



Exploration & Production

GENERAL SPECIFICATION

CIVIL WORKS

GS EP CIV 300

Reinforced and prestressed concrete

04	10/08	General review
03	10/07	Update of Reference documents and change of sections 3, 4, 5, 6, 7, 8, 9 and 11
02	10/05	Addition of "EP" root to GS identification
01	09/03	Change of Group name and logo
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1. Scope

This specification defines the minimum requirements applicable to the construction of reinforced and prestressed concrete structures.

Nonetheless some equipment and/or works may present particular problems. In such a case the COMPANY reserves the right to modify the general specifications or supplement them with particular specifications.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Where there are national regulations, their particular requirements, and those of the standards or codes to which they refer, must be applied, supplementing or amending the provisions of this document.

If there are no mandatory national regulations, international regulations, standards and codes shall be applied.

If there are no applicable international standards and codes, the national standards and codes shall be chosen from those listed below according to the projects in hand and shall be defined in the job specification.

In the absence of any particular specifications from the OWNER, French national regulations shall be applied.

In the absence of a specific exemption, duly justified by the CONTRACTOR and agreed by the OWNER, codes and standards of different origins may not be used in whole or in part.

If certain points in these regulations need to be clarified, the CONTRACTOR shall describe and justify the changes and/or additions to be made so that they can be adapted to the nature and environment of the structure. Such proposals shall be considered acceptable only when they have been examined and approved by the COMPANY.

A definitive list of regulations, standards and codes proposed by the CONTRACTOR shall be taken from the reference documents defined in this specification and the project's job specification.

Only the main standards are mentioned; the CONTRACTOR shall be responsible for compliance with any secondary standards. The list provided in this document should not be regarded as exhaustive.

Unless otherwise indicated in specific contractual conditions, for all documents cited for reference and their addenda, the latest issue applies.

Standards

International standards and codes

Reference	Title
ISO 1803	Building construction - Tolerances - Expression of dimensional accuracy - Principles and terminology
ISO 1920-1	Testing of concrete – Part 1: Sampling of fresh concrete
ISO 1920-2	Testing of concrete – Part 2: Properties of fresh concrete
ISO 1920-3	Testing of concrete – Part 3: Making and curing test specimens
ISO 1920-4	Testing of concrete – Part 4: Strength of hardened concrete
ISO 1920-5	Testing of concrete – Part 5: Properties of hardened concrete other than strength
ISO 1920-6	Testing of concrete – Part 6: Sampling, preparing and testing of concrete cores
ISO 1920-7	Testing of concrete – Part 7: Non-destructive tests on hardened concrete
ISO 2736	Concrete tests - Tests specimens
ISO 3443	Tolerances for building
ISO 3443-1	Tolerances for building – Part 1: Basic principles for evaluation and specification
ISO 3443-2	Tolerances for building – Part 2: Statistical basis for predicting fit between components having a normal distribution of sizes
ISO 3443-3	Tolerances for building – Part 3: Procedures for selecting target size and predicting
ISO 3443-4	Tolerances for building – Part 4: Method for predicting deviations of assemblies and for allocation of tolerances
ISO 3893	Concrete – Classification by compressive strength
ISO 4103	Concrete - Classification of consistency
ISO 4108	Concrete - Determination of tensile splitting strength of test specimens
ISO 4109	Fresh concrete - Determination of the consistency - Slump test
ISO 4110	Fresh concrete - Determination of the consistency - Vebe test
ISO 4111	Fresh concrete - Determination of the consistency - Degree of compactibility (Compaction index)
ISO 4848	Concrete - Determination of air content of freshly mixed concrete - Pressure method
ISO 6105-1	Blanks for superabrasive cutting-off wheels – Part 1: Manually guided cutting-off in building and civil engineering
ISO 6105-2	Blanks for superabrasive cutting-off wheels – Part 2: Hand-held cutting-off in building and civil engineering
ISO 6275	Concrete, hardened - Determination of density

Reference	Title
ISO 6276	Concrete, compacted fresh - Determination of density
ISO 6782	Aggregates for concrete - Determination of bulk density
ISO 6783	Coarse aggregates for concrete - Determination of particle density and water absorption - Hydrostatic balance method
ISO 6784	Concrete - Determination of static modulus
ISO 6934	Steel for the prestressing of concrete
ISO 6935	Steel for the reinforcement of concrete
ISO 7033	Fine and coarse aggregates for concrete - Determination of the particle mass-per-volume and water absorption - Pycnometer method
ISO 7728	Typical horizontal joints between AN external wall of prefabricated ordinary concrete components and A concrete floor. Properties, Characteristics and classification criteria
ISO 7729	Typical joints between two prefabricated ordinary concrete external wall components. Properties, characteristics and classification criteria
ISO 7844	Grooved vertical joints with connecting bars concrete infill between large reinforced concrete panels. Laboratory mechanical tests. Effect of tangential loading
ISO 7845	Horizontal joints between load-bearing walls and concrete floors. Laboratory mechanical tests. Effect of vertical loading and of moments transmitted by the floors
ISO 9882	Performance standards in building. Performance test for precast concrete floors. Behavior under non-concentrated load
ISO 9883	Performance standards in building. Performance test for precast concrete floors. Behavior under concentrated load
ISO 11082	Certification scheme for welded fabric for the reinforcement of concrete structures
ISO/TR 12662	Certification scheme for prestressing steels
ISO 14654	Epoxy-coated steel for the reinforcement of concrete
ISO 14655	Epoxy-coated strand for the prestressing of concrete
ISO 14656	Epoxy powder and sealing material for the coating of steel for the reinforcement of concrete
ISO 15630-1	Steel for the reinforcement and prestressing of concrete – Test methods – Part 1: Reinforcing bars, wire rod and wires
ISO 15630-2	Steel for the reinforcement and prestressing of concrete – Test methods – Part 2 : welded fabric
ISO 15630-3	Steel for reinforcement and prestressing of concrete – Test methods – Part 3: Prestressing steel
ISO 16020	Steel for the reinforcement and prestressing of concrete – Vocabulary

Reference	Title
ISO 19338	Performance and assessment requirements for design standards on structural concrete
ISO 22965-1	Concrete – Part 1 : Methods of specifying and guidance for the specifier
ISO 22965-2	Concrete – Part 2 : Specification and constituent materials, production of concrete and compliance of concrete
IBC	International Building Code

European standards and codes

Reference	Title
EN 196-1	Method of testing cement – Part 1: Determination of strength
EN 196-2	Method of testing cement – Part 2: Chemical analysis of cement
EN 196-3	Methods of testing cement – Part 3: Determination of setting times and soundness
EN 196-5	Methods of testing cement – Part 5: Pozzolanicity test for pozzolanic cement
EN 196-6	Methods of testing cement – Part 6: Determination of fineness
EN 196-7	Methods of testing cement – Part 7: Methods of taking and preparing samples of cement
EN 196-8	Methods of testing cement – Part 8: Heat of hydration – Solution method
EN 196-9	Methods of testing cement – Part 9: Heat of hydration – Semi-adiabatic method
EN 197-1	Cement – Part 1: composition, specifications and conformity criteria for common cements
EN 197-2	Cement – Part 2: Conformity evaluation
EN 197-4	Cement – Part 4: Composition, specifications and conformity criteria for low early strength
EN 206-1	Cement – Part 1: Specification, performance, production and conformity
EN 413-1	Masonry cement – Part 1: Composition, specifications and conformity criteria
EN 413-2	Masonry cement – Part 2: Test methods
EN 445	Grout for prestressing tendons. Test methods
EN 446	Grout for prestressing tendons. Grouting procedures
EN 447	Grout for prestressing tendons. Specification for common grout
EN 450-2	Fly ash for concrete - Part 2 : conformity evaluation

Reference	Title
EN 451-1	Method of testing fly ash - Part 1 : determination of free calcium oxide content
EN 451-2	Method of testing fly ash. Part 2 : determination of fineness by wet sieving
EN 480-13	Admixtures for concrete, mortar and grout – Test methods – Part 13: Reference masonry mortar for testing mortar admixtures
EN 480-14	Admixtures for concrete, mortar and grout – Test methods – Part 14: Determination of the effect on corrosion susceptibility of reinforcing steel by potentiostatic electro-chemical test
EN 523	Steel strip sheaths for prestressing tendons – Terminology, quality control,
EN 524-1	Steel strip sheaths for prestressing tendons – Part 1: Test methods
EN 524-2	Steel strip sheaths for prestressing tendons – Part 2: Determination of flexural behavior
EN 524-3	Steel strip sheaths for prestressing tendons – Part 3: to –and-fro bending test
EN 524-4	Steel strip sheaths for prestressing tendons – Part 4: Determination of lateral load resistance
EN 524-5	Steel strip sheaths for prestressing tendons – Part 5: Determination of tensile load resistance
EN 524-6	Steel strip sheaths for prestressing tendons – Part 6: Determination of leaktightness (Determination of water loss)
EN 932-1	Tests for general properties of aggregates – Part 1: Methods for sampling
EN 932-2	Tests for general properties of aggregates – Part 2: Methods for reducing laboratory samples
EN 932-3	Tests for general properties of aggregates – Part 3: Procedures and terminology for simplified petrographic description
EN 932-5	Tests for general properties of aggregates – Part 5: Common equipment and calibration
EN 932-6	Tests for general properties of aggregates – Part 6: Definitions of repeatability and reproducibility
EN 933-1	Tests for geometrical properties of aggregates – Part 1: Determination of particle size distribution. Sieving method
EN 933-2	Tests for geometrical properties of aggregates. Part 2 : determination of particle size distribution. Test sieves, nominal size of apertures
EN 933-3	Tests for geometrical properties of aggregates. Part 3 : determination of particle shape. Flakiness index
EN 933-4	Tests for geometrical properties of aggregates - Part 4 : determination of particle shape - Shape index
EN 933-5	Tests for geometrical properties of aggregates. Part 5 : determination of percentage of crushed and broken surfaces in coarse aggregate particles.

Reference	Title
EN 933-6	Test for geometrical properties of aggregates - Part 6 : assessment of surface characteristics - Flow coefficient of aggregates
EN 933-7	Tests for geometrical properties of aggregates - Part 7 : determination of shell content - Percentage of shells in coarse aggregates
EN 933-8	Tests for geometrical properties of aggregates. Part 8 : assessment of fines. Sand equivalent test
EN 933-9	Tests for geometrical properties of aggregates. Part 9: assessment of fines. Methylene blue test
EN 934-2	Admixtures for concrete, mortar and grout - Part 2 : concrete admixtures - Definitions, requirements, conformity, marking and labeling
EN 934-3	Admixtures for concrete, mortar and grout - Part 3 : admixtures for masonry mortar - Definitions, requirements, conformity, marking and labelling
EN 934-4	Admixtures for concrete, mortar and grout - Part 4 : admixtures for grout for prestressing tendons - Definitions, requirements, conformity, marking and labeling
EN 934-6	Admixtures for concrete, mortar and grout - Part 6 : sampling, conformity control and evaluation of conformity
EN 1097-1	Tests for mechanical and physical properties of aggregates - Part 1 : determination of the resistance to wear (micro-Deval)
EN 1097-2	Tests for mechanical and physical properties of aggregates - Part 2 : methods for the determination of resistance to fragmentation
EN 1097-3	Tests for mechanical and physical properties of aggregates - Part 3 : determination of loose bulk density and voids
EN 1097-4	Tests for mechanical and physical properties of aggregates - Part 4 : determination of the voids of dry compacted filler
EN 1097-5	Test for mechanical and physical properties of aggregates - Part 5 : determination of the water content by drying in a ventilated oven
EN 1097-6	Tests for mechanical and physical properties of aggregates - Part 6 : determination of particle density and water absorption
EN 1097-7	Tests for mechanical and physical properties of aggregates - Part 7 : determination of the particle density of filler - Pyknometer method
EN 1097-8	Tests for mechanical and physical properties of aggregates - Part 8 : determination of the polished stone value
EN 1097-9	Tests for mechanical and physical properties of aggregates. Part 9 : determination of the resistance to wear by abrasion from studded tyres. Nordic test.
EN 1097-10	Tests for mechanical and physical properties of aggregates - Part 10 : determination of water suction height

Reference	Title
EN 1169	Precast concrete products – general Rules for factory production control of glass-fibre reinforced cement
EN 1170-1	Precast concrete products. Test method for glass-fibre reinforced cement. Part 1: Measuring the consistency of the matrix, “Slump test” method
EN 1170-2	Precast concrete products. Test method for glass-fibre reinforced cement. Part 2: Measuring the fiber content in fresh GRC, “ Wash test”
EN 1170-3	Precast concrete products. Test method for glass-fibre reinforced cement. Part 3: Measuring the fibre content of sprayed GRC
EN 1170-4	Precast concrete products. Test method for glass-fibre reinforced cement. Part 4: Measuring bending strength, “ Simplified bending test” method
EN 1170-5	Precast concrete products. Test method for glass-fibre reinforced cement. Part 5: Measuring bending strength, “ Complete bending test” method
EN 1170-6	Precast concrete products. Test method for glass-fibre reinforced cement. Part 6: Determination of the absorption of water by immersion and determination of the dry density
EN 1170-7	Precast concrete products. Test method for glass-fibre reinforced cement. Part 7: Measurement of extremes of dimensional variations due to moisture content
EN 1328	Cement bonded particleboards. Determination of frost resistance
EN 1744-3	Tests for chemical properties of aggregates - Part 3 : preparation of eluates by leaching of aggregates
EN 1744-4	Tests for chemical properties of aggregates - Part 4 : determination of water susceptibility of fillers for bituminous mixtures
EN 1744-5	Tests for chemical properties of aggregates - Part 5 : determination of acid soluble chloride salts
EN 1744-6	Tests for chemical properties of aggregates - Part 6 : determination of the influence of recycled aggregate extract on the initial setting time of cement
EN 12350-1	Testing fresh concrete - Part 1 : sampling
EN 12350-2	Testing fresh concrete - Part 2 : slump test
EN 12350-3	Testing fresh concrete - Part 3 : Vebe test
EN 12350-4	Testing fresh concrete - Part 4 : degree of compactability
EN 12350-5	Testing fresh concrete - Part 5 : flow table test
EN 12350-6	Testing fresh concrete - Part 6 : density
EN 12350-7	Testing fresh concrete - Part 7 : air content - Pressure methods
EN 12390-1	Testing hardened concrete - Part 1 : shape, dimensions and other requirements for test specimens and moulds
EN 12390-2	Testing hardened concrete - Part 2 : making and curing specimens for strength tests

Reference	Title
EN 12390-3	Testing hardened concrete - Part 3 : compressive strength of test specimens
EN 12390-4	Testing hardened concrete - Part 4 : compressive strength - Specification for testing machines
EN 12390-5	Testing hardened concrete - Part 5 : flexural strength of test specimens
EN 12390-6	Testing hardened concrete - Part 6 : tensile splitting strength of test specimens
EN 12390-7	Testing hardened concrete - Part 7 : density of hardened concrete
EN 12390-8	Testing hardened concrete - Part 8 : depth of penetration of water under pressure
PR EN 12390-9	TEST METHODS FOR THE FREEZE/ THAW RESISTANCE OF CONCRETE - Testing hardened concrete - Part 9 : freeze-thaw resistance - Scaling - PART 1 : SCALING
EN 12504-1	Testing concrete in structures - Part 1 : cored specimens - Taking, examining and testing in compression
EN 12504-2	Testing concrete in structures - Part 2 : non-destructive testing - Determination of rebound number
EN 12504-3	Testing concrete in structures - Part 3 : determination of pull-out force
EN 12504-4	Testing concrete - Part 4 : determination of ultrasonic pulse velocity
EN 13263 1 & 2	Silica fume for concrete
EN 13851	Methods of test for hydraulic setting floor smoothing and/or leveling compounds – Determination of flexural and compressive strength
EN 13872	Method of test for smoothing and/or leveling compounds – Determination of shrinkage
EN 14216	Cement – Composition, specifications and conformity criteria for very low heat special cements
EN 14227-1	Hydraulically bound mixtures – Specifications – Part 1 : Cement bound granular mixtures
EN 14647	Calcium aluminates cement – Composition, specifications and conformity criteria
EN 14649	Precast concrete products – Test method for strength retention of glass fibres in cement and concrete
EN 14845-1	Test methods for fibres in concrete – Part 1: Reference concretes
EN 15057	Fibre cement profiled sheets – Impact resistance test method

