, weather tight, properly ventilated covered structure, with adequate provisions for preventing the absorption of moisture and raised at least 150mm off the ground to prevent deterioration. The storage shall be large enough to allow sufficient cement to be kept allowing continuity of work. Not more than 10 small bags or 3 'Big Bags' shall be piled one on top of the other while storing at site. Suitable shading shall be provided to limit the temperature to 40° C.
 - d) No cement shall be stored on site for more than 3 months.
 - e) The use of loose cement from partly used bags will not be permitted. Concrete mixes shall be based on the use of whole numbers of bags of cement or bulk cement.

8.2 Aggregates

- 8.2.1 All aggregates shall comply with ASTM C33 or BS EN 12620 or in case of lightweight aggregates (for fire proofing concrete) ASTM C330 or BS EN 13055-1, and comply with further restrictions indicated in this section. They shall be well graded, clean, hard, durable, not “gap-graded”, and free from undesirable materials and obtained from an approved source.
- 8.2.2 Coarse and fine aggregates shall be crushed rock to ASTM C33 or BS EN 12620 from Ras Al-Khaimah (R.A.K) or equivalent. The crushed rock fine aggregate shall be blended with Al Ain Dune Sand to facilitate correct grading. Al Ain dune sand alone as fine aggregate is not acceptable.
- 8.2.3 Aggregates shall consist of fine aggregates (those passing a 5mm sieve), and coarse aggregates (those retained on a 5 mm sieve) batched separately which, when combined together, shall meet the requirements of ASTM C33 or BS EN 12620 on aggregate grading.
- 8.2.4 All aggregates shall be obtained from the same source, approved by COMPANY at the commencement of the works, throughout the contract. Aggregates shall be obtained from the source and tested to ensure only aggregates conforming to this specification would arrive at the batch plant.
- 8.2.5 During excavation at a particular source of aggregate, care shall be taken to ensure that the excavation does not get too close to the high-water mark (maximum recorded sea level at high tide) where there may be a high concentration of salts due to the evaporation of water.
- 8.2.6 In addition to the general requirements, fine aggregate shall be mechanically de-dusted (preferably) or washed, if necessary, to reduce contamination and ensure compliance with permissible limits of the clay, silt and dust.
- 8.2.7 All fine and coarse aggregates for normal weight concrete shall be within the limits laid down in Table 8-1:

Table 8-1- Limits and Standards for Normal Weight Aggregates

Property/Deleterious Substance	Method of Test & Standards	Maximum Limit (% by weight)	
Clay, Silt and Dust	Wet Sieving through 75 µm sieve (BS EN 933-1)	<u>Coarse Aggregates</u>	
		Crushed rock	3%
		<u>Fine Aggregates</u>	
		Natural dune sand/crushed gravel	3%
Clay Lumps and friable particles	ASTM C 142, ASTM C 33	Crushed rock	5%
		Coarse Aggregates	2%
Organic Impurities	ASTM C40, ASTM C87 or BS EN 1744-1 Clause 15	Fine Aggregates	1%
		Concrete hardening time difference	< 30min
Chlorides as Cl	Analysis following acid* extraction (BS EN 1744-1 Clause 7 or AASHTO T259)	Compressive strength difference	< 5%
		Coarse Aggregates	0.03% ⁽¹⁾
Sulphates as SO ₃	Analysis following acid extraction	Fine Aggregates	0.06% ⁽¹⁾
		Coarse Aggregates	0.4%
		Fine Aggregates	0.4%

	(BS EN 1744-1 Clause 12 or ASTM C1012)		
Alkali Reactivity	ASTM C 289 (Chemical Method)		Innocuous
	ASTM 1260 (Accelerated Mortar bar Method)		< 0.1%
Alkali-Silica Reactivity	ASTM C227 or BS 1881, Part 124, Method 10.1	If this limit is exceeded, then the Alkali in the cement shall be limited such that the total alkalis in the concrete is less than 3 kg/m ³	< 0.5%
Alkali-Carbonate Reactivity	ASTM C295, C1105 and C1105 or BS EN 933-1		
Cement - Alkali Reaction	ASTM C 227 (Mortar bar method) Note: If the result of ASTM C 289 is potentially deleterious or the ASTM C 1260 is > 0.10 %, then this test is to be carried out.	6-month expansion	< 0.1%
Grading	ASTM C33 or BS EN 933-1 & BS EN 933-2 (Sieve analysis)		
Surface texture	Descriptive (BS EN 932-3)	Limit not applicable	
Particle density (SSD)	BS EN 1097-6	Limit not applicable	
Water absorption	BS EN 1097-6 ASTM C127 and 128	Coarse Fine	3% 3%
Soundness	BS 812-121, ASTM C88	Loss after 5 cycles with: a) MgSO ₄ b) Na ₂ SO ₄	<15% <10%
Drying shrinkage	BS EN 1367-4	Shrinkage of dry length	< 0.05%
Flakiness index	BS EN 933-3	Maximum	25%
Elongation index	ASTM C490 or BS 812 Part 105.2	Maximum	25%
Mechanical Properties	10% Fines Value (BS 812-111)	For wearing surfaces Elsewhere	≥100KN ≥75KN
	Los Angeles abrasion test (ASTM C131 and C535)	For wearing surfaces Elsewhere	<25% <30%
Note (1): Strict control shall be exercised to ensure that the maximum chloride content indicated is not exceeded at any time. Any violations shall be cause enough for rejection at any stage of the construction.			

8.2.8 Lightweight aggregates shall be used for fireproofing concrete only. Lightweight aggregates shall conform to the requirements of BS EN 13055 "Lightweight Aggregates". Maximum size of lightweight aggregates shall be 10mm. Aggregates shall be within the limits laid down in Table 8-2:

Table 8-2 - Lightweight Aggregates

Property	Method of Test and Standards	Maximum Limit (% by weight)	
Sampling	BS EN 932-1		
Grading	BS EN 933-1 or ASTM C33		
Bulk Density	BS EN 1097-3	a) Coarse aggregates 250 to 1000 kg/m ³ b) Fine aggregates 400 to 1000 kg/m ³	
Sulphate Content	BS EN 1744-1 Clause 12 ASTM C1012M	S03	<1%
Loss on Ignition	BS EN 1744-1 Clause 17	Blast furnace slag	Limit not applicable
		Clinker and furnace bottom ash	10%

8.2.9 Aggregate Storage:

- At all times, the concrete plant shall maintain sufficient quantities of each type of aggregate to ensure continuity of work.
- Each type and grade of aggregate shall be stored separately in bins; in such a manner that segregation of the various size particles shall not occur. The floors of the bins shall be of concrete or other approved material having adequate slope to ensure proper drainage of aggregates before being used for concreting. Storage bins shall be emptied and cleaned at regular intervals.
- Strict precautions shall be taken to avoid contamination of aggregates by windblown dust, chlorides, etc., during transportation and storage at site.
- Suitable means shall be provided to ensure that the temperature of the concrete when deposited does not exceed 32 degrees C. Aggregate stockpiles shall be shielded from direct sunshine.
- Suitable shading shall be provided to control the temperature and any contaminations especially chlorides.

8.3 Water

- 8.3.1 All water, including but not limited to, mixing, ice production, cooling aggregates, washing down delivery vehicles and plant, washing aggregates and concrete curing shall be obtained from an approved source and shall be clean and free of acids, oils, vegetable, and deleterious matter which may have an effect on the strength, and appearance of the hardened concrete by discoloration or efflorescence. Seawater shall not be permitted for any of the above works/applications.
- 8.3.2 The water shall comply in all respects with the requirements of ACI 318, ASTM C94/C94M, and ASTM C1602/C1602M or BS EN 1008. Testing shall be done at source (trucked) or at site (piped to holding tank), for chlorides and sulphates.

- 8.3.3 The pH value of water shall be within the range of 6.5 to 9 and the maximum concentration of inorganic contamination shall be as shown in Table 8-3:

Table 8-3 - Impurities in Mixing Water

Item	PPM	%
Sulphates (a)	750	0.075
Alkali carbonates or bicarbonates (b)	750	0.075
Chlorides (c)	500	0.05
Other dissolved solids (d)	2000	0.20
Suspended solids (e)	2000	0.20
Note: Total impurities of mixing water [a+b+c+d] shall not exceed 3000 ppm		

- 8.3.4 Suitable means shall be provided to ensure that the temperature of the concrete when deposited does not exceed 32 degrees C. Mixing water shall be refrigerated or have flake ice added.

The CONTRACTOR shall arrange for analysis of samples of water as per the COMPANY specification for testing water.

8.4 Admixtures and Additives

8.4.1 General

- a) Admixtures and additives may be used with the prior approval of the COMPANY. Test certificates shall be provided by MANUFACTURER for every batch or shipment.
- b) Admixtures/Additive shall be as follows:
 - 1) Be compatible with the cement.
 - 2) Have no adverse effect on the durability, shrinkage and water tightness properties of finished concrete.
 - 3) Shall not combine with the ingredients to increase the risk of corrosion of the reinforcement.
 - 4) Calcium chloride and admixtures containing soluble chlorides shall not be permitted.
 - 5) Shall not affect long-term strength of the concrete
- c) The CONTRACTOR shall advise of the following:

- 1) The long- and short-term effects of the admixture on the concrete.
- 2) The effects of under and over dosage.
- 3) Whether or not the admixture entrains air or has an effect on air content.
- 4) Safety precautions in handling.
- 5) Storage Life and Conditions.
- 6) Effects on use of other admixtures used in the mix.
- 7) The water content of the admixture.
- 8) The necessity for agitation prior to use.

8.4.2 Plasticizing (Water-Reducing) and Retarding Admixtures

- a) Plasticizing and retarding admixtures shall be in accordance with ASTM C494/C494M Type D or BS EN 480-1.
- b) CONTRACTOR to be aware that such admixture may increase the time for adequate curing and protection.

8.4.3 Plasticizer Admixtures (normal water reducers)

- a) Plasticizer admixtures shall be in accordance with BS EN 934-2, BS EN 934-6, BS 5075 or ASTM C494/C494M Type F and ASTM C1017/C1017M Type 1.
- b) Hydroxyl-Carboxylic acid-based plasticizers may be used, subject to site tests and COMPANY approval.

8.4.4 Super-Plasticizer Admixtures (High Range Water Reducing Agent - HRWRA)

- a) Shall be in accordance with BS EN 5075 part 3 or ASTM C1017/C1017M Type 2 or ASTM C494/C494M Type G.
- b) For blast furnace slag cement concrete melamine-formaldehyde based super plasticizers may be used.

8.4.5 Colour (Red Oxide for Underground Electrical and Green Oxide for Underground Instrument Cables) in duct banks, trench covers, slabs and paving above underground cables:

- a) Shall be in accordance with BS EN 12878 or ASTM C 979/C979.
- b) Shall be added at the rate in accordance with the SUPPLIER'S recommendations.

8.4.6 Optional Additives in Concrete

Corrosion inhibitor where specified by the COMPANY in project documents shall have the following specifications:

Organic corrosion inhibitor classified as Mixed Corrosion Inhibitor (ANODIC + CATHODIC) shall be used complying with the requirement of ASTM C1582/1582M and dosage shall be maintained at MANUFACTURER's recommendation. The corrosion inhibitor shall be incorporated into the mixing water for the purpose of determining the water cement ratio of the concrete.

8.5 Fibre Reinforcing

- a) Fibre reinforcement shall be polypropylene or steel fibres. All large flat areas of concrete which are externally exposed (such as paving including trenches, ditches, grade slabs and slope protection panels) shall contain polypropylene fibres at a dosage of 0.6 to 0.9 Kg/m³ of concrete volume, depending on the cement content and the fibre MANUFACTURER's recommendations. Fibrillated fibres shall be used where a broom finish is required, and monofilament fibres shall be used where a trowelled finish is required. Fibres shall be in accordance with ACI 544.1R and BS EN 14889-1 and ASTM C1116/C1116M.
- b) Fibres shall not be considered as substitute for all or part of the steel reinforcement.

