O'CONNOR SUTTON CRONIN

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CONTROLLED DOCUMENTATION

CAST INSITU CONCRETE SPECIFICATION

OCSC
O'CONNOR · SUTTON · CRONIN
MULTIDISCIPLINARY CONSULTING ENGINEERS

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CAST INSITU CONCRETE SPECIFICATION

1 General

1.1 Contents

1.1.1 THIS DOCUMENT

This specification includes

1) General issues
2) Documentation
3) Formwork
4) Reinforcement
5) Concrete
6) Workmanship Generally
7) Watertight Concrete
8) Permitted Tolerances

1.2 Responsibilities

1.2.1 CONTRACTOR

All designs, materials and workmanship shall comply with the relevant Eurocodes (I.S. EN Ref's); EU Standard's Codes of Practice or equivalent Irish Standards or Codes of Practice. Where Eurocodes are used, the referred Irish National Annex to each respective EN shall be considered. Where no Eurocode, EU Standard or Irish Standard exists, compliance shall be obtained through relevant British or other Internationally recognised standard or Good Industry Practice.

In each case the standards or Codes of Practice which are the most current and appropriate, at the time that the relevant obligation is to be performed, shall be applied.

1.3 Definitions

1.3.1 ACTION

a) Set of forces (loads) applied to the structure (direct action);
b) Set of imposed deformations or accelerations caused for example, by temperature changes, moisture variation, uneven settlement or earthquakes (indirect action).

1.3.2 CONSTRUCTION WORKS

Everything that is constructed or results from construction operations.

1.3.3 EFFECT OF ACTION

Internal force (e.g. moment, stress, strain) on structural members or on the whole structure due to an action(s).

1.3.4	ELEMENT	Shall apply as for "Member"
1.3.5	ENGINEER	Defined as the individual or company responsible for the procedure or algorithm for determination of action effects in a structure. While another party may have qualified engineers in their organisation, this specification refers only to the individual/organisation described (i.e. OCSC)
1.3.6	ETA	European Technical Approval (issued in accordance with an European Technical Approval Guidance document, ETAG)
1.3.7	EXECUTION	Execution refers to all activities carried out for the physical completion of the work including procurement, the inspection and documentation thereof. It may refer to the overall project or to an individual construction activity within the project. It may also refer to work on site or the fabrication of components off site and their subsequent erection on site.
1.3.8	MAIN CONTRACTOR	The company responsible for the co-ordination of all construction activities on site.
1.3.9	MEMBER	Is a physically distinguishable part of a structure (e.g. a column, a beam, a slab, a foundation pile).
1.3.10	STRUCTURE	The organized combination of connected parts designed to carry loads and provide adequate rigidity.

1.4 References

1.4.1 GENERAL

All concrete design specification and execution shall be in accordance with the following non exhaustive list:

1.4.2 CODES

EN 1990	Basis of Structural Design
EN 1991	Actions on Structures
EN 1992	Design of Concrete Structures
EN 1997	Geotechnical Design
EN 197	Cement
EN 12620	Aggregates for Concrete
EN 1008	Mixing Water for Concrete

EN 206	Concrete Specification, Performance, Production and Conformity
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
EN 10080	Steel for the Reinforcement of Concrete
EN 10138	Prestressing Steels
EN ISO 17760	Permitted Welding Process for Reinforcement
EN 13670	Execution of Concrete Structures
EN 12350	Testing Fresh Concrete
EN 12390	Testing Hardened Concrete
EN 13791	Assessment of Insitu Compressive Strength
EN ISO 15630	Steel for the Reinforcement and Prestressing of Concrete : Test Methods
BS 81020	Code of Practice for Protection of Below Ground Structures against Water from the Ground.
BS 8666	Scheduling, Dimensions, Bending and Cutting of Steel
EN 12812	Falsework – Performance Design and General Requirements
BS 5975	Code of Practice for Falsework
BS 8204	Screeds Bases and Insitu Flooring

1.5 Other General Conditions

1.5.1 GLAZING

Where needed channels to receive glazing shall be cast in to the insitu concrete members.

1.5.2 ADJOINING MASONRY

Notwithstanding all clauses provided in the OCSC Masonry specification, where masonry adjoins vertical concrete members, suitable masonry starter ties shall be provided to connect the masonry.

1.5.3	OPENINGS	No unauthorised openings shall be made in any concrete element.
1.5.4	UPSTANDS AND RECESSES	Refer to architectural drawings for all details and layout of structural up stands and recesses

2 Documentation

2.1 Quality Control

2.1.1	CONTRACTOR QUALITY SYSTEM	The Contractor is to operate an agreed quality management system to ISO 9000. The system shall be accessible for audit. If it is agreed that a quality management system is not required the Contractor shall prepare a quality plan for the project.
2.1.2	QUALITY SYSTEM DOCUMENTS	Copies of all documents required for the construction of the structure, including all inspection reports shall be available for review on site during the contract period.
2.1.3	METHOD STATEMENTS	Method statements for erection and dismantling of temporary works including all details of propping/re-propping and back-propping shall be prepared by the Contractor and submitted to the Engineer for review. In addition method statements shall include single sided pours, pours in staged sequence and pours adjoining historic structures or sensitive boundary structures.
2.1.4	INSPECTIONS	The Contractor is to give reasonable notice to allow inspection by the Engineer: • Before each concrete pour; • Before prestressing works start; • Before covering up or backfilling; For water resisting construction: Inspection of water resisting joints and waterproof/vapour proof systems. Inspection shall also be carried out by the supplier or their approved person and the supplier's comments shall be sent to the Engineer.
2.1.5	TEST REPORTS	Supply one copy of all test reports to the Engineer as soon as they are available.

2.1.6 AS-BUILT SURVEY

The Contractor is to submit a post pour survey when required by the Engineer.

2.1.7 HEALTH & SAFETY

The Contractor shall comply with the relevant Health and Safety requirements in the design construction and supervision of all works.

2.2 Corrective Actions

2.2.1 INADEQUACY AFTER TESTING

Any test or inspection reports that show that any part of the structure does not meet the specified criteria shall be reported to the Engineer, as soon as the results are available.

2.2.2 REQUIRED ACTION

Provide proposals for dealing with non-conformity to the Engineer within five working days of report the results.

A course of action shall be agreed within a further five working days.

2.2.3 COST OF CORRECTIVE ACTION

The cost of all additional testing and remedial works shall be at the Contractors expense.

2.3 Environment

2.3.1 ENVIRONMENTAL MANAGEMENT SYSTEM

The Contactor shall operate an agreed Environmental Management System in accordance with I.S. EN ISO 14001 and shall adopt best practice in respect to transport of materials, managing site works, noise, vibration, dust controls and groundwater control.

2.3.2 GROUNDWATER

Any pumping of groundwater shall be approved under licence from the relevant Local Authority.

3 Formwork

3.1 Design and Construction Generally

3.1.1 GENERAL

All formwork shall be designed, constructed and supervised in accordance with EN 12812, Falsework – Performance requirements and general design and BS 5975, Code of Practice for temporary works procedures and the permissible stress design of falsework.