French standards and codes

Reference	Title
NF A35-015	Reinforcing steels - Weldable smooth steel - Bars and coils
NF A35-016-1	Reinforcing steels - Weldable ribbed steel - Part 1 : bars and coils
NF A35-016-2	Reinforcing steels - Weldable ribbed steel - Part 2 : welded fabric
NF A35-017	Steels for concrete reinforcement - Non weldable ribbed bars and coils
NF A35-019-1	Reinforcing steels - Weldable intended steel - Part 1 : bars and coils
NF A35-019-2	Reinforcing steels - Weldable indented steel - Part 2 : welded fabric
NF A35-020-1	Steel products. End coupling or anchoring devices for high adherence steel for concrete reinforcement. Part 1 : requirements for mechanical performances.
NF A35-020-2	Steel products - End coupling and anchoring steel devices for high adherence steel for concrete reinforcement - Part 2 : test methods
NF A35-021	Steels for concrete. Weldable wires used for the fabrication of reinforcing steels.
NF A35-024	Steels for concrete reinforcement - Surface welded fabric composed of wires with a diameter less than 5 mm
NF A35-027	Steel products for reinforced concrete - Reinforcements
NF A35-029	Armatures pour béton armé - Assemblages soudés - Qualification d'un mode opératoire de soudage. Qualification des soudeurs
PR NF A35-030	Steel products - High-bond ribbed steel bars for concrete poles, supports for over head lines
NF A35-031	Armatures pour béton armé - Barres soudables à verrous de diamètre supérieur à 40 mm
XP A35-045-1	Steel products - Prestressing steels - Part 1 : general requirements
XP A35-045-2	Steel products - Prestressing steels - Part 2 : wire
XP A35-045-3	Steel products - Prestressing steels - Part 3 : strand
P12-223	Specification for Mortar for masonry – Part 3: Products for external rendering and internal plastering based on organic binders
EN 197-1	Cement – Part 1 : Composition, specifications and conformity criteria for common cements – Sulfate resisting cement
EN 197-4	Cement – Part 4: composition, specifications and conformity criteria for low early strength balstfurnace cements
P 15-317	Ciments pour travaux à la mer
P15-318	Hydraulic binders – Cement with limited sulphides content for use un prestressed concrete
P15-330	Hydraulic binders. Calcium aluminate cement for refractories. Composition, specifications and conformity criteria

Reference	Title
P15-431	Hydraulic binders. Methods for testing cement. Setting test
P15-433	Methods of testing cement. Determination of shrinkage and swelling
P15-466	Binders. Rapid recognition of cement at the time of delivery in comparison with a reference sample
P15-467	Hydraulic binders. Practical instrumental method for the analysis of cement X-ray fluorescence spectrometry
P15-471-7	Methods of testing cement – Part 7: methods of taking and preparing samples of cement
P15-481PR	Methods of testing cement – Part 10: Determination of the water-soluble chromium (VI) content of cement
P15-590	Cement – Assessment of the conformity of cement to the requirements of Directive 2003/53/EC concerning the soluble hexavalent chromium content
P18-805	Special products for hydraulic constructions. Hydraulic binder based products. Determination of hydraulic binder
P18-808	Special products for hydraulic constructions. Hydraulic binder based products. Mineralogical analysis and potential composition according to bogue
P19-829-8	Test method for glass-fibre reinforced cement – Part 8: Cyclic weathering type test
P98-171	Cement concrete roadways. Dense concrete formulation study. Determination of the granular composition leading to the maximum density of fresh concrete
P98-240-1	Road testing. Measurement of the rate of hydraulic binders and additives in the cementitious materials. Part 1: Chemical method for the determination of the cement content in a new mixed material
P98-244	Test relating to pavements. Measurement of the position steel in cement concrete
P98-246	Tests relating to pavements. Measurements of the impermeability of joints on cement concrete pavements

American standards and codes

Reference	Title
ACI 117	Standard specifications for tolerances for concrete construction and materials
ACI 201.2R	Guide to durable concrete
ACI 211.1	Standard practice for selecting proportions for normal, heavyweight and mass concrete

Reference	Title
ACI 212.3R	Chemical admixtures for concrete
ACI 212.4R	Guide for the use of high-range water-reducing admixtures (superplasticizers) in concrete
ACI 214	Recommended practice for evaluation of strength test results of concrete
ACI 221R	Guide for use of normal weight and heavyweight aggregates in concrete
ACI 222R	Corrosion of metals in concrete
ACI 223	Standard practice for the use of shrinkage-compensating concrete
ACI 224R	Control of cracking in concrete structures
ACI 224.1R	Causes, evaluation and repair of cracks in concrete structures
ACI 224.2R	Cracking of concrete members in direct tension
ACI 224.3R	Joints in concrete construction
ACI 225R	Guide to the selection and use of hydraulic cements
ACI 228.1R	In-place methods to estimate concrete strength
ACI 228.2R	Nondestructive test methods for evaluation of concrete in structures
ACI 232.2R	Use of fly ash in concrete
ACI 233R	Ground granulated blast-furnace slag as a cementitious constituent of concrete
ACI 234R	Guide for use of silica fume in concrete
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	Placing concrete by pumping methods
ACI 304.4R	Placing concrete with belt conveyors
ACI 305R	Hot weather concreting
ACI 306R	Cold weather concreting
ACI 306.1	Standard specification for cold weather concreting
ACI 308R	Guide to curing concrete
ACI 308.1	Standard specification for curing concrete
ACI 309R	Guide for consolidation of concrete
ACI 309.1R	Behavior of fresh concrete during vibration
ACI 309.2R	Identification and control of visible effects of consolidation on formed concrete surfaces

Reference	Title
ACI 309.3R	Guide to consolidation of concrete in congested areas
ACI 311.4R	Guide for concrete inspection
ACI 318	Building code requirements for structural concrete
ACI 347	Guide to formwork for concrete
ACI 357R	Guide for the design and construction of fixed offshore concrete structures
ACI 372R	Design and construction of circular wire and strand wrapped prestressed concrete structures
ACI 373R	Design and construction of circular prestressed concrete structures with circumferential tendons
ACI 423.3R	Recommendations for concrete members prestressed with unbonded tendons
ACI 439.3R	Mechanical connections of reinforcing bars
ACI 504R	Guide to sealing joints in concrete structures
IBC	International Building Code
ASTM A82	Specification for steel wire, plain, for concrete reinforcement
ASTM A184/A184M	Specification for fabricated deformed steel bar mats for concrete reinforcement
ASTM A185 -	Specification for steel welded wire fabric, plain, for concrete reinforcement
ASTM A416/A416M	Specification for steel strand, uncoated seven-wire for prestressed concrete
ASTM A421/A421M	Specification for uncoated stress-relieved steel wire for prestressed concrete
ASTM A496	Specification for steel wire, deformed, for concrete reinforcement
ASTM A497	Specification for steel welded wire fabric, deformed, for concrete reinforcement
ASTM A615/A615M	Specification for deformed and plain billet-steel bars for concrete reinforcement
ASTM A704/A704M	Specification for welded steel plain bar or rod mats for concrete reinforcement
ASTM A706/A706M	Specification for low-alloy steel deformed and plain bars for concrete reinforcement
ASTM A722/A722M	Specification for uncoated high-strength steel bar for prestressing concrete
ASTM A779/A779M	Specification for steel strand, seven-wire, uncoated, compacted, stress-relieved for prestressed concrete

Reference	Title
ASTM Volume 04.01	Cement - Lime - Gypsum
ASTM Volume 04.02	Concrete and aggregates
ASTM C642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C682	Standard Practice for Evaluation of Frost Resistance of Coarse Aggregates in Air-Entrained Concrete by Critical Dilation procedures
ASTM D512	Standard test methods for chloride ion in water

British standards and codes

Reference	Title
BS 410	Specification for test sieves
BS 476	Fire test on building materials and structures (Part 3 to 7, 21 to 24 and 31)
BS 812	Testing aggregates
BS 1370	Specification for low heat Portland cement
BS 1881	Testing concrete
BS 4027	Specification for sulfate-resisting Portland cement
BS 4248	Specification for supersulphated cement
BS 4449	Specification for carbon steel bars for the reinforcement of concrete
BS 4482	Specification for cold reduced steel wire for the reinforcement of concrete
BS 4483	Steel fabric for the reinforcement of concrete
BS 4486	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 4550	Methods of testing cement
BS 5896	Specification for high tensile steel wire and strand for the prestressing of concrete
BS 6089	Guide to assessment of concrete strength in existing structures
BS 6610	Specification for Pozzolanic pulverized-fuel ash cement
BS 7583	Specification for Portland limestone cement
BS 8000-2.1 and 2.2	Workmanship on building sites. Code of practice for concrete work
BS 8110	Structural use of concrete

Professional Documents

International documents

Reference	Title
RILEM report (1988)	Corrosion of steel in concrete P. SCHIESSL

French documents

Reference	Title
LCPC	Recommandations pour la prévention des désordres dus à l'alcalinité (Recommendations for preventing alkali-related damage)
SNBATI - ITBTP – AFAC	Recommandations professionnelles relatives à l'utilisation des démoulants (Professional recommendations related to the use of demoulding products)

American documents

Reference	Title
	Manual of cement testing Manual of aggregate and concrete testing

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP CIV 301	Design of reinforced and prestressed concrete
GS EP CIV 401	Minimum requirements for building design and construction

3. Field of application

3.1 Weather conditions

3.1.1 Hot weather

In addition to the standards to be used for the construction of reinforced and prestressed concrete, special considerations listed in Section 12 shall be applied for concrete manufacturing and placing in the following conditions (measurements performed over a 24-hour period):

- Maximum temperature $> 33^{\circ}\text{C}$
- and/or mean temperature $> 28^{\circ}\text{C}$

If The COMPANY judges it necessary, temperature could be lower, particularly in case of drying wind. It shall be defined in Particular Specifications.

3.1.2 Cold weather

In addition to the standards to be used for the construction of reinforced and prestressed concrete, special considerations listed in Section 13 shall be applied for concrete manufacturing and placing in the conditions described below.

The temperatures shall be measured by means of a thermometer set on the work site, in open air, 1.50 m above ground and sheltered from solar radiation and rain. A log shall summarize temperatures recorded at 7 a.m. ($t_{\min}$) and at 2:30 p.m. ($t_{\max}$) as well as their arithmetic mean value (t_{mean}).

Intervals of mean temperature (t_{mean}) and minimum temperature ($t_{\min}$) characterize each one of the types of weather considered below. The selected type shall correspond to the most severe interval, taking into account aggravation expected within three days.

Type 1: $5^{\circ}\text{C} > t_{\min} > 0^{\circ}\text{C}$

Type 2: $5^{\circ}\text{C} > t_{\text{mean}} > 0^{\circ}\text{C}$ or $0^{\circ}\text{C} > t_{\min} > -3^{\circ}\text{C}$

Type 3: $0^{\circ}\text{C} > t_{\text{mean}} > -5^{\circ}\text{C}$ or $-3^{\circ}\text{C} > t_{\min} > -7^{\circ}\text{C}$

Type 4: $-5^{\circ}\text{C} > t_{\text{mean}} > -10^{\circ}\text{C}$ or $-7^{\circ}\text{C} > t_{\min} > -12^{\circ}\text{C}$

In case concreting with more severe temperature conditions is necessary, a special study suited to the appropriate case shall be made.

The Construction CONTRACTOR shall submit all construction procedures for COMPANY approval.

3.2 Type of construction

3.2.1 Onshore construction

Onshore construction is located on a site not affected by sea condition. Near shore (1km from the sea) construction are concerned by particular specifications due to the chloride effect on concrete structure.

3.2.2 Offshore construction

Offshore construction concerns all works performed at sea and refers in particular to offshore platforms or Floating Production Unit.

3.3 Type of concreting

3.3.1 Cast-in-place concrete

Cast-in-place concrete is poured on site.

Specific measures for placing concrete must be taken according to the weather conditions prevailing on the site (see Section 3.1).

3.3.2 Precast concrete

Precast concrete is implemented using manufacturing processes producing concrete elements to be assembled on site.

4. Technical specifications for materials

4.1 General principles

The materials and products to be used for the construction works will be supplied by the Construction CONTRACTOR and submitted to the COMPANY for approval.

Materials, including fabrication and supply, shall be submitted to tests: composition or approval tests, operational tests and acceptance tests.

4.2 Submission of sample materials

Upon award of the contract to the Construction CONTRACTOR, a list of SUPPLIERS for materials shall be submitted to the COMPANY for approval and material samples shall be made available to the COMPANY, at the Construction CONTRACTOR expenses. The COMPANY shall keep these material samples until the contract is fulfilled. Samples supplied later on shall strictly have the same characteristics.

No change in the list of SUPPLIERS will be allowed without prior approval from the COMPANY.

4.3 Cement

4.3.1 Cement types

The types of cement shall be selected according to the type of works to be performed (marine works, underground works, structural works, etc.).

Selected cements shall comply with standards listed here above and particular specifications.

All cements must be certified by the MANUFACTURER in compliance with the required standards.

The certificates shall specify the mechanical and physical-chemical characteristics.

The Construction CONTRACTOR shall issue to the COMPANY the relevant certificates.

In case certification proves to be unsatisfactory to the COMPANY representatives on site, the latter may require additional tests to be carried out. These tests will be performed at the Construction CONTRACTOR expenses.

Only one brand of cement should be used for a specific work. In case this requirement cannot be fulfilled, whichever the reason is, the Construction CONTRACTOR shall prove the compatibility between brands.

Under no circumstance shall different types of cement be used in the same mix.

a) For general works

Unless specified otherwise, cement shall be Ordinary Portland Cement (OPC).

Only cement suited to the environment and produced by plants approved by the COMPANY shall be used.

b) For works in water with high sulphate content

Sulphate Resisting Cement (SRC) shall be used.

c) For works in chemically pure water

Cement with a high slag content shall be used.

d) For mass concrete

Cement with a low heat of hydration shall be used.

The cement heat of hydration should be assessed according to the semi-adiabatic method given in [EN 196-9](#) when uncracked concrete properties are to be adopted in design. An upper limit of 270 J/g is suggested where a low heat concrete is targeted due to warm weather working. This can typically be achieved by using either 50% ground-granulated blast furnace slag or 30% pulverised fuel ash as the cement replacement.

4.3.2 Sampling

The COMPANY reserves, at any time, the right to ask the Construction CONTRACTOR to supply cement samples taken from the stock intended for the work site. The COMPANY laboratory shall test these samples.