8.6 Anchor Bolts and Embedments

- a) Anchor bolts, nuts, washers, and sleeves shall be specified and detailed in accordance with the COMPANY specification for Anchor Bolts.
- b) Embedment steel shall be in accordance with ASTM A36/A36M and ACI 355.2 or BS EN 10025-3 and BS 8539 or as indicated on the drawings approved by the COMPANY.
- c) Embedment steel shall be hot-dipped galvanized in accordance with ASTM A123/A123M or BS EN ISO 1461.
- d) Aluminium items shall not be used for concrete embedment.
- e) Galvanization/painting requirements shall be as specified in the COMPANY specification for Galvanizing and for Painting.
- f) Chemical adhesive anchors shall use an epoxy resin adhesive and hardener in accordance with MANUFACTURER's recommendations. Material approval shall be obtained from the COMPANY prior to commencement of work. CONTRACTOR shall develop an applicable standard to COMPANY's satisfaction.

8.7 Reinforcing Steel and Pre-stressing Tendons

- a) Steel for main and secondary reinforcement for general concrete works shall be Type 2 hot rolled deformed high yield bars and shall comply with BS EN 10080 and BS 4449 with minimum yield strength of 500 N/mm², or 420 N/mm² to ASTM A615/A615M.

- b) Fabric reinforcement (standard mesh) of Grade 500 shall comply with the requirements of BS 4483 or ASTM A185/ A185M, made with cold reduced steel wire complying with BS 4482 with a minimum yield strength of 460 N/mm². The weights and dimensions shall be as indicated on the drawings approved by the COMPANY and shall be supplied in flat sheets. Rolls of fabric reinforcements will not be accepted.
- c) Reinforcement for pre-stressed concrete in cryogenic environment shall be suitable for cryogenic temperatures and in accordance with EN 1008.
- d) Epoxy coated rebar shall not be used.

8.8 Forms

- a) Form faces shall be made of marine plywood, steel or GRP. Formwork materials shall be in good condition when brought to the construction site and shall be properly coated, protected, and maintained throughout their use. Materials that are damaged, cracked, weathered or otherwise unsuited for producing smooth, uniformly textured formed surfaces shall be rejected.
- b) Internal form ties shall be permanently embedded metal non cavity type and shall have removable ends. Outer ends of the permanently embedded portions of form ties shall be at least 75 mm from adjacent outer concrete faces. Non fabricated wire shall not be used.
- c) CONTRACTOR shall develop design calculations for formwork supporting concrete weight and all other applicable loads.

8.9 Joint Fillers

- a) Filler material shall be compressible, non-extruding, bitumen impregnated fibreboard as per ASTM D1751 or Preformed Expansion Joint Filler (Bituminous Type) as per ASTM D944/D994M.
- b) Filler for expansion joint shall be fixed firmly to the first-placed concrete. If more than one strip is used within a joint, the ends shall be taped together to prevent grout leakage. The concrete on both sides of the joint shall be thoroughly compacted to form a dense, uniform mass.
- c) The use of crack inducers for contraction joints shall be subject to the COMPANY approval.

8.10 Joint Sealers

- a) Joint sealer shall be compatible with the product coming in contact.
- b) Joint sealer shall be chemical resistant (regarding possible spills) two component polysulfide compound.
- c) Joint sealer for down hand application shall be liquid self-levelling grade and in accordance with ASTM D6690.
- d) Joint sealer for vertical joints or for overhead application shall be trowel grade and in accordance with ASTM C881/C881M Type IV Grade Grade-3, Class-B/C.

8.11 Waterstops

- a) Waterstops shall be factory preformed ribbed type (dumbbell/ centre bulb type) 10mm minimum thickness in accordance with BS 2571 and ASTM D412-75 and ASTM D638 for PVC or of other approved material as required to ensure compatibility with any chemicals it may come in contact with as specified on the drawings approved by the COMPANY .
- b) Minimum width of water stop shall be 230mm for concrete section greater than 200mm wide and 150mm for concrete section less than 200mm. All water stops shall be placed centrally within the section.
- c) The CONTRACTOR shall demonstrate adequacy of the material of selected water stop tested in accordance with BS/ASTM for the following typical values (as shown in Table 8-4):

Table 8-4 – Waterstop Material Properties

Property	Test Method		Typical Value
	BS/ISO/DIN	ASTM	
Ultimate tensile strength	EN ISO 527-2 BS2782-0:2011	ASTM D-638	$\geq 12.0 \text{ N/mm}^2$
Ultimate elongation	EN ISO 527-2 BS2782-0:2011	ASTM D-638	$\geq 320\%$
Elastic modulus	BS2782-0:2011	ASTM D-747	$> 8.0 \text{ N/mm}^2$
Hardness	DIN 53505 BS2782-0:2011	ASTM D-2240	75 $\pm$ 5%
Water absorption	BS2782-0:2011	ASTM D-6570	0.1% - 0.15%

8.12 Vapour Barrier

Unless specified otherwise in the Contract Documents, vapour barriers to underside of concrete in contact with the ground shall be heavy duty, minimum thickness 1000-gauge (0.25mm thick) polythene sheeting in longest length and widest width available and lapped not less than 300mm at all joints and intersections.

8.13 Curing Compound

- a) The use of curing compound shall be restricted to areas where the use of water is not practical, such as suspended slab soffits, wall heads, etc., but it shall not be generally be used as the primary curing system.

- b) Curing compound if used shall be compatible with subsequent surface applications to the concrete.
- c) Curing compound shall be white-pigmented in accordance with ASTM C 309 (type-II) and shall be accompanied by a certificate from an approved institute, stating:
 - 1) Exact range and method of application
 - 2) Physical and chemical composition
 - 3) Positive and negative side effects
 - 4) Proportioning at application
 - 5) No chlorides
 - 6) Compatibility with proposed surface treatment
- d) The efficiency of the curing compound shall be demonstrated by testing trial panels for absorption using Senbetta and Scholer method.

8.14 Test

CONTRACTOR shall be responsible for performing reviews, inspections, audits and/or witnessing tests at the SUPPLIER'S facility as appropriate to ensure quality of procured items. The CONTRACTOR shall provide access to COMPANY to perform similar activities if the need is established.

9.0 EXECUTION

9.1 General

Storage, handling, measuring, mixing, transporting, and placing concrete shall follow the recommendations of this specification in accordance with BS EN 206 and BS 8500 or alternatively ACI 304R; and comply with MANUFACTURER's recommendation for handling, storage, and protection.

9.2 Concrete Mix Design

9.2.1 Grades of Concrete

9.2.1.1 Concrete grades shall be as shown in Table 9-1. The criteria given in the table are designed to produce concrete of the required durability and strength. HRWRA shall be used in the concrete mixes.

9.2.1.2 The concrete mixes shall be designed in accordance with BS 8500 or ACI 301 and ASTM C94/C94M for ready-mix concrete. Performance and acceptance criteria of concrete mixes shall be as per BS EN 1992-1-1 or ACI 318 except where BS 8007 or this specification differs. Sampling for test purposes shall comply with BS EN 12350-1 and BS EN 12390-1 and making and curing of specimens shall comply with BS EN 12390-2 or ASTM C31.

9.2.1.3 Before concrete placement the CONTRACTOR shall obtain approval by the COMPANY for the proposed mixes for each class of concrete. The mixes shall be designed to achieve the minimum workability for the placement and compacting the concrete with the equipment proposed for use.

Table 9-1 - Concrete Grades and 28-days Strengths

Nominal Grade (1) (2) (3) (4) (5) (6)	Strength MPa		Application	Maximum Free Water/ Cementitious Ratio	Cementitious Content Minimum (kg/m ³)
	Cube	Cylinder			
20	20	16	Blinding, Electrical Duct banks, Screed	0.50	250
25FP ⁽⁵⁾	25	20	Fireproofing	0.50	250
40	40	32	Equipment Foundations, Structures, Footings, Pipe Sleepers, Pits, Basins, walls, water retaining structures	0.42	360
30F ⁽¹⁾	30	25	Paving Slabs, Trenches, Ditches, slope protection panels	0.42	320
50	50	40	Prestressed Concrete, Piles, Marine Facilities over water, Structures in continuous contact with sea water	0.40	380
Notes: 1) Grade 30F concrete containing fibres shall be used for large areas of concrete, which are externally exposed such as paving slabs, trenches, ditches and slope protection panels. 2) All concrete mixes to be designed for pumping. 3) Grade is included only to provide a strength basis for design. It is not intended to identify durability levels. 4) Concrete shall have a maximum aggregate size of 20mm except the concrete for screeding and fireproofing, which shall have a maximum aggregate size of 10mm. 5) Grade 25FP designates fireproofing concrete using lightweight aggregate. Any of the cement types from either 'mass concrete' or 'general use concrete' indicated in Section 8.1.1 can be used. 6) Strength level acceptance shall meet the requirements of ACI 301 or BS206-1.					

9.2.2 Concrete Slump

Various concrete mixes shall be proportioned so as to comply with working (target) slump at the point of delivery as shown below:

- Working slump range for normal concrete with plasticizer/superplasticizer: 100 to 150mm.
- Working slump range for ggbs/silica fume added concrete: 150 to 200mm.

Slump shall be tested in accordance with ASTM C143/C143M and BSEN 12350-2. Concrete with a

collapsed slump shall not be used.

Concrete that has been rejected for failing to meet slump limits shall not be salvaged for use in the concrete work. Increased mixing time, addition of dry materials, or similar modifications of a rejected batch for the purpose of conforming to slump limits shall not be permitted.

9.2.3 Bleeding and segregation

The mix design shall be such that the bleeding and segregation is kept to a minimum.

9.2.4 W/C Ratio

Total cementitious contents shall be limited to those required for durability to avoid excessive risk of thermal and shrinkage cracking. The proportioning of mixes for durability will be primarily controlled through the specified limits on free w/c ratio. The w/c ratio shall be equal to or less than the values shown in Table 9-1 above. Appropriate use shall be made of approved admixtures to simultaneously meet the requirements for w/c ratio and workability.

9.2.5 Trial Mixes

Trial mixes shall be performed both in a laboratory and in the field.

CONTRACTOR shall employ an independent testing laboratory approved by COMPANY to perform all testing of materials used in the concrete mixes and concrete samples.

The testing laboratory shall furnish all equipment, facilities, and labour required for field sampling, curing, transporting test samples, and field and laboratory tests, recording of test results, and preparing necessary reports.

The time required for any trial mixes with associated testing shall be included as part of the construction schedule, being completed one month prior to commencement of concrete works. Method statements for trial mixes shall be developed and submitted to the COMPANY for review and approval.

9.2.5.1 Laboratory Trials

- a) After the basic materials for concrete are approved by the COMPANY, the CONTRACTOR shall carry out preliminary laboratory tests to determine the mixes using the approved materials to satisfy the requirements of this Specification.

Trial mixes shall be tested to determine the following properties for initial field tests (prior to the commencement of concrete work):

- 1) Durability parameters at trial mix stage to be in accordance with clause 9.2.5.2 (e).
- 2) Bleeding in accordance with BS EN 480-4 or ASTM C232.
- 3) Workability in accordance with BS EN 12350-2 or ASTM C143/C143M.
- 4) Density in accordance with BS EN 12390-7 or ASTM C138/C138M.

- 5) Crushing strength in accordance with BS EN 12390-3 or ASTM C39/C39M.
- 6) Admixtures, super plasticizer or retarding super plasticizer with ASTM C494.

If the values obtained are unacceptable, the mix shall be re-designed until satisfactory results are obtained.

b) Samples for durability testing shall consist of:

- 1) 6 Nos. 150mm cubes for water penetration testing to BS EN 12390-8.
- 2) 8 Nos. 150mm cubes from which 1 N° 100mm diameter x 75mm long core shall be taken from each cube and trimmed for 50mm length for rapid chloride permeability testing to ASTM C.1202.

Laboratory trial mixes of structural concrete shall be tested at an age of 28 days after casting.

c) Curing of the samples shall be:

- 1) One half of each number to be fully water cured for 28 days in accordance with the Standard Test Method.
- 2) The other half of each number to be water cured for 14 days and then exposed to the external environment until tested, so as to replicate site conditions.