3.2 Formwork Design

3.2.1 FORMWORK DESIGN

The design, erection and removal of formwork shall be the responsibility of the Contractor. Formwork and formwork support should be designed by a

suitably qualified Chartered Engineer with adequate experience and professional indemnity insurance.

3.2.2 MINIMUM DESIGN LOADING

Design and construct the formwork, and formwork support, to produce hardened concrete to the tolerances, levels and finishes specified and to withstand the worst combination of:

a) Total weight of formwork, reinforcement and concrete.

b) Hydrostatic pressure of plastic concrete.

c) Construction loads, including static and dynamic effects of placing, compacting and construction traffic.

d) Wind and snow loads.

3.2.3 CONSTRUCTION SETTLEMENTS

The Contractor shall make allowances for any settlement or deflection of formwork likely to arise during construction so that the hardened concrete conforms accurately to the drawings and unless specified otherwise to the tolerances set out in EN 13670 and this specification.

3.2.4 NEIGHBOURING / ADJOINING BUILDINGS

Where neighbouring buildings or elements of neighbouring buildings are to be used for formwork support then the Contractor is responsible to provide temporary shoring to these elements to ensure overstressing of these elements does not occur during concreting operations, notwithstanding the above, concrete pours should be limited or staged to ensure overstressing does not occur.

3.2.5 METAL PARTS

No metal part of any device shall remain within the concrete for the purpose of providing cover to the reinforcement. The material and position of any ties passing through the concrete shall be fit for their purpose. Any holes left after the removal of ties shall be filled with concrete or mortar to approved composition. Location of holes on internal exposed (fair faced) concrete to be discussed with Engineer/Architect.

3.2.6 REMOVAL THROUGH FIXINGS

Do not use removal through fixings unless agreed with the Engineer.

3.2.7 TWISTED WIRE TIES

Do not use twisted wire ties as through fixings.

3.2.8	FORMWORK SUPPORT	Carry down formwork to a foundation or such other construction that is sufficiently strong to provide effective support without causing excessive stress or movement in the foundation or construction.
3.2.9	FORMWORK STRIKING	Design and construct the formwork so that striking will not subject the structure to shock, overloading or damage.
3.2.10	KICKERS	Kickers shall typically be used as transition from horizontal to vertical surfaces. Kickers shall not be less than 150mm in height.
3.2.11	CAMBER	Construct formwork with no soffit camber, unless otherwise shown on the drawings. Where cambers are used the finished dimension of the concrete shall be that specified on the drawing.
3.2.12	JOINTS	Design and construct the formwork and joints between the formwork and completed work to achieve the specified finish. Where concrete is to be exposed for architectural purposes the formwork layout shall be subject to architectural review/approval.
3.2.13	EXTERNAL WALL FACES	Provide formwork for concrete below ground level in the following locations: 1. Columns and Walls. 2. Bases where specified. 3. Ground Beams. 4. Pile Caps.
3.2.14	Re-use	Formwork may be re-used provided it remains fit for purpose. The formwork may only be re-used if it is still capable of producing the required finish and is structurally capable of resisting the actions during construction. The requirements of this specification must be complied with for the formwork to be considered fit for purpose.

3.3 Preparation

3.3.1	RELEASE AGENTS	Store and use release agents in accordance with the manufacturers written instructions. Use the same release agent throughout the entire area of only one finish. Release agents to be approved by the Engineer. Re-use of products will only be allowed in accordance with suppliers instructions.

3.4 Joints, Inserts, Holes and Chases

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3.4.1	CONSTRUCTION JOINTS NORMAL	Form construction or day joints in the following positions, unless otherwise shown on the drawings.
3.4.2	BEAMS	To be approved by the Engineer.
3.4.3	SUSPENDED SLABS	To be approved by the Engineer.
3.4.4	COLUMN AND WALLS	50mm below the junction of the vertical member and the soffit of beams, haunch or slab, and at positions defined by kickers where used. The Contractor shall obtain approval for his proposal for forming and preparing construction joints before work starts. Where the Contractor's proposals result in alterations to the reinforcement the Contractor shall be responsible for providing full revised details for approval prior to the work commencing on site.
3.4.5	CONSTRUCTION, JOINTS, APPROVAL	Obtain approval for the position and design of construction or day joints not described in the contract documents.
3.4.6	CONSTRUCTION, JOINTS, SIZE OF SINGLE OPERATION	Form construction of day joints in accordance with the following criteria: 1. Maximum area of 450m^2 where base restraint is fully released or continuously restrained. All joints to be agreed with the Engineer prior to construction; 2. Have regularly shaped bays, with a length to width ratio less than 2; 3. Cast bays sequentially rather than hit and miss; 4. Work away from areas of greatest restraint (e.g., cores);
3.4.7	CONSTRUCTION JOINTS	Form construction or day joints with rigid stop boards.
3.4.8	EXPANSION JOINTS	Expansion joints shall be positioned and formed in accordance with the details shown on the drawings. Expansion joints shall be kept free of all deleterious material. Expansion joints shall satisfy the free movement specified by the Engineer and the acoustic and fire performance specified by others.
3.4.9	INSERTS	Fix or box out for inserts or channels in accordance with the drawings or as instructed, prior to placing the concrete.

3.4.10	HOLES AND CHASES	Form holes and chases in accordance with the drawings or as instructed, prior to placing the concrete. The position of all holes, chases etc… are subject to the Engineer's approval. They shall be formed as work proceeds and shall not be cut after pouring.
3.4.11	HOLES AND CHASES CUTTING OUT	Do not cut cast concrete without written instructions from the Engineer.

3.5 Joints

3.5.1	JOINT SURFACES	The surface of the joint prior to the deposition of the next lift or section of concrete shall be free from all laitance scum. It shall show a lightly roughened texture over the full cross section of the work in which the tops of the aggregates are exposed but not be too grossly uneven as to cause porosity in the next lift or section of the concrete. The most efficient method for achieving this requirement will depend on the age of the concrete. Contractor proposals and method statements shall be submitted to the Engineer prior to commencement of any work.
3.5.2	SURFACE PREPARING	Air-and-water jet or wire brushing of green concrete may be used one to three hours after compaction. Harder concrete must be lightly chipped. Chipping must not be so vigorous as to damage the projecting aggregate.
3.5.3	SURFACE CLEANING	On completion of the fixing of reinforcement and erection of formwork for the next lift of concrete, surface and joints shall be thoroughly cleaned by air-and-water jets.
3.5.4		Excess water shall be removed and areas to be concreted left for several hours so that the joints prepared in this way shall have concrete placed and compacted without prior application of mortar.
3.5.5	PRECAUTIONS	Precaution shall be taken during assembly prior to concreting to prevent fouling of the concrete surface.
3.5.6	CLOSE FIT	It is particularly important to ensure that the junction between the lower edge of the formwork to the upper lift of concrete section is close fitting, since seepage of the cement passed from newly deposited concrete or grout loss will cause a consequent potential point of weakness.