4.3.3 Delivery and storage

Supplier's certificates shall be provided to COMPANY confirming that cement delivered to the site has been tested and found to comply with the requirements of the appropriate Standards. The certificates shall be sent to site prior to dispatch of each consignment from Supplier's works. If subsequent tests on any consignment of cement show it not to comply with requirements Standards, the whole consignment shall be removed immediately from the site.

Unless authorization is given for bulk delivery under specific conditions, cement must be delivered in strong, solid bags or containers.

The cement store for bagged cement shall be a weatherproof building or shed, ventilated, free of dampness. The size shall be sufficient to hold enough cement for continuous execution of the works. Bags for cement shall be lined in polythene or other damp-proof material.

Access facilities shall be provided to allow for inspection, easy sampling and identification on each delivery.

Each delivery shall be stored separately and distinctively, after having been controlled by weighing.

Any cement from torn bags or unsealed containers shall be rejected.

If cement in bulk is to be used, prior approval by COMPANY must be obtained. It shall be stored in silos purpose made for storage of cement. These storage devices must be approved by the COMPANY and equipped with thermometric probes.

Cement must be supplied in adequate quantities to ensure concrete work being neither stopped nor suspended.

No cement shall be kept on the site longer than 3 months from the certificate date before use.

Any cement; which is stored on site in excess of 28 days, shall be tested in accordance with relevant standard prior to use, and evacuated within 48 hours in case of failure to meet the required Standards. Sufficient cement for one week's consumption shall be available at all times. Cement shall be in sequence in which it is delivered.

The COMPANY reserves the right to adapt maximum storage time if the concrete works take place by hot or cold weather.

Cement temperature shall not exceed 50°C before use, except by special agreement of the COMPANY.

4.3.4 Rejection

The COMPANY reserves the right to order that any shipment or part of a shipment shall not be used in the works and be removed from the site for failing to comply with the standards.

4.4 Aggregates

4.4.1 General

Aggregates shall be in compliance with the relevant standards.

The reaction of aggregates to alkalis shall be in compliance with [ASTM C 33](#), Section 8.1 and appendix A1.

The characteristics of aggregates shall be selected according to the quality of concrete to be produced.

Otherwise the possibility of not supplying the desired aggregates might lead to limitation of concrete characteristics.

4.4.2 Aggregate characteristics and source of supply

Aggregates for concrete shall be obtained from quarries proposed by the Construction CONTRACTOR and approved by the COMPANY. Their quality, grading and other characteristics shall be in compliance with the relevant specifications. The aggregates may be either natural (rolled stone) or crushed stone.

Aggregates shall be in compliance with the standards for cleanliness, strength, hardness and durability. They shall be free from adherent coatings, laminated particles or admixtures likely to be deleterious of concrete. They shall have a suitable grading from fine to coarse, within the allowed limits.

4.4.3 Grading

Gravel size shall be limited to a maximum being compatible with the type of works to be carried out. Aggregate grading and maximum dimensions shall be submitted for COMPANY approval.

If necessary, the Construction CONTRACTOR may submit limitation methods or grading correction methods for the COMPANY approval.

4.4.4 Fine aggregates or sand

Fine aggregates shall consist of crushed gravel, crushed stone or natural sand with rounded particles. It must be free of organic matter or other harmful substance, such as excessively fine or friable particles

Fine aggregates shall be washed as necessary to comply with Standards requirements:

- Clay lumps and friable particle < 2 %
- Material finer than 75 μ : Sand or Crushed graded 3%, Crushed rock 5%
- Organic Impurities < 0.5%
- Water Absorption < 2%
- Chlorides < 0.06%
- Sulfates < 0.04%
- Sand equivalent > 85% (One test of sand equivalence shall be provided per 75 m³ of sand supplied)

Fine aggregates containing more than 15 % of their weight in flat and/or sharp particles shall be rejected.

Nominal maximum size of fine aggregate shall be 4 mm particle. The fineness modulus shall be between 2.3 and 3.0.

Aggregates shall be obtained from sources approved by COMPANY

One test of sand equivalence shall be provided per 100 m³ of sand supplied.

4.4.5 Coarse aggregates (gravel)

Coarse aggregate shall be clean, hard, strong, free from adherent coating or organic matter or other deleterious substance. It shall consist of crushed or uncrushed gravel or crushed rock. It shall be selected, re-crushed, screened and washed with water meeting requirements of section 4.5 to comply with the following:

- Flakiness Index 25% by weight
- Elongation Index 25% by weight
- Water absorption < 2.5%
- Drying shrinkage 0.05%
- Thermal expansion $12 \times 10^{-6} / ^\circ\text{C}$
- Clay lumps and friable particles < 2 %
- Shell NMS < 10 mm: 15 %, NMS > 10 mm: 8%
- Material finer than 75 μ : natural/crushed gravel 1%, crushed rock 3%

- Sulfates < 0.4%
- Chlorides < 0.03%

Grading: In general, coarse aggregates for reinforced concrete shall be limited to 25 mm maximum nominal size. This may be increase to a maximum of 40 mm or decreased to 12.5 mm for certain structures/foundations subject to COMPANY approval.

4.4.6 Cleanliness

If the COMPANY judges it necessary, aggregates shall be washed and/or screened to eliminate any salt, earth, dust, clay particles and muddy matter. Only freshwater meeting requirements of section 4.5 shall be used for washing aggregates. In particular all crushed aggregates shall be washed to eliminate fines.

4.4.7 Transportation, Storage and Testing

During transportation, all aggregates are to be protected from wind-borne contaminants. Should these contaminants be present at the time of delivery to site, then the aggregates shall be washed with water meeting the requirements of section 4.5. Transport vehicles shall be cleaned from possible contamination due to previous use.

Storage areas shall be sheltered.

Different type or size of aggregates shall be stored separately according to their granulometry in order to avoid segregation and excessive gradation variation, separated by permanent partition walls. Sufficient quantities of each type of aggregate shall be maintained on site all times to ensure continuity of work.

Storage areas shall be drained and covered with a 10-cm thick layer of concrete mixed with 150 kg of cement per m³. Other arrangements (floors or silos) may be acceptable, on the condition that similar cleanliness is provided (prevention of contamination).

The Construction CONTRACTOR shall back up his offer with a complete description and detailed drawings of the site arrangement in order to assure the COMPANY of the suitability of storage, handling, inspection and casting concrete conditions according to the magnitude of the works to be undertaken.

4.5 Water

Water used for mixing concrete shall be fresh, clean and free of any harmful particle, oil, organic matter or other substances detrimental to concrete or reinforcement.

The PH of water shall be greater than 7 and less than 9.

The salt content pf water and limitation of inorganic contamination shall not be such the maximum limits specified herein shall not be exceeded:

- Dissolved solids excluding those listed below: 0.2%
- Sulphates: 0.075%
- Alkali carbonates or bicarbonates: 0.075%
- Chlorides 0.05%
- Total dissolved solids: 0.30%
- Suspended solids: 0.20%

If the Company judges it necessary, maximum and minimum temperatures may be specified.

Once a source of satisfactory supply has been established, further tests shall be made daily with a portable electrical conductivity probe calibrated against the satisfactory supply. If the conductivity exceeds that of the satisfactory supply, then further chemical tests shall be performed.

A water sample shall be supplied each month for laboratory testing.

4.6 Admixtures

Admixtures to produce a cohesive mix with a low water/cement ratio and adequate workability or to improve concrete resistivity against chemical attack (chloride, sulfates, etc...) shall be used only with prior approval of COMPANY. They shall comply with the relevant standards. No air-entraining agent shall be used without prior trials and approved by COMPANY. Admixtures containing chlorides shall not be used.

Admixtures Suppliers shall be well known.

All admixtures used to modify one or more characteristic of the concrete shall be accompanied by a certificate from an approved institute, stating:

- Exact range and method of applications
- Physical and chemical composition
- Positive and negative side effect
- A recommendation on the maximum allowable quantities (as a percentage of the mass of the cement)
- Proportioning and mixing
- Compatibility with cement intended to be used
- The long and short effects of the admixture on the concrete
- The effects of under and over dosage
- Combined effect of several admixtures where it is intended to use two or more in one batch
- Whether or not the admixture entrains air or has an effect on air content
- Safety precautions in handling
- Storage life and conditions
- The water content of the admixture

Admixtures shall be applied strictly in accordance with Supplier's instructions. However Subcontractor shall be responsible for any defective concrete that may result from the use of such admixtures. Subcontractor shall perform a trial batch and casting to substantiate Supplier's claims for workability, retardation and air entrainment.

If the COMPANY judges it necessary, admixtures may be tested within specific development tests. Development tests program requires prior approval of CAOMPANY.

4.7 Silica fume

Silica fume shall not be used without prior approval of COMPANY.

5. Concrete

5.1 General

5.1.1 Proportioning of concrete

CONTRACTOR shall design mixes for reinforced and plain concrete in accordance with the relevant standards, with a designated of nominal size of aggregates and workability. Optimization of concrete mixes shall be done to obtain concrete with adequate workability and impermeability.

5.1.2 Codes

Studies and test shall be in accordance with the relevant standards.

5.1.3 Concrete strength

The contractual strength for concrete is the “characteristic strength required σ_{sr} ” for compression at 28 days.

The strength classes shall be defined more accurately in particular specifications to comply with intended use.

5.2 Concrete classification

For the same site, several classes of concrete may be used, i.e. several compositions and/or strengths, depending upon the nature of works to be performed.

All classes of concrete can be used: ordinary and high-strength concrete. These classes shall be stipulated by the Engineering CONTRACTOR according to intended use and the requirements of [NF EN 206](#):

- Concrete exposed to sea water and precast concrete: $\sigma_{sr} = 35$ MPa, Cement content ≥ 350 Kg/m³, Cement Type: CEM I, CEM II/A, CEM II/B, CEM III/A, CEM III/B, CEM III/C, CEM V/A and CEM V/B in accordance with [EN 197-1](#) or CEM III/A, CEM III/B and CEM III/C in accordance with [EN 197-4](#) or CSS in accordance with [NF P 15-313](#), or CNP in accordance with [NF P 15-314](#) or CA in accordance with [NF P 15-315](#) or CAC in accordance with [prNF EN 14547](#), water/cement Ratio = 0.42 to 0.35
- Concrete for foundations, slabs, walls and columns: $\sigma_{sr} = 30$ MPa, Cement content ≥ 350 Kg/m³, Cement Type: II or III, water/cement Ratio = 0.42
- Concrete for paving and ditches: $\sigma_{sr} = 25$ MPa, Cement content ≥ 300 Kg/m³, Cement Type: II or III, water/cement Ratio = 0.45
- Lean Concrete: $\sigma_{sr} = 15$ MPa, Cement content ≥ 200 Kg/m³, Cement Type: II or III, water/cement Ratio = 0.55
- For structures exposed to Sulphates, Cement Type (Sulphate resisting) shall be used
- For Mass concrete, cement Type IV (Low heat) shall be used.

The maximum cementitious content (cement + admixture if any – prior approval of COMPANY is required-), whatever the type of reinforced concrete, shall not exceed 400 Kg/m³.

For practical reasons, the Engineering CONTRACTOR shall try to limit the number of concrete classes to a minimum acceptable for the correct performance of the works.

5.3 Concrete tests

5.3.1 Definitions

The Construction CONTRACTOR shall provide three series of tests:

- **Development tests**, performed by the laboratory, to define optimal composition of concrete according to the qualities of aggregates and cements proposed by the Construction CONTRACTOR and the requirements stipulated in particular specifications
- **Feasibility tests**, using concrete made on site with worksite materials and using composition defined by the development tests
- **Control tests**, using concrete prepared for construction.

The purpose of these tests is to check that the quality of concrete obtained is compatible with the "characteristic value required" as defined in specifications and used in work calculations.

All test results shall be given to the COMPANY under the form stipulated in appendices attached to this specification.

5.3.2 Development tests

At least five weeks before concrete works start, the Construction CONTRACTOR shall provide the laboratory with adequate quantities of the material samples he intends to use on the work site (aggregates, cement, water, admixtures).

The laboratory shall proceed with standard physical-chemical analyses and determine the optimal composition of concrete with respect to the required mechanical characteristics, placing method, density of reinforcement, and shrinkage amounts (minimum E/C), etc.

Chemical analysis shall point out the quantities of percentages of harmful elements included within the proposed materials; the test for sulphates and chloride ions content shall be particularly careful. The percentages of these ions to the weight of cement included in concrete shall be less than:

- Sulphate ions: SO_4^{2-} 4,00%
- Chloride ions Cl^- (following table)

The total chloride content of the concrete mix including aggregates, admixtures if any, and any other source shall under no circumstances exceed the following limits expressed as a percentage of chloride ion to the weight of cement in the mix.

Type or use of concrete	% of chloride ion by weight of cement
Steam cured structural concrete	0.1
Concrete made with ASTM class V cement	0.2
Concrete containing embedded metal and made with ASTM class II blast furnace slag cement or similar	0.35 for 95% of test results with no result greater than 0.50

The laboratory shall make at least 3 batches, each allowing the preparation of 9 standardized compression tests and a slump test. Three cylinders from each batch shall be tested at 3 days' time, 3 at 7 days, and 3 at 28 days.

The concrete consistency shall be adequate in order to assure correct placement in form corners and around reinforcements.

Cylinders shall be prepared, protected, stored, transported and tested for compression in compliance with standards.

For large sites, particular specifications may impose more sophisticated tests.

Before works start, the Construction CONTRACTOR shall provide to the COMPANY all information related to the test mixes and strength values obtained.

5.3.3 Feasibility tests

At least three weeks before concrete works start, the Construction CONTRACTOR shall produce the test cylinders for the feasibility tests, and supply them to the laboratory.

The Construction CONTRACTOR shall use the basic materials from the site i.e. the same as those defined by development tests and with the same proportions.

The site batch plant and other equipment shall be used to make the test mixes. These shall be transported to a significant distance by the actual methods for used for the performance of works. A clean and dry concrete mixer shall be used.

Compression test samples shall be taken from the mix as follows:

- For each batch, six test samples shall be taken and two slump tests made
- Six samples for each test at 3, 7 and 28 days are required. These samples shall be prepared, protected, stored, transported and tested for compression as per relevant standards.

5.3.4 Control tests

a) Batch water control

The water/cement ratio (E/C) shall be maintained at the value determined by the development tests, with the understanding that "total" water shall be counted for; i.e., including the free moisture in aggregates before mixing. A tolerance of $\pm 1.5\%$ will be allowed.

b) Strength control and workability

Per each $B \text{ m}^3$ of concrete or per one day of concrete production, if the quantity to be placed is less than 100 m^3 , the following samples shall be taken:

- $2 + B/100$ samples for compression tests
- $B/100$ samples for slump test.

Samples shall be tested at 3, 7 and 28 days. Depending on the results obtained, the COMPANY reserves the right to require a greater number of samples. The COMPANY also reserves the right to require tension tests.

The samples shall be fabricated, protected, stored, transported and tested in accordance with the relevant standards.



Minimum resistance for each sample and the average minimum resistance for each test batch shall be defined by the Engineering CONTRACTOR.

The Engineering CONTRACTOR shall make an overall statistical check on completion of works. This check report shall be submitted to the COMPANY.

5.4 Changing materials and mixture proportions

Neither mixture proportions nor source of material supply shall be changed without COMPANY approval.

This approval may only be granted after new tests have been carried out satisfactorily, as described in paragraph 5.3 here above.

5.5 Impossibility for obtaining required results

If the required results, anticipated within particular specifications, cannot be obtained during tests, the Construction CONTRACTOR and the Engineering CONTRACTOR shall submit new propositions for the COMPANY approval.

