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02-Civil Concrete work

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Table of contents

1	Responsibility	4
2	Scope and Field of Application	4
2.1	Scope Definition	4
2.2	Document Conflicts	4
3	References and Definitions	4
3.1	References	4
4	Design	6
4.1	Owners specific requirements	6
4.1.1	Materials.....	6
4.1.2	Imposed loads	6
4.1.3	Equipment load	6
4.1.4	Stability of members	6
4.1.5	Deformations	6
4.1.6	Symbols and units	7
4.1.7	Other	7
5	Execution	7
5.1	Management	7
5.2	Foundation for Concrete	8
5.2.1	General	8
5.2.2	Preparation of foundation	8
5.3	Falsework and Formwork	9
5.3.1	Construction joints	9
5.3.2	Expansion joints	9
5.3.3	Joint sealants	9
5.3.4	Embedded items and concrete embedment	10
5.4	Concrete Surfaces	11
5.4.1	General	11
5.4.2	Formed surfaces	11
5.4.3	Unformed surfaces	11
5.4.4	Floor hardeners	11
5.5	Reinforcement	12
5.6	Concrete	12
5.6.1	Production	12
5.6.2	Concrete types	12
5.6.3	Additional requirements for frost resistant concrete	13
5.6.4	Testing and inspection.....	13
5.6.5	Execution classes.....	13
5.6.6	Non-shrinking grout	13
5.7	Concreting	14
5.7.1	General	14
5.7.2	Concreting in cold weather	14
5.7.3	Curing and protection in cold weather	14
5.7.4	Heat development control.....	14
5.7.5	Removal of formwork.....	15
5.7.6	Repair of damage.....	15
5.7.7	Repair of leakage and cracks	15
5.8	Execution with precast elements	15
5.8.1	General	15

5.8.2 Storage of products	15
5.8.3 Transport.....	15
5.8.4 Testing, inspection and submittals.....	16
5.8.5 Installation	16
5.8.6 Specific elements	16
5.9 Geometrical tolerances	16

1 Responsibility

This Standard Technical Specification (STS) is the responsibility of the Owner. The revision and date of issue are on the front page.

All deviations from the specifications must be approved in writing by the Owner.

2 Scope and Field of Application

2.1 Scope Definition

This Standard Technical Specification details the minimum technical requirements for design and execution of structural concrete.

2.2 Document Conflicts

Eventual conflicts between the referenced documents shall be reported, without delay, to the Owner in writing for resolution.

3 References and Definitions

3.1 References

All materials, workmanship, design calculation and tests shall be performed in compliance and read in conjunction with the NA-00-STS001 General Technical Standard and other relevant standards.

The relevance order of standards shall be according to NA-00-STS001.

All materials intended for use at Norðurál (NA) shall be approved by the Owner prior to use. The following referenced documents should be considered for the application of this document.

In general, the latest edition of the referenced documents shall be used. Exception is for example when mandatory regulations stipulate the use of previous versions, where the edition stipulated shall be used.

If this standard specification references an outdated version the Owner shall be notified.