9.2.5.2 Field Trials

a) Field trial mixes shall be prepared and cured under full-scale site conditions and utilizing the actual batch plant and materials provided for the project and tested in accordance with BS EN 12350-1 and BS EN 12390 or ACI 301. Field trial mixes are to be performed early enough to obtain 28 days durability test results. Mixes shall be made on three different days.

b) Testing for Durability

The CONTRACTOR shall prepare trial panel for each structural mix design from which the following samples shall be prepared for testing after 28 days:

- 1) 3 Nos. cores, 75mm diameter x 75mm long for water absorption testing in accordance with BS 1881-122 or ASTM C642.
- 2) 3 Nos. cores, 150mm dia. x 75mm long for porosity testing in accordance with RILEM CPC 11.1.
- 3) 4 Nos. cores, 100mm dia. x 75mm long for RCP testing in accordance with ASTM C1202/C1012M. These cores will be saw cut to a specimen thickness of 50mm.

c) Additionally, 150mm cubes shall be cast from the same batches of concrete used to cast the panels, as follows:

- 1) 6 Nos. for water penetration testing to BS EN 12390-8.

- 2) 2 Nos. from which 1 N° x 75 mm dia. X 75 mm long core shall be taken from each for water absorption testing to BS 1881, Part 122 or ASTM C642.
- 3) 2 Nos. from which from 1 N° x 150 mm dia. X 75 mm long core shall be taken from each for porosity testing to RILEM CPC 11.1.
- 4) 4 Nos. from which 1 N° x 100 mm dia. X 75 mm long core shall be taken from each and trimmed to 50 mm length for rapid chloride permeability testing to ASTM C1202.
- 5) Curing of the samples shall be as described in Clause 9.2.5.1(c). Testing of all specimens shall be at 28 days after casting.

Curing the Trial Panel shall be as close to the future site practice as possible. Further trials/mixes shall be made and tested if any test result falls below the specified value by more than 10%.

d) Testing for Strength

- 1) Twelve (12) x 150mm cubes shall be taken from each mix design. Test 2 Nos. at 3 days, 3 Nos. at 7 days, 2 Nos. at 14 days and 4 Nos. at 28 days for compressive strength.
- 2) Further trials/mixes shall be made and tested if the average of the eleven cubes at any of the above ages is less than the target mean strength (the twelfth cube is a spare). Standard deviation and required average strength shall be calculated in accordance with ACI 301 or BS EN 206:2013+A1:2016. The mix proportions shall then be selected to produce the required average strength in accordance with ACI 301 or BS EN 206: 2013+A1:2016 and BS 8500-1 and 8500-2.

e) Durability Criteria

The Criteria for the approval of the mix designs for Nominal Grades 25FP, 30F, 40 and 50 for samples cured in accordance with Clause 9.2.5.1 (c) shall be as follows:

- 1) Water Absorption (BS 1881, Part 122 or ASTM C642) < 2.0%
- 2) Porosity (RILEM CPC 11.1) < 10.0%
- 3) Rapid Chloride Permeability (ASTM C.1202) < 1,500 coulombs
- 4) Water Penetration (BS EN 12390-8) < 10mm
- 5) Air content of concrete (ACI 318-08, ASTM C231/C231M, BS EN 12350-7) < 5% by Vol

The CONTRACTOR shall not be entitled to any additional cost or time expended during the approval process of the design mix.

9.3 Concrete Acceptance Criteria for Durability, Strength & Chemical Limits

- a) Only individual materials and concrete fully meeting the requirements of this specification shall be presented to COMPANY for acceptance.
- b) Only concrete from approved SUPPLIERS with a proven record shall be used after satisfying all the requirements of this specification.

- c) The CONTRACTOR'S Batch Plant Manager shall be responsible for the control of quality of all batch plant operations.

9.3.1 Durability Requirements

- a) For the first three months of concreting, the On-Site Testing Laboratory/Approved Testing agency shall prepare a trial panel from each structural mix each month from which the following samples shall be prepared and tested at the age of 28 days after casting:
 - 1) 3 Nos. cores, 75mm dia. x 75mm long for water absorption testing in accordance with BS 1881-122 or ASTM C642.
 - 2) 3 Nos. cores, 150mm dia. x 75mm long for porosity testing in accordance with RILEM CPC 11.1.
 - 3) 4 Nos. cores, 100mm dia. x 75mm long for RCP testing in accordance with ASTM C1202. These cores will be saw cut to a specimen thickness of 50mm.
- b) The CONTRACTOR shall also make 3No, 150mm cubes for testing at 28 days in accordance with BS EN 12390-8. Curing of these samples shall be in accordance with the requirements of BS EN 12390-2.
- c) Curing of the Trial Panel shall be as close to the site practice conditions as possible.
- d) Individual test results carried out at the age of 28 days shall be compared with the 28-days field trial results, clause 9.2.5.2 (e) but shall not be more than 10% different.
- e) The On-Site Testing Laboratory/Approved Testing agency shall test the prepared panels and cubes.
- f) The On-Site Testing Laboratory/Approved Testing agency shall repeat the above trial panels and cubes for durability testing every 3 months.
- g) The durability acceptance criteria for Nominal Grades 25FP, 30F, 40 and 50 concretes during the routine QC testing shall be the average value of each of the parameters obtained from the tests carried out on the cores and cubes at the field trial stage plus an allowance of 10% in accordance with clause 9.2.5.2 (e).
- h) In the event that the acceptance criteria in clause 9.2.5.2 (e) is not achieved, the CONTRACTOR shall immediately inform the COMPANY and stop further concreting on works where that particular concrete mix is being used and shall identify all areas where durability acceptable limits have not been met.
- i) For each area where the concrete has been identified as questionable with regards to durability, the CONTRACTOR shall take 4 number cores, 100mm dia. X 70mm long for Rapid Chloride Permeability (RCP) testing in accordance with ASTM C1202. The cores shall be saw-cut for a 50mm test length. Care must be taken to avoid contact with rebar during concrete coring and a cover meter shall be used to identify locations of reinforcing bars. The average value of the 4 Nos.

RCP testing shall not be less than the average value of all RCP tests obtained from the routine QC trial panels with a 10% allowance.

- j) In areas where taking core samples is impracticable or is structurally unacceptable to the COMPANY, then the CONTRACTOR shall carry out in-situ air permeability tests as developed by the British Cement Association (or an alternative non-destructive test method approved by the COMPANY).
- k) The CONTRACTOR shall demonstrate a satisfactory correlation between the in-situ air permeability test, or alternative non-destructive test, with the rapid chloride permeability value. Subject to COMPANY approval, such method may be used in lieu of the coring in other areas.
- l) For areas which are confirmed as not meeting COMPANY durability criteria CONTRACTOR shall take the following actions:
 - 1) Identify and implement further protective methods in order to guarantee the design life of the structure where durability parameters have not been met, at no cost to the COMPANY.
 - 2) Revise the mix design, materials control and/or construction method to meet durability requirements. This shall be approved by COMPANY.

9.3.2 Strength Requirements

- a) One (1) set of three (3) cubes shall be taken at the point of placement by the On-Site Testing Laboratory/Approved Testing agency on each day of concrete pours for every 60m³ or fraction thereof. Two (2) cubes shall be tested at 28 days and one (1) cube at 7 days.
- b) Acceptance criteria is defined as:
 - 1) The average of each set of two cubes (tested at 28 days) constitutes a test result.
 - 2) The average of any 4 consecutive test results shall exceed the specified characteristic strength by at least 3 N/mm².
 - 3) No individual test result shall be less than the specified characteristic strength minus 3N/mm².
- c) In the event that the acceptance criteria in section 9.3.2 (b) above is not achieved, the COMPANY will decide whether the concrete in the work represented by those cubes can be accepted or not. Failing acceptance, the CONTRACTOR shall carry out one or more of the following actions at his own expense to prove the concrete used in the works is within acceptable limits:
 - 1) Drilling and testing of cylindrical core samples in accordance with the procedures laid down in BS EN 12504-1 and BS 1881: Part 124 or ASTM C42/C42M and ACI 214.4R-10.
 - 2) Carrying out load tests, or other non-destructive tests in accordance with BS 1881: Parts 201 to 209.
 - 3) The course of action to be taken, types and number of tests, and size and location of cores for testing and interpretation will be decided by the COMPANY who will also approve the

testing authority and laboratory. If the COMPANY, after these secondary testing procedures have been completed, still considers the concrete to be unacceptable, the CONTRACTOR shall remove all sections containing defective concretes and replace them with approved concrete at his own expense.

9.3.3 Chemical Limits Requirements

- a) Chloride Content: The total chloride content of concrete shall not exceed 0.20% expressed as % of chloride ion by weight of cementitious material for normal reinforced concrete. The method of assessment and test shall be in accordance with BS1881-124.
- b) Sulphate Content: The total sulphate content of concrete (including sulphate ions in cement and slag) shall not exceed 4.0%, expressed as % of SO₃ by weight of cementitious material.

9.4 Formworks

9.4.1 General

- a) The CONTRACTOR/SUBCONTRACTOR shall provide details of the methods and materials proposed for formwork for each section of the work, and design calculations for formwork supporting concrete weight and pressure, and any construction and wind loads. Details of formwork to produce special finishes are to be submitted for approval in writing to the COMPANY before any materials are brought on to the site.
- b) The design and construction of formwork shall be in accordance with ACI 301, ACI 304R and ACI 347R or BS EN 1992-2 and BS 5975.
- c) Forms shall be constructed from sound material of sufficient strength, properly braced, strutted and shored to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. All formworks shall be watertight to prevent grout loss.
- d) Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the drawings approved by the COMPANY. Due allowance shall be made for any deflection which will occur during the placing of concrete within the forms.
- e) Forms shall be constructed such that they can be removed without shock or vibration to the concrete.
- f) Chamfer strips 25mmx25mm shall be placed in forms to bevel all permanent salient edges and corners except bottom edges of foundations.
- g) Temporary openings shall be provided where necessary to drain away water and to assist in the removal of rubbish. These shall be closed tight before pouring concrete.
- h) Formwork shall be coated with a COMPANY approved release agent before the reinforcement is placed. The release agent shall be non-staining, free from chlorides and sulphates, insoluble in water, nonreactive, rust preventive and guaranteed to be compatible with subsequent surface applications to the concrete. All excess shall be carefully removed. Form release oil shall not be allowed to come into contact with concrete already placed, with reinforcement or other embedded items.

- i) Before concrete is placed, all formwork and supports shall be thoroughly cleaned.
- j) Insulated formwork to control concrete temperature differentials in thick sections shall be used where determined necessary by trial, calculation or whenever directed by the COMPANY.
- k) Concrete shall not be placed until the relevant formwork has been inspected and approved by the COMPANY. This shall not relieve the CONTRACTOR from the requirements as to soundness, finish and accuracy specified elsewhere.

9.4.2 Accuracy of Formed Surfaces

Formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in Table 9-2:

Table 9-2 – Tolerances of Formed Surfaces

Item	Element/Surface		Tolerance (mm)
Plumbing (permissible deviation on verticality of vertical element)	Lines and surfaces of columns, piers, walls, arises	Any 3000mm of length	±7
		Maximum for entire length	±15
	Exposed corner columns, control joint grooves, other conspicuous lines	Any 6000mm length	±7
		Maximum for entire length	±13
Levels (permissible deviation from specified level)	Slab soffits, ceilings, beam soffits, arises (measured before removal of supporting shoes)	Any 3000mm of length	±7
		Any 6000mm of length or any bay	±9
		Maximum for entire length	±10
	Exposed lintels, sills, parapets, horizontal grooves, other conspicuous lines	Any 6000mm length	±7
		Maximum for entire length	±10
Position in plan (permissible deviation of building elements from specified plan position)	Columns, walls, partitions	Any bay	±10
		Any 6000mm length	±10
		Maximum for entire length	±20
Cross section dimensions	Columns, beams, thickness of slabs and walls		+13, -7

Foundations (reinforced concrete)	Deviation in level	Blinding	±15
		Upper surface	±10
	Deviation in plan dimensions		+30, -13
	Misplacement/eccentricity in direction of misplacement	Foundations of concrete structures and concrete buildings	2% of foundation width but ≤30mm
		Foundations of steel structures and steel buildings	≤10mm
	Deviation in thickness		±5
Ground slab	Deviation in level	Blinding	+0, -15
		Upper surface	±5
Steps (permissible deviation from specified dimensions)	In a flight of stair	Riser	±3
		Tread	±7
	In consecutive steps	Riser	±2
		Tread	±3
Sleeves, floor, and wall openings	Deviation in size and location		±7
Note: Tolerances apply to concrete dimensions only and not to positioning of reinforcing steel, dowels or embedded items.			