5.6 Concrete production plant

5.6.1 Batching and mixing

The concrete mixer shall be able to combine aggregates, cement, water and possibly admixtures and to discharge the mixture without any segregation.

Batching of materials shall be weighted within an accuracy of +/- 3%/

All weighing equipment shall be calibrated and documentation shall be provided by Construction CONTRACTOR to establish that the accuracy is continuously maintained in accordance with the relevant standards. Particularly, the scale zero shall be adjusted daily during operating periods.

If the cement is supplied in bags, the batches for the various qualities of concrete shall be proportioned in such a manner as to avoid the necessity of using part bags in any batch. If the cement is stored in bulk, the measuring equipment shall be approved by Construction CONTRACTOR before use.

The COMPANY reserves the right to proceed with intermediate checks while the work is in progress.

After each control test, the Construction CONTRACTOR shall make any adjustment, repair or substitution required to provide satisfactory results.

The concrete production plant shall be able to make adjustments required to compensate for free moisture variations in aggregates and to modify the weight of the materials set for a batch.

Construction CONTRACTOR shall establish accurate procedures for determining the quantities of moisture in the aggregates. Moisture determinations shall be made daily and whenever there is an apparent change in the moisture content. The moisture content shall be recorded. The moisture of aggregates shall be utilized to adjust the weight of aggregate added to the mix. The water added to the mix shall be adjusted accordingly.

The supplying water device to the concrete mixer shall not leak when the valves are closed.

Supply and drain valves for the water tank shall be controlled so that the drain valve cannot be opened unless the supply valve is completely shut off.

Each mixer shall be provided with an efficient device keeping the discharging mechanism closed.

Mixers shall not be loaded beyond the capacity recommended by the MANUFACTURER. Mixers shall be operated at the speed displayed on the MANUFACTURER plate. Before contract award, the Construction CONTRACTOR shall provide the information required for the COMPANY to check the suitability of the concrete production installation planned on the site.

For works regarded as especially difficult, the COMPANY reserves the right to request drawings for formwork and shoring. Information on concrete pouring sequences and methods (spouts, hoppers, conveyors, etc.), the stability of forms, shoring, etc... shall be requested.

5.6.2 Control of admixtures

Air-entraining and other chemical admixtures shall, in general, be loaded into the mixer in solution form.

Their preparation shall be carried out in compliance with the MANUFACTURER instructions.

The liquid shall be considered as part of the total water content of the batch. Admixtures that cannot be loaded as solutions shall be weighed or measured by volume, following the MANUFACTURER recommendations.

If two or more admixtures are to be used in the concrete, they shall be added separately to prevent any possible spot interaction. The Construction CONTRACTOR shall also ensure compatibility between admixtures.

Use of admixtures requires COMPANY approval. It shall comply with the MANUFACTURER specifications.

5.6.3 Immediate placing of concrete

Concrete shall be manufactured according to immediate amounts required. Concrete which has started to set shall be thrown away and not re-mixed.

5.7 Concrete delivery

The Construction CONTRACTOR shall submit to the COMPANY methods intended to be used for transporting concrete from the batching plant to the construction site.

Concrete mixing, transport and storage equipment shall be thoroughly cleaned after use.

Special attention shall be brought to the cleanliness of pumps, pipes and conveyor belts particularly at each breakdown or stoppage.

In case the concrete manufacturing plant is not on site (e.g. ready - mix concrete transported from the plant to the site by truck mixers), the Construction CONTRACTOR shall provide all equipment and personnel to maintain permanent contact between the plant and the site.

The exact time between truck filling and arrival at construction site shall be checked and recorded on site. Any concrete load not placed within 90 minutes after filling the truck shall be rejected. (This time may be modified for concrete placed in hot weather).

The complete procedure planned shall be submitted for the COMPANY approval. The overall means of control shall be at the Construction CONTRACTOR expenses. If the concrete is to be placed by pumping, the first cubic meters of concrete coming out of the pump shall be set aside until the Engineering CONTRACTOR decides if a regular concrete flow, complying with specifications, has been reached.

6. Forms

6.1 General

Four types of forms may be used:

- Ordinary, made of wood boards, parallel with sharp edges. Wood boards may result from rough sawing. Joints between boards shall be less than 1 mm
- Smooth, made of planed wood boards on the four sides, parallel with sharp edges. Joints shall be less than 0.5 mm and carefully treated (adhesive tapes). Form panels may also be made of plywood or iron plates
- Well-finished, made of plywood, possibly with a plastic coating, or of well planed iron plates. Joints shall be less 0.5 mm, carefully plugged with a suitable filling and smoothed. (Adhesive tapes not accepted). No projection shall be accepted along with the joints. No tie holes visible
- Special forms, such as for architectural concrete, as required by particular specifications.

The required finishing types and tolerances shall be given in particular specifications and on formwork drawings.

Formwork shall comply with the geometry of elements shown in the drawings.

They shall be of reliable construction and safe for both workers and public; they shall be sealed against leak or loss of grout, rigid, plumb, well braced and interconnected to prevent any warping or displacement.

6.2 Design and construction of forms

CONTRACTOR shall provide documentation detailing methods and materials proposed for formwork for each section of the work. He shall provide drawings for formwork and shoring and detailed information on concrete pouring sequences and methods (spouts, hoppers, conveyors, etc ...), the stability of forms, shoring etc.

CONTRACTOR shall provide all precautions to ensure safe working during all kinds of weather.

Inspection openings may be provided at the base of the forms or other locations to facilitate cleaning, observation within forms of placement and vibration concrete. Concrete finishing on these opening areas shall be stipulated in particular specifications.

All formworks shall be watertight to prevent grout loss

Formworks shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the drawings. Due an allowance shall be made for any deflection which will occur during the placing of concrete within the forms.

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. Forms shall be so constructed that they can be removed without shock or vibration to the concrete.

Positive means of adjustments (wedges or jacks) on shores and struts shall be provided and all settlement shall be compensated during concrete placing operation.

Form ties or spacers to be partially or wholly embedded in the concrete, shall be of an acceptable commercially manufactured type.

Form ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the surface of the concrete.

After the ends or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than the minimum specified concrete cover distance from the formed surface of concrete.

At construction joint, contact surface of the form sheeting for flush surfaces shall overlap the hardened concrete in the previous placement by not less than 25 mm. the forms shall be held securely against the hardened concrete to prevent offsets or loss of mortar at the construction joint and to maintain a true surface.

Formwork shall be anchored to shores or other supporting surfaces or members that upward or lateral movement of any part of the formwork system during concrete placement will be prevented.

6.3 Preparation of form contact surfaces

6.3.1 Form contact surface cleanliness

All form surfaces and inserts shall be cleaned of any trace of mortar or other foreign matter before concrete is being placed. The bottom of moulds shall be carefully blown out with compressed air.

6.3.2 Form coating and surface treatment

Form surfaces shall be treated as follows:

- Before reinforcement is set in place or concrete placed, all form surfaces shall be thoroughly cleaned. Temporary openings shall be provided where necessary to drain away water and rubbish. Form surfaces shall be treated with an approved product, so as to efficiently prevent humidity absorption and bond with concrete. This shall not stain the concrete surface
- Form coating shall not weaken the concrete, nor prevent surface treatment (curing, painting), nor be harmful in any way
- No excess of coating product shall be tolerated (puddles in the forms) and the product shall not come into contact with set concrete against which fresh concrete is to be poured (construction joints).

6.3.3 Re-use of forms

Re-usable forms shall be designed and maintained so that the quality of concrete surfaces complies with specifications and meets the COMPANY approval.

6.4 Removal of forms

Time for removal of forms shall be submitted for COMPANY approval.

Forms shall be removed in such a way to provide full safety of the structure according to concrete test results.

Forms used for concrete curing purpose shall not be removed before the curing period has expired.

All precautions must be taken to avoid damaging the concrete surfaces.

6.5 Dimensional tolerances

Upon removal of forms, the works shall be in compliance with tolerances stipulated in the particular specifications or in relevant standards.

6.6 Slipforming

The above specifications for formworks are applicable to slipforms. They are completed by the following special recommendations applicable to slipforms.

6.6.1 Design and construction

Slipforms shall be designed and constructed with sufficient bracing to insure that the shape of the structure will not be disturbed beyond the allowable tolerances (see § 6.5) during the sliding operation.

The Construction CONTRACTOR shall submit the following information for COMPANY approval:

- Design and drawing of slipforms (including tolerances)
- Positioning and alignment procedure
- Jacking system
- Sliding rate of the forms
- System for removal of forms.

The Construction CONTRACTOR shall submit his proposal:

- For fabricating steel reinforcement and templates for positioning the ducts for prestressing tendons
- For fabricating and placing embedded parts. The laying out tolerances for them shall be defined in special specifications.

Finally, the Construction CONTRACTOR offer shall take into consideration the problems of access for personnel and equipment along with safety regulations.

This proposal shall be submitted for COMPANY approval.

6.6.2 Sliding operations

As the sliding operations proceed, the quality of concrete shall be checked as soon as cleared from the form. The next sliding sequence shall not be carried out until this check is made and recorded.

The check shall emphasize the following points:

1. Maximum and minimum air temperature. If the temperature is lower than +10°C or higher than +30°C, these checks should be made every 6 hours.
2. The number and respective qualification of personnel responsible for the sliding operation.
3. Concrete levels at the beginning and end of slide.
4. Various operations performed.
5. Problems encountered.
6. Problems to be solved before next sliding sequence.

7. Reports made after each check, after completion of each phase of the work, after necessary correction and authorization to proceed with the next phase.
8. Instructions given by the experienced slipform supervisor, or the work site foreman, or the COMPANY representative during the sliding operation.
9. Errors, faults, as well as their causes and corrections.
10. All tolerances exceeded, and means of correction. Such means shall be submitted for COMPANY approval and especially those relative to the following points:
 - Wall thickness
 - Checking of slipforms once in place with check data indicated
 - Alignment and plumbness tolerance
 - Horizontal tolerance
 - The embedment placement tolerance
 - Concrete cover to steel reinforcement.

6.6.3 Defects and repairs

If major defects appear, such as very poor surface condition of concrete (peeling zones, honeycombs, numerous and continuous cracks), the Construction CONTRACTOR must at once and at the same time stop the work, take the steps required to ensure adequate protection of the concrete, inform the COMPANY and submit his proposal for necessary repairs to the concrete and for the corrective measures.

No repair work shall be started before the approval has been given, unless it has come to a decision for demolishing the faulty work.

It is expressly prohibited to patch any defective zone without first proceeding with removal of all concrete in poor condition, and without COMPANY agreement.

After a major defect has been detected, no work can be started over again without the COMPANY acceptance.

6.6.4 Procedures for stopping the work

The Construction CONTRACTOR shall provide to the COMPANY a description of emergency procedures in the event work is stopped for any of the following reasons:

- 1) Power supply shutdown: acceptable maximum delay for stopping work without any emergency measures shall be:
 - For temperature lower than 15°C: 1 hour
 - For temperature higher than 15°C: 1/2 hour
- 2) Shutdown of concrete production plant
- 3) Bad weather
- 4) Hydraulic pumps inoperative
- 5) Jacking operations being blocked
- 6) Leakage in jacking system

- 7) Rupture of tubing of the hydraulic system
- 8) Problems with jacking rods, pipes, yokes or ducts.

7. Steel reinforcement

7.1 General

The drawings shall indicate:

- Steel characteristics for re-bars
- Rebar shape and location
- Rebar dimension
- Bracing
- Positioning devices
- Pouring spaces (clearance between re-bars)
- Embedded parts and placement tolerances.

Complex reinforcement assembly shall be drawn at a large scale.

A bending schedule giving the steel weights by diameter shall be attached to each reinforcement drawing.

7.2 Steel reinforcement

7.2.1 Qualities

As a general rule, one SUPPLIER only shall provide steel reinforcement. In case of impossibility, each delivery must be accompanied with its respective SUPPLIER test certificate.

SUPPLIERS and MANUFACTURERS shall be approved by the COMPANY before any order is delivered.

A copy of supplier's test certificate for ultimate strength, elongation and cold bending together with the chemical analysis of the steel shall be submitted to COMPANY for each consignment of reinforcing steel delivered to site.

Each batch of reinforcement steel supplied to site shall be identified and traceable to such certification.

CONTRACTOR shall submit for COMPANY approval a quality control plan to ensure all reinforcement supplied to site complies with the requirements of the standards.

7.2.2 Bar cleanliness

Before placing concrete, the rebar shall be free of grease, dirt, or harmful surface covering or deposit.

If oxidized bars are used, they shall not show any scaling.

Flakes and scales resulting from steel rolling shall be eliminated.

Compliance with the above requirements shall be rigorously checked by the COMPANY representative before the forms are closed.

7.2.3 Mechanical tests

The type of tests (bending, tensile stresses, etc.) and their number shall comply with standard requirements.

7.2.4 Bars supports, ties, spacers and other fittings

Supports, ties, spacers, bracing and other fittings shall be sufficient to prevent any steel bar from moving during concrete placing. Any fitting in contact with the forms and which remain visible in the works shall be covered with plastic end-pieces.

Care shall be taken not to use copper, aluminium, or any embedded metal other than steel.

7.2.5 Storage conditions

Reinforcement must be free of loose rust, grease, paint, oil and any other matter, which may inhibit the bond with concrete.

Reinforcement shall be stored on site above ground on racks, skids or other approved supports, in such a way that it shall not be damaged both before and after bending. It shall be stored in separate lots by size and type, and clearly identified before and after shaping.

Storage area shall be properly drained.

7.3 Welding

When weldable steel is provided, the SUPPLIER shall submit test certificates with each delivery to confirm that the steel can be welded, and also the welding methods which best preserve the steel mechanical properties. The COMPANY reserves the right to proceed with all tests considered necessary.

No welding shall be made on the bent part of a bar.

Spot-welding at intersection of bars must receive the COMPANY approval.

Welders' names and qualifications shall be submitted for the COMPANY approval before any welding is done.

The COMPANY reserves the right to require additional pre-qualification tests for welders proposed by the Construction CONTRACTOR.

The COMPANY may appoint an independent specialist welder to inspect the welds.

7.4 Mechanical splices

Mechanical splicing may be accepted with tests and calculation notes.

The materials used shall be approved by the COMPANY.

7.5 Preparation of steel bars

The Construction CONTRACTOR shall prepare the steel bars and put them in place according to drawings and specifications. Steel bars with reduced sections (e.g. due to oxidation) shall not be used.

Starter bars exposed to splashing shall be protected with sleeves made of plastic or another material. Starter bars shall be inspected and cleaned, if necessary, before placement of concrete is started.

Bars shall not be bent or stretched in such a way that their mechanical properties are altered.

All bending and cutting shall be done cold, heating is prohibited.

Rebending or straightening of high yield bars is not permitted.

Fabric reinforcement has to be bent accurately to the required shapes before the fabric is laid in position

Reinforcement shall not be welded unless specifically shown on the Drawings, and approved by COMPANY.

The welds shall be tested to confirm adequacy. Welding of reinforcement shall comply with Appropriate Standards.

Bars with bends not shown on the drawings shall not be accepted.

7.6 Positioning

- Reinforcement shall be accurately placed as shown on drawings and shall be adequately secured and held in position. Reinforcement shall be set true to line and level with the correct cover, as specified on the drawings.

CONTRACTOR shall provide sufficient support, by means of approved chairs, spacers, etc, to ensure that all reinforcement is held in the correct position whilst concreting is taking place. Reinforcement shall be rigidly bound together at every inter-section of two bars soft annealed iron wire binding. All starter bars shall be set in position prior to concreting and securely held during concreting. Any fitting in contact with the forms and which remain visible in the works shall be covered with plastic end-pieces.