Table 3.1- References / Standards

Standard Nr.	Subject/Name
Icelandic and European standards	
ÍST EN 1990:2002	Eurocode 0 - Basis of structural design
ÍST EN 1991-1-1:2002	Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings
ÍST EN 1991-1-2:2002	Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire
ÍST EN 1991-1-3:2003	Eurocode 1: Actions on structures - Part 1-3: General actions - Snow loads
ÍST EN 1991-1-4:2005	Eurocode 1: Actions on structures - General actions - Part 1-4: Wind actions
ÍST EN 1991-1-5:2003	Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions
ÍST EN 1991-1-6:2005	Eurocode 1: Actions on structures - Part 1-6: General actions - Actions during execution
ÍST EN 1991-1-7:2006	Eurocode 1 - Actions on structures - Part 1-7: General actions - Accidental actions
ÍST EN 1991-2:2003	Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges
ÍST EN 1991-3:2006	Eurocode 1 - Actions on structures - Part 3: Actions induced by cranes and machinery
ÍST EN 1991-4:2006	Eurocode 1: Actions on structures - Part 4: Silos and tanks
ÍST EN 1992-1-1:2004	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
ÍST EN 1992-1-2:2004	Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design
ÍST EN 1992-2:2005	Eurocode 2: Design of concrete structures - Part 2: Concrete bridges - Design and detailing rules
ÍST EN 1992-3:2006	Eurocode 2: Design of concrete structures - Part 3: Liquid retaining and containment structures
ÍST EN 1998 -1:2004	Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings
ÍST EN 1998 -2:2005	Eurocode 8: Design of structures for earthquake resistance - Part 2: Bridges
ÍST EN 1998 -4:2006	Eurocode 8: Design of structures for earthquake resistance - Part 4: Silos, tanks and pipelines
ÍST EN 1998 -6:2005	Eurocode 8: Design of structures for earthquake resistance - Part 6: Towers, masts and chimneys
ÍST 16:2016	Steel for the reinforcement of concrete - Ribbed bars and welded fabric
IST EN 206:2013	Concrete - Specification, performance, production and conformity
ÍST EN 1168:2005	Precast concrete products - Hollow core slabs
ÍST EN 12620:2002	Aggregates for concrete
IST EN 13369:2013	Common rules for precast products
IST EN 13670:2009	Execution of concrete structures
ISO/TS 8000	Data quality

ISO 8601:2004	Data elements and interchange formats
Regulations	
Byggingarreglugerð 112/2012	Building regulation of Iceland (Byggingareglugerð, nr 112/2012)
NA Standards	
00/00/STS001	General Standard Technical Specification
00/03/STS001	Surface treatment and painting
00/03/STS002	Structural steel
00/03/STS003	Cladding
NA Guidelines/ Rules	
NAG-HSE	Safety Rules

4 Design

All structural design shall be according to the Icelandic building regulation and the Icelandic Eurocodes with accompanying National Annexes.

4.1 Owners specific requirements

Enclosed are Owners specific requirements

4.1.1 Materials

Materials shall be new and of first class quality, free from defects and imperfections and shall fulfill the designated classification.

Members and sections requiring routine maintenance or exchange shall be from standard sections are subject to prior approval by the Owner.

4.1.2 Imposed loads

If codes, regulations or design brief do not specify higher loads, the following loads shall be used as a minimum (live loads, characteristic values):

- Vertical point load on roof 1,5 kN
- Vertical uniform loads on platforms, walkways and staircases 3,0 kN/m²
- Vertical point loads on platforms, walkways and staircases 2,0 kN
- Horizontal load on top of handrails 1,0 kN/m

4.1.3 Equipment load

Equipment load and reactions (dead, static, dynamic, wind and earthquake loads etc.) shall be obtained from the equipment vendor. The loads shall be multiplied by impact/dynamic load factors when applicable.

Same applies to specific events like impact and explosions as relevant.

4.1.4 Stability of members

Removable concrete elements shall not be considered as restraining the top flange of its supporting beam or used as diaphragm.

4.1.5 Deformations

The limits on maximum allowable deflection are based on the Icelandic building regulation (Icelandic: Byggingareglugerð/112, 2012).

4.1.6 Symbols and units

All measuring units shall be expressed in the metric system and shall be used in all information and communication. All documents, drawings, calculations shall use metric units.

- Units of the SI-System measurements are applied according to ISO/TS 8000
- Instruments shall be calibrated as per SI-System
- Numerical date representations shall comply with the ISO 8601 (EN 28601)
- A comma (,) is used as the decimal delimiter

Reference to other equivalent national and international Standards is subject to prior approval by the Owner.

4.1.7 Other

The design working life of permanent structures, including structures supporting equipment is 50yrs. Shorter working life is subject to prior approval by the Owner.

5 Execution

Execution (procurement, scaffolding, formwork, reinforcing, concreting, curing, erection of precast elements etc., and the inspection and documentation) of structural concrete shall be according to ÍST EN13670, ÍST EN13369 and this specification.