9.4.3 Striking Formwork

- The formwork shall be removed in accordance with ACI 301 and ACI 347 or BS EN1992-2, except as stated hereunder. No superimposed load shall be applied to self-supporting members before the 28 days strength has been verified by field-cured specimens.
- Forms shall be removed in such a manner as to not damage the concrete. No forms shall be removed until the concrete has gained sufficient strength to support itself (for minimum striking period see Table 9-3).
- At no stage shall the loosening or removal of formwork interrupt or prevent the immediate and continuous curing of the concrete.
- Centres and props may be removed when the member being supported has gained sufficient strength to carry itself and the load to be imposed on it with an acceptable factor of safety.
- A formwork striking plan shall be produced by the CONTRACTOR, which anticipates climatic conditions, heat of hydration, strength development, load conditions and relevant curing methods. Table 9-3 provides the minimum periods which must elapse between the completion of the

concreting operations and the removal of formwork.

- f) After removal of formwork no remedial works shall be attempted until the work has been inspected by the COMPANY.
- g) Providing the concrete strength is confirmed by tests on cubes, cured and stored under the same environmental conditions, formwork supporting cast in-situ concrete may be struck when the cube strength is 25 N/mm² or twice the stress to which it will be subjected, whichever is the greater, provided that such earlier striking will not result in unacceptable deflections due to shrinkage, creep, etc. Self-supporting member forms may be removed after 7 days provided concrete strength is at least 80% of design strength as determined by field-cured specimens or other approved methods.
- h) For thick sections, formwork shall be left in place for the required period determined by trial and/or calculation.
- i) Forms shall not be left permanently in place unless otherwise it has approved by the COMPANY.

Table 9-3 – Striking Formwork Minimum Period

Type of formwork	Min. period
Vertical formwork to columns, beams, walls where lift does not exceed 1.2m	24 hrs
Vertical formwork to columns, beams, walls where lift exceeds 1.2m	36 hrs
Soffit forms to beams (Props left under)	14 days
Soffit forms to slabs (Props left under)	6 days
Props to beams and slabs (Depending on back propping arrangement and calculations)	21 days
Tank walls	48 hrs
Construction joints	24 hrs

9.5 Fixing Reinforcement

9.5.1 General

- a) Reinforcement detail drawings and bar bending schedules shall be prepared in accordance with BS EN ISO 3766 or ACI SP-66 and COMPANY approved engineering drawings. Drawings and schedules shall show number, grade, size, length, mark, location, and bending diagrams for reinforcing bars and be submitted to COMPANY for information/records.
- b) The reinforcement shall be positioned as indicated on the Engineering drawings approved by the COMPANY. Spacers of suitable size shall be used to hold the reinforcement in position and

provide the specified covers. All reinforcement shall be in place prior to pouring concrete. No wet placing (i.e. during concreting operations) is permitted.

- c) Corner bars in columns and beams shall be tied for the entire length of the lap so that the minimum cover requirements are achieved, and the true alignment of the reinforcement is maintained. This may be achieved by cranked bars for the entire length of the lap.
- d) Reinforcing shall be tied with minimum 1.5mm soft annealed or galvanized wire.
- e) Welding reinforcement is prohibited, unless noted on the Engineering drawings and approved by the COMPANY. Reinforcement with unauthorized welds shall be removed and replaced. Where indicated and approved the welds shall be tested to confirm adequacy. Where indicated and approved, the welding shall be in accordance with AWS D1.4, a weld procedure shall be submitted and approved, and the welds shall be tested to confirm adequacy.
- f) Re-bending or re-straightening reinforcement is prohibited.
- g) All fabric mesh shall be lapped for a minimum length of 300mm, UNO on the drawings approved by the COMPANY, and tied together on both main and cross wires. All lap lengths shall be sufficient to develop the full strength of the reinforcement bars.
- h) Fabrication tolerances shall comply with the requirements of ACI 117.
- i) The CONTRACTOR shall furnish certificates of conformance stating that on the basis of appropriate and relevant certified mill test reports, the materials supplied meet the requirements of the specification. The mill test reports shall also be furnished.

9.5.2 Cover

- a) Cover to reinforcement shall be in accordance with ACI 318 or BS EN1992-2. As a minimum, the concrete cover to the reinforcement shall be as specified in Table 9-4.

Table 9-4 – Minimum Cover to Reinforcement

Concrete Exposure & Structural Member	Cover (mm)
Concrete cast against or permanently exposed to earth (all below grade structures)	75
Concrete in splash and atmospheric zone subject to salt spray	75
Concrete substructure exposed permanently to seawater	75
Concrete exposed to weather (all above grade structures not enclosed by a temperature and humidity-controlled building)	50
Concrete not exposed to weather (beams, columns, walls) located within a temperature and humidity-controlled building	40
Concrete not exposed to weather (slabs) located within a temperature and humidity-controlled building	35
Notes: 1) Cover is measured to the outside of all reinforcement. 2) Where any individual structural element falls within two or more categories then the most stringent criteria shall apply for the entire element	

- b) Under no circumstances shall concrete cover be reduced below the minimum given in this specification.
- c) Required covers shall not be reduced by provision of protective coatings, membranes or by membrane protective screed.
- d) To obtain the required concrete cover, concrete spacer blocks with identical compressive strength with concrete or hard plastic blocks shall be used. Spacers shall have a proven record of satisfactory performance in the field and shall not deform under the load of the reinforcement cage or displace and fail to provide the specified cover. Spacers shall be adequately distributed to prevent reinforcement deformation under the reinforcement self-weight and the construction loads. Oversize spacers shall not be used to give more than the specified cover as this compromises the structural design of the member.
- e) Cover to reinforcement shall be carefully checked before any concrete is cast. Special attention shall be given to reinforcement at kicker strip level, as misplaced starter bars can impede the fixing of reinforcement for the next lift at the correct cover.

9.5.3 Reinforcement Handling

- a) The reinforcement steel condition shall conform to ACI 301 until the time of placement of concrete. If the reinforcement steel develops rust due to delay in placement of concrete it shall be sweep blasted using grit meeting the requirements of BS EN ISO 8501 Part 3 until it is free from loose mill scale or rust, oil, grease and other harmful matter immediately before inclusion in the works. The steel after cleaning shall remain within the limits of weight tolerance allowed in ASTM A615/A615M or BS 4449.
- b) After installation, all reinforcement exposed for longer than 7 days shall be protected from contamination before and between pours by wrapping the formwork with suitable sheeting.
- c) All reinforcement shall be washed clean, using water suitable for producing concrete, prior to placement of concrete.
- d) All reinforcement shall be stored under cover on timber over concrete or steel crib support suitably spaced and of adequate height to keep the steel at least 200mm above ground level. Reinforcement shall be protected from all aggressive elements, including chlorides and moisture, by covering with suitable protection material. It shall be neatly separated in sizes and clearly marked with its diameter.
- e) If for any reason reinforcing bars are to be impounded or stored on site for long periods of time, a protective sacrificial coating or spray of corrosion inhibitor shall be used. If the coating will reduce the reinforcing/concrete bond, the coating shall be entirely removed prior to installation in the formwork.

9.6 Fixing Anchor Bolts and Embedments

- a) All sleeves, inserts, anchors, expansion or isolation joint materials, water stops, anchor bolts, conduit, piping, nose angles, ladder rungs, and other embedded items shall be positioned accurately and supported against displacement. Welding of these items to the reinforcing bars shall not be permitted.

Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

- b) For anchor bolts reference shall be made to the COMPANY specification for Anchor Bolts. The following shall apply:
 - 1) Anchor bolts shall be placed as indicated on the drawings before concreting.
 - 2) A template shall always be used to hold the anchor bolts in their correct position. The template shall be of rigid construction and fabricated from a suitable robust material. Anchor bolts shall not come in contact with the reinforcing steel. The template type, general arrangement and installation details shall be submitted for COMPANY review and approval prior to fabrication.
 - 3) Forging and heating of anchor bolts is not allowed.
 - 4) Before installation, anchor bolts shall be de-greased by an approved method.
 - 5) Anchor bolt sleeves shall be capped and/or filled with nonbonding mouldable material to keep out water, concrete, and debris during the placement of concrete and grout.
 - 6) Wet dipping (placement after concrete pouring) of anchor bolts shall not be permitted.
 - 7) Unless otherwise specified by equipment/supplier, installation tolerances shall be as follows:
 - i) All anchor bolts shall be installed to $\pm 2\text{mm}$ of their design position.
 - ii) Anchor bolts shall be plumb to $\pm 1:100$.
 - iii) Level tolerance to top of bolts shall be $- 0\text{ mm} + 15\text{mm}$.
- c) Insert plates shall be of the material and size as indicated on the Engineering drawings approved by the COMPANY and shall be installed to the following tolerances:
 - 1) Insert plates in the horizontal plane shall be installed so as to ensure that the variation from level does not exceed 3.0mm in either direction, and that the centre of the surface of the insert is within 2.0mm of the elevation shown on the drawings approved by the COMPANY.
 - 2) Insert plates whose least dimensions are greater than 300mm shall have sufficient weep holes to ensure full bearing.
 - 3) The centre of the surface of the insert shall be within 1.5mm of the vertical surface and within 3mm of the location and elevation as shown on the Engineering drawings approved by the COMPANY. Out of plumbness tolerance shall be 5mm maximum.

9.7 Waterstop

- a) Waterstops shall be installed in accordance with the Engineering drawings approved by the COMPANY, COMPANY specifications, contract documents, and MANUFACTURER's recommendations.
- b) Damaged products shall not be used.

- c) The method of joining waterstops shall be in accordance with MANUFACTURER's recommendations. Joining waterbars with adhesives is prohibited.
- d) Concrete around waterstop shall be fully compacted with no voids or porous areas.

9.8 Joints

9.8.1 General

All joints shall be located and constructed in accordance with the COMPANY specification and Engineering drawings. Any variation from the specified type and location of the joints shall be approved by the COMPANY. Slabs and paving shall be laid in an approved sequential fashion. Concrete shall not be placed in adjacent paving panel until 3 days from pouring have elapsed

For Joint filler and joint sealer materials reference shall be made to clauses 8.9 and 8.10.

9.8.2 Expansion Joints

Expansion joints shall be positioned accurately and formed straight, well-aligned and truly vertical or horizontal or parallel with setting out lines of the structure.

Concrete shall not be placed simultaneously in both sides of expansion joints and shall be prevented from entering the joints or penetrating or impregnating compressible joint fillers. Joints shall be sealed in accordance with this specification and the Contract Documents.

9.8.3 Control Joints

Control joints shall be installed in accordance with ACI 302.1R.

Saw cut joints shall be cut as soon as concrete has hardened sufficiently to prevent dislodgment of aggregates. Sawing shall be completed within 12 hours after placement. Saw cut shall be continuous to a depth of one-fourth the thickness of the slab (min 25mm), as per ACI 301. Alternative timing or depth proposed by the CONTRACTOR shall be submitted for COMPANY review and approval.

9.8.4 Construction Joints

Construction joints shall be installed in accordance with ACI 301. The CONTRACTOR shall submit information for acceptance of the number, proposed locations, and treatment of construction joints not indicated on the Engineering drawings. The number of joints shall be kept to a minimum and be located so as to least impair the strength of the structure. Provision shall be made for transfer of shear and other forces through the construction joint.

Construction joints shall be perpendicular to the main reinforcement, and the reinforcement bars in turn shall be continued across the joints.