3.5.7	MOVEMENT JOINT FILLERS	Fix movement joint fillers rigidly to resist deformation during placing of the concrete where specified. The joint filler shall provide complete separation between adjacent members.

3.6 Striking Forms

3.6.1	STRIKING	Strike all formwork other than permanent forms without disturbing, damaging or overloading the concrete structure.
3.6.2	STABILITY AND PROTECTION STRIKING	The stability of the structure and the protection of the concrete after striking the formwork shall remain the responsibility of the Contractor.
3.6.3	MINIMUM PERIODS	The minimum period for retaining formwork in position before striking shall not be less than indicated in Table 3.1.
3.6.4	AIR SHADE	Periods during which the air shade temperature remains below 5°C shall not be taken into account. Providing always that the minimum periods before striking are as in the tables, the actual times of striking shall remain the responsibility of the Contractor.
3.6.5	FURTHER GUIDANCE	Further guidance is available in CIRIA Report 136 Formwork Striking Times-criteria, prediction and method of assessment.
3.6.6	MECHANICAL DAMAGE AND CURING	Note that the formwork striking times for resistance to mechanical damage should also be read in conjunction with the curing tables in Section 5.0.
3.6.7	EARLY STRIKING	Where the Contractor can submit evidence that the performance of the structure will not be adversely affected by reducing the specified periods before striking, reduced striking times may be reviewed. Proposals shall be in accordance with formwork striking times – criteria, prediction and methods of assessment.
3.6.8	PROPPING	Re-propping shall not be permitted unless approval is obtained.

Table 3.1 *Minimum striking times for formwork*

CEMENT TYPE - NORMAL PORTLAND CEMENT		
TYPE OF FORMWORK	MEAN AIR SHADE TEMPERATURE	
	7◦C	16◦C
Vertical facing columns, walls and beams	18 hrs	12 hrs
Soffit facing to slabs & beams	5 days	4 days
Supports to slabs	15 days	10 days
Support to beams	21 days	14 days

4 Reinforcing

4.1 Steel Products

4.1.1 HIGH YIELD HOT ROLLED DEFORMED BARS

Hot rolled high yield deformed bars shall comply with BS 4449.

4.1.2 GRADE AND DUCTILITY CLASS

All high yield reinforcing bars shall have a characteristic yield strength of 500Mpa and shall as a minimum comply with ductility Class B (Grade B500B)

4.1.3 STEEL FABRIC

Steel fabric shall comply with BS 4483.

Note that mesh bars below 8mm shall be grade B500B or B500C.

4.1.4 HARD DRAWN STEEL WIRE

Hard drawn mild steel wire for concrete reinforcement shall comply with BS 4482.

4.1.5 IRON TYING

Use annealed iron tying wire of not less than 1.14mm diameter.

4.1.6 CERTIFICATES

Provide manufacturer's test certificates for:

1. Hot rolled mild steel to BS 4482.
2. Hot rolled high yield steel to BS 4449.
3. Hot rolled mild steel to BS 4449.

4.2 Quality Control

4.2.1	BAR SAMPLES	Select in accordance with BS 4449 bar samples of the following types for testing from material to be used in the works.
4.2.2	TESTING SAMPLES NAMED AUTHORITY	Arrange for the tests by an approved testing authority. The testing authority chosen shall be submitted to the Engineer for approval. The contractor shall be responsible for the delivery of the samples to the testing authority.
4.2.3	CONFORMITY	The reinforcement shall be tested to the following standards: 1. Mild steel to conform to BS 4449. 2. High yield steel to confirm to BS 4449.
4.2.4	REPORTING OF TEST RESULTS	Arrange that the testing authority shall furnish copies of the test results directly to the Engineer.

4.3 Preparation

4.3.1	HANDLING AND STORING	Handle reinforcement so as not to impair its qualities or cause permanent deformation. Store reinforcement clear of the ground on a clean site and with adequate protection to prevent deterioration.
4.3.2	IDENTIFIED STORAGE	Store reinforcement which has been cut and bent for each portion of the works in clearly identified storage and in separate bundles.
4.3.3	CLEANLINESS	All reinforcement shall be free of loose mill scale, loose rust, oil, grease, release agents and other deleterious materials at the time of placing concrete.
4.3.4	RUST STAINING	Prevent projecting reinforcement from causing rust staining of exposed concrete surfaces.

4.4 Cutting and Bending

4.4.1	GENERALLY	Cut and bend reinforcement in accordance with BS 8666 and the schedule provided, except where specific conditions require a closer tolerance.
4.4.2	COLD WEATHER BENDING	Do not cold bend high yield reinforcement when the air shade temperature is below 5°C unless approval is obtained. Do not bend mild steel reinforcement when the air shade temperature is below 0°C unless approval is obtained.

4.4.3	COLD WORKED STEEL	Do not heat cold worked steel reinforcement
4.4.4	REBENDING	Do not re-bend or remove bends from bars without approval.

4.5 Fixing

4.5.1	GENERALLY	Place and fix securely all reinforcement in the positions indicated on the drawings. Any discrepancies with the reinforcement drawings to be highlighted immediately to the Engineer. Support top reinforcement in slabs at not more than 1m centres. Fix cover spacers to maintain the specified concrete cover except where other methods are required.
4.5.2	LAPS	Do not, without approval, form laps in reinforcement other than those shown on the drawings.
4.5.3	FIXING/TIES	Fix reinforcement adequately with tying wire of approved proprietary fixings.
4.5.4	FIXING/COVER	No metal part of any device for fixing reinforcement shall remain within the concrete provided as cover to the reinforcement unless otherwise shown on the drawings.
4.5.5	WELDING	Weld mild steel reinforcement in accordance with EN ISO 17660. Do not weld without approval.
4.5.6	ANCILLARY FIXINGS	The ends of any tying wire are to be turned into the concrete and all steel used in the fabrication and positioning of reinforcement and shuttering shall have the minimum cover equal to that specified to the main reinforcement.

4.6 Spacers

4.6.1	SPACERS GENERALLY	Spacers and chairs for steel reinforcement shall comply with BS 7973-1:2001.
4.6.2	PROVISION OF SPACERS/CHAIRS	All chairs and spacers are to be provided by the Main Contractor and will not be detailed by the Engineer.
4.6.3	SPACER TYPES	Use other ordinary spacers as necessary to support reinforcement in position. Use special spacers to support reinforcement where such are shown on the drawings or schedules.

