

GENERAL SPECIFICATION

CIVIL WORKS

GS EP CIV 300

Reinforced and prestressed concrete - execution

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1. Scope

This specification defines the minimum requirements applicable to the construction of reinforced and prestressed concrete structures linked to **GS EP STR 500** and **GS EP STR 510**.

It addresses both onshore and marine (located offshore or nearshore) concrete structures.

Pipeline coating is out of the scope of this document.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
ASTM A416/A416M	Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM C150/C150M	Standard Specification for Portland Cement
ASTM C33/C33M	Standard Specification for Concrete Aggregates
ASTM C330/C330M	Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
BAW code of practice	Frost Resistance Tests for Concrete (MFB), issue 2012
DNVGL-ST-C502	Offshore concrete structures
EN 10080	Steel for the reinforcement of concrete - Weldable reinforcing steel - General
EN 1097 (All Parts)	Tests for mechanical and physical properties of aggregates - All Parts
EN 12390 (All Parts)	Testing hardened concrete - All Parts
EN 12620	Aggregates for concrete
EN 1367 (All Parts)	Tests for thermal and weathering properties of aggregates - All Parts
EN 13670	Execution of concrete structures
EN 14487 (Parts 1; 2)	Sprayed concrete - Parts 1; 2
EN 14889 (Parts 1; 2)	Fibres for concrete - Parts 1; 2
EN 196 (All Parts)	Method of testing cement - All Parts
EN 197 (All Parts)	Cement - All Parts

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Reference	Title
EN 1992 (All Parts)	Eurocode 2: Design of concrete structures – All Parts
EN 206 (All Parts)	Concrete - All Parts
EN 206	Concrete - Specification, performance, production and conformity
EN 445	Grout for prestressing tendons - Test methods
EN 446	Grout for prestressing tendons - Grouting Procedures
EN 447	Grout for prestressing tendons - Basic requirements
EN 934 (All Parts)	Admixtures for concrete, mortar and grout - All Parts
EN ISO 15630 (All Parts)	Steel for the reinforcement and prestressing of concrete - Test methods - All Parts
ISO 1920 (All Parts)	Testing of concrete - All Parts
ISO 19903	Petroleum and natural gas industries Fixed concrete offshore structures
ISO 22965 (All Parts)	Concrete - All Parts
ISO 6934 (All Parts)	Steel for the prestressing of concrete - All Parts
NF P11-213	DTU 13.3 - Paving - Design, calculation and production
NF P15-317	Hydraulic binders - Sea-water resisting cements

Total General Specifications

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Reference	Title
GS EP CIV 201	Design and construction of roads and stabilized areas
GS EP CIV 650	Floating Concrete Structure
GS EP ELE 032	Design of Earthing and Bonding Systems and Lightning Protection for Onshore Installations
GS EP STR 500	Onshore Structure - General
GS EP STR 510	Onshore Structure - Design

3. Applicability

This specification defines the minimum requirements for the design and built of reinforced or prestressed concrete structures in Total E&P project.

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This specification is within the scope of the following engineering & construction tasks:

- Preliminary and basic design
- Development of Project Particular Specifications
- Detailed design
- Construction
- Expertise.

3.1 Type of construction

3.1.1 Onshore construction

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

3.1.2 Offshore construction

Nearshore structures, typically Gravity Based Structures (GBS), offshore platforms or Floating Production Unit are addressed in section 10 for minimum requirements.

4. Terms and definitions

For the purpose of this document, the following terms and definitions apply:

Approval	Means Managing entity of the referential written assent. Approval by managing entity shall in no way relieve Contractor of any of his obligations, responsibilities or liabilities. The words "Approve", "Approved" and "Approval" shall be construed accordingly.
Company (CPY)	Company refers to the company that has awarded to Contractor the construction of the work on Company's site and/or Contractor's site.
Contractor (CTR)	Contractor refers to the company that was awarded by Company the construction of the work on Company' site and/or Contractor's site. It includes all sub-contractors and vendors who perform any work on Company's site or Contractor's site. Subcontractor refers to any company or person to whom Contractor has subcontracted performance of any part of the work.
Project	A project includes all activities carried out by Contractors in the frame of a contract which has been awarded to them. A project may include several construction, phase and installation site.
Project Particular Specifications (PPS)	Project document fitted for purpose to the project taken into account basis of design (BoD) project data, requirements and specifications.

5. Design

Design of reinforced concrete structures is according to **GS EP STR 510**.

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For sea exposed area or chemical product or dropped object, concrete cover shall be in accordance with [EN 1992-1-1](#) for typical structure XS2. The structural class and the location of the structure (tidal area, splash zone, etc.) will give final requirements (XS3 for example).

6. Manufacture and Materials

6.1 Materials for concrete

The materials and products to be used for the construction works is supplied by the Contractor and submitted to Company for approval.

6.1.1 Cement

The cements shall comply with [EN 197](#).