Starter bars exposed to splashing shall be protected with sleeves made of plastic or another material.

Starter bars shall be inspected and cleaned, if necessary, before placement of concrete is started.

Heating of steel bars for the purpose of bending is prohibited.

- Concrete spacers shall be made from materials in no way inferior to those specified for the concrete in which the spacer is to be used. All concrete spacers shall be wet cured for 10 days and kept clean prior to installation in concrete structure.

Plastic and metal spacers are not permitted

- Concrete cover to reinforcement shall be specified on the drawings and particular specifications. It shall comply with the relevant Standards.

8. Placing of concrete

8.1 Method of placing

Before carrying out the work, the Construction CONTRACTOR shall give all the details of concrete placing procedures, for examples: method for placing of concrete without interruption for some structural members, location of construction joints (in compliance with design), forms to be erected depending on a definite schedule, depth of concrete layers, definite delay between mixing and placing, vibration equipment and methods, etc.

Essential points shall be noted on the drawings. The detailed procedure shall be submitted for the COMPANY approval. Workers and supervisors shall be selected by the Construction

CONTRACTOR in sufficient numbers and with the level of ability and workmanship required to provide top quality work.

The Construction CONTRACTOR shall organize and maintain a high level of supervision at all time for each phase of all the operations.

8.2 Procedures before placing concrete, embedded parts, etc.

All mixing, delivery and storage equipment shall be cleaned before concrete is batched.

Hardened concrete, foreign matter, debris, dirt, water, snow and ice shall be removed from areas into which concrete is to be placed. Forms shall be carefully humidified or coated.

Starter bars and studs shall be clean of all foreign matter (mortar, grout, grease, etc.). Bending and re-bending for cold rolled steel bars shall not be accepted.

All embedments (hole reservations, attachments, embedded items, water stops, etc.) required for permanent or temporary devices shall be rigidly positioned in the forms as per specifications and drawings. Mechanical items (bolts, threaded rods) shall be greased and/or protected. The Construction CONTRACTOR shall organize a special checking system to ensure that all embedments other than reinforcement bars are correctly positioned. The checking register (for example: work site logs, check list, etc.) shall be submitted to the COMPANY.

8.3 Checking before placing concrete

Before concrete is placed the COMPANY will check the following phases:

- The reinforcement being positioned before closing the forms
- Forms being erected, ready for concrete placing.

All authorizations for concreting shall be jointly signed by the COMPANY and the Construction CONTRACTOR. This shall not relieve CONTRACTOR from his responsibility and commitment to procure soundness, finish and accuracy concrete.

8.4 Placing of concrete

Placing of concrete shall not be authorized if the COMPANY considers the quality of forms and reinforcement, weather conditions, equipment, supplies, etc... are inadequate to enable proper finishing and curing of the concrete.

The concrete shall be transported directly from the batch plant to the work site, as quickly as possible so as to prevent its segregation or to prevent it starting to harden. CONTRACTOR shall submit to the COMPANY methods intended to be used for transporting concrete from the batching plant to the construction site.

Concrete mixing, transport and storage equipment shall be thoroughly cleaned after use.

Special attention shall be brought to the cleanliness of pumps, pipes and conveyor belts particularly at each breakdown or stoppage.

The rate of deliver of concrete during concreting operations shall be such that the interval between batches shall not exceed 20 minutes. If the interval exceeds 20 minutes the fresh concrete shall not be placed against concrete already poured.

Great care shall be taken to prevent foreign matter from being introduced into the concrete from any source.

Concrete shall be placed either continuously or in a layer of such thickness that no concrete is being placed over any concrete already set.

Precautions shall be taken to prevent the formwork and reinforcement moving during the placing or setting of the concrete and any remedial work that is necessary shall be executed promptly.

Forms and reinforcement located outside the work area shall not be splashed with concrete.

Extra water or admixtures shall not be allowed at the construction area.

The work shall be organized so that the placing of concrete is efficient and continuous between specified or approved construction joints.

Immediately after placing, concrete shall be consolidated by vibration especially in the corners of the forms, around reinforcement and embedment.

In the case of an accidental interruption not specified in the drawings, CONTRACTOR

8.5 Consolidation

Compaction of fresh concrete shall be undertaken as per the relevant Standards quoted above.

Full compaction of the concrete shall be achieved throughout the entire depth of the layer. It shall be thoroughly worked against the formwork and around the reinforcement and successive layers shall be thoroughly bonded together. Air bubbles formed during the mixing and casting shall be expelled.

Unless directed otherwise, approved power driven poker vibrators shall be used for compaction. Internal vibrators used shall be the largest size and the most powerful that can be used properly in the work.

Vibrators shall be inserted vertically at such distances apart, or applied in such manner, as will ensure that the concrete is satisfactorily and uniformly compacted. Immersion vibrators shall penetrate the full depth of the layer, and when the underlying layer is of fresh concrete, shall enter and revibrate that layer to ensure that successive layers are bonded together.

Over-vibration causing segregation, surface laitance or leakage through formwork shall be avoided.

Immersion vibrators shall be withdrawn slowly to prevent the formation of voids.

Vibrators shall not be used to work the concrete along the forms, or in such a way as to segregate the mix, damage formwork or other parts of the work, or displace the reinforcement. External vibrators shall not be used.

Use of vibrators to transport concrete within forms shall not be allowed.

A set of vibrators and spare parts for their repair shall be kept in sufficient quantity on site throughout the duration of the works.

Vibrators shall be placed at the most effective location for the equipment. The construction CONTRACTOR shall list the type and the number of vibrators planned to be used for the work.

8.6 Construction joints

Where construction joints are defined in construction documents, no deviation shall be allowed without the agreement of COMPANY.

Additional construction joints (i.e joints required because of limitation of concreting or shuttering) shall be kept to a minimum and be limited to those agreed by COMPANY.

Where no construction joints are not defined in construction documents, their location shall be carefully considered and agreed before concrete is placed. The position of the joints shall generally be at points of minimum shear and at right angles to the main rebar in the member.

At each construction joint location, the hardened face shall be chipped, cut-away and freshly cleaned with compressed air. The surface shall be saturated with water so that adherence between old and fresh concrete is correct. However, the surface should not be dripping or should not show any puddle of water.

Excess water shall be eliminated by compressed air. If concrete is to be consolidated by internal vibration, the vibration time shall be increased by one half of the time that would be needed if the preceding layer was still plastic.

Construction joints may need specific treatment due to particular stability conditions. In this case, the Engineering CONTRACTOR shall stipulate the adequate treatment on the drawings.

A non-forecast construction joint, which has to be executed in compliance with the above specifications, can only be undertaken after COMPANY approval of its final configuration. The COMPANY can specify the demolitions required so as to guarantee the required strength and a good appearance of the joining surface. CONTRACTOR shall check need for additional reinforcement through any unforeseen construction joint.

All construction joints badly executed shall be redone at the Construction CONTRACTOR expense.

The use of retarding admixtures, sprays or other applications on construction joints is prohibited unless there is a previous written approval by the COMPANY.

The use of special mortars to improve joint quality shall be submitted for COMPANY approval.

8.7 Curing and protection

Curing must be carried out according to hydrothermal conditions.

The curing product characteristics and implementation procedure shall be submitted to the COMPANY approval. Curing must begin as soon as possible after form removal or after the surface is finished.

No curing product except fresh water meeting requirements of section 4.5 can be used on construction joints.

Regular and frequent inspection shall be made of concrete being cured and tests shall be made on the permeability of cured concrete which will establish whether or not curing has been correctly carried out.

Special precautions shall be taken to prevent settlement cracking in top and side surfaces and particularly at the top of thin elements.

The exposed surfaces of the concrete shall be protected during hardening from the effects of sunshine, drying winds, rain or running water.

Curing of the concrete after the initial set shall be by one of following methods subjected to acceptance:

- Pounding with water including protection from atmospheric contamination
- Application of absorptive mats of fabric or Hessian kept continuously wet

- Curing compound may be used in specific approved situations. It shall comply with the relevant Standards and shall be compatible with the finish painting of the concrete. CONTRACTOR shall obtain from Supplier of the curing compound, confirmation that it meets these requirements. A stating there is no chloride shall accompany the curing compound. Curing compound shall not be used on concrete surfaces which are to be bonded with concrete to be cast later (e.g; construction joints), and they should not be allowed to contaminate reinforcement.

The site supervisor shall be particularly demanding in order to guarantee that the correct technical applications are respected.

8.8 Removal of forms

Report to Section 6.4.

8.9 Defects and repairs

All major defects in placement of concrete (concrete not complying with specifications, lack of closeness, voids, honeycombs, cracks, etc.) shall be brought to the COMPANY attention as soon as the defect is discovered.

Repair means and procedure shall be submitted for the COMPANY approval before work is being started.

Superficial cleaning down with slop shall be prohibited.

8.10 Measures and procedures for emergency cases

The Construction CONTRACTOR shall take all necessary measures (equipment, organization, etc.) to handle critical circumstances. He must have available at any time sufficient means, material, stand-by equipment, personnel, etc. required to carry on concrete work even in the case of an incident (for example: storms, power shortage, interruption of material supply, equipment break-down, etc.).

The Construction CONTRACTOR must submit all emergency measures, procedures and their implementation to the COMPANY.

9. Embedded items

SUPPLIERS shall be approved by the COMPANY before any order is delivered.

CONTRACTOR shall submit for COMPANY approval a quality control plan to ensure all the material supplied to site comply with the relevant Standards.

9.1 Rods and anchor bolts

Rods and anchor bolts shall be either:

- Placed directly at the time concrete is placed
- Preferably set in a second stage in the recess provided for that purpose.

In the first case proper location shall be ensured by the use of rigidly held templates, enabling solid embedment and guaranteeing that there shall be no movement during placement of concrete.

In the second case, the sealing product shall be of non-shrinking type with a high cohesion capacity. The characteristics of this product and the procedures for its implementation shall be approved by the COMPANY.

Anchoring systems by means of concrete drilling and self-blocking or sealing of bolts may be used. The types envisaged for use shall be approved by the COMPANY.

The embedment for the various types of anchor shall be decided upon by the Engineering CONTRACTOR, depending on the nature and the intensity of loads to be transferred to concrete.

Steel items shall be degreased and shall not be painted before placing. After welding structural member or connection angles or insert, the exposed surface shall be painted. All the insert items shall be completely cleaned and the rust, dirt... shall be removed and receive 2 layers of painting. Sliding plates and levelling plates shall not be coated. Top surface of slide plates shall be oiled before installation of equipment.

9.2 Anchor rails

Rails to be incorporated during placement of concrete shall be well positioned and rigidly fastened. Tightness between rail and the forms shall be adequate to prevent any grout from entering into the rail.

9.3 Watertight joints (waterstops)

Material and type of watertight joints (waterstops) shall be submitted for prior approval of COMPANY.

Watertight joints (waterstops type) shall be used in all construction joints in water retaining structures, or where other wise indicated. Watertight joints shall be located as shown on the drawings. They must be cut exactly, adjusted and fully connected to provide a continuous tight diaphragm. Particular care shall be taken for their fastening and protection while the work is in progress.

Specialists shall carry out setting in place and welds.

All waterstops shall be installed to form a continuous watertight diaphragm in each joint. Adequate provisions shall be made to support and completely protect the waterstops during progress of the work.

Maximum density of the concrete shall be insured by thorough consolidation of the concrete in the vicinity of all waterstops. Suitable guards shall be provided to protect edges and ends of partially embedded waterstops from mechanical damage when concrete placement has been discontinued. Damaged joints must be replaced or repaired.

The choice of joint quality shall be made depending on requirements for use (for instance presence of hydrocarbon). The choice shall be approved by the COMPANY.

10. Prestressed concrete

10.1 Prestressing systems and materials

10.1.1 General

Prestressing systems to be used shall be internationally known with brand references and services well known as satisfactory in the field of major civil engineering works. The

prestressing system shall be submitted for COMPANY approval. All supplies and procedures related to prestressing works shall basically comply with the technical specifications of the prestressing system. These specifications shall be supplied to the COMPANY in due time.

10.1.2 Anchorage devices

Anchorage devices shall be of the type and make normally used by the MANUFACTURER of the proposed prestressing system. If these anchorage devices or parts of them (for example: wedge anchorage) are not made by the same MANUFACTURER, the latter shall nevertheless remain responsible.

All anchorage devices shall be stored in their original packages in a dry area and not in contact with the ground. Unless otherwise indicated on the drawings, standard reinforcement behind the anchorages (for example: grids, spirals) shall comply with those specified by the prestressing system of the MANUFACTURER.

10.1.3 Steel for prestressed concrete

a) Wires

If the tendons are made up of straight wires, these shall comply with the following standards:

- [EN 10138](#)
- or [BS 5896](#)
- or [ASTM A421](#).

Other types of wires must be approved by the COMPANY (especially the single wire prestressing system to which may be connected tensioning by bar systems).

In any case, there shall be no weld or joint in a finished wire.

b) Strands

If the tendons are made up with strands, these shall comply with the following standards:

- [EN 10138](#)
- or [BS 5896](#)
- or [ASTM A416](#) and [A779](#)

In any case, there shall be no weld (the strands shall be “no-weld type” as specified in [ASTM A416](#)).

c) Characteristics

The Construction CONTRACTOR shall provide the COMPANY with all the useful characteristics of the tendons to be used, as follows:

- **Geometrical**
 - Diameter (for single wires)
 - Number and diameter of individual wires, wire arrangement drawings, diameter of the circumscribed circle (for strands)
 - Nominal steel section
 - Nominal weight per unit length.

- **Mechanical**

- Breaking strength
- Nominal ultimate strength
- Elongation
- Reduction of area of a single wire or each individual wire of a strand
- Isothermal relaxation.

- **Technical**

- Brittleness
- Resistance to fatigue (bending, wrapping and rounding tests)
- Resistance to corrosion.

A strand sample having a chord length of 2000 mm shall have an offset at the center of the chord of not more than 100 mm.

d) Approval of material and SUPPLIERS

The Construction CONTRACTOR shall submit for COMPANY approval the detailed specifications of tendons for prestressed concrete, the names of SUPPLIERS, factories and references.

Several specifications and/or SUPPLIERS may be approved.

Only tendons with specifications and SUPPLIERS approved by the COMPANY shall be used for prestressed concrete. Any change shall be submitted for COMPANY approval.

The Construction CONTRACTOR shall supply the COMPANY with sufficient supporting evidences of the characteristics described above (for example: certified test results) and detailed data concerning the procedures and trial techniques to justify the given values.

The Construction CONTRACTOR shall supply the COMPANY with satisfactory trial tests (for example: certified test results) including characteristics not available from the SUPPLIER (for example: bending and unbending for brittleness, fatigue, corrosion under stress states, etc.).

For this purpose, the Construction CONTRACTOR shall take an adequate number of samples from SUPPLIERS and make or have made, at its own expenses, all the tests required that the COMPANY may judge necessary.

The Construction CONTRACTOR shall make all arrangements with the parties involved so that the COMPANY may attend on notification any test of whatever character.

e) Control tests, test results

Control tests of tendons for prestressed concrete shall be made by the MANUFACTURER laboratory free of charge for the COMPANY.

The Construction CONTRACTOR shall make all arrangements with parties involved so that, on simple notice, the COMPANY may be present at any time for these tests.