All execution of work shall be in accordance with Norðurál's (Owners) HSE Safety Rules, NAG-HSE.

5.1 Management

Unless noted otherwise the informative annexes in EN13670 and EN 13369 shall also be met.

The Contractor shall set up a Quality Plan and submit to the Owner for acceptance.

The quality plan shall include items listed in table 1, 2 and 3 in EN 13670.

The Contractor shall also in due time submit to the Owner, for approval, information on materials and products as listed in table 1, 2 and 3 in EN 13670, including but not limited to:

- a) The design of falsework and formwork. The design shall include i.e.:
 - the layout of the falsework and formwork,
 - supports and cladding material,
 - form ties, type and pattern,
 - type of form oil.
- b) A certified mill report for each delivery lot of reinforcement.
- c) Information on the storage area and processing facilities for reinforcing steel,
- d) Concreting plan, showing proposed lifts and construction joints. Lift drawings and all detail drawings necessary to ensure the proper construction of each part of the Works.
- e) Detailed reinforcement drawings and bar lists prepared on the basis of the Drawings, which will indicate only the main structural reinforcement required in the structures. These reinforcement drawings and bar lists shall be submitted to the Owner for approval 28 days prior to cutting of reinforcement.
- f) Information on facilities for curing concrete, such as:
 - devices for heat treatment of concrete during the hardening process, e.g. arrangements for internal cooling, and devices for monitoring heat development,
 - facilities for curing concrete in cold weather,

- measures for preventing excessive drying of concrete surfaces.

In ample time prior to start of concreting operations, the Contractor shall apply for the Owner's inspection and approval of installed reinforcement and embedded items.

The Contractor shall apply in writing to the Owner for issue of a "Concrete pour clearance" not less than 24 h prior to placing of a concrete lift. All formwork, reinforcement, embedded items and preparations for concreting of the lift must be completed before the clearance is issued. The Concrete pour clearance, prepared in triplicate, shall i.e. give account of:

- a) date and hour of scheduled commencement and finish of placing,
- b) location of placement,
- c) concrete type,
- d) estimated volume of concrete to be placed,
- e) reinforcement placed,
- f) expected temperature of air and concrete,
- g) proposed methods for heating of forms, reinforcement, hardened concrete etc. in cold weather,
- h) placement and compacting equipment,
- i) curing methods including i.e. heat control of concrete, e.g. embedded cooling system and insulation of forms and surfaces, concrete temperature measurements, maturity control, expected strength development of concrete, removal of forms and prevention of premature drying of concrete surfaces.

The Contractor shall not later than 35 days prior to any concrete pours in permanent structures submit to the Owner conclusive results of test of the concrete mixes to be used for properties described in 5.6.2 and 5.6.3

The Contractor shall not later than 14 days prior to concreting operations submit to the Owner various information concerning his concrete activities, i.e. the following:

- a) names and qualification of the foremen for batching, mixing and placing of concrete,
- b) proposed method for ascertaining that the concrete has obtained sufficient strength for removal of forms and has become frost resistant,
- c) proposed material for repair of concrete and method of application.

The Contractor shall without undue delay submit to the Owner any requested information concerning his inspection and control of the concrete work.

The (execution) contractor shall submit his structural calculations and production drawings for concrete elements to the Owner for approval.

5.2 Foundation for Concrete

5.2.1 General

The Contractor shall appropriately prepare any foundation for concrete prior to installation of formwork and the placing of concrete. Such preparation includes i.e.:

- a) drainage of water from the surface,
- b) cleaning of rock surfaces by approved means,
- c) placing of a layer of lean concrete or other approved cover on surfaces subject to weathering.

5.2.2 Preparation of foundation

All fill base materials on which concrete shall be placed must be adequately compacted with vibratory equipment suited to the conditions.

Preheating of concrete foundation in cold weather is described in 5.7.2 Concreting in cold weather.

5.3 Falsework and Formwork

Forms for outside concrete corners shall be chamfered 20 × 20 mm, except otherwise shown on the Drawings or directed.