4.6.4	CHAIRS	Steel chairs shall be used in the spacing of top reinforcement in slabs or other elements and be of suitable strength and number to hold the reinforcement in its correct position. The supply of steel chairs shall be the responsibility of the contractor and will not be detailed on the Engineer's reinforcement schedules.
4.6.5	MORTAR COVER SPACERS	Use 1:2 cement-sand mortar cover spacers complete with fixing wire for all reinforcement of 20mm and greater in beams and slabs. Where spacer blocks are required in exposed concrete they shall be made from material used in the surrounding concrete.
4.6.6	PLASTIC COVER SPACERS	Only approved plastic cover spacers for providing supports for bars of 16mm or less should be used in slabs and only after written agreement is provided by the Engineer.
4.6.7	PROPRIETARY FIXINGS	Obtain approval for the use of proprietary fixing for reinforcement.
4.6.8	PROPRIETARY COUPLINGS	The Contractor should submit details for the use of proprietary couplers for reinforcement to the Engineer for review.
4.6.9	REQUIREMENTS WHEN USING COUPLERS	Contractor should pay particular attention to the following when using couplers: 1. Potential to reduce cover; 2. Congestion to reinforcement; 3. Checking/sign-off procedures to ensure correct installation.

5 Concrete Mix Specification

5.1 General

5.1.1	GENERAL	Specification, performance, production and conformity of concrete shall comply with I.S. EN 206. Minimum 30% GGBS Environmental Product Declaration is required CEM 1 products not permitted

5.2 Admixtures

5.2.1	ADMIXTURES	Admixtures shall be in compliance with I.S. EN 934.

5.3 Design of Mix

5.3.1	WATER	Mixing water shall be in compliance with I.S. EN 1008.
5.3.2	METHOD OF DESIGN	The concrete mix shall normally be a designed concrete mix to the requirements of I.S. EN 206. The minimum strength, exposure class, sulphate class, cover and finish shall be as indicated on the drawings. Consistency class is to be specified by the contractor depending on method of placement.
5.3.3	ON-SITE CONCERETE MIXERS	Where prescribed concrete mixes are specified, the testing regime for conformity and identity testing shall be the same as that for designed concrete as described in EN 206.

5.4 Cement

5.4.1	CEMENT	Cement and cement replacements shall be in accordance with I.S. EN 197. Provide details of proposed cement for approval. Do not use unapproved cements.

5.5 Aggregate

5.5.1	COARSE AND FINE AGGREGATES	Coarse and fine aggregates from natural sources for concrete shall comply with I.S. EN 12620 and I.S. EN 13055. Provide details of proposed aggregates for approval. Do not use unapproved aggregate.
5.5.2	AGGREGATES CHLORIDE CONTENT	The acid-soluble chloride ion content of aggregates and recycled aggregates shall be determined in accordance with EN1744. The Contractor shall provide confirmation of compliance at intervals of one month or less during the supply of concrete to the works.
5.5.3	RECYCLED AGGREGATES	The use of recycled aggregates shall be discussed and agreed with the Engineer. Full details of material, quantity and chemical composition to be submitted to the Engineer for review.
5.5.4	NATURAL AGGREGATES SHRINKAGE	The aggregate drying shrinkage shall not be more than 0.075% when determined in accordance with BS EN 1367-4.

5.5.5 ALKALI-SILICA REACTION (ASR) RESISTANT CONCRETE

For resistance to Alkali Silica Reaction (ASR) refer to IEI/ICS Publication 'Alkali-Silica Reaction: General Recommendations and Guidance in the specifications of Building and Civil Engineer Works 2002'. The risk of damaging Alkali-Silica Reaction shall be minimised in accordance with the guidance set out in BRE Digest 330.

5.5.6 CONCRETE CHLORIDE CONTENT

For concrete applications in Ireland the maximum chloride content shall be in accordance with Table 5.1 (extracted from Table 10 I.S. EN 206-1):

Table 5.1 *Maximum chloride content of concrete (Table 10 I.S. EN 206-1)*

Concrete Use	Chloride Content Class	Max. Cl Content by Mass of Cement [a,b]
Not containing steel reinforcement or other embedded metal with the exemption of corrosion-resisting lifting devices	Cl 1,0	1,0%
Containing steel reinforcement or other embedded metal [c]	Cl 0,40	0,40%
Containing prestressing steel reinforcement	Cl 0,10	0,10%

[a]	Where type II additions are used and are taken into account for the cement content, the chloride content is expressed as the percentage chloride ion by mass of cement plus the total mass of additions that are taken into account.
[b]	Cement type CEM III and GGBS as a type II addition may contain more than 0.10% chloride but in that case the maximum chloride content shall be stated on the packaging and/or delivery note.
[c]	In the case of SR cements the maximum chloride by mass of cement shall be 0.20% with a chloride class of Cl 0.20.

5.5.7 SULPHATES

Limits for acid-soluble sulphate content shall be in accordance with I.S. EN 197.

5.5.8 CONCRETE IN CONTACT WITH GROUND

For all concrete which is in contact with the ground in the finished state, the contractor will provide a mix design for review which takes into account any sulphates, chlorides, or other contaminants that may be present in the ground. The mix design shall be in compliance with EN 206-1 and Clause 4.4.1.3 EN 1992-1-1

5.5.9 BLINDING

All concrete cast against the ground shall be placed on a bed of 75 mm lean-mix or non-structural grade blinding.

5.6 Recommended Limited Values of Concrete Mixes

5.6.1 RECOMMENDED LIMITED VALUES OF

Recommended limited values for composition and properties of concrete for the specified design life

CEMENT AND WATER/CEMENT RATINGS

span and exposure conditions shall comply with the following tables. These tables have been extracted from the Irish National Annex to I.S. EN 206. For Aggressive Chemical Environments of Exposure Class XA2 and XA3, the guidance in BRE Digest 1 shall be complied with.

5.6.2 INDEX OF LIMIT TABLES

The following tables describe the limiting values of cement, water/cement ratio and cover for 50- or 100-year design life:

Table 5.2	Carbonation/chloride (50-year design life)
Table 5.3	Freeze/Thaw environments
Table 5.4	Aggressive chemical environments
Table 5.5	Alternative limits for carbonation (50-year design life)
Table 5.6	Alternative limits for sea Chlorides (50-year design life)
Table 5.7	Alternative limits for non-sea chlorides (50-year design life)
Table 5.8	Alternative limits for carbonation (100-year design life)
Table 5.9	Alternative limits for sea Chlorides (100-year design life)
Table 5.10	Alternative limits for non-sea chlorides (100-year design life)

Table 5.2 *Recommended limiting values for composition and properties of concrete (Table NA.5 NA I.S. EN 206-1)*