The types of cement shall be selected according to the type of works to be performed (marine works, underground works, structural works, etc.) as specified in paragraph 6.2.3.

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

All cements shall be certified by the manufacturer in compliance with the required standards.

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

Contractor shall issue to Company the relevant certificates.

6.1.2 Aggregates

Aggregates shall be in compliance with the relevant standards ([EN 12620](#)).

6.1.3 Water

Water used for mixing concrete shall be according to [EN 10080](#).

6.1.4 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 such [EN 934](#). Admixtures containing chlorides shall not be used.

Admixtures Suppliers shall be well known. A certificate of origin shall be provided for each delivery of admixture to the worksite or use of admixture in the concrete works, giving the date of fabrication and the use by date.

6.1.5 Silica fume

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

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6.2 Concrete

6.2.1 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.

Methods for mix design is addressed in paragraph 7.1.

6.2.2 Concrete strength

The contractual strength for concrete is the “characteristic strength required” for compression at 28 days on cylinder specimens and determined using [ISO 1920](#).

6.2.3 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 Company according to intended use and the requirements of [EN 206](#) (Exposure class and water/Cement ratio in accordance with [EN 206](#) definition - additions included):

- Concrete exposed to sea water (class exposure XS1 or XS2) and precast concrete:
 - Cement Type: 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](#).
- Concrete exposed to arctic environment (class exposure XF4):
 - Cement Type: 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](#).
- Concrete for foundations, slabs, walls and columns:
 - $\sigma_{sr} \geq 30$ MPa
 - Cement Type: II or III
- Concrete for paving and ditches:
 - $\sigma_{sr} \geq 25$ MPa
 - Cement Type: II or III
- Lean Concrete and mass concrete shall be at least C 15/20.
- For structures exposed to Sulphates, Sulphate Resisting Cement shall be used.
- For Mass concrete, cement Type IV (Low heat) shall be used.

The maximum cement content (cement + admixture if any - prior approval of Company is required - value in accordance with [EN 1992](#) and [EN 206](#)), whatever the type of reinforced concrete, shall not exceed 400 kg/m³.

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6.2.4 Changing materials and mixture proportions

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

6.2.5 Concrete for hot weather

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

- Maximum temperature > 33°C
- and/or mean temperature > 28°C

Depending on site conditions, those temperature limits could be lower, particularly in case of drying wind. It shall be defined in the PPS.

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

6.2.5.1 Cement

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

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.

6.2.5.2 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.

6.2.5.3 Water and ice

Mixing water may be cooled in order to have a batch with a temperature less than 35°C. However, use of ice chips may prove to be far more effective. The quantity of added ice shall not be more than 50 kg/m³.

6.2.5.4 Admixtures

Contractor shall submit a written request to Company for the addition of admixtures into the concrete. The admixture shall conform to [EN 934](#).

6.2.6 Concrete for cold weather

In addition to the standards to be used for the construction of reinforced concrete, special considerations listed here below shall be applied for concrete manufacturing 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

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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:** $5^{\circ}\text{C} > t_{mean} > 0^{\circ}\text{C}$ or $0^{\circ}\text{C} > t_{min} > -3^{\circ}\text{C}$
- **Type 3:** $0^{\circ}\text{C} > t_{mean} > -5^{\circ}\text{C}$ or $-3^{\circ}\text{C} > t_{min} > -7^{\circ}\text{C}$
- **Type 4:** $-5^{\circ}\text{C} > t_{mean} > -10^{\circ}\text{C}$ 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.

6.2.6.1 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.

6.2.6.2 Water

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

For temperature types 3 and 4, the water may be heated.

6.2.6.3 Admixtures

Contractor shall submit a written request to Company for the addition of admixtures into the concrete. The admixture shall conform to [EN 934](#).

6.2.6.4 Special requirements for concrete production

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.

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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.

6.2.6.5 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.

6.2.6.6 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).

6.3 Concrete delivery

The Contractor shall submit to 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 (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), 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 120 minutes after filling the truck shall be rejected (this duration may be modified for concrete placed in hot weather).

The rate of delivery of concrete during concreting operations shall be such that the interval between batches shall not exceed the interval defined by mix design or 20 minutes if no interval is defined. If the interval exceeds this limit the fresh concrete shall not be placed against concrete already poured.

The complete procedure planned shall be submitted for Company approval. The overall means of control shall be at the Contractor expenses.

In case of slipforming, a minimum of two batching plants and one spare are mandatory.

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On arrival at the concreting site, the concrete delivery form, complying with the standard [EN 206-1](#), following verifications shall be carried out:

- The date and time of fabrication
- The nature and weight of the components, taking account of humidity corrections, and origin (quarry, works)
- The cement class
- The quantity of concrete (the capacity of the mixer lorry shall not be exceeded).

6.4 Forms

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

They shall be sealed against leak or loss of grout, rigid, plumb, well braced and interconnected to prevent any warping or displacement.