Form ties shall generally be of the cone and rod type or other approved type for waterproof concrete members. The embedded metal rods shall terminate not less than 50 mm inside the formed face of the concrete, unless otherwise approved. A hole left in a face by a fastener shall be filled by an approved method, cf. 5.7.6 Repair of damage.

Form ties in sheath pipes may, if approved, be used through walls which are not subject to unilateral water pressure. The sheath pipes shall subsequently be cut at least 50 mm inside the concrete surface and the hole filled with concrete, unless otherwise approved.

Form ties shall be placed in regular patterns appropriate for the particular structure. The proposed pattern shall be approved by the Owner.

Tolerances, for members, structure, opening, embedded items etc. shall be according to Class 1 in IST EN 13670 if not specified otherwise in execution specification.

5.3.1 Construction joints

Construction joints are the common boundaries of concrete lifts, or boundaries of prefabricated elements and in-situ concrete, not separated by a movement joint. In general construction joints will not be shown on the Structural Drawings.

Location of construction joints not shown on the Structural Drawings or directed shall be proposed by the Contractor on lift drawings submitted to the Owner for approval as part of the concreting plan.

The face of a construction joint where water tightness is required must be appropriately prepared mechanically or by 30 - 40 MPa water jet prior to the placing of the subsequent lift of fresh concrete. The preceding concrete lift shall be saturated by water but surface dry when the successive lift is placed.

At construction joints, forms shall be constructed with strips to produce a straight joint at the exposed surface, unless otherwise directed.

5.3.2 Expansion joints

Expansion joints shall be placed where indicated on the Drawings

A filler shall be provided in expansion joints as shown on the Drawings or as directed.

If not otherwise specified, the expansion joint filler may be plate strips of expanded polystyrene (24 kg/m³), rock wool boards (150 kg/m³), bitumen impregnated fiber boards, bitumen coated cork boards or other filler approved.

Any material used for expansion joint filler must be approved by the Owner.

Joint backing rods shall be compatible with the joint sealant and shall be the type recommended by the sealant manufacturer.

5.3.3 Joint sealants

Field moulded joint sealants shall be either hot or cold applied materials which, upon curing, form an impermeable barrier to water, debris and any specified chemicals. The cured materials shall be elastic, cohesive and remain adhered to the joint faces throughout the range of joint movement or service temperatures. The sealants shall not be adversely affected by aging or weathering.

Sealants in horizontal joints, subject to pedestrian and vehicular traffic such as roadways and passageways, shall be one of the following:

- a) Hot applied, self-levelling polyvinylchloride-coal tar compound with an allowable extension and compression of 25 %.

- b) A two component neoprene or polyurethane or a modified urethane coal tar compound, both cold applied and self-levelling, with an allowable extension and compression of 12,5 %.
- c) Silicone rubber sealant of adequate quality. Backer rods with silicone treatment shall be used.

The manufacturer's recommended preparation, primers, installation methods etc. shall be used with sealants.

Sealants in vertical joints in walls or horizontal joints not subject to traffic shall be either polysulfide or polyurethane compounds, cold applied at a nonsag consistency.

Preformed joint sealer shall have straight and parallel sides, shall be of virgin crystallization-resistant neoprene, and shall be compatible with the concrete and with the lubricant adhesive used for installation. The joint sealer shall be flexible and pliable and retain its elasticity at temperatures from -30 to +100 °C. A lubricant-adhesive approved by the sealer manufacturer shall be used in the installation of the preformed sealer.

At least 56 days before its intended use, the Contractor shall submit to the Owner a sample of the proposed sealing compound together with the manufacturer's technical data and the details of the recommended method of application.

5.3.4 Embedded items and concrete embedment

Before placing concrete, care shall be taken that all embedded items are firmly and securely fastened in place, and that they are thoroughly clean. This applies both to items furnished by the Contractor and to items furnished and/or installed by others.