	EXPOSURE CLASSES																
	No risk of corrosion	Carbonation-induced corrosion				Chloride-induced corrosion						Freeze/thaw attack				Aggressive chemical environments		
						Sea Water			Chloride Other than Sea Water									
	X0	XC1	XC2	XC3	XC4	XS1	XS2	XS3	XD1	XD2	XD3	XF1	XF2	XF3	XF4	XA1	XA2	XA3
Min Cover C_{min}		15	25	25	30	35	40	45	35	40	45	-	-	-	-	-	-	-
Max w/c ratio	-	0.65	0.60	0.55	0.55	0.50	0.50	0.45	0.55	0.50	0.45	See Table 5.3 for recommended limiting values for XF classes				See Table 5.4 for recommended limited values for XA classes		
Min Strength Class	C12/15	C25/30	C28/35	C30/37	C30/37	C35/45	C35/45	C40/50	C30/37	C35/45	C40/50							
Min Cement Content (kg/m³)	-	280	300	320	320	360	360	400	320	360	400							
Note 1	These recommendations are for the cements and combinations listed in sub clauses NA 2.2 and NA 2.7 of I.S. EN 206 Irish National Annex. In XS, XD classes when GGBS >35% and Fly Ash > 20%, lower minimum strength classes can be used, see Table NC.1 to NC.6 of I.S. EN 206. Limiting values for alternative covers are also given in Table NC.1 to NC.6 of I.S. EN 206.																
Note 2	The minimum cover to reinforcement in XC classes should be increased by 5mm in concretes where the GGBS content exceeds 50%.																
Note 3	The values in this table are based on the assumption of an intended working life of at least 50 years under the anticipated maintenance conditions. For advice on longer service life in Exposure Classes XC, XS and XD, See Annex NC of I.S. EN 206.																
Note 4	For definition of minimum cover C_{min}, see EN 1992-1-1, Section 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. (ΔC_{dev} = 10mm unless otherwise noted.)																
Note 5	The recommendations in respect of Exposure Classes XA relate to aggressive conditions defined in Table 2 of EN 206-1. For combinations of aggressive chemicals see guidance in Table 2 of I.S. EN 206. Further guidance for aggressive chemicals and complex site conditions, is contained in BRE Special Digest 1.																
Note 6	The minimum strength classes are based on a survey of CEM 1 cements (Class 42.5).																

Table 5.3 *Recommended limiting values for freeze thaw exposure classes (Table NA.6 NA I.S. EN 206-1)*

EXPOSURE CLASS	MIN STRENGTH CLASS	MAX W/C RATIO	MIN. AIR CONTENT & MIN. CEMENT CONTENT FOR 20mm MAX. AGGREGATE SIZE (See Note 2)
XF1 (See Note 1)	C25/30	0.60	3.5
			300
	C28/35	0.60	-
			300
XF2	C30/37	0.55	3.5
			320
	C35/45	0.50	-
			360
XF3	C30/37	0.55	3.5
			320
	C40/50	0.45	-
			400
XF4	C32/40	0.50	3.5
			340
	C40/50	0.45	-
			400
NOTE 1	In exposure class XF1, maximum w/c ratio and minimum cement content are 0.60 and 300kg/m^3 irrespective of whether an air-entraining agent is used. However, a lower minimum strength class is permitted with air entrainment.		
NOTE 2	For different aggregate sizes, the minimum air content recommended is: 3.0% for 40mm, 4.5% for 14mm, 5.5% for 10mm. In addition, the minimum cement contents may need to be adjusted.		
NOTE 3	All cements and combinations (See NA.2.2 and sub clause 2.7 of I.S. EN 206) may be used but cements or combinations containing more than 50% GGBS or more than 31% pfa may not be suitable for the wearing surface of pavement concrete due to the possibility of surface scaling. The limit of 50% GGBS may be increased to 65% if CEM I is used.		
NOTE 4	These recommended concretes are suitable for design lives of both "at least 50 years" and "at least 100 years". However, pavements and hard standings are often designed with a shorter intended working life than "at least 50 years".		
NOTE 5	See also I.S. EN 12620 and SR16 in respect of aggregate.		

Table 5.4 *Recommended limiting values for aggressive chemical environments exposure classes (Table NA.7 NA I.S. EN 206-1)*

EXPOSURE CLASS	MIN STRENGTH CLASS	MAX W/C RATIO	MIN CEMENT CONTENT	CEMENT TYPE
XA1	C32/40	0.50	340	CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S Combinations of CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S with up to 49% total GGBS content
	C30/37	0.55	320	Combinations of CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S with (50 – 70%) total GGBS content SRPC, CEM II/B-V, CEM III/A, (See Note 1) CEM III/B
XA2	C35/45 (See Note 2)	0.50	360	CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S, Combination of CEM I, CEM II/A_L, LL, CEM II/A-V or CEM II/A-S with up to 65% total GGBS content CEM II/B-V, CEM III/A
	C30/37 (See Note 3)	0.50	340	Combination of CEM I, CEM II/A_L, LL, CEM II/A-V or CEM II/A-S with up to (66 - 70%) total GGBS content SPRC, CEM III/B
XA3	C40/50 (See Note 2)	0.45	400	CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S Combination of CEM I, CEM II/A-L, LL, CEM II/A-V or CEM II/A-S with up to 65% total GGBS content CEM II/B-V, CEM III/A
	C32/40 (See Note 3)	0.45	360	Combination of CEM I, CEM II/A-L, LL, CEM II/A-V, CEM II/A-S with (66 – 70%) total GGBS content SRPC, CEM III/B
NOTE 1	With the additional requirement for a minimum of 50% GGBS in the CEM III/A cement.			
NOTE 2	If SO_4^2 > 1400 mg/l (groundwater) use only the lower rows of either XA2 or XA3 exposure classes as appropriate.			
NOTE 3	For these cement types a lower minimum strength class is permitted to reflect lower strength development at 28 days			
NOTE 4	For combinations, where the alumina content of the GGBS exceeds 14%, the C_3A content of the CEM I or CEM II/A fraction shall not exceed 10%.			
NOTE 5	The values in this Table are based on the assumption of an intended working life of at least 50 years under the anticipated maintenance conditions.			
NOTE 6	The recommendations in respect of Exposure Classes XA relate to aggressive conditions defined in Table 2 of EN 206-1. For combinations of aggressive chemicals see guidance in Table 2. Further guidance for aggressive chemicals and complex site conditions, is contained in BRE Special Digest 1.			

Table 5.5 *Alternative limiting values for carbonation corrosion classes for 50-year design life (Table NC.1 NA I.S. EN 206-1)*

50 Year Design Life											Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XC1	**C25/30 0,65 280**										Cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	C25/30 0,65 280									Cements and combinations where the GGBS content exceeds 50%		
XC2	N/A	C32/40 0,50 340	**C28/35 0,60 300**	C25/30 0,65 280							All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	N/A	C32/40 0,50 340	C28/35 0,60 300	C25/30 0,65 280						Cements and combinations where the GGBS content exceeds 50%		
XC3	N/A	C35/45 0.5 360	**C30/37 0,55 320**	C28/35 0,60 300	C25/30 0,65 280						All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	N/A	C35/45 0,50 360	C30/37 0,55 320	C28/35 0,60 300	C25/30 0,65 280					Cements and combinations where the GGBS content exceeds 50%C		
XC4	N/A	C40/50 0,45 400	C35/45 0,50 360	**C30/37 0,55 320**	C28/35 0,60 300	C25/30 0,65 280					All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	N/A	C40/50 0,45 400	C35/45 0,50 360	C30/37 0,55 320	C28/35 0,60 300	C25/30 0,65 280				Cements and combinations where the GGBS content exceeds 50%		
Note 1	For definition of minimum cover C_{min} see EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\,y}$. (ΔC_{dev} = 10mm unless otherwise noted)												
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1 (Table 5.3 of this standard). In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.												
Note 3	For any given cover, which lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specified at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).												
Note 4	Where trade-offs of cover are being considered a revised cover value will need to be used in the crack width Calculations.												