Stop ends for vertical joints shall be removed as soon as it is practical without damaging the concrete face. Laitance shall be removed and the joints thoroughly cleaned and dampen before placement of fresh concrete.

When bond is required the joint surface shall be roughened by pressure jetting with air and water, in a manner that exposes the aggregate uniformly (without disturbing the coarse aggregate) and does not leave laitance, loosened particles of aggregate, or damaged concrete at the surface. After the joint surface is thoroughly cleaned, it shall be coated with a cement grout of the same proportions as the mortar in the concrete immediately prior to placing fresh concrete. The new concrete shall be well worked against the old face to ensure a sound joint.

9.8.5 Isolation Joints

Isolation joints shall be placed where the floor or pavement adjoins vertical surfaces such as walls, columns, catch basins, manholes, and equipment foundations, in accordance with the Contract Documents.

The joint surface shall be thoroughly cleaned of laitance and scale and dampen before placing adjoining concrete.

9.9 Concrete Preparation and Placement

9.9.1 Concrete Production

9.9.1.1 General

- a) All concrete shall be produced from a controlled fully automatic computerized central plant. The central plant shall be provided by CONTRACTOR or a Ready-Mix Concrete SUPPLIER subcontracted by CONTRACTOR (approved by COMPANY). The rated capacity of the plant shall suit the project execution schedule.
- b) Mixing at the central plant shall conform to the applicable requirements of ASTM C94/C94M, CPMB100-00, ACI 304R, BS EN 206-1, and this Specification.
- c) Concrete shall not be hand-mixed or re-tempered.
- d) Mixing of concrete shall not be done in concrete trucks.
- e) Water shall not be added to increase slump.
- f) No additives or ingredients shall be added to the concrete after batching.
- g) Any proposed change in mix design during the concrete work shall be subject to approval by COMPANY.

9.9.1.2 The Batch Plant shall include the following:

- a) Full computerization.
- b) Full segregation of materials.

- c) Means for materials to be shaded and covered against contamination by air borne chlorides, dust and other contaminants.
- d) Automatic compensation for moisture in fine aggregate.
- e) Adequate ice and chilled water plants.
- f) Fully automated.
- g) Calibration every 3 months for aggregate.
- h) Calibration every 6 weeks for water, cement and admixtures.
- i) Print out of mix design together with actual mix.
- j) Calculation and print out of actual water/cementitious ratio.

9.9.1.3 The mixing machines (scales/meters, etc.) capacity shall be selected such that the required maximum production can be achieved satisfactorily.

- a) The mixer shall be fitted with an approved accurate mechanism for weighing the cement, fine and coarse aggregates, separately.
- b) The mixing machines (scales/meters, etc.) shall be tested and calibrated in accordance with ASTM C94/C94m and BS EN 206-1 for their accuracy by a specialist at regular intervals not exceeding three months or as required by COMPANY. Test certificates shall be provided before the commencement of works and after each test.
- c) The accuracy of the measuring equipment shall be within $\pm 1\%$ of actual reading. The measuring equipment shall be maintained in a clean and serviceable condition.

9.9.1.4 The quantities of all materials used for concrete shall be proportioned by weight.

- a) The weights of fine and coarse aggregates shall be automatically adjusted to allow for any free water contained in them. Accordingly, the amount of water to be added shall be reduced by this amount of free water contained in the aggregates.
- b) Admixtures that have been approved as part of the design mix shall be added by an approved automatic dosing equipment.
- c) Cement when contained in bags, shall be used in such a way that each batch requires a number of whole bags.
- d) Water shall be measured by volume or weight, but either way the delivery shall be a predetermined amount to meet the design water/cement ratio.
- e) The CONTRACTOR shall ensure that the materials used for each batch in the mixer do not exceed the MANUFACTURER's rated capacity for the machine.

9.9.1.5 Mixing shall ensure a uniform distribution of materials and the concrete is of uniform colour and consistency. The mixing shall be continued until the mix is homogeneous.

- a) The time required to produce a homogeneous mix shall be determined by satisfying the requirement of ASTM C 94/C 94M Annex A1.
- b) The mixer and mixing platform shall be suitably protected from the wind to prevent loss of the cement.

9.9.1.6 The machine shall be kept clean, free from any residual material after depositing each batch of concrete and the mixer pan drum shall be washed and cleaned out immediately following the completion of each concreting operation or when changing to a mix with a different type of cement.

9.9.1.7 The batch plant shall be able to provide a computer printout of the following for each truck:

- a) Grade of concrete.
- b) Cement type.
- c) Admixture types.
- d) Actual measurement of all components of water in the mix.
- e) Actual batched weights of cement, aggregates (separately), water and admixtures.
- f) Date and Time of batching.
- g) Calculation of the actual water/cement ratio.

9.9.1.8 Prior to commencement of the work the CONTRACTOR shall furnish the following details to COMPANY:

- a) Name and qualification of SUPPLIER(s).
- b) Certificate of quality assurance.
- c) Quality control facilities/procedures.
- d) Certificate and test reports on concrete production and products.
- e) Source(s) of aggregates, cement, etc.
- f) Quality of water aggregates and cement.
- g) Production capacities.
- h) Description of Plant Equipment and Facilities.

- i) SUPPLIER'S test certificate giving results of tests on aggregates for durability, strength and chloride content shall be submitted by CONTRACTOR to COMPANY at weekly intervals.
- j) Any other relevant data such as workability of concrete, admixtures, etc.
- k) Qualifications of personnel ear-marked for the Project (approved personnel shall not be changed without prior approval of COMPANY).

9.9.1.9 The arrangements for inspection, testing, reporting and verification shall be approved by COMPANY. As a minimum, the controls system implemented shall address the following:

- a) Liaison with the site laboratory so as to ensure that the test status of materials is known.
- b) Supervision and recording of receipt, storage, handling and protection of materials.
- c) Supervision and recording of batching and mixing, including verification of batch computer printouts before trucks are released.
- d) Control of moisture adjustments.
- e) Initial and routine batch plant calibration and maintenance procedure.
- f) Regular reporting formats.

COMPANY will verify that the control system is being implemented and verify the documentation raised, in accordance with an approved system.

The CONTRACTOR'S Batch Plant Manager will be responsible for the control of the quality of all batch plant operations.

9.9.2 Concrete Transportation

9.9.2.1 General

Concrete, after being discharged from the mixer shall be transported as rapidly as possible to its final position by approved means which shall prevent segregation, loss of workability or contamination of concrete constituents.

- a) The concrete shall be placed and compacted in its final position in the form within 60 minutes of the water being added to the mix. Depending on the circumstances and subject to COMPANY approval, the placement time may be increased to 120 minutes with the use of approved retarders and transported in truck mixers with agitators. The addition of water at the point of discharge is prohibited. Re-tempering and further mixing shall not be permitted.
- b) The containers that convey the concrete shall be kept clean and free from hardened or partially hardened concrete at all times.
- c) The use of chutes, spouts, skips and pumps shall be to COMPANY approval.

- d) The use of any aluminium pipe to be in contact with fresh concrete or other conveying equipment containing aluminium is prohibited.

9.9.2.2 Concrete Trucks

- a) Concrete trucks and their manner of operation shall conform to the applicable requirements of ASTM C94/C 94M.
- b) Concrete trucks shall be of a size, design, and required number to accommodate the anticipated placement rates.
- c) Truck mixers shall be of the revolving drum type, watertight, and so constructed that the concrete can be conveyed and discharged at the site maintaining the uniform distribution of materials throughout the operation.
- d) The drum shall be painted white and kept clean to ensure maximum reflectivity.
- e) The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the MANUFACTURER and stamped in metal on the mixer.
- f) In no circumstances shall water from the concrete truck be used in the mix.
- g) Each and every delivery to site shall be accompanied with a computer printout containing the information listed in section 9.9.1.7 of this specification.
- h) Scheduling and dispatching of trucks shall be such that they arrive at the work site just before the concrete is required.
- i) Equipment shall be cleaned at the end of each operation or workday.

9.9.3 Concrete Placement

9.9.3.1 General

- a) The placement of concrete shall be in accordance with ACI 301 or BS 1992-1-1.
- b) Concrete shall not be placed unless the positioning, fixing and condition of the reinforcement and any other embedded items, the cleanliness, alignment and suitability of the containing surfaces have all been previously examined and approved. Adequate time shall be allowed for inspection when scheduling concrete pours.
- c) The concrete temperature when deposited shall not exceed 32°C. The temperature of reinforcement or forms shall not exceed 38°C.
- d) Forms shall be well soaked with water, but no standing water shall be present inside forms when concreting.
- e) A 24-hour notice shall be given to the COMPANY before placing concrete.

- f) The concrete shall be placed in sequences approved by COMPANY and shall be deposited as near as possible to its final position in such a manner as to avoid segregation of the concrete, or displacement of the reinforcement or formwork.
- g) The concrete shall be deposited in regular courses or layer not exceeding 200 mm in thickness when hand compacted and 400 mm thickness when mechanically compacted.
- h) The placement of concrete shall be continuous between specified or approved construction joints.
- i) When placement of concrete has been interrupted or delayed and concrete has gained its initial set and cannot be adequately worked or compacted, subject to COMPANY approval the following procedure shall apply:
 - 1) Horizontal sections:
 - i) The surface of the unfinished concrete shall be thoroughly cleaned, preferably by air and water jetting, to expose the aggregate and washed with cement grout immediately before fresh concrete is added.
 - ii) The first layer of new concrete placed shall not exceed 150mm in depth and particular care shall be taken with the compaction of this layer to ensure a good bond.
 - iii) If an interruption of more than one hour occurs, or is anticipated, during the concreting of a long horizontal member, a stop-end shall be installed at a location approved by the COMPANY to provide a clean vertical surface of the joint. Concreting within the stop-end shall be continued as far as possible to terminate with a horizontal surface at a suitable level or, preferably, to complete the full height of the pour.
 - 2) Vertical columns:
 - i) The unfinished concrete shall be cleaned and left for 12 hours to set before any further concrete is placed.
 - ii) The surface shall be thoroughly cleaned of all loose, foreign matter and all laitance before casting the remaining concrete. Such cleaning may require temporary removal of all or part of the form work.
- j) In the case of an accidental interruption not specified in the drawings, the CONTRACTOR must advise the COMPANY immediately. Such a situation may require partial or complete demolition.
- k) Casting of thin sections such as floor slabs in two layers shall not be permitted.
- l) Concrete that has achieved initial set or has been contaminated by foreign matter shall not be deposited in the structure or foundation.
- m) Concrete shall not be placed during rain unless protection is provided to avoid any changes in concrete design and material properties.

- n) For underwater structures, prior to the pour, a concrete placing plan shall be submitted to the COMPANY for review and approval. Concrete trials to demonstrate the required quality and consistency of the concrete mix shall be provided in accordance with BS 8443 and ACI 304R.
- o) Concrete shall not be allowed to fall-freely from a height more than 1.5m. Greater heights shall require an approved down pipe or chute.
- p) Prior to pouring concrete against an adjacent face (construction joint), the face shall be clean and free of dirt, films, paint, coatings or other foreign matter, and:
 - 1) The adjacent face shall have all laitance to a depth of 2 to 3mm removed, so as the coarse aggregate is exposed.
 - 2) Prior to concreting, the concrete surface shall be wetted so that water is not drawn into from the new concrete.
 - 3) The reinforcement and water bars carefully cleaned and checked for integrity.
- q) The reinforcement and all embedded items shall be adequately secured to prevent movement during the placing or setting of the concrete.
- r) If surface retarder has been used on the concrete, then the MANUFACTURER shall be consulted to determine the length of time before the surface retarder is washed off.
- s) If concrete is placed directly against rock or ground, the fresh concrete shall be protected against intermixing and water suction (blinding concrete, building paper).
- t) Suitable wind breaks shall be erected prior to pouring concrete. These shall be effective in shielding the concrete from drying winds during placing and for the full curing period if curing compound is used or until the wet curing system is in place.