The installation of steel items which the Contractor shall embed in concrete will be as follows:

- a) Embedded steel items furnished by the Contractor.
- b) Embedded steel items furnished by others; items to be installed and embedded by the Contractor but furnished by others will be delivered by the Owner.
- c) Steel items furnished and installed by other contractors but which the Contractor shall embed in concrete.

Conduits and ducts:

- d) The Contractor shall furnish all material needed for the embedded conduits and ducts. All material shall be subject to approval by the Owner.
- e) Embedded conduits shall be made of polyethylene, polyvinylchloride or other approved material for the intended installation. The thickness of the conduit walls shall be appropriate.
- f) Embedded surfaces of inserts and sleeves shall be unpainted.
- g) Conduits for electrical cables shall have long sweep field bends wherever possible but shall in no case have smaller radius bends than are recommended by the manufacturer of the conduits. The interior of the conduits shall be smooth and suitable for installation of the cables.
- h) Conduits for electrical cables cut in the field shall have the ends properly machine tapered with tools designed for the purpose, or end in a smooth end bell, as directed. The Contractor shall keep the number of conduit joints to a minimum. Each embedded conduit joint shall be made securely watertight by welding the conduits together using an approved method.
- i) Embedded air ducts shall be made of galvanized steel plates as shown on the Drawings or directed.

5.4 Concrete Surfaces

5.4.1 General

Surface finish classes (F1, F2, U1, U2 or U3) are indicated on the Drawings.

In general the surface shall be free from honeycombs, segregation, loss of cement or fine material, damage due to stripping of forms, bolt holes, abrupt irregularities caused by movement of forms or their components, loose knots and similar features and bulges or depressions in the general plane of the surface.

Care shall be taken to keep uniform color of concrete surfaces permanently exposed to view, both regarding different lifts and repairs, unless otherwise directed.

5.4.2 Formed surfaces

The classes of finish for formed surfaces are designated F1 and F2.

- a) Finish F1 (rough finish), shall apply to any surface concealed from view, including surface upon or against which backfill or concrete is to be placed, and formed surfaces of joints or block outs. Minor blemishes caused by entrapped air or water will be accepted. The surface treatment after removal of forms includes i.e. the filling of form-tie holes, the correction of major surface depressions and bulges, and the repair of defective concrete and curing as specified.
- b) Finish F2 (smooth finish), will generally apply to any surface exposed to view. After removal of forms, the surface shall be improved by removing all fins and other projections, washing down, and the filling of the most noticeable blemishes. Form-tie holes shall be filled along with all voids as specified. In general, not more than 50 air voids of 5 - 15 mm diameter per m² will be accepted. Air voids exceeding 15 mm in diameter shall be repaired. When filling holes and repairing defective areas of permanently exposed surfaces, effort shall be made to match the color of the concrete. The use of release agents which may permanently stain or discolor the finished surface will not be permitted.

5.4.3 Unformed surfaces

The classes of finish for unformed concrete surface are designated as U1, U2 and U3.

- a) Finish U1 (screed finish) will apply to an unformed surface to be covered by fill or concrete. Finishing shall consist of levelling and screeding to produce a uniform surface. This finish is also the first stage of finishes U2 and U3.
- b) Finish U2 (float finish) will apply to an unformed surface not permanently covered by fill or concrete. Finishing shall consist of levelling and screeding to produce an even surface. Floating shall be started as soon as the screeded surface has stiffened sufficiently to produce a surface that is free from screed marks and is uniform in color and texture. This finish is also the second stage of finish U3.
- c) Finish U3 (steel trowel finish) will apply for particular exterior surfaces and for interior floors in buildings, except where a bonded concrete finish or tile floor is foreseen, in which case finish U1 shall apply. The finished surface shall be free from blemishes, ripples and trowel marks. If a non-slippery surface is required, brooming of finished surface may be directed.

Interior surfaces shall be sloped for drainage where shown on the Drawings. Exterior surfaces exposed to weather shall generally be sloped for drainage, even if not shown on the Drawings. The slope shall be at least 2 % but not more than 3 %, unless otherwise directed.