Table 5.6 *Alternative limiting values for sea chloride exposure classes for 50-year design life (Table NC.2 NA I.S. EN 206-1)*

50 Year Design Life											Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XS1	N/A	N/A	N/A	C40/50 0,45 400	**C35/45** **0,50 360**	C30/37 0,55 320					All cements in Tables NA.2 & 3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	C35/45 0,45 400	C32/40 0,50 360	C28/35 0,55 320					CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C32/40 0,45 400	C28/35 0,50 360	C28/35 0,55 320					CEM III/B	66 – 70	
XS2	N/A	N/A	N/A	C45/55 0,40 420	C40/50 0,45 400	**C35/45** **0,50 360**	C32/40 0,50 340				All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360	C30/37 0,50 340				CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C35/45 0,40 420	C32/40 0,45 400	C30/37 0,50 360	C28/35 0,50 340				CEM III/B	66 – 70	
XS3	N/A	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	**C40/50** **0,45 400**	C35/45 0,50 360			All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360			CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	N/A	C40/50 0,40 440	C35/45 0,40 420	C32/40 0,45 400	C28/35 0,50 360			CEM III/B	66 – 70	
Note 1	For definition of minimum cover C_{min} see EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\,y}$. . (ΔC_{dev} = 10mm unless otherwise noted)												
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1. In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.												
Note 3	For any given cover, while lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specified at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).												
Note 4	Where trade-offs of cover are being considered a revised cover value will need to be used in the crack width Calculations												

Table 5.7 *Alternative limiting values for non-sea corrosion exposure classes for 50-year design life (Table NC.3 NA I.S. EN 206-1*

50 Year Design Life											Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XD1	N/A	N/A	C40/50 0,45 400	C35/45 0,50 360	**C30/37** **0,55 320**	C28/35 0,60 300					All cements in Tables NA.2 & 3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	C35/45 0,45 400	C32/40 0,50 360	C28/35 0,55 320	C25/30 0,60 300					CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	C35/45 0,45 400	C30/37 0,50 360	C25/30 0,55 320	C25/30 0,60 300					CEM III/B	66 – 70	
XD2	N/A	N/A	N/A	C45/55 0,40 420	C40/50 0,45 400	**C35/45** **0,50 360**	C30/37 0,55 320				All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360	C28/35 0,55 320				CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C35/45 0,40 420	C32/40 0,45 400	C28/35 0,50 360	C25/30 0,55 320				CEM III/B	66 – 70	
XD3	N/A	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	C40/50 0,45 400	C35/45 0,50 360			All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360			CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	N/A	C40/50 0,40 440	C40/45 0,40 420	C32/40 0,42 400	C28/35 0,50 360			CEM III/B	66 – 70	
Note 1	For definition of minimum cover C_{min} see I.E. EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\ y}$.												
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1. In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.												
Note 3	For any given cover, which lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specifie4d at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).												

Table 5.8 *Alternative limiting values for carbonation corrosion classes for 100-year design life (Table NC.4 NA I.S. EN 206-1)*

100 Year Design Life									Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XC1	**C25/30 0,65 280**								Cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	C25/30 0,65 280							Cements and combinations where the GGBS content exceeds 50%		
XC2	C35/45 0,50 360	C32/40 0,50 340	**C28/35 0,60 300**	C25/30 0,65 280					All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	C35/45 0,50 360	C32/40 0,50 340	C28/35 0,60 300	C25/30 0,65 280				Cements and combinations where the GGBS content exceeds 50%		
XC3	C45/55 0,40 420	C35/45 0,50 360	**C30/37 0,55 320**	C28/35 0,55 320	C25/30 0,65 280				All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	C45/55 0,40 420	C35/45 0,50 360	C30/37 0,55 320	C28/35 0,55 320	C25/30 0,65 280			Cements and combinations where the GGBS content exceeds 50%		
XC4	N/A	C45/55 0,40 420	C35/45 0,50 360	**C30/37 0,55 320**	C28/35 0,55 320	C25/30 0,65 280			All cements and combinations **except** where the GGBS content exceeds 50%		
	N/A	N/A	C45/55 0,40 420	C35/45 0,50 360	C30/37 0,55 320	C28/35 0,55 320	C25/30 0,65 280		Cements and combinations where the GGBS content exceeds 50%C		
Note 1	For definition of minimum cover C_{min} see I.E. EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\,y}$.										
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1. In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.										
Note 3	For any given cover, which lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specifie4d at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).										

Table 5.9 *Alternative limiting values for sea chloride exposure classes for 100-year design life (Table NC.5 NA I.S. EN 206-1)*

100 Year Design Life									Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XS1	N/A	N/A	C45/55 0,40 420	C40/50 0,45 400	**C35/45** **0,50 360**	C32/40 0,50 340			All cements in Tables NA.2 & 3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360	C30/37 0,50 340			CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	C35/45 0,40 420	C30/37 0,45 400	C28/35 0,50 360	C28/35 0,50 340			CEM III/B	66 – 70	
XS2	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	C35/45 0,50 360	C32/40 0,50 340		All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C32/40 0,50 360	C30/37 0,50 340		CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C40/50 0,40 440	C35/45 0,40 420	C30/37 0,50 360	C28/35 0,50 340		CEM III/B	66 – 70	
XS3	N/A	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	C40/50 0,45 400	C35/45 0,50 360	All cements in Tables NA.2 and NA.3 of I.S. EN 206	≤ 35	6 – 20
	N/A	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360	CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	N/A	C40/50 0,40 440	C35/45 0,40 420	C32/40 0,45 400	C30/37 0,50 360	CEM III/B	66 – 70	
Note 1	For definition of minimum cover C_{min} see I.E. EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\,y}$.										
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1. In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.										
Note 3	For any given cover, which lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specifie4d at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).										