The control tests at least required are as follows:

- From each reel, at least one sample shall be taken:
 - Breaking strength
 - Reduction area.
- For one out of five reels, at least one sample shall be taken:
 - Yield strength
 - Corresponding elongation.
- For each production lot (cast steel) or at least for each 20 tons, a detailed stress-strain diagram (elongation under load) shall be established (to be used in estimating and checking tendon elongation).

Periodic brittleness tests shall be made. The sampling and testing procedure shall be submitted for the COMPANY approval. Test results and diagrams shall be carefully referenced so that the test results are evidently related to the reels actually tested. The Construction CONTRACTOR shall provide to the COMPANY, on simple request, any document containing test evidences.

f) Storage and shipping

Reels and/or spools shall be carefully labelled so that specification, MANUFACTURER and lot can be easily identified.

Storage and shipping shall be done in such a way that the steel shows no signs of corrosion other than superficial rust, requiring no surface scraping.

Prestressing steel displaying corrosion other than superficial rust shall be rejected.

A coating of approved and water-soluble oil shall be used. Tendons for prestressed concrete shall not be exposed to mechanical damages or other harmful acts during handling.

The site storage area shall be a dry warehouse and reels and/or spools shall not be in direct contact with the ground.

Storage means, allowing for accessibility for inspection and identification of shipments, shall be provided and submitted for approval.

10.1.4 Ducts

Specification and makes for rigid and semi-rigid (flexible-metal sheathing) ducts shall be submitted for COMPANY approval. Only approved ducts shall be used and any change must be submitted for the COMPANY written approval.

All ducts shall be made of steel either galvanized or temporarily protected against corrosion with water-soluble oil.

a) Rigid tubing

All vertical tendons, looped tendons and some specially requested tendons shall be run inside smooth finish steel pipes.

The minimum interior diameter and thickness of wall shall be specified on drawings.

For general instructions, refer to Section 11.1. Either spigot or screw type joints shall be used.

Spigot joints shall be sealed with effective means that can be checked and approved by the COMPANY.

It is extremely important to respect the direction of the spigot-joint bell (or the female end if a screw type is used) with respect to the direction in which the tendon is run through.

The maximum allowed ovalization is:

$$D_{\max} \leq D_{\min} + 10 \text{ mm}$$

Bends shall be free of irregularities.

b) Semi-rigid ducts (flexible tubing - metal sheathing)

For horizontal tendons other than looped tendons, flexible tubing may be used as ducts if the following precautions are taken:

- 1) Ducts shall be mortar-tight to a pressure of 1.5 bar.
- 2) Ducts must be bent on site, without damage, to the specified curves or profiles of the drawings and without any crack, buckling or excessive ovalization.
- 3) Splices shall be made with standard threaded couplers and sleeves 30 cm long, minimum, providing a rigid assembly (as a general rule, the diameter of the coupling sleeve shall be 5 mm maximum larger than the duct diameter).
- 4) This connection with coupling sleeve shall be made mortar-tight by efficient and easily checked means.

c) General requirements (rigid and semi-rigid ducts)

The joints between ducts and flared end tubing as well as the joints between flared end tubing and anchorages shall be made mortar-tight by efficient and easily checked means. These means are submitted for COMPANY approval.

Ducts shall be handled, transported and stored so as to avoid any harmful corrosion or buckling. They shall not be stored in contact with the ground.

The Construction CONTRACTOR shall supply samples of ducts, provide the necessary tests and supply the COMPANY with sufficient test results as follows:

- Efficiency of the anti-corrosion protection when exposed to special atmospheric conditions
- Tightness - including tests on coupling sleeves
- Mechanical resistance.

Duct samples shall be provided by the Construction CONTRACTOR, on request from the COMPANY, for their testing by the COMPANY, as may be judged necessary.

In addition, the Construction CONTRACTOR shall:

- Demonstrate the correct operation of the bending equipment for pipes and ducts
- Submit his study for duct supports
- Prepare a model of a portion of a typical reinforcement cage of a sufficient length in order to show the suitability of the proposed method for supporting ducts
- Provide certified reports of all friction tests
- Make all tests for running tendons through ducts.

As mentioned above, the minimum requirements for interior diameter and wall thickness of pipes and ducts shall be as specified on the drawings.

For each tendon type and considering different layouts, the Construction CONTRACTOR shall indicate the duct type intended to be used and its geometry according to the following table:

Type of tendon	Minimum interior diameter (mm)	Minimum wall thickness (mm)	Duct type
Vertical	73.5	12/10	Smooth finish steel pipe
Loop with bend radius > 1.5 m	76	15/10	Smooth finish steel pipe
Loop with bend radius between 1.00 and 1.5 m	83	20/10	Smooth finish steel pipe
Horizontal tendons other than lopped tendons	74	6/10	Flexible duct

This specification shall be submitted to the COMPANY for approval.

d) Vents and drains

On horizontal ducts vents shall be placed to a maximum of 50 m. On undulating ducts vents shall be placed at the highest points and every 50 m maximum.

Drains shall be placed at low points on U-shaped vertical ducts, to allow for a draining-off by gravity.

10.2 Manufacturing tendons, placing ducts, running tendons through ducts and tensioning

10.2.1 Tendon manufacturing

Only steel with the same characteristics and make, provided by the same SUPPLIER shall be used for manufacturing a given tendon. This is important in order to avoid use of strands or wires with different characteristics (for example: different relaxation losses) in the same tendon.

The tendons shall be carefully labelled and a chart shall be made enabling immediate correlation between a given tendon and the steel used for manufacturing it (with reference to the characteristics and the stress-strain diagram of steel).

10.2.2 Placing ducts

The ducts shall be solidly fastened to prevent any movement during placement of concrete. The ends of the ducts shall be permanently and efficiently protected to prevent water or debris from entering. For ducts set in place without tendons, a check shall be made immediately after concreting is over to ensure free running of tendon through the duct.

Steel pipes of curved shape shall be pre-shaped with a uniform radius. The Construction CONTRACTOR shall submit for COMPANY approval the tolerances planned for placing the ducts. Once these tolerances are approved, the Construction CONTRACTOR shall take all necessary measures to stick to these tolerances.

It is also recommended that guide tubes, duct tubes or similar be used when horizontal tendons cannot be aligned to the COMPANY satisfaction (for example: when parts of the regular anchoring system are positioned before concreting).

The approved duct supports shall be set by welding with a maximum interval of 2.00 m between centerlines. An intermediate tie inside each 2.00 m interval shall be made with a connection wire.

If bandstrips are used for joint coverings, the Construction CONTRACTOR shall check that each joint is well adjusted (bell-mouth or sleeve) rather than simply butt assembled (a butt joint might cause a blocking-up and make the pulling of the tendon impossible).

10.2.3 Running tendon through duct and checking of the non-blocking-up of tendon

The Construction CONTRACTOR shall be responsible for pulling the tendon. It shall be systematically checked as soon as possible that the tendon may run free and that the duct is not blocked with grout. Such leaks might prevent from running the tendons (for tendons run in ducts after concrete pouring) or prevent the effective tensioning and/or injection (for tendons placed with their ducts before concrete pouring).

In the event a duct appears to be blocked, the Construction CONTRACTOR shall submit a proposed method for repairing it.

Tendons shall be run through the ducts, at the latest possible time, just before tensioning. If tensioning cannot follow immediately, any part of the prestressing system shall be protected by effective means to keep the steel and anchorage fittings clean and to prevent any foreign matter from entering into the anchorages and/or the ducts.

The same means of protection shall be applied to the ends of tendons placed in ducts before concrete work.

Any burning or welding operations in the vicinity of the tendons shall be submitted for COMPANY approval for each and any case.

10.2.4 Tensioning of tendons

Prestressing tendons shall be tensioned by means of hydraulic jacks provided by the MANUFACTURER of the prestressing system.

The tendons shall be simultaneously tensioned from both ends unless otherwise specified.

Pressure gauges shall be graduated every 10 bars.

Elongation shall be measured with an accuracy of 1 mm. Before tensioning operations are being started, the friction coefficient of the jack shall be measured on the cylinder.

The correlation between pressure gauge and elongation shall be 5%, that is:

If the forecast elongation A_0 is reached before the forecast pressure P_0 , continue tensioning until P_0 is attained, providing that elongation is not exceeding $1.05 A_0$.

If under pressure P_0 , elongation A_0 is not reached, tensioning shall continue by intervals of 5 bars until elongation A_0 is attained with a pressure not greater than $1.05 P_0$.

After the first ten tendons of a series have been tensioned, elongation and pressure gauge reading shall be recalculated if necessary. If, after the above readjustment and in COMPANY opinion, frequent discrepancies greater than 5% appear, tensioning shall be stopped and the cause of these discrepancies determined before tensioning is resumed. If frequent

discrepancies appear, the overtensioning of adjacent tendons, within the limits given above, is allowed.

Friction and standard values taken into account for the calculation of forecast elongation A_0 shall conform to the recommendations of the prestressing process. Major differences between the measured elongation and that specified may require a verification of calculation assumptions.

Upon request from the COMPANY, the Construction CONTRACTOR shall provide all necessary equipment and perform all tests (tendon cross-section, modulus of steel, friction within hydraulic jacks, friction of tendons inside ducts, etc.), that the COMPANY would consider necessary to explain the differences and to give a correct basis in order to specify elongations and pressures.

It should be kept in mind that the goal is to stress the tendon up to the nominative tensile strength for which it is designed. The elongation measurement is a check of the tensile load and not a goal in itself.

The minimum concrete strength required before tensioning shall be provided in agreement with the prestressing system specialists.

10.2.5 Quality control of operations

The Construction CONTRACTOR shall provide the following quality control phases:

Pressure gauges:

The pressure gauge on each pump shall be checked after 100 tensioning sequences and at least once per month with a standard calibrated pressure gauge. This can be done by changing the pressure gauge.

Tensioning of tendons:

The Construction CONTRACTOR is responsible for tensioning tendons. Tensioning shall be done with at least four measurements (pressure and elongation) at each active tendon end. Tendon slippage shall be simultaneously measured at the passive end, if necessary. Any change in this operative method shall be submitted for the COMPANY written approval.

The Construction CONTRACTOR shall supply automatically to the COMPANY, every day, all recorded tensioning measurements done during the last 24 hours.

Any incident or irregularity shall immediately be reported to the COMPANY with all available information.

10.2.6 Cutting the ends of pretensioned tendons

The procedure for cutting the extra length of exposed pretensioned tendons shall be submitted to COMPANY authorization.

10.3 Injection

10.3.1 General

All tendon ducts shall be completely injected after tensioning.

Delay between tensioning and injection shall not exceed 5 days.

The process for injection under vacuum is highly recommended.

10.3.2 Material

Portland cement shall be carefully chosen for a normal setting time. The chlorine content of chlorides must be less or equal to 0.02% of cement weight; the sulphur content of sulphides must be less or equal to 0.10% of cement weight. The cement must be fresh, dry and free of slag or agglomerates with a maximum temperature of 40°C.

Water shall be fresh, with a chlorine content less than 250 mg/l. It shall not contain substances that might cause steel corrosion and shall be free of detergents.

A retarding, expansion producing and water reducing admixture shall be used and submitted for COMPANY approval.

10.3.3 Grout characteristics

The grout for injection must have adequate flowability to penetrate into the ducts and also have sufficient stability to provide proper protection of the tendons.

Flowability shall be measured by flow time measurement with a standard Marsh flow cone. The flow time shall be at least 15 seconds with a maximum of 25 seconds. The recommended flow time from a batching plant is from 17 to 18 seconds.

The stability of the injected grout is characterized by the bleeding of grouts. Bleeding water on top of a grout sample after 3 hours rest shall not exceed 2% of the grout volume. This exuded water shall be completely reabsorbed by the grout after 24 hours, (evaporation being naturally prevented).

The water-cement ratio (E/C) shall not exceed 0.38. The corresponding bleeding rate shall show whether or not the E/C ratio should not be kept lower in order to comply with the requirement of 2% for bleeding water.

Shrinkage of grout shall not exceed 2800 microns per meter at 28 days. Compression strength at 28 days shall be least 300 bars. Tensile strength (0.6 time the tensile stress as calculated by flexure method) shall be at least 40 bars at 28 days on grout prisms preserved in airtight plastic bags.

10.3.4 Trial mix properties for grout

The trial mix shall be the Construction CONTRACTOR responsibility. The Construction CONTRACTOR shall study a mix in order to comply with the specified requirements, prepared with the same materials as those to be used on the work site and taking into account ducts characteristics (length, profile, section, etc.).

The Construction CONTRACTOR shall make systematic tests to determine the optimum water-cement ratio (E/C) and the final trial mix. These tests shall include:

- The measurement of flowability and bleeding compared to water-cement ratio (E/C): determination of a range of water-cement ratios (E/C) consistent with high flowability and low bleeding
- Measurement of shrinkage for the proposed mix, with three different values of water content (variation of ± 1 to 2 litres of water for 100 kg of optimum water content)
- Grout strength (compression and tensile strength by flexure method).

Mixing time shall be specified taking into account the equipment on work site.

The COMPANY may request additional trial test such as: setting time, capillary absorption, resistance to frost, etc.).

The mix study and all tests shall be at the Construction CONTRACTOR expenses.

10.3.5 Equipment and procedure for injection grout

The Construction CONTRACTOR, in agreement with the MANUFACTURER of the prestressing system, shall submit to the COMPANY a detailed specification concerning all equipment and procedures provided for mixing and transporting the grout.

In addition, detailed procedures shall be specified for injection operations, including special problems foreseen (for example: injection of U-shaped ducts from the topside, expulsion of bleeding water towards the top of a vertical duct, etc.).

The specifications shall also include injection sequences as well as emergency procedures for all unfavourable situations (equipment breakdown, plugged-up ducts, communication ducts, sudden frost, etc.).

10.3.6 Acceptance tests

Before injection is being started on the work site, acceptance tests shall demonstrate that the chosen mix for grout complies with the requirements of work site conditions. The Construction CONTRACTOR shall make the acceptance tests with the work site equipment and team, using materials supplied on site and following the procedures provided for here above. It shall be the Construction CONTRACTOR responsibility to provide and install in due time all equipment, facilities and personnel on the work site before the first injection operations, in order that acceptance tests can be made and the mix and/or equipment changed, should tests not meet the COMPANY requirements.

Batches for acceptance tests shall be made with quantities of materials corresponding to the normal capacity of the mixing plant. Acceptance tests shall include flowability (flowrate on the Marsh cone) and bleeding of injection grout, with samples taken at the start and the end of discharging of the feed drum of the mixing plant.

The mixing time determined by trial tests shall be checked with acceptance tests.

Flow time shall be equal to that specified in trial test with a tolerance of ± 3 sec.; bleeding should not exceed 2%. In the event the trial mix should not give satisfactory test results, new batches should be made in having the water content to vary by ± 1 to 2 litres per 100 kg of cement starting from the optimum value.

If these batches should not give the anticipated results, the Construction CONTRACTOR would propose a new grout mix and/or another type of mixing plant.

The COMPANY can request acceptance tests at any time, even after injection has begun on the work site (for example: to check suitability of a given cement supply).

All acceptance tests shall be at the Construction CONTRACTOR expenses.

10.3.7 Placement

Proportioning shall be done with a weighable method. Cement shall be supplied in 50 kg bags. Admixtures shall be prepared in proportions corresponding to a bag of cement or a full batch.

The accuracy of the mix shall be:

- 2% of cement weight
- 1% of water weight.



Materials for grout shall be fed into the mixer strictly in the same order as provided for in the trial mix. The mixer shall produce a perfect uniform colloidal grout, with the cement fully dispersed and deflocculated.