Tolerances for surfaces are according to table G.10.7 in EN 13670. Generally all surfaces shall meet tolerance class 1 except for surface class U3 where permitted deviation for global and local deviation are 1 and 3mm respectively for both moulded and not moulded surfaces.

5.4.4 Floor hardeners

Floor hardeners shall be as specified in the execution specification.

Liquid floor hardeners shall be a colorless chemical solution of magnesium or zinc fluor silicate in combination with a wetting agent. Liquid floor hardeners are recommended only for limiting the dusting of existing low quality floors. Should not be used on exterior slabs exposed to freezing conditions.

Floor hardeners, to minimize the dusting and increase the abrasion resistance of new floors, shall be premixed dry shake hardeners consisting of size-graded hard quartz aggregate and cementitious binder. A hardener with metallic aggregate may be specified for impact resistance or in areas of severe abrasion.

5.5 Reinforcement

Non prestressed reinforcement shall be grade B500NC according to ÍST 16.

Pre stressing systems; strands, tendons, kits, assemblies etc. shall be as specified in the execution specification.

Welding and or heating of reinforcement is subject to Owner prior approval and shall be according to chapter 6.4 in EN 13670.

NOTE: For safety reasons, concrete in potroom areas shall contain no electrically conductive supports, such as metallic chairs, bolsters, spacers or tie wires. Only special nonmetallic, nonconductive reinforcing supports shall be used. Similar rules may apply close to bus bars in other areas.

5.6 Concrete

5.6.1 Production

Structural concrete shall be ready mix concrete produced in a batch plant with operating permit (Icelandic: starfsleyfi) and fulfilling chapter 8.3.10 in Building regulation of Iceland (Icelandic: Byggingareglugerð)

Non prestressed concrete shall be in Chloride class 0,2, table 15 in EN 206

Prestressed concrete shall be in Chloride class 0,1, table 15 in EN 206.

Any cement type used must be approved by the Owner.

All bulk cement used in the Work shall be transported to Site in weather tight cement transport trucks and stored in adequately designed cement storage silos.

All sacked cement used in the Work shall be delivered to the Site in factory sealed bags. Damaged or broken bags will be rejected. Sacked cement shall be stored, immediately upon receipt at the site, in a dry, weathertight and properly ventilated building. All sacks shall be clearly and permanently marked by date of receipt at the site. This marking shall remain clearly visible on sacks in storage.

The Contractor shall organize his transports so that cement is stored for the shortest possible time at the Site. No cement stored at the site for more than three months shall be used unless retests prove it to be satisfactory according to EN 196.

5.6.2 Concrete types

On the Drawings the concrete type will be designated as **Cbb/cc:XEi-D-Ax**, where **Cbb/cc** indicates the compressive strength class of concrete (cf. EN 206), **XEi** the exposure class, **D** the upper sieve size of the aggregate in mm (cf. ÍST EN 12620), **Ae** for air-entrained concrete and **Ao** for non air-entrained.

The general concrete types are as follows:

- a) C12/15:X0-D-Ao: Concrete without reinforcement or embedded metal, not subject to freeze/thaw, abrasion or chemical attack.
- b) C16/20:X0-D-Ao: Concrete without reinforcement or embedded metal, not subject to freeze/thaw, abrasion or chemical attack.

- c) C20/25:XC1-D-Ax: Concrete designed for dry or permanently wet environment, Ae or Ao depending on if it is subject to freeze/thaw or not.
- d) C30/37:XC1-D-Ax: Concrete designed for dry or permanently wet environment, Ae or Ao depending on if it is subject to freeze/thaw or not..
- e) C30/37:XF3-D-Ae: Concrete designed for concrete surfaces exposed to high water saturation and freezing, but not subject to de-icing agent or seawater.

Special concrete types may be prescribed in the execution specifications for particular purposes.