Table 5.10 *Alternative limiting values for non-sea corrosion exposure classes for 100-year design life (Table NC.6 NA I.S. EN 206-1)*

100 Year Design Life									Cement Type	Corresponding GGBS % for mixer addition	Corresponding PFA % for mixer addition
Minimum cover Cmin	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**			
XD1	N/A	N/A	C45/55 0,40 420	C35/45 0,50 360	C30/37 0,55 320				All cements in Tables NA.2 & 3	≤ 35	6 – 20
	N/A	N/A	C40/50 0,40 420	C32/40 0,50 360	C28/35 0,55 320				CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	C35/45 0,40 420	C30/37 0,50 360	C28/35 0,55 320				CEM III/B	66 – 70	
XD2	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	C35/45 0,50 360	C32/40 0,50 340		All cements in Tables NA.2 and NA.3	≤ 35	6 – 20
	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C32/40 0,50 360	C30/37 0,50 340		CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C40/50 0,40 440	C35/45 0,40 420	C30/37 0,50 360	C28/35 0,50 340		CEM III/B	66 – 70	
XD3	N/A	N/A	N/A	C50/60 0,40 440	C45/55 0,40 420	C40/50 0,45 400	C35/45 0,50 360		All cements in Tables NA.2 and NA.3	≤ 35	6 – 20
	N/A	N/A	N/A	C45/55 0,40 440	C40/50 0,40 420	C35/45 0,45 400	C32/40 0,50 360		CEM III/A, CEM II/B-V	36 – 65	21 – 35
	N/A	N/A	N/A	C40/50 0,40 440	C35/45 0,40 420	C32/40 0,42 400	C30/37 0,50 360		CEM III/B	66 – 70	
Note 1	For definition of minimum cover C_{min} see I.E. EN 1992-1-1, sub clause 4.4.1. Note that nominal cover $C_{nom} = C_{min} + \Delta C_{dev}$. Designers should consider whether the above minimum cover values when used for prestressed steel are to be adjusted by an additional factor of $\Delta C_{dur\,y}$.										
Note 2	Trade-offs of cover against strength are permissible for the various cement types and combinations, as indicated. The bold values are the default limited values from the current Table NA.5 in I.S. EN 206-1. In each box, the maximum water cement ratio and minimum cement contents (in kg/m^3) are given, together with a grade of concrete which will be deemed to satisfy this durability requirement for that particular cement type.										
Note 3	For any given cover, which lower compressive strength classes are specified for concrete mixes using CEM III/A, CEM III/B, CEM II/B-V cements or equivalent combinations, the strength class equal to that for mixes using CEM I or CEM II/A cement types can be specifie4d at a later age (56 days), since concrete mixes using the former cements will give increased strength gain beyond 28 days (compared to the latter cement types).										

5.7 Workmanship generally

5.7.1 RECORDS

Accurate daily records shall be kept on site of the maximum/minimum temperatures, inclement weather periods, concrete pours and concrete cubes taken, with the identification marks noted. Keep for inspection by the Engineer.

5.7.2 FROZEN SURFACES

Do not place concrete against frozen or covered surfaces.

5.7.3 MAXIMUM CONCRETE TEMPERATURE

Do not place concrete which has a temperature in excess of 30◦C without approval.

5.8 Tolerances, Acceptance Criteria

5.8.1 COMPRESSIVE STRENGTH

Compressive strength shall be indicated on the drawings. Conformity criteria for compressive strength shall be in compliance with I.S. EN 206.

Any concrete which does not comply with the requirements of I.S. EN 206 and/or this specification will not be accepted.

5.8.2 FLEXURAL TENSILE STRENGTH

Conformance criteria for splitting strength shall be in compliance with I.S. EN 206.

5.8.3 WORKABILITY

The permissible deviation for slump for designed mixes shall be in accordance with I.S. EN 206.

5.8.4 AIR CONTENT DESIGNED MIXES

The permissible deviation for the air content determined from individual samples shall be ±0.5% of the specified value.

5.8.5 TRANSPORT AND TIME OF DELIVERY OF CONCRETE

Concrete shall be transported in a truck mixer or agitator unless the specifier agrees to use non agitator vehicles. Where non agitator vehicles are used the fresh concrete shall be protected from gain or loss of water. When transported in truck mixers or agitators, concrete shall be delivered within 1 hour after the time of loading or within 0.5 hours after the time of loading when non agitating equipment is used.

5.8.6 TIME OF PLACEMENT OF CONCRETE

Concrete shall be transported from the place of mixing to the place of final deposit immediately upon discharge from the mixer agitator by methods that will prevent segregation or loss of constituents.

5.9 Batching/Production

5.9.1 THIRD PARTY ACCREDITATION

All concrete shall be manufactured and supplied by companies with third party production control certification incorporating the requirements of ISO 9001.

5.9.2 AGGREGATE TESTING

Aggregate testing shall be in accordance with I.S. EN 12620.

5.9.3 SUPPLIER CONFORMITY CONTROL FOR DESIGNED CONCRETE

Conformity control for designed concrete samples shall be implemented by the supplier in accordance with I.S. EN 12350. Sampling shall be carried out on each family of concrete produced under conditions that are deemed to be uniform.

5.9.4 SAMPLES

A sample of concrete shall be as defined in I.S. EN 12350-1.

5.9.5 SAMPLING RATE

Sampling of fresh concrete shall be carried out in accordance with I.S. EN 12350-1. The minimum rate of sampling for strength testing of concrete shall be in accordance with Table 5.11.

The minimum rate of sampling for properties other than strength shall be in accordance with Table 5.12.

5.9.6 CONFORMANCE CRITERIA

Conformance criteria for compressive strength shall be in accordance with Table 5.13 and 5.14.

Conformity criteria for consistence shall be in accordance with Table 5.15.

Table 5.11 Minimum rate of sampling by supplier for assessing conformity *(Table 13 I.S. EN 206-1)*

PRODUCTION	MINIMUM RATE OF SAMPLING		
	First 50m³ of production	Subsequent to first 50m³ production	
		Concrete with Production Control Cert	Concrete without Production Control Cert
Initial (until at least 35 tests are obtained)	3 Samples	1/ 200m³ or 2/ Production week	1/ 150m³ or 1/ Production Day
Continuous (when at least 35 test results are obtained)	-	1/ 400m³ or 1/Production week	

Table 5.12 Conformity criteria for properties other than strength *(Table 17 I.S. EN 206-1)*

Property	Test Method or Method of Determination	Minimum Number of Samples or Determinations	Acceptance Number	Maximum allowed deviation of single test results from the limits of the specified class or from the tolerance on the target value	
				Lower Limit	Upper Limit
Density of heavy weight concrete	EN 12390-7	As for compressive strength	See Table A I.S. EN206-1	-30 kg/m^3	No Limit
Density of light weight concrete	EN 12390-7	As for compressive strength	See Table A I.S. EN206-1	-30 kg/m^3	+30 kg/m^3
Water/cement ratio	I.S. EN 206 5.4.2	1 determination per day	See Table A I.S. EN206-1	No Limit	+0.02
Cement content	I.S. EN 206 5.4.2	1 determination per day	See Table A I.S. EN206-1	-10 kg/m^3	+10 kg/m^3
Air content of air-entrained fresh concrete	EN 12350-7 for normal-weight and heavy weight concrete and ASTM C 173 for light-weight concrete	1 sample/production day when stabilised	See Table A I.S. EN206-1	-0.5% absolute value	+1.0% absolute value
Chloride content of concrete	I.S. EN 206 5.2.7	the determination shall be made for each concrete composition and shall be repeated if there is an increase in the chloride content of any of the constituents	0	No Limit	No higher value permitted

Table 5.13 Conformity criteria for compressive strength *(Table 14 I.S. EN 206-1)*