Temperature in the mixer and the drum shall be maintained at 25°C or less.

The grout shall pass through a 2-mm sieve before flowing into the feed drum of the storage tank. Grout in the feed drum or storage tank should be continually mixed to prevent segregation.

The delay between mixing and injection time should not exceed 60 minutes. Grout older than 60 minutes shall be rejected. Just before injection, the ducts shall be washed with pressurized freshwater and dried with compressed air.

Concrete around the injected ducts shall be kept at an adequate temperature to prevent frost on fresh grout and ensure its correct setting.

10.3.8 Approval of material, equipment and procedures

The Construction CONTRACTOR shall submit for COMPANY approval detailed specifications covering all materials, final mix, equipment and procedures planned for grout manufacturing and transport as well as injection procedures (see also paragraph 10.3.4 above).

Any change shall be submitted for the COMPANY written approval.

10.3.9 Quality control of the injection grout

Quality control of the injection grout shall be made by the Construction CONTRACTOR at his own expenses. The quality control shall cover at least the following points:

a) Control tests

Control tests must check that the grout normally used complies with the requirements. The control tests shall include:

Flowability (flow time):

The flow time shall be measured on grout samples taken:

- At the end of the duct on the injection pump side (tubing shall have a bypass for sampling) with a frequency of 3 tests per metric ton of grout
- At the other end of the injected duct and with a frequency of 3 tests per metric ton of cement or if this is more unfavourable, 1 test per series of ducts injected simultaneously.

Flow time must be equal to that selected for acceptance tests.

In the event where flow time measured at the far end of the duct is lower than the minimum required time, injection shall be maintained until the correct flowability is obtained at the farthest end of the duct.

Bleeding:

Bleeding shall be measured on set mortar:

- At the pump outlet (near the tendon end)
- At the other end of the tendon.

Test frequency: 1 measurement per metric ton of cement

Bleeding shall never exceed 2%. In the case where results on samples taken at a point near the end of a tendon do not agree with this requirement, injection shall be stopped and the Construction CONTRACTOR shall proceed with a careful checking of batching and mixing.

If the correct values cannot be obtained, the injection ducts shall be immediately washed and the Construction CONTRACTOR shall proceed with a careful checking of batching and mixing.

b) Procedure control

Procedures related to batching, mixing and transportation of grout, etc, shall be covered by the Construction CONTRACTOR quality control.

The reports shall include:

- Exact starting time for the mixing operation
- Grout temperature in the storage tank and at the end of the injection duct
- Checking that the grout is no more than 60 minutes old
- Verification that the storage tank was completely empty and clean before receiving the next grout mix
- Verification that a stirring-mixing of the grout was kept on a full time scale inside the storage tank
- Date and hour of the last cleaning of the mixer and injection pump and the last checking of the pressure gauge
- Verification that the mixer and pumps are cleaned and that the pressure gauges are checked at least after every 12 hours of operation.

The COMPANY can request additional tests on grout samples during normal injection operations (for example: expansion, shrinkage, strength of cured mortar, etc.). All tests shall be made at Construction CONTRACTOR expenses.

The COMPANY shall be provided with all results. All records shall be kept and made available to the COMPANY for inspection at any time, without notice.

10.3.10 Quality control of the injection

The Construction CONTRACTOR shall make quality controls of injection operations to ensure that all ducts are correctly injected. For each duct injected, a standard report form shall be filled out and signed by the responsible team supervisors.

All reports shall be kept in the Construction CONTRACTOR files and made available for the COMPANY inspection at any time, without notice.

Considering the short time available for setting of grout, any rising problem shall be reported **immediately** to the COMPANY.

The report shall contain complete descriptions of this problem and the procedure used to solve it.

The COMPANY signature is required for acceptance of measures taken to solve the problem.

10.4 Finishing (protection of anchorage zones)

All anchorages and end blocks shall be handled with great care, anchorage zones shall be successively cleaned, roughened by brushing, hammering or any other valid method and

cleaned again; epoxy resin mortar shall be then applied on the clean and dry surface according to the SUPPLIER's specifications and the anchorage zones filled with high quality and carefully vibrated concrete, using internal mechanical vibrators. Only skilled workers are permitted to do this extremely important work.

The Construction CONTRACTOR shall submit to COMPANY approval all detailed specifications concerning the procedures and materials forecast for finishing.

10.5 Technical assistance

Highly skilled technical assistance shall be provided by the Construction CONTRACTOR for correct initiation of the following operations:

- Placing of ducts
- Tensioning
- Injection
- Final protection of anchorages.

A list of the supervisors' names and qualifications shall be submitted for COMPANY approval. In each team of workers, at least 50% of the workers must have prior experience with this specialized work. All workers shall receive an instruction book before works begin.

The COMPANY reserves the right to test the craftsmanship of any worker according to his specialization and to refuse his employment.

11. Precast concrete

11.1 General

The specifications concerning precast concrete follow those of reinforced and prestressed concrete specifications described in the preceding paragraphs; these specifications are completed in the following sections concerning the manufacturing of precast concrete.

11.2 Methods for prefabricating concrete

11.2.1 Precast concrete at job-site

This includes all precast structural elements manufactured at job-site close to erection spot. These components are subject to COMPANY specifications related to reinforced and prestressed concrete.

11.2.2 Prefabrication factory

This includes components prefabricated in a specialized prefabrication factory. The COMPANY shall be very strict for these components since prefabrication in a factory involves a fine workmanship and a perfect control of all operations.

11.2.3 Design

The COMPANY may accept precast elements on condition that the monolithism of the final structure is preserved. This involves especially a good design of the connections and joints with reinforcing steel.

Design calculation shall be produced to demonstrate that all handling stresses have been catered for.

Consideration shall be given for the provision of additional reinforcement through the joint of precast members or through the joint to be formed with adjacent in-situ construction.

11.3 Precasting yard

The yard in which precasting work is to be undertaken shall be clean and shall have firm level beds, preferably of concrete, with drainage channels between the beds. The beds shall have a surface of suitable quality to give the precast units the required class of finish.

11.4 Moulds for precast concrete

The moulds shall be strongly constructed, closely jointed and true to the required shape with edges, corners and surfaces which comply with the relevant class of finish. Moulds are to be so designed that they can be readily taken apart and reassembled.

11.5 Marking

All units shall be marked on a face, which will not be exposed, in the permanent works, the date of manufacture and such distinguishing letters or numbers as are required to identify the work.

11.6 Materials

11.6.1 General

As a general rule, materials shall be checked by applying specifications described in the preceding sections.

11.6.2 Prestressing with bonded wires

Prestressing with bonded wires being not explicitly defined in COMPANY specification, the Construction CONTRACTOR is referred to the following additional information:

a) Type of wires

For wire types and steel characteristics refer to above specifications.

b) Tensioning

Bench tensioning and related other operations are the same as those listed for single wires.

c) Releasing wire tension after setting of concrete

The required concrete strength for release of pre-stressing shall be at least 300 bars.

This release can only be done when tests shall prove this strength has been reached.

Wires shall be symmetrically released by use of jacks.

Measurements for wire shortening should be made to check that the withdrawal of wires in the anchorage zone is 2 mm or less.

The use of power-driven disks, flushing machines or cutting torches is strictly prohibited for release of tensioning.

11.7 Check of manufacturing stages

11.7.1 Manufacturing

a) Concreting operation

Concrete manufacturing and placing shall be checked according to specifications described in the previous sections.

In case the Construction CONTRACTOR uses a steam curing of the precast elements in factory, the entire procedure should be submitted to COMPANY approval.

b) Quality control

This shall comply with requirements of specifications above.

The Construction CONTRACTOR shall give special care to external surface finishes of the elements (surface free of voids, honeycombs, etc.) and if necessary shall protect the edges of the elements to prevent chipping.

11.7.2 Storage

Storage of precast concrete elements after manufacturing and before erection shall be carefully checked.

Effective means shall be used to provide uniform supports for prefabricated elements and to prevent shocks or direct impacts.

Chipped, broken or cracked elements shall be rejected.

Drawings for precast members shall specify the lifting inserts for handling and storage.

11.7.3 Handling and transportation

Transport and handling procedures shall be submitted for COMPANY approval.

11.7.4 Erection

a) Erection

Precast members shall be erected with great care and good accuracy.

Bearing surfaces should be levelled and prepared before the precast elements arrive on site.

The erection drawings shall specify the shoring systems and all means (temporary guys, braces, falsework, cribbing) to insure stability of precast elements during erection operations and on-site concreting.

b) Cast-in-place concrete

The Construction CONTRACTOR shall provide proper construction joints between precast elements and cast-in-place concrete. Jointing is best done by chipping and cutting away precast concrete, thoroughly cleaning it of dust and loose particles and saturating it with water before pouring concrete.

11.8 Strength control of concrete elements

11.8.1 Elements justified by calculations

The strength of precast elements shall be checked according to design criteria specified in building codes in force.

The Construction CONTRACTOR shall justify design and calculation of these elements in compliance with prefabrication, curing, handling, delivery, erection and connection to form the final structure (refer to paragraph 11.7).

11.8.2 Elements justified by tests

Subject to the COMPANY prior approval, the Construction CONTRACTOR may justify the strength of precast elements by a series of tests.

These shall comply with regulations of building codes in force.

12. Hot weather concrete

12.1 General

The specifications of this section apply to hot weather concrete as supplemental specifications to those previously defined for the general reinforced and prestressed concrete specifications.

12.2 Materials

12.2.1 Cement

The chosen cement shall have preferably a low hydration temperature, and its brand shall be submitted to COMPANY approval.

The Construction CONTRACTOR shall take particular care for storage and provide effective protection against sun radiation. In particular, protection roofs shall be painted with reflecting white enamel.

12.2.2 Aggregates

Special precautions shall be taken concerning stock piling in batch plant bins. Aggregates shall be protected against excessive sun radiation and, if necessary, sprayed with freshwater.

Thermometric probes shall be placed in each storage bin. In addition, water content shall be checked according to the general specifications.

12.2.3 Water and ice

a) Water quality shall comply with the basic general specifications

Mixing water may be cooled in order to have a batch with a temperature less than 35°C. However, use of ice may prove to be far more effective.

b) Ice

Only ice chips are to be used.

These chips shall be several centimetres wide and several millimetres thick.

Usual food industry equipment is capable of producing 3 to 30 tons of chipped ice per day. Special storage bins are available for such. The type and capacity shall be the Construction CONTRACTOR responsibility.

12.2.4 Admixtures

The Construction CONTRACTOR may refer to the documents published by:

- Cement and Concrete Association: super plasticizing admixtures in concrete.
- ASTM: C494 Chemical admixtures for concrete
C260 Air entraining admixtures for concrete.

Types, purpose and use of admixtures must be submitted for COMPANY agreement.

12.3 Concrete production

Special requirements:

All the precautions defined here below combine for manufacturing concrete of a specified quality and for a temperature lower than 35°C.

a) Cement temperature

In view of the difficulty to lower cement temperature, all efforts should be set forth to maintain the storage conditions as defined in Section 12.2.1.

b) Aggregates temperature

Aggregate temperature shall be lowered as much as possible by water spraying, as defined in Section 12.2.2.

c) Water temperature

Water temperature shall be calculated so as to obtain a correct value for concrete placing temperatures.

Water may be cooled by addition of ice.

d) Addition of ice

The attention is drawn upon the necessity of adding ice, in the form of ice chips as defined in § 12.2.3.

The quantity of added ice shall not be more than 50 kg/m³.

e) Temperature of concrete as placed

The temperature of the various ingredients for concrete shall be calculated so as to obtain a mixture at a temperature less than 35°C.

12.3.1 Effect of admixtures

All tests or concrete specimens shall be made using the admixtures as provided for in the definitive concrete and complying with the general specifications.

12.3.2 Production of concrete

Concrete production shall comply with the general specifications.

Additional precautions shall be taken to provide control of concrete temperature at the point of mixing.

Special provisions shall be made by the Construction CONTRACTOR in his schedule for the possibility of not producing any concrete between 6 A.M. and noon.

This measure shall be applied only on COMPANY decision.

a) Batching and mixing

Batching and mixing shall comply with the provisions of Section 5.6.1.

b) Control of admixtures

Admixture use and mixing shall comply with the current standards and MANUFACTURER recommendations. The Construction CONTRACTOR control methods shall be submitted for COMPANY approval.

c) Immediate placing of concrete

Refer to Section 5.6.3.

The Construction CONTRACTOR shall speed up the placement and the finishing of concrete so as to reduce as much as possible temperature rising of concrete due to ambient hot temperature.

12.3.3 Concrete delivery

Refer to Section 5.7.

In addition to these specifications, the Construction CONTRACTOR shall take the necessary steps required to avoid temperature rising in concrete during its delivery.

12.4 Forms

12.4.1 Protection of forms against sun radiation

All exterior faces of the forms, including reinforcement bracing and vertical members shall be painted white.

12.4.2 Form removal

A form removal program, based on strength test results upon test specimens and on the type of structure, shall be prepared by the Construction CONTRACTOR and submitted to COMPANY approval.

12.4.3 Reinforcing steel

Steel rebars shall be stored in a ventilated shelter protected against sun radiation.

12.5 Placing of concrete

12.5.1 Concrete temperature

The temperature of the concrete placed in the forms shall not exceed 35°C; in case it does, it shall be rejected.

12.5.2 Construction joints

Inasmuch as possible, construction joints should be avoided in favour of a monolithic placement of concrete.

Construction joints shall comply with the general specifications. Fast drying shall be avoided by promptly protecting all exposed surfaces from sun radiation.

12.5.3 Curing and protection

Team and equipment assigned to curing and to protection of concrete shall be submitted by the Construction CONTRACTOR to COMPANY approval. Curing shall comply with the general specifications unless specified more stringently hereunder:

- a) The Construction CONTRACTOR shall be responsible for protecting the concrete against inclement weather. In particular, in case of wind higher than 25 km/hr, fresh concrete must be covered while maintaining water curing with saturated material.
- b) Prior to form removal, burlap shall be placed on horizontal and all vertical surfaces. This burlap, as well as the forms shall be kept moist.
- c) In case of water scarcity and/or according to COMPANY decision, curing products may be applied to the concrete, as per MANUFACTURER recommendations.

13. Cold weather concrete

13.1 General

The specifications of this section apply to cold weather concreting as supplemental specifications to those previously defined for the general reinforced and prestressed concrete specifications.

13.2 Materials

13.2.1 Cement

A fast-setting brand of cement as Portland class 45 or 55 is recommended in accordance with EN 2006.

13.2.2 Aggregates

Restrictions or precautions shall be applied as follows depending on the recorded temperature type:

Type 1: No restriction

Type 2: Crushed gravel aggregates are not acceptable.

Type 3: Crushed gravel aggregates are not acceptable. Selected aggregates shall be completely free of ice.

Type 4: Ditto No. 3, with heating of aggregates required.

13.2.3 Water

Water quality shall comply with the basic general specifications (See section 4.5).

The water to be used shall be free of snow or ice.

For temperature types 3 and 4, the water may be heated (refer to Section 13.3.1.c).

13.2.4 Admixtures

The Construction CONTRACTOR may refer to the documents published by:

- Cement and Concrete Association: super plasticizing admixtures in concrete.
- ASTM: C494 Chemical admixtures for concrete
C260 Air entraining admixtures for concrete.

For the types of admixtures to be used, refer to paragraph 13.3.2.

13.3 Concrete production

13.3.1 Special requirements

All the precautions listed below are minimum requirements to be taken to prevent concrete temperature from falling down below 0°C during the early setting period.

a) Aggregates temperature

As a general rule, aggregates shall be free of snow, ice or frost.

The thawing of aggregates shall be completed, and depending on the recorded temperature type, heating may be used (refer to Section 13.2.2).

b) Water temperature

The water to be used shall be free of snow, ice, or frost.

Heating up of the water may be possible depending on the recorded temperature type.

Premature contact of hot water over 40°C with cement shall be avoided.

In case hot water over 40°C is used, the order of mixing the ingredients shall be adjusted: hot water first and then coarse aggregates.

c) Temperature of concrete as placed

The temperature of the concrete as placed shall be over 5°C. In other case, special precautions shall be proposed by the designer.

13.3.2 Effect of admixtures

In order to reduce the water-cement ratio E/C and have it less or equal to 0.45 (including aggregate water), a plasticizer can be used for temperature types 1 and 2.

For temperature types 3 and 4, a multi-purpose admixture (plasticizer, air-entraining, setting and hardening accelerator) is required.

13.3.3 Production of concrete

Concrete production shall comply with the general specifications.

Additional precautions shall be taken during mixing operations to protect suitably the batch plant from inclement weather (snow, ice, and wind).

13.3.4 Concrete delivery

Concrete delivery shall comply with the general specifications.

Additional precautions shall be taken for maintaining the concrete temperature to a suitable level until its placement in the forms.

13.4 Forms

13.4.1 Protection against cold weather

As a general rule, forms and all surfaces to come in contact with newly placed concrete shall be free of snow, ice or frost.

When temperature types 3 and 4 are prevailing, the followings are required:

- Metal forms must be insulated
- Not-housed work areas shall have an insulation equivalent to a wooden form, for at least one week.

13.5 Reinforcing steel

Rebars shall be free of snow, ice or frost.

They must be stored in a shelter at a temperature not below 5°C.

13.6 Placing of concrete

13.6.1 Concrete temperature

The temperature of concrete being placed shall be at least 5°C.

It shall be maintained so, until setting of concrete takes place and until the initial strength reaches 5 N/mm² (around 50 bars). Additional tests shall be carried out to verify attainment of this strength.

13.6.2 Construction joints

Concrete joints shall comply with the general specifications.

Before pouring concrete, the Construction CONTRACTOR shall make sure that all the surfaces to come in contact with newly placed concrete are free of snow, ice or frost. These surfaces should be at the temperature of the concrete being placed.

All concrete damaged by frost shall be removed.

13.6.3 Curing and protection

Rather than using water curing, special curing compounds for low temperatures are preferred. Along construction joints, the Construction CONTRACTOR shall take all the necessary steps required to avoid desiccation, curing compounds being excluded.

The Construction CONTRACTOR shall provide protection for newly placed concrete against effects of cold wind as well as the necessary insulation to maintain the concrete temperature as stated in Section 13.6.1.

14. Offshore

14.1 General

This part covers offshore reinforced and prestressed concrete and completes the general specifications with respect to offshore reinforced and prestressed concrete.

14.2 Materials

14.2.1 Cement

Cement to be used shall comply with the following standards (see §5.2):

[NF P 15-317](#) (cement for setting at sea) with [EN 206](#) and [EN 197](#)
or [BS 4027](#): Specification for Sulfate-Resisting Portland Cement
or [ASTM C150](#): Standard Specification for Portland Cement

The chemical composition must respect the following limitations:

- Tricalcic aluminate $3\text{CaOAl}_2\text{O}_3$ content must not exceed 7%
- Chlorine contained in chloride ingredients shall not exceed the following limits:
 - reinforced concrete: 0.65% of cement weight,
 - prestressed concrete: 0.02% of cement weight.

In addition, for prestressed concrete, the sulphur contained in sulphides must not exceed 0.10%.

The certificate from the cement plant must also include the contents of $3\text{CaOAl}_2\text{O}_3$.

14.2.2 Aggregates

Refer to Section 4.4 above for the general specifications.

The quality of aggregates to be used for offshore concrete and the freezing point tests shall comply with the following standards:

[ASTM C682](#).

As a general rule the COMPANY requires that natural siliceous gravel be used for aggregates.

If these requirements cannot be met, supply of other types of aggregates shall be submitted for prior COMPANY written approval.

14.3 Concrete properties

In addition to the regulations in Section 5, the COMPANY might require density test (tests for concrete porosity): refer to standard [ASTM C642](#).

The ratio Water/Cement shall be under 0.42 and preferably near 0.35 with use of silicate fume.

14.4 Reinforcing steel

Bent steel rebars can be stored on barges provided that necessary measures are taken to prevent seawater splashes. The storage time is limited to the following limits:

- Reinforced concrete: maximum 2 weeks
- Prestressed concrete: maximum 1 week.

14.5 Placing of concrete

In case of prestressed concrete, the Construction CONTRACTOR attention is drawn upon additional precautions to be taken with respect to construction joints. Especially in case of horizontal tendons, these joints should be located midway between two successive layers of tendons.

Appendix 1 Results of physical tests made on cement samples

(sampling made according to standard [NF P 15-300](#))

Sample No. (1)	Normal consistency	Fineness mm	Specific weight	Specific surface cm ² /g	Setting time		Compression tests				Expansion test		Cracking test	
					Initial	Final	Mortar MPa		Concrete MPa		7 days	28 days	7 days	28 days
					Hrs Min	Hrs Min	7 days	28 days	7 days	28 days				
AFNOR Requirements														



Appendix 2 Results of chemical tests made on cement samples

% of chemical ingredients	Samples (1)				
	No. 1	No. 2	No. 3	No. 4	
INSOLUBLE RESIDUES					
Silica (Si O ₂)					
Alumina (Al ₂ O ₃)					
Total iron (Fe ₂ O ₃)					
Calcium (Ca O)					
Magnesium (Mg O)					
Potassium (K ₂ O)					
Sodium (Na ₂ O)					
Sulfate (So ₃)					
Loss on ignition					
Hydration heat at 7 days (Calories /g)					
Lime saturation rate					
Tricalcium silicate (C3 A)					
Total alkalis (Na ₂ O)					
+					
Alumina / Iron ratio A/I					

(1) To be attached to MANUFACTURER's technical sheets

Laboratory:

Supervisor Engineer:

Date:

Date:



Appendix 3 Sieve analysis of aggregates

Contract:

Sieves	Sand																		Gravel						Stones						
Supplementary sets	0,090	0,112	0,140	0,180	0,224	0,280	0,355	0,45	0,50	0,71	0,90	1,12	1,40	1,80	2,24	2,80	3,55	4,50	5,60	7,10	9,0	11,2	14	18	22,4	28	35,5	45	56	71	
Elementary quantity en %																															
Cumulative quantity en %																															
100																															
90																															
80																															
70																															
60																															
50																															
40																															
30																															
20																															
10																															
0																															
Standards sets	0,09	0,10	0,125	0,16	0,20	0,25	0,315	0,4	0,5	0,63	0,8	1,0	1,25	1,60	2,0	2,5	3,15	4,0	5,0	6,3	8	10	12,5	16	20	25	31,5	40	50	63	80
Elementary quantity en %																															
Cumulative quantity en %																															

Laboratory :

Supervisor Engineer :

Date :

Date :



Appendix 4 Test for sand equivalence

Project No.:

Work:

Laboratory:

Date:

File:

Operator:

	Sample No. 1		Sample No. 2		Sample No. 3	
	Trial test No. 1	Trial test No. 2	Trial test No. 1	Trial test No. 2	Trial test No. 1	Trial test No. 2
Top level of the clay suspension (clay reading): h_1 (cm)						
Sand reading under weighed foot: h_2 (cm)						
Sand reading at sight h_2 (cm)						
SE on trial test Under weighed foot: At sight:						
SE on sample Under weighed foot: At sight:						
Temperature (°C)						

(CF NF P 18-598)

Laboratory:

Supervisor Engineer:

Date:

Date:



Appendix 5 Analysis of water used in concrete mix

Contract:

Origin:

Sampling date:

Aspect:

Matters in suspension:

pH °C

Resistivity °C Ω /cm / cm²:

Free CO₂

Dissolved oxygen

Total hardness	Th			
Phenolphthalein alkalinity				
Methylorange alkalinity				
Titre with strong acid salts				
Chlorine	Cl			
Sulphur	SO ₄			
Sodium				
Potassium				
Silicates	SiO ₃			
Calcium	Ca ++			
Magnesium	Mg ++ per difference (Th-C ₃)			
Iron	Fe +++			

Trial date:

Made by

Laboratory

Conclusion

Water accepted for mixing concrete

Yes

No

LABORATORY:

SUPERVISOR ENGINEER:



Appendix 6 Concrete - Development tests

Works destination:

Contract:

Test No	PROPORTIONS IN DRY WEIGHTS						DRY WEIGHTS IN kg / m ³						ADMIXTURES			Slump mm	Effective Water/ cement ratio	Compression strength in KN / m ²		
	Cement	Sand	Fines (crushed)	5-15 mm	15-25 mm		Cement	Sand	Fines (crushed)	5-15 mm	15-25 mm		N° 1	N° 2	N° 3			3 days	7 days	28 days

NOTE: At the end of each test technical sheets shall be attached defining components (aggregates, cements, water admixtures, etc.)

OBSERVATIONS

Laboratory:

Supervisor Engineer:

Date:

Date:

Appendix 7 Concrete test - For feasibility - For control

Contract:

Test report:

No

Test date:

Samples

tested at $\frac{7}{28}$ days

a) CONCRETE CHARACTERISTICS	TYPE
-----------------------------	------

Cement : Quality

Quantities: kg/m³

Gravel : Origin/particle size

Quantities:

Sand : Origin

Quantities:

Moisture content of sand:

Added water

k/m³ batch

b) Works or sections of work concerned:

c) **Date and time of concrete pour:**

d) Temperature during concrete pour: °C

e) Results

Sample N°	Compression strength (on cylinder Ø 16 cm H 32 cm)		Slump test	Test Accepted (yes or no)	Remarks
	Breaking strength MPa	Average Resistance per batch			

NOTE: Breaking strength of sample shall be > R min =

Average strength of batch shall be > Rm =

Laboratory:

Supervisor Engineer:

Date:

Date:



Appendix 8 Authorization for placing concrete

Contract:

Designation of work							
No. of guide drawing:	Formwork drawing No.:			Reinforcement drawing No.:			
1) Topographical checking	Construction CONTRACTOR			Supervisor			
	Date	Hour	Sign.	Date 1st visit	Date Acc.	Hour	Sign.
	General lay-out						
	General levelling						
	Center line of anchors and embedments						
	Level of anchors and embedments						
Observations							
2) Check before placing of concrete							
	Cleaning of construction joints						
	Main reinforcement or embedments						
	Plumb and alignment of forms						
	Conformity of forms						
	Conformity of anchors and embedments						
Observations							
3) Ready for placing concrete							
	Cleaning of work						
Access and placing							

GOOD FOR CONCRETING

Day:

CONTRACTOR:

Supervisor Engineer:

Hour:

Appendix 9 Crushing tests on stone sample

Contract:

Samples	Type of stone	Output after crushing (% by weight)		Specific gravity voids and shape of particles								Water absorption % by weight	Bulk specific gravity		Tests on aggregates			
		Fine	Coarse	Size of particles mm	Apparent dry specific gravity kg / m ³		Voids %		Numbers of angula- rities	Index of elonga- -tion	Index of form		Oven dry	Satur- ated surface dry	Cru- shing index %	Impact index %	DEVAL abrasion index %	Los Angeles abrasio
					Loose	Dense	Loose	Dense										

Laboratory:

Date:

Supervisor Engineer:

Date:



Appendix 10 Fast determination of moisture content by pycnometer method

Contract:

Sample No.					
Total weight Moist soil + pycnometer = W1					
Weight of the pycnometer = T					
Weight of moist soil Wh = W1 – T					
Moist soil + pycnometer + water = W2					
Weight of additional water V2 = W2 – W1					
Volume of pycnometer V1					
Exact volume of sample V=V1-V2					
Moisture content W %					
average					
$w = \frac{V_p - W_h}{(W_h - V)\rho} \cdot 100$ V = volume of moist sample Wh = weight of moist sample ρ = specific gravity of sample					

Laboratory:

Supervisor Engineer:

Date:

Date:



Appendix 11 Report from concrete batch plant

Contract:

REPORT FROM CONCRETE BATCH PLANT OF

Total cast-concrete

M³ of which

M³ of mortar

C ₁ =	C ₂ =	C ₃ =	C ₄ =	M ₁ =	M ₂ =
------------------	------------------	------------------	------------------	------------------	------------------

Day	18 h	19 h	20 h	21 h	22 h	23 h	0 h	1 h	2 h	3 h	4 h	5 h	6 h
Night	6 h	7 h	8 h	9 h	10 h	11 h	12 h	13 h	14 h	15 h	16 h	17h	18h

Stoppages and services responsible:

Notes:

Construction CONTRACTOR:

Supervisor Engineer:

Date:

Date:



Appendix 12 Report on sampling made

Contract:

Place of sampling: batching plant transport site			
1 st series	Hour: Slump test:	Number of samples:	Reference marks:
Observations:			
2 nd series	Hour: Slump test:	Number of samples:	Reference marks:
Observations:			
3 rd series	Hour: Slump test:	Number of samples:	Reference marks:
Observations:			

Construction CONTRACTOR:**Supervisor Engineer:****Date:****Date:**

Appendix 13 Tensioning of steel

Contract No:

Work:

TENSIONING

CONTRACTOR: _____ DATE: _____

COMPONENT: _____ CONCRETE POUR DATE: _____

TENDON No: TYPE: STEEL:

PRESSURE IN BARS IN PUMP PRESSURE GAUGE	ELONGATION OBTAINED (mm)			
	JACK END	OPPOSITE END	TOTAL	CORRECTION

(EMPTY JACK)

DIFFERENCE

FORECAST PRESSURE:

FORECAST ELONGATION:

BLOCKED PRESSURE:

OBSERVATIONS AND INCIDENTS

TENSIONING SUPERVISOR
DATE

SUPERVISOR ENGINEER
DATE

Appendix 14 Tensioning summary sheet

Contract No:

Work:

CONTRACTOR: _____ LOCATION OF STRUCTURAL MEMBER: _____

TENDON No.	ELONGATION			DATE	TYPE OF TENDON	FROM 1 OR 2 ENDS	REMARKS
	CALCULATED	PRESSURE IN THE JACK	MEASURED				



Appendix 15 Injection

Contract No.:

Work:

CONTRACTOR: _____

DATE: _____

COMPONENT: _____

DUCT		TYPE		GROUT COMPOSITION			
ARRIVAL DATE ON SITE OF TENDON:				CEMENT	kg	WATER	LITERS
TENSIONING DATE:				SAND or		TYPE OF	ADMIXTURE
INJECTION DATE:				FILLER	kg		
TYPE OF TENDON:				FLOWING TIME			
TEMPERATURE UNDER SHELTER:				FOR MARSH CONE TEST			
TENDON No.	RINCING	BLOWING	PRESSURE IN BARS AT THE END OF INJECTION	PRESSURE MAINTAINING TIME AT 5 BARS	REMARKS		

TENSIONING SUPERVISOR:
DATE

SUPERVISOR ENGINEER:
DATE



Appendix 16 Injection summary sheet

Contract No.:

Work:

CONTRACTOR: _____ LOCATION OF
STRUCTURAL MEMBER: _____

TENDON No	INJECTION DATE	PRESSURE AT THE END OF INJECTION	TIME FOR PRESSURE MAINTAINING	REMARKS