5.6.3 Additional requirements for frost resistant concrete

The following requirements are made for frost resistant concrete, C30/37:XF3-D-Ae:

- Water/cement ratio < 0,45
- Minimum air content of fresh concrete at placement 5 - 7 %
Spacing factor (cf. ASTM C457) of the entrained air void system: < 0,20 mm
Specific surface: > 25 mm⁻¹
- Maximum Cl- by mass of cement < 0,2 % (cf. EN 206)
- Frost resistance tested by ASTM C666, procedure A:
Durability factor > 80
- Water penetration (cf. ÍST EN 12390-8)
maximum depth < 50 mm
estimated average depth < 20 mm

5.6.4 Testing and inspection

The Contractor shall keep logs on all his concrete activities, i.e. production, placing, supervision and production control, inspection and testing. These logs shall at any time be available to the Owner for examination.

The Owner may at any time inspect and test any Contractor's equipment intended for batching, mixing, transporting, placing and testing concrete.

The Owner may at any time take his own samples from the concrete mixes and the constituent materials of the concrete for testing. The Contractor shall assist the Owner in obtaining such samples.

5.6.5 Execution classes

In the execution specifications the structure or components of structures will be classified into execution classes as per EN 13670.

If a structure component has not been classified into an execution class in the execution documents, it shall be assumed to belong to Execution Class 3.

5.6.6 Non-shrinking grout

Non-shrinking grout to be placed under bearing plates, machinery bases, rails and where otherwise directed, shall be of a standard ready mix type, only to be mixed with water.

The grout mix shall be ready mix type of appropriate strength and quality, minimum one (1) strength class higher than the concrete upon which the base plate is erected. The grout mix,

mixing method, curing etc. shall be according to mix manufacturers recommendation and be submitted to the Owner for approval prior to use.

Forms for the grouting shall be installed where necessary, and care shall be taken that the grout fills all intended spaces, leaving no voids.

5.7 Concreting

5.7.1 General

Concrete shall be inspected at the point of placing.

Unless noted otherwise, concrete shall be in curing class 4.

Contractors inspection plan shall include requirements in table 1, table 2, table 3 and Annex B of EN 13670

"Concrete pour clearance" (cf. 5.1 Management) will not be issued until the Owner has approved all preparation and pre-concreting operations.

Curing shall be in accordance with EN 13670-1, 8.5 Curing and protection.

The minimum curing period for concrete in surface structures shall be as in EN 13670-1:, annex F, table F.3.

5.7.2 Concreting in cold weather

Concrete placement shall not commence without approved special provisions if ambient temperature below 3 °C is expected. Such provisions include i.e.:

- a) surfaces adjacent to the concrete lift to be placed shall be heated to at least 3 °C prior to pouring of concrete.
- b) forms shall be adequately insulated to keep concrete temperature above 3 °C, taking into account the shape of the concrete member and the expected heat generation in the concrete.

The concrete may be heated during batching and mixing. The following criteria shall not be exceeded:

- a) the maximum temperature of fresh concrete shall not exceed 25 °C during mixing, transporting and placing,
- b) mixing water shall not be heated above 60 °C, unless it is mixed with the aggregates before cement is added; care must be taken that neither quick set nor flash set occurs,
- c) the aggregates shall be heated uniformly and carefully; all frozen lumps, ice and snow shall be eliminated before entering the concrete mix; average aggregate temperature shall not exceed 60 °C and maximum spot temperature shall be below 100 °C.

5.7.3 Curing and protection in cold weather

The surface temperature of concrete shall be kept above 3 °C until the concrete is frost-resistant, i.e. has acquired compressive strength of $f_c > 10$ MPa.

The strength development of the concrete shall be deduced from that of comparable representative specimens, or by cored cylinders.

Minimum curing period for concrete is specified in 5.7.1

5.7.4 Heat development control

To avoid surface cracking caused by heat generated in the concrete, the temperature difference between a measuring point at the surface and a measuring point in the center of a concrete body, or 1000 mm inside the surface if the body is more than 2 m thick, shall be less than 20 °C, if not otherwise approved by the Owner. The location of the measuring point at the surface plane shall be defined as 10 mm inside the surface on a perpendicular projection of the structure member's centre point to the surface plane.