9.9.3.2 Placing by Pump

- a) Unless prevented by access requirements, majority of concrete shall be placed by pumping in accordance with ACI 304.2R or BS 8476:2007. Individual pours less than 2 m³ may be placed by alternative means.
- b) Pumping or pneumatic conveying equipment shall be of a suitable kind with adequate pumping capacity. Pneumatic placement shall be controlled so that segregation does not occur in the discharged concrete. Concrete shall not be conveyed through pipe made of aluminium or aluminium alloy. The following shall apply:
 - 1) The CONTRACTOR shall submit a method statement indicating full details of the pneumatic conveying equipment and operating system. CONTRACTOR shall ensure that pumping shocks shall not be transferred from the pipeline to the formwork, previously laid concrete or the structure.
 - 2) The CONTRACTOR shall demonstrate suitability of each concrete pump and system by submitting the following information for COMPANY approval:

- i) Description of equipment.
 - ii) Concrete mix design, including slumps at pump entry to pipe and at exit from pipe.
 - iii) Concrete temperature at exit from pipe.
 - iv) Stand-by arrangements.
 - v) List of spare parts kept at Site.
- 3) Each pump shall deliver a continuous flow of concrete to the job without air pockets and other voids. Prior to use of a pump for construction activities the CONTRACTOR shall carry out a full-scale test.
- 4) The initial discharge of any pumped concrete shall be discarded and not be incorporated in the permanent works.
- c) Riser and fixed pipe sections of the pneumatic conveying equipment shall be effectively insulated. After each operation the entire equipment shall be thoroughly cleaned.
- d) When concrete is conveyed by chuting or pipes, the size and design of the plant and pipes shall be so selected to ensure continuous flow in the chute or pipe. The slope of the chute or the pressure of the pump shall allow the concrete to flow without the use of any water to produce the required consistency and without causing segregation of the ingredients. The delivery end of the chute or pipe shall be close to the point of deposit.
- e) The chute or pipe shall be thoroughly flushed with water before and after each working period and kept clean. The water used for this purpose shall be discharged outside and away from any permanent works.
- f) Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation and suitable spouts or baffles shall be provided where necessary.
- g) A contingency plan (including facilities), to ensure the continuity of concrete placing in case the pump should fail, shall be submitted for COMPANY review and approval.

9.9.4 Concrete Compaction

- a) Except where otherwise permitted by the COMPANY concrete shall be compacted during placing by approved pattern internal vibrators in accordance with recommendations and guidelines of ACI 309R.
- b) The performance of vibrators shall be such as to suit the working conditions and they shall be selected accordingly. For normal use they shall not be more than 75mm diameter and will be subject to examination by the COMPANY. The radius of influence shall be at least 300mm. The vibrators shall be disposed in such a manner that the whole of the mass under treatment shall be adequately compacted at a speed commensurate with the supply of concrete from the mixers and to the satisfaction of the COMPANY. In confined areas, smaller vibrators shall be used.

- c) Internal vibrators should penetrate the full depth of the layer of concrete placed and compaction of newly placed concrete layer shall extend to upper 100mm of the underlying layer to ensure a proper mixing.
- d) Vibration is not to be applied directly or indirectly to concrete after the initial set has taken place.
- e) External vibrators shall not be used without the permission of the COMPANY. The power supply to drive the vibrator(s) must be "spark free" etc., for use in live gas/oil plant. If external vibrators are permitted to be used for concrete compaction, the type of vibrator, design of formwork and method of fixing the vibrator shall be approved by the COMPANY.
- f) Vibrators shall not be allowed to touch the reinforcement as this can create voids under horizontal bars.
- g) Concreting shall not be started without standby arrangement of compactor and vibrators.

9.10 Mass Concrete

Mass concrete is defined in clause 8.1.6. The following shall apply:

- a) For mix design, the control method statement shall be subject to COMPANY approval.
- b) Requirement for mass concreting shall be in accordance with ACI 207.1R, ACI 207.2R and ACI 207.4R.
- c) The temperature of concrete at the point of discharge shall not exceed 26°C.
- d) The maximum peak temperature in the inside of the concrete pour shall not exceed 70 °C.
- e) The temperature gradient between the inside and outside faces of the concrete shall not exceed 20°C.
- f) Curing duration for mass concreting shall be as per ACI 308 section 3.3.
- g) Observe bleeding and the general condition of the concrete during the pour.
- h) Implement protective measurements, insulation and curing to avoid crack formation.
- i) After removal of formwork, check on crack formation.
- j) When forms are removed before the specified curing is completed, measures shall be taken to continue the curing and provide adequate thermal protection for the concrete.

9.11 Extreme Weather Provisions

- a) Concrete placed in ambient air temperatures 32°C or higher shall follow ACI 305.1, Specification for Hot Weather Concrete.

- b) If the ambient temperature is expected to be high (hot weather concreting) at the time of casting or in the curing period, precautions shall be taken to protect the concrete against damaging effects (e.g. drying out or excessive shrinkage).
- c) Concrete shall not be placed when the temperature of reinforcement or forms exceeds 38°C, then items shall be sprayed with water prior to placing concrete.
- d) From June 1st until Sept 30th, placing concrete shall preferably be in the early morning hours or late evening/night hours. Approval shall be sought from the COMPANY before placing concrete at any other time.

9.12 Finishing

The concrete finish shall be without objectionable surface fins, holes, or rough patches.

9.12.1 Unformed Surfaces

The unformed surface finishes shall be as shown in Table 9-5 unless otherwise specified.

Table 9-5 – Concrete Unformed Surface Finishes

Surface	Finish
Area Paving	Broom or Belt
Compressor house floors	Broom or Belt
Cooling tower basin, Flume	Floated
Curbs	Broom or Belt
Foundations and pedestals to be grouted	Scratched
Foundations and pedestals to be coated	Floated
Equipment bases	Floated
Floor Slabs	Trowelled
Garage floors, ramps	Broom or Belt
Platforms	Broom or Belt
Stair steps and landings, exterior platforms, pedestrian ramps	Nonslip
Surface requiring plastering or tiling	Scratched
Surfaces to receive bonded applied cementitious finishes	Scratched
Surfaces to receive roofing, waterproofing membrane, sand bed terrazzo	Floated

9.12.1.1 The specified finishes for unformed surfaces shall conform to the following:

a) Floated Finish

After the concrete has been placed, consolidated, struck off, and levelled, the concrete shall not be worked further until ready for floating. Floating with a hand float or with a bladed power trowel equipped with float shoes, or with a powered disc float shall begin when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. During or after the first floating, planeness of surface shall be checked with a 3000mm straight edge applied at not less than two different angles. All high spots shall be cut down and all low spots filled during this procedure to produce a surface within Class B tolerance as per Table 9-6. The slab shall then be re-floated immediately to a uniform sandy texture.

b) Trowelled Finish

The surface shall first be float-finished as specified in section 9.12.1.1 (a). It shall next be power trowelled, and finally hand trowelled. The first trowelling after power floating shall produce a smooth surface that is somewhat free of defects, but which may still show some trowel marks. Additional trowelling shall be done by hand after the surface has hardened sufficiently. The final trowelling shall be done when a ringing sound is produced as the trowel is moved over the surface. The surface shall be thoroughly consolidated by the hand trowelling operations. The finished surface shall be essentially free of trowel marks, uniform in texture and appearance and shall be plane to a Class A tolerance, except tolerance for concrete on metal deck shall be Class B as per Table 9-6.

On surfaces intended to support floor coverings, any defects of sufficient magnitude to show through the floor covering shall be removed by grinding.

c) Broom and Belt Finish

Immediately after the concrete has received a float finish as specified in section 9.12.1.1 (a), it shall be given a coarse transverse scored texture by drawing a broom or burlap belt across the surface.

d) Scratched Finish

After the concrete has been placed, consolidated, struck off, and levelled to a Class C tolerance as per Table 9-6, the surface shall be roughened with stiff brushes or rakes before the final set.

e) Nonslip Finish

Where the contract documents require a nonslip finish, the surface shall be given a Dry-Shake application, as specified in section 9.12.1.1 (f), using crushed ceramic bonded aluminium oxide or other specified selected abrasive particles. The rate of application of such material shall not be less than 1.25 Kg per m².

f) Dry-Shake Finish

Dry-Shake application (for nonslip finish) shall use a metallic or mineral aggregate. The aggregate shall be blended with Portland cement in the proportions recommended by the aggregate MANUFACTURER.

Approximately two-thirds of the blended material for the required coverage shall be applied to the surface by a method that ensures an even application without segregation. The surface shall be given a float finish as specified in section 9.12.1.1 (a), immediately after the application of the first dry shake.

The remainder of the blended material shall then be applied to the surface at a right angle to the previous application.

The second application shall be heavier in areas not sufficiently covered by the first application. This shall be followed immediately by a second floating. After placement of dry-shake material, the operation shall be completed with a final broom, float, or trowel finish, as specified in the contract documents. Concrete to receive the dry shake shall be non-air entrained concrete.

9.12.1.2 Surface Classes

Tolerance classes for unformed surfaces shall be as shown in Table 9-6.

Table 9-6 - Tolerance Classes for Unformed Surfaces

Surface Class	Tolerance
Class A	Finish shall be true planes within 5mm in 3000mm as determined by a 3000mm straightedge place anywhere on the slab in any direction.
Class B	Finish shall be true planes within 8mm in 3000mm as determined by a 3000mm straightedge placed anywhere on the slab in any direction.
Class C	Finish shall be true planes within 6mm in 600mm as determined by a 600mm straightedge placed anywhere on the slab in any direction.
Special- floors subject to wheel loads	Finish shall be 3mm in 3000mm as determined by a 3000mm straightedge placed anywhere on the slab in any direction including across movement joints.

9.12.2 Formed Surfaces

Unless otherwise specified in the contract documents, the following finishes shall be used as applicable:

- a) Rough form finish:
For all concrete surfaces not exposed to public view and that will not receive protective coating.
- b) Smooth form finish with smooth rubbed finish:
For all concrete surfaces exposed to public view or surfaces that will receive protective coatings.

9.12.2.1 The specified finishes for formed surfaces shall conform to the following:

a) Rough Form Finish

Form facing materials shall be approved for rough form finish surfaces. Tie holes and defects shall be patched. Fins exceeding 6mm in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms. When membrane waterproofing is to be applied all fins and protrusions shall be removed.

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 acceptable 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 minimum as practically as possible. It shall be supported by studs or other backings capable of preventing excessive deflection. Material with raised grain, torn surfaces, worn edges, patches, dents, or other defects that will impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched to the satisfaction of the DESIGNER. All fins shall be completely removed.

c) Smooth Rubbed Finish

Smooth rubbed finish shall be produced on newly hardened concrete no later than the day following form removal. Surfaces shall be wetted and rubbed with carborundum rubbing brick or other abrasive until uniform colour and texture are produced. No cement grout shall be used other than the cement paste drawn from the concrete itself by the rubbing process.

d) Grout Cleaned Finish

No cleaning operations shall be undertaken until all contiguous surfaces to be cleaned are completed and accessible. Cleaning while the work is on progresses shall not be permitted. The grout mix shall contain 1 part Portland cement and 1½ part fine sand with sufficient water to produce a grout capable of receiving thick paint, where applicable. White Portland cement shall be substituted for a part of the grey Portland cement in order to produce a colour matching that of the surrounding concrete, as determined by a trial patch.

The surface of the concrete shall be made wet sufficiently to prevent absorption of water from the grout. The grout shall be applied uniformly using brushes or a spray gun. Immediately after applying the grout, the surface shall be scrubbed vigorously with a cork float or stone to coat the surface and fill all air bubbles and holes. While the grout is still plastic, all excess grout shall be removed by working the surface with a rubber float, burlap, 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.

e) Cork Floated Finish

Forms and ties shall be removed at an early stage, within 2 to 3 days of placement, where possible. All burrs and fins shall be removed. A stiff mortar shall be provided by mixing 1 part Portland cement and 1 part fine sand with sufficient water. Dampen wall surface. The mortar shall be applied on dampened wall surfaces with a firm rubber float or trowel, filling all surface voids. The mortar shall be compressed into voids using a slow-speed grinder or stone. If the mortar surface dries too rapidly to permit proper compaction and finishing, a small amount of water shall be applied with a fog sprayer. The final texture shall be produced with a cork float using a swirling motion.

f) Special Architectural Finish

Textured finish, exposed aggregate finish, and aggregate transfer finish are architectural concrete finishes and shall be produced in accordance with the requirements of the contract documents.

9.12.3 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 consistent with that of formed surfaces. Final treatment on formed surfaces shall continue uniformly across the unformed surfaces.

9.13 Curing

9.13.1 General

Curing and protection shall be in accordance with ACI 301, ACI 305.1 and ACI 308R or BS EN 1992-2 and BS 8500-2. The following shall apply:

- a) Water used for concrete curing shall comply in all respects with the requirements of BS EN 1008 or ACI 308R and this specification.
- b) Minimum curing period for concrete with ggbs/micro silica shall not be less than 10 days.
- c) The use of curing compounds shall be permitted subject to COMPANY approval and shall comply with the requirements of ASTM C309-19. However, it shall be applied after minimum 7 days of wet curing, for concrete with ggbs/micro silica.
- d) Hessian shall be in accordance with AASHTO M182 and shall weigh a minimum of 0.3 kg/m².
- e) Impervious sheeting shall be minimum 0.10mm thick, white opaque, polyethylene in accordance with ASTM C 171.
- f) Efficient monitoring to ensure that curing is continuous and effective throughout the curing period shall be properly scheduled and supervised.

9.13.2 Horizontal Surfaces

Every part of the exposed surface shall be covered with a layer of sealed polyethylene per ASTM C171 or similar impermeable sheeting immediately after finishing. The sheeting shall be in close contact with the concrete, unless some initial separation is necessary to obtain a particular surface finish. The sheets shall overlap adjacent sheets at the edges by at least 400mm, and they shall be fixed down at the ends and edges to prevent air circulation over the concrete. The following shall apply:

- a) As soon as the concrete has stiffened sufficiently and after not more than 6 hours, the sheeting layer shall be completely replaced with a layer of wet hessian or absorptive mats covered with a layer of sealed polyethylene or similar impermeable sheeting.
- b) Additional water shall frequently be introduced under the sheeting in order to keep the hessian thoroughly and permanently wet.
- c) When it is impossible to cover the whole of the surface closely with wet hessian (e.g. where a lot of starter bars protrude from it), pounding with water of the quality recommended for mixing is an acceptable alternative. Water shall be renewed regularly to ensure that salt concentration in the water is not increased by evaporation.

9.13.3 Vertical Surfaces

Immediately after concrete placement, metal formwork shall be kept continuously wet until formwork is removed, and normal curing can commence. The following shall apply:

- a) Directly upon removal of the formwork, the concrete shall be closely wrapped with wet hessian and enclosed with sealed polyethylene sheeting. Battening shall be used to keep both hessian and polyethylene lightly in contact with the concrete surface. Care shall be taken to ensure that pressure from the battens does not impede the downward flow of water within the hessian layer.
- b) Additional water shall continuously be introduced on the hessian by means of trickle water hoses in order to keep the hessian thoroughly and permanently wet.
- c) If striking operation of large vertical areas is planned to take longer than 4 hours, all exposed concrete must be continuously sprayed with water until the curing system is installed. Alternatively, if practicable the curing system shall be installed as the formwork striking operation proceeds.

9.13.4 Inaccessible Areas

Curing compound may be used on slab soffits, elevated beams sides and soffits, inaccessible column faces and high shear walls. The following shall apply:

- a) Curing compound shall be sprayed on the surfaces immediately upon stripping the formwork in accordance with the MANUFACTURER's recommendations, with care to be taken to ensure the required rate of spread is achieved. Brushing is generally better than spraying.
- b) The curing compound must be compatible with any future finishes, where required, or otherwise to be totally removable.

9.13.5 Large Foundations

Particular attention shall be given to the curing of large foundations, typically those for compressors and other heavy machinery that extend above ground level. At the point of placement, the fresh concrete shall be protected from drying winds and solar radiation by the provision of a PVC or similar tented shelter which shall remain in place throughout the curing period. The tent shall cover the entire foundation and shall be constructed such that the operation can be carried out whilst it is in place.

To prevent early drying and cracking, the relative humidity shall be kept high and the concrete surfaces kept moist by spraying with clean water and covered with wet hessian.

9.14 Protection of Concrete Surfaces

All concretes, except top surfaces of general paving areas shall be protected in accordance with Table 9-7.

All membranes and/or protective coatings shall be applied after completion of curing and adequate drying time of the concrete surface. The surface moisture content shall be less than 4% by volume up to 20mm deep or as per the coating MANUFACTURER's recommendations, whichever is governing. Concrete surfaces shall be free from contamination such as oil, grease, loose particles, surface laitance, form release agents and curing compounds. Concrete surfaces shall be lightly grit blasted or power washed if/as required by the coating MANUFACTURER. The following shall apply:

- a) Honey combing, blowholes, hairlines cracks, and other surface imperfections shall be filled and repaired prior to any coating application.
- b) All coating systems and extent of coatings shall be in accordance with this specification and Engineering drawings.
- c) The concrete work SUBCONTRACTOR shall have a minimum of 5 years' experience in the preparation and installation of concrete protective coatings.
- d) All coatings shall be installed in strict compliance with the MANUFACTURER's instructions. This shall include surface preparation, priming, application, curing and protection. A detailed method statement shall be submitted.
- e) To ensure MANUFACTURER's recommendations and instructions are fully understood and followed, a pre-construction meeting shall be held with the coating MANUFACTURER and concrete work SUBCONTRACTOR representatives.
- f) All submissions of membranes and coatings shall be accompanied by independent test certifications that verify properties of the submitted products.

Table 9-7- Protection of Concrete Surfaces

Application		Protection System	Material Specifications	
			Properties	Limit
1) Below ground concrete	a) Where groundwater is high (Ground Water Table ranges from grade level to a depth of 2.0m below the foundation formation level)	All surfaces shall be encapsulated with one layer of minimum 1.5mm thick self-adhesive, high density polyethylene laminated bitumen sheet membrane	Elongation (Film) ASTM D638	170%
			Tear Resistance (both direction) ASTM D1004	270 N/mm
			Adhesion to Self ASTM D1000	1.8 N/mm ²
			Adhesion to Primed Concrete ASTM D1000	1.8 N/mm ²
			Puncture Resistance ASTM E154	225 N
			Moisture Vapour Transmission ASTM E96	<0.3g/m ² /24 hr
			Crack bridging ASTM C836	1.5mm
			Adhesive softening point ASTMD36	>100 ⁰ C
			Tensile strength: longitudinal Tensile strength: transverse	6.3 N/mm ² 4.8 N/mm ²
		- The extent of membrane, details at interface with above ground protection, termination at blinding, etc. shall be as per COMPANY standard drawings. - The membrane shall be protected from damage due to construction activities and backfilling by covering with a protection board of 3.5mm thick bitumen impregnated fibreboard or 12mm thick bitumen impregnated soft board.		
	b) Where ground water table is high but membrane is not feasible (e.g. small miscellaneous foundations)	Two coats of pitch free epoxy resin (Total DFT= 500 microns)	Solids Content	100%
			Specific Gravity	1.35
			Water Absorption ASTM D570	Nil
			Adhesion Strength ASTM D4541	>1.0 N/mm ²
			Abrasion resistance ASTM C944	0.1 g
	The small miscellaneous foundations include stair/ladder footings, non-equipment footings less than 2m by 1m in plan, and non-hydrocarbon piping service pipe sleepers less than 300mm wide by 500mm depth.			
	c) Where groundwater is low (Ground Water Table deeper than 2.0m below the foundation formation level)	Two coats of pitch free epoxy resin (Total DFT= 400 microns)	As above in 1b	As above in 1b

Application		Protection System	Material Specifications	
			Properties	Limit
2) Above ground concrete	a) All above ground Surfaces except for 2b below.	- Primer: a penetrating silane siloxane hydrophobic primer applied as a flood coat at a rate of 0.4 liters/m ² - Two coats of an acrylic polymer coating system of 150 microns (DFT) each	Solid contents by Volume	>50%
			Reduction in chloride ion penetration AASHTO T259	>92%
			Moisture Vapour Transmission	45g/m ² /24hr
			Reduction in water absorption ASTM C642	>82%
			CO ₂ diffusion resistance, equivalent thickness of concrete (Taywood Method), BSEN 1062-6	>500mm
			Chloride ion diffusion coefficient (Taywood Method)	No chloride diffusion after 60 days
			Bond Strength BSEN 1542, ASTM D7234	≥1 N/mm ²
			Crack bridging ability of the coating system BSEN1062-7	Class B2
	b) All surfaces subjected to occasional chemical/hydrocarbon spillage	- Primer compatible with subsequent coats - (i) One coat of solvent free epoxy coating (DFT=200 microns) - (ii) Two coats of UV resistant polyurethane (DFT=75 microns each)	For (i)	
			Solid contents by volume	100%
			Water absorption ASTM C642	Nil
			Resistance to CO ₂ diffusion BSEN 1062-6	No carbonation
			Resistance to chloride ion penetration (Taywood Method)	100%
			Bond strength BSEN 1542, ASTM D7234	≥1 N/mm ²
			For (ii)	
			Solid contents by volume	>50%
			Water absorption ASTM C642	NIL
			Resistance to CO ₂ diffusion BSEN 1062-6	1.0x10 ⁻⁷ cm ² /s
			Resistance to chloride ion penetration (Taywood Method)	100%
			Bond strength BSEN 1542, ASTM D7234	≥1 N/mm ²

Application		Protection System	Material Specifications	
			Properties	Limit
3) Other applications	a) Surfaces subject to continuous contact with chemical effluent (e.g. neutralization pit, etc.)	- Primer compatible with subsequent coats - Lining, minimum 5mm thick, of solvent free epoxy mortar with silica aggregates - One coat of chemical resistant epoxy Novalac coating (DFT=250 microns)	Resistance to sulphuric acid	15%
			Resistance to hydrochloric acid	25%
			Resistance to caustic/bleach	100%
			Bond strength	≥1 N/mm ²
			Water absorption ASTM D570(*)	Nil
			Abrasion resistance(*)	<0.1mg/cycle
			(*) Applicable for Novalac coating only	
	b) Internal surfaces of Sulphur pits	- Walls and pit floor: 100 mm thick refractory castable with SS anchors. - Soffit of the pit roof slab: 3mm thick stainless steel lining throughout, with 75mm insulation.	- Stainless steel lining Grade ASTM A316L - Anchors - SS V-anchors, complying with AISI 310 (min. 6mm dia., 75 mm length, max. spacing of 300 mm c/c) - Refractory castable - Acid resistant with minimum temperature resistance of 700⁰ C. - Insulation - Rigid insulation complying to ASTM C610	Tensile strength ≥ 515 N/mm ² Tensile strength ≥ 600 N/mm ²
			- The thicknesses of castable/insulation shall be suitable for achieving the resulting temperature of less than 50°C on internal concrete surface. - The thermal calculation verifying the same shall be submitted for COMPANY approval	
			External surfaces protection as per applicable below ground system.	
	c) Internal surfaces of concrete water structures: (e.g. cooling water, sanitary/storm water, oily water, etc.)	Acrylic modified cementitious flexible waterproof coating (DFT=2mm)	Bond strength ASTM D4551	≥1 N/mm ²
			Chloride ion diffusivity	Not measurable after 24 months
			Depth of water penetration under pressure BS EN 12390 Part 8	Nil
			Water permeability BS EN 1062-3	<0.1kg/(m ² xh ^{0.5})
			Carbon dioxide permeability BS EN 1062-6 Method A	>50m
	External surfaces protection as per applicable below ground system			

d) Internal surfaces of cooling water structures for extended turnaround period of up to 10 years.	<u>Option 1:</u> Pure polyurea elastomeric waterproof coating (DFT=2mm)	Solids by volume	100%
		Tensile strength ASTM D412	>19 N/mm ²
		Tear resistance ASTM D624	86 N/mm
		Elongation ASTM D412	>300%
		Abrasion ASTM D4060	<0.036mg/cycle
	<u>Option 2:</u> Hybrid Xolutedec coating system consisting of: - Two component penetrating primer (DFT=0.2mm) - Two component crack-bridging membrane (DFT=0.8mm)	Adhesion to concrete BS EN 1542	>2 N/mm ²
		Tensile strength BS EN ISO 527-1/-2	>20 N/mm ²
		CO2 permeability BS EN 1062-6	>50m
		Water vapour permeability BS EN ISO 7783	>50m
		Water permeability BS EN 1062-3	<0.1kg/(m ² xh ^{0.5})
		Abrasion resistance - Taber test (mass loss) BS EN ISO 5470 -1	<3000mg
	External surfaces protection as per applicable below ground system		
Notes: - Concrete surface preparation, application, and minimum drying time of coating and temperature at time of application shall be as per Manufacturer's recommendation.			

9.14.1 Preparatory Layers under Foundations and Bases

- a) All foundations and bases of underground structures (sumps /pits/ manholes/ culverts/ etc.) where ground water is high shall be installed on the following layers (placed in same sequence):
- 1) Vapour barrier, polyethylene sheet of 0.25mm thick. Overlaps shall not be less than 150mm
 - 2) 50mm thick layer of blinding concrete with minimum 100mm projection from the edge of foundation/base
 - 3) 1.5mm thick membrane as in Table 9-7, application -1a
 - 4) 30mm layer of screed (can be replaced with 5mm thick hard polypropylene based protection board or similar approved, subject to COMPANY approval).
- b) All foundations and bases of underground structures (sumps /pits/ manholes/ culverts/ etc.) where ground water is low, and slabs on ground for buildings shall be installed on the following layers (placed in same sequence):
- 1) Vapour barrier, polyethylene sheet of 0.25mm thick. Overlaps shall not be less than 150mm.
 - 2) 50mm thick layer of blinding concrete with minimum 100mm projection from the edge of foundation/base.

- c) Paving slabs shall be installed on a vapour barrier-polyethylene sheet of 0.25mm thick, overlaps shall not be less than 200mm. Vertical sides of slabs shall be coated with pitch free epoxy resin (Total DFT= 500 microns) as in Table 9-7, application -1b.

9.15 Liquid Retaining Structures

9.15.1 General

Construction of liquid retaining structures shall conform to ACI 301 or BS EN1992-3 in conjunction with BS EN1992-1-1. Any structure designated as a hydraulic (liquid containing) structure on the Engineering drawings shall comply with the following:

- a) Hydraulic structures shall be cured by a wet-cure procedure only (e.g., use of ponding, sprinkling, or a moisture-retaining fabric).
- b) Moist wood forms in contact with concrete shall not be considered as curing for hydraulic structures.
- c) Immediately after placement, concrete shall be protected from premature drying, excessive high or low temperatures, rain, flowing water, or mechanical damage.
- d) Curing shall occur for a minimum of 14 days.

9.15.2 Water Tightness Test

All liquid retaining structures, underground pits, basins, sumps, manholes, etc. subjected to ground water table influence, shall pass a water-tightness test. This test shall be conducted prior to application of protection system by filling up the structure with water to the top in accordance with ACI 350-1 and maintaining for a period of at least 48 hours. A method statement shall be provided for COMPANY approval.

9.15.3 Fire Protection of Waterstops

Where expansion joints are required in accordance with Engineering drawings, waterstops shall be protected for fire on external surfaces of the structure. This shall be achieved by application of an approved built-in fire rated sealant or alternative methods subject to COMPANY approval.

9.16 Fibre Reinforced Concrete

9.16.1 Methods of Preparing Fibre Reinforced Concrete

The preparation method for fibre reinforced concrete depends on the quantity of work and nature of the application such ground bearing concrete slabs. Fibres can be used in various ways such as manual mixing, and site mixing using batch plants.

a) Manual Mixing

In this method, initially the required quantity of fibres is added to mixing water. The water shall be stirred continuously to ensure fibres have been separated from each other and dispersed evenly.

The water in which fibres are dispersed shall then be added immediately to the dry mix ingredients to prepare the concrete depot.

b) Batch Plant

When large amount of concrete is required, usually batch plants are used. In this procedure, the required mixing water is added to mixer vessel and the required quantity of fibres is added to the rotating drum. All other ingredients such as sand, gravels, and cement shall then be added and rotated until a homogenous concrete is prepared and ready for use.

9.16.2 During the mixing process the reinforcing fibres shall be uniformly and rapidly dispersed without balling or agglomeration.

9.17 Precast Concrete

All precast members shall comply with this specification and the applicable requirements of ACI 318, ACI 301, and BS EN 1992-1-1. In addition, the following requirements shall apply:

- a) The production schedule shall allow for curing precast concrete in accordance with this specification. Slings, transporting, stacking and installation shall take place when the required concrete strengths have been attained. Precast members shall not be lifted or handled within 72 hours of the completion of pouring and finishing.
- b) Structures and members shall be handled and supported carefully at positions in a manner that does not compromise the integrity of the member.
- c) A lifting and erection procedure for precast wall members shall be submitted to COMPANY for review. Once accepted, no other method shall be used during the entire period of construction, unless specifically approved by COMPANY.
- d) Connections for precast members shall be in accordance with ACI 550.2R and shall be approved by COMPANY.
- e) Installation details including location and assembly drawings showing every aspect of the construction, incorporated components and features shall be submitted for COMPANY approval.
- f) Cement/sand mortar for bedding and jointing members shall be of equivalent strength, quality and colour to that of the member being bedded or jointed. Cement/sand mortar shall be mixed in small quantities and used immediately. Particular attention shall be paid to compact the cement/sand mortar to prevent the formation of voids and air pockets.
- g) Where precast units have projecting reinforcement, the moulds shall be raised on stools above the general level of the pre-casting yard.
- h) All units shall be marked on a face which will not be exposed in the permanent position, with the date of manufacture and such distinguishing letters or numbers required for erection identification.

9.18 Concrete Repair

The concrete surfaces shall be sound, solid and free from defects. All corners (except underside of foundation) shall have a 25 x 25 mm chamfer. Concrete surfaces shall not be repaired or touched up after the removal of formwork until the surfaces have been inspected and released in accordance with the quality procedures. The following shall apply:

- a) Before starting any concrete work, a repair method statement shall be developed and submitted to the COMPANY for review and approval. The following shall apply:
 - 1) The repair materials shall be based on cement types.
 - 2) The cured mortar colour shall be approximate to the colour of cured parent material.
 - 3) No rendering of imperfect concrete faces shall be allowed and any concrete that is defective in any way (including colour) is to be cut out and replaced to such depths or be made good in such manner as the COMPANY may direct.
 - 4) Any concrete that is damaged or unsound shall be demolished if necessary and shall be repaired and re-instated.
 - 5) Repair shall not proceed until concrete has been fully cured.
 - 6) Only the highest quality materials compatible with the parent concrete shall be used for the repair.
- b) For any cracks observed post formwork removal (other than minor hairline & shrinkage cracks), CONTRACTOR shall furnish his corrective proposals for COMPANY review and approval, prior to proceeding with any repair works. The cracks are deemed as hairline/shrinkage cracks if the crack width is less than 0.1mm
- c) Tie holes shall be patched with waterproofing materials in accordance with MANUFACTURER's recommendations.
- d) Repair of surface defects other than tie holes shall comply with the requirements of ACI 301 clause 5.3.7.3 and BS EN 1504-9, or an approved equivalent standard.

10.0 CATHODIC PROTECTION FOR STEEL IN CONCRETE

For the design philosophy and description of the construction details for cathodic protection of the reinforcement reference shall be made to ADNOC Specification 'Design, Installation, Commissioning and Monitoring of Cathodic Protection for Plant Facilities'.

11.0 PREPARATORY WORK AND EXISTING SERVICES

11.1 Preparatory Work

- a) Setting out of work and foundation earthworks including grade preparation, excavation and backfilling shall be in accordance with the "Specification for Site Preparation and Earthworks" and site specific Geo-Technical report.

- b) All work shall be set out accurately from datum and benchmarks. During execution the correct position, level and alignment of all parts of the work shall be ensured at all times.
- c) The CONTRACTOR shall co-operate in preserving all control benchmark monuments and stakes, and other markers establishing lines, elevations, slopes, etc. The CONTRACTOR/ SUBCONTRACTOR shall replace at no cost to the COMPANY, monuments, stakes, and other markers which he disturbs or destroys during the course of his work.
- d) The COMPANY may check lines, grades, and locations established by the CONTRACTOR. The CONTRACTOR shall be responsible for the accuracy of their work.

11.2 Existing Services

- a) Before beginning work, the CONTRACTOR shall ascertain the nature and location of all existing above and underground services and facilities on site and in adjacent areas by inspecting available plans or, if necessary, by hand excavation. The COMPANY will make available, for review, any existing layout drawings which cover the area of work. CONTRACTOR will be responsible for confirmation, or otherwise, of any such information given.
- b) The CONTRACTOR shall take every precaution including providing temporary supports, bridging, shoring, and safety barriers to protect the existing services and facilities from damage or interference during construction. The CONTRACTOR's precautions shall be subject to approval by the COMPANY. The stability of supports, bridging, shoring, etc., shall be proven by calculation based on realistic and available data.
- c) The CONTRACTOR shall notify the COMPANY in writing if any previously unrecorded services or other objects are discovered before or during construction.
- d) The CONTRACTOR shall record and give to the COMPANY accurate description, dimensions, location, and elevations related to reference datum and other relevant details of such services.
- e) A certificate or permit shall be obtained from the COMPANY, indicating that services have been cut off and made safe and specifying any services or other facilities adjacent to site including related safety aspects and measures which must be maintained during the execution of the work.
- f) The CONTRACTOR shall confirm independently that service have in fact been cut off and made safe.
- g) When the CONTRACTOR needs to block drainage paths during construction, they shall provide temporary or permanent alternate routing during construction and restore the drainage to the satisfaction of COMPANY when construction is complete.
- h) When the SUBCONTRACTOR accidentally damages existing structures or facilities, they shall repair or replace them at no cost and time impact and to the satisfaction of COMPANY.
- i) Suitable temporary roads shall be laid to provide access for all construction activities and should preferably coincide with permanent routes.

12.0 MATERIAL AND CERTIFICATES

12.1 Material Sources

- 12.1.1 All material sources shall be approved by company. All materials must be selected from the approved sources.
- 12.1.2 The CONTRACTOR shall submit full details of each proposed material a minimum of two weeks prior to establishing the mix designs to allow detailed COMPANY review. Submittals shall include the following:
- a) MANUFACTURER'S details.
 - b) Fully detailed data sheets showing all chemical and physical information.
 - c) Recent test results (not more than 3 months old).
 - d) Detailed technical assessment, which confirms that all materials meet the requirements of this Specification.
 - e) Details of MANUFACTURER'S Quality Assurance System.
 - f) Details of MANUFACTURER'S Quality Control Procedures.

The CONTRACTOR shall submit an "Affidavit of Compliance" before beginning construction. The affidavit shall confirm that all material meets the requirements of this Specification.

13.0 SUBCONTRACTORS/SUBVENDORS

- a) The CONTRACTOR shall assume unit responsibility and overall guarantee for the concrete supply and construction.
- b) It is the CONTRACTOR'S responsibility to enforce all Purchase Order and General Specification requirements on its SUBCONTRACTORS/VENDORS.
- c) The CONTRACTOR shall submit all relevant SUBCONTRACTORS/VENDORS engineering data to the COMPANY.
- d) The CONTRACTOR shall obtain and transmit all SUBCONTRACTORS/VENDORS warranties to the COMPANY.

14.0 DOCUMENTATION/MANUFACTURER DATA RECORDS

Not Applicable.

SECTION D

APPENDIX: 1 ADDITIONAL SPECIFIC REQUIREMENTS - SPECIFIC TO A PARTICULAR APPLICATION OR BUSINESS UNIT (LIKE OFFSHORE OR PETROCHEMICAL)

Not Applicable.

APPENDIX: 2 SPECIFIC LESSONS LEARNT

Not Applicable.