Production	Number "n" of test results for compressive strength in the group	Criterion 1	Criterion 2
		Mean of "n" results (f_{cm})	Any individual test result (f_{ci}) N/mm^2
Initial	3	$\geq f_{ck} + 4$	$\geq f_{ck} - 4$
Continuous	15	$\geq f_{ck} + 1{,}48\ \sigma$	$\geq f_{ck} - 4$

Table 5.14 Conformity criterion for family members *(Table 15 I.S. EN 206-1)*

Number "n" of test results for compressive strength for a single concrete	Criterion 3
	Mean of "n" results (f_{cm}) for a single family member N/mm²
2	$\geq f_{ck} + 1.0$
3	$\geq f_{ck} + 1.0$
4	$\geq f_{ck} + 2.0$
5	$\geq f_{ck} + 2.5$
6	$\geq f_{ck} + 3.0$

Table 5.15 Conformity criterion for consistence *(Table 18 I.S. EN 206-1)*

Test Method		Minimum Number of Samples or Determinations	Acceptance Number	Maximum allowed deviation [a] of single test results from the limits of the specified class or from the tolerance on the target value	
				Lower Limit	Upper Limit
Visual Inspection	Comparison of the appearance with the normal appearance of concrete with the specified consistence	Each batch; for vehicle deliveries, each load	-	-	-
Slump	EN 12350-2	Frequency as given in strength; when testing air content; In case of doubt following visual inspection.	See Table B I.S. EN 206-1	-10mm	+20mm
				-20mm [b]	+30mm [b]
Vebe Time	EN 12350-3		See Table B I.S. EN 206-1	-4 sec	+2 sec
				-6 sec [b]	+4 sec [b]
Degree of Compactability	EN 12350-4		See Table B I.S. EN 206-1	-0.05	+0.03
				-0.07 [b]	+0.05 [b]
Flow	EN 12350-5		See Table B I.S. EN 206-1	-15mm	+30mm
				-25mm [b]	+40mm [b]

5.10 Contractor Identity Testing

5.10.1 DEFINITION

In accordance with I.S. EN 206-1 identity testing is defined as the identification that a particular batch or batches of concrete come from a conforming population.

5.10.2 GENERAL

Obtain concrete and prepare test specimens in accordance with I.S. EN 12350.

5.10.3 SAMPLING

For site identity testing one sample shall consist of 4 No. cubes for strength testing. The cubes shall be prepared for strength testing at 3 days, 7 days, 28 days and one shall be retained in reserve. Test specimens shall be prepared and cured in accordance with EN 12390-2.

PREPARATION OF SAMPLES

Samples shall be prepared as follows:

1. Each day concrete is poured
2. For concrete supplied to different mix designs
3. For concrete supplied by different producers

In addition, for large pours samples shall be taken from alternate deliveries.

5.10.4 STRENGTH TESTING

Strength testing of contractor identity testing samples shall be carried out in accordance with I.S. EN 12390. The strength shall be determined at 3 days, 7 days and 28 days. Where required, testing at 3 days shall incorporate temperature matched curing to match conditions on site.

5.10.5 CRIETRIA FOR IDENTITY STRENGTH TESTING

Identity of concrete is assessed for each individual strength test result and the average of "n" non-overlapping discrete results, as identified in Table 5.16 (Table B.1 I.S. EN 206-1)

Concrete is deemed to come from a conforming population if both the criteria requirements in the Table 5.16 are satisfied for "n" results derived from strength tests on samples taken from the defined volume of concrete.

Table 5.16 *Identity criteria for compressive strength (Table B.1 I.S. EN 206-1)*

Number "n" of test results for compressive strength from the defined volume of concrete	Criterion 1	Criterion 2
	Mean of "n" results (f_{cm}) N/mm²	Any individual test result (f_{ci}) N/mm²
1	Not Applicable	$\geq f_{ck} - 4$
2 – 4	$\geq f_{ck} + 1$	$\geq f_{ck} - 4$
5 - 6	$\geq f_{ck} + 2$	$\geq f_{ck} - 4$

Note: The identify criteria of the table above gives a probability of 1% that a conforming concrete volume is rejected.

5.10.6 SLUMP TESTING

Identity slump testing shall be prepared by the contractor as required. The contractor specified slump class shall be fit for use, particularly for elements with congested reinforcement or exposed concrete finishes.

5.10.7	STRENGTH TESTING ASSESSOR	Strength testing is to be carried out by an approved and certified testing company. Results of testing shall be sent directly to the Engineer by the testing company.
5.10.8	AIR CONTENT	Sampling shall be a composite sample taken in accordance with I.S. EN 12350. The air content shall be measured in accordance with I.S. EN 12350 for normal and heavyweight concretes and in accordance with ASTMC173 for lightweight concrete. No test results shall be more than 0.5% below the specified minimum air content or more than 5% above the minimum air content.

5.11 Placing and Compacting

5.11.1	GENERAL	The Contractor is to ensure all quality control procedures and checks as described in the method of working statements are carried out prior to commencement of concrete works.
5.11.2	CLEANING FORMWORK AND EXCAVATION	Formwork and excavations shall be clean and free from water at the time of placing concrete.
5.11.3	CONCRETE PLACING	All concrete shall be placed continuously between predetermined square butt joints. Concrete shall be deposited as near as possible to the point at which it is required and shall not be allowed to 'flow' horizontally under the action of the vibrator. Refer to BS EN 13670 and I.S. EN 1992-3 for recommendations and workmanship.
5.11.4	PLACING	Complete each unit of construction or each section of work between predetermined and approved construction joints in one operation. Discharge concrete into formwork and excavations in such a way as to prevent segregation or loss of ingredients. Discharge all concrete as close as practicably possible to its final position. Partially hardened concrete or concrete adversely affected by delay or weather shall not be used. No additional water or admixtures are to be added to the concrete to assist placing.
5.11.5	COMPACTION	Concrete shall be deposited in layers of not more than 600mm which shall follow one another within thirty minutes. Each layer shall be mechanically vibrated subject to other clauses in this specification. Horizontal slabs shall be laid in one operation to the full thickness and beams in one

operation to the full cross section. Existing walls shall not be used as permanent shuttering.

5.11.6 CONSTRUCTION JOINT USING BEAMS

If required, beams may be cast up to the underside of the floor slab with the prior agreement of the Engineer to form a horizontal construction joint.

5.11.7 MECHANICAL COMPACTION

Mechanical compaction shall be carried out with approved vibration equipment and which shall not damage shuttering or reinforcement.

Where mechanical compaction is deemed inappropriate consideration shall be given to self-compacting concrete to the approval of the Engineer.

5.11.8 MANUAL COMPACTION

Manual compaction may only be carried out with approved tools and may be used in all reinforced work and elsewhere with prior approval from the Engineer. This does not include ground floor slabs whether they contain reinforcement or not.

5.11.9 DEFECTIVE CONCRETE

Any concrete which in