Temperature difference across construction joints shall be less than 15 °C at the time of concrete placement.

The maximum temperature of the concrete shall not exceed 55 °C except approved by the Owner

5.7.5 Removal of formwork

Provided that requirements for concrete temperature and moisture are fulfilled, the conditions for the removal of formwork and falsework shall be:

- a) vertical forms may be removed when the concrete has attained a compressive strength of 6 MPa, deduced from the strength development of comparable test specimens cured under similar conditions;
- b) beam, deck and slab shoring shall not be removed until the concrete has obtained 75 % of its design strength, deduced equally.

5.7.6 Repair of damage

Imperfections in concrete shall be repaired as soon as practicable and as approved. Fins and encrustations shall be neatly removed from exposed surfaces. Irregularities exceeding the limits specified in 5.9 Geometrical tolerances, shall be reduced by bush hammering and grinding.

Approximately 25 mm deep cuts shall be made perpendicular to the surface around areas of defective or damaged concrete, the damaged concrete shall be chipped off to sound base, and replaced with filling. The filling for repair shall be commercial repairing materials or concrete, as approved, applied as recommended by the manufacturer. Concrete reparations shall be cured and protected in the same way as concrete.

Any damage observed in the concrete which may have structural consequences, leading to reduced safety of the construction or impaired use of the facilities, shall be repaired so as to obtain the specified strength and functionality. Such repairs may include demolishing and reconstructing the damaged structure member.

5.7.7 Repair of leakage and cracks

The Contractor shall repair all leakage spots in concrete joints or elsewhere by an approved method.

In concrete members with unilateral water pressure, leaky cracks shall be made watertight by injection of an approved grout, e.g. polyurethane water cut-off grout. This applies to any crack that causes wet spots.

5.8 Execution with precast elements

5.8.1 General

This standard applies to on Site and off Site (factory) produced elements. For factory produced elements some clauses in this standard are not relevant (e.g. requirement for concrete in hollow core slabs in which the relevant European Product Standard applies)

5.8.2 Storage of products

The Contractor shall store the products safely both as regards the prefabricated units and all personnel.

Intermediate storage shall be avoided as possible.

Location, supports and spacers for intermediate storage, on or off Site are subject to Owner prior approval. Temporary supports shall be of wood at least 100mm wide and 50mm thick.

5.8.3 Transport

Transport of prefabricated elements shall be carried out using adequate lifting and transporting equipment to ensure safe transport and delivery.

The Contractor shall follow instructions given on the Drawings regarding location and details of hook-up points.

5.8.4 Testing, inspection and submittals

The Contractor shall apply for an "Installation approval" 24 h in advance of installing prefabricated elements, or in less time provided that preparatory work has been completed. All temporary support work, formwork, reinforcement, embedded items and other preparations must be completed before the approval is issued.

The Contractor shall before applying for Installation approval and before starting transport of prefabricated elements inspect at least the following items:

- a) the elements tolerances are within specified limits,
- b) hook-up points are according to the drawings,
- c) supporting structures for the elements are complete,
- d) strength of concrete members carrying the elements is adequate,
- e) access routes are open and safe,
- f) lifting devices and equipment is adequate,
- g) Needed manpower is available.

5.8.5 Installation

The Contractor shall install the prefabricated elements and secure their position and stability until they are permanently secured in the final structure.

The Contractor shall design and carry out all temporary support operations needed for safe installation of prefabricated elements.

The Contractor shall prepare a lifting scheme, storage instructions and erection specification for precast elements and send the Owner for acceptance.

5.8.6 Specific elements

Hollow core slabs shall have drainage holes into the voids at ca. 10cm from each end.

Hollow core slabs shall have closures of the voids at each end according to manufacturer's recommendations.

5.9 Geometrical tolerances

Tolerances for cast in situ concrete and completed structure, including precast elements, shall be according to EN 13670.

If other tolerances apply, these shall be given in the execution specification.