If required by Company, Contractor shall provide documentation detailing methods and materials proposed for formwork. 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.

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

6.4.1 Preparation of form contact surfaces

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).

6.4.2 Re-use of forms

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

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6.4.3 Stay in place formworks

The use of stay in place formworks is authorized for buried works and slabs in elevation. It allows:

- A significant time saving in comparison with traditional formworks
- An economy in concrete and a better mastery of the form comparatively with a concrete poured in trenches.

However, the use of stay in place formworks does not allow the inspection of the siding. Thus, the control of the concrete pouring shall be particularly rigorous.

Stay in place formworks shall be made of:

- For buried works, rigid and sealed polypropylene plates
- For slabs in elevation, steel sheets which shall be justified with a calculation note.

6.4.4 Slipforming

The formulation of the concrete shall be adapted to the site conditions and to the rise speed of the formwork. Concrete needs to be workable enough to be placed into the form and consolidated (via vibration), yet quick-setting enough to emerge from the form with strength. Formula and tests will be performed in order to provide a concrete with these requirements. Mock-up is mandatory to test reinforcement methods, concrete specifications and delivery methods.

The inevitable aspect blemishes shall be limited by the use of adequate curing agents immediately at exit of the formwork.

6.4.4.1 General

The technique of slipforming is interesting in case of concrete work with regular and important size (chimney, tower, tank...). If this technique is envisaged, Contractor shall justify a minimum of 5 years experience in slipforming technique.

The 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
- All details for sliding operations
- System for removal of forms
- Steel reinforcement: detail, fabrication and supply
- Embedded parts: detail, fabrication, supply and positioning
- Template for positioning the ducts for prestressing tendons, if any: detail, supply and positioning
- Detail of workers teams
- Detail of lifting means.

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Contractor shall take into consideration the possible difficulties related to workers accesses and equipment delivery along with safety regulations.

6.4.4.2 Sliding operations, defects and repairs

As the sliding operations proceed, the quality of concrete shall be checked as soon as cleared from the form.

If defects appear, such as poor surface condition of concrete (peeling zones, honeycombs, cracks; Contractor shall take the steps required to come back to a normal situation of concreting and inform Company on the measures taken.

6.5 Steel reinforcement

6.5.1 General

Steel reinforcement shall be in accordance with [EN 10080](#) or the applicable local code and with the PPS.

The use of plain steels with yield strength of 235 MPa can be allowed for two types of reinforced steels:

- Secondary reinforcement that do not contribute directly to the mechanical strength of sections
- Reinforcement of less than 12 mm diameter undergoing successive folding-unfolding.

6.5.2 Preparation of steel bars

Contractor shall prepare the steel bars and put them in place according to drawings and specifications. 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.

Reinforcement shall preferably be joined by overlapping with ligature. The use of splice sleeves is subject to the agreement by Company.

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

6.5.3 Earthing

Concrete reinforcement shall be earthed according to [GS EP ELE 032](#).

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6.5.4 Concrete cover

Concrete cover shall be according to [GS EP STR 510](#).

6.6 Prestressing systems and materials

6.6.1 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.

6.6.2 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.

6.6.3 Steel for prestressed concrete

a) Wires

If the tendons are made up of straight wires, these shall comply with [ISO 6934](#) and be tested according to [EN ISO 15630](#).

Other types of wires shall be approved by 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 [ISO 6934](#) and be tested according to [EN ISO 15630](#).

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

6.6.4 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 shall be submitted for Company written approval.

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

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For each tendon type and considering different layouts, the 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

6.6.5 Grout

Portland cement shall be carefully chosen for a normal setting time. The chlorine content of chlorides shall be less or equal to 0.02% of cement weight; the sulphur content of sulphides shall be less or equal to 0.10% of cement weight. The cement shall 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.

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

7. Inspection and Testing

7.1 Concrete tests

7.1.1 Definitions

The Contractor shall provide three series of tests during the mix design phase and construction phase:

- **Development (or design) tests**, performed by the laboratory, to define optimal composition of concrete according to the qualities of aggregates and cements proposed by the Contractor and the requirements stipulated in particular specifications.
- **Feasibility (or suitability) tests**, using concrete made on site with worksite materials and using composition defined by the development tests.
- **Control (or inspection) 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.

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Development and feasibility tests are not mandatory if Contractor uses a ready mixed concrete produced by a factory for which the production control is certified (according to [EN 206-1](#)). In such a case, those tests may be replaced by the results of continuous inspection tests carried out in the factory after agreement by Company.

7.1.2 Development tests

At least five weeks before concrete works start, the 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.

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.

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

Before works start, the Contractor shall provide to Company all information related to the test mixes and strength values obtained.

The Contractor may use the results of laboratory tests for previous worksites where identical categories of concrete were used. Company reserves the right, however, to accept or reject the results proposed by Contractor depending on the nature of the previous sites and the inspections carried out.

7.1.3 Feasibility tests

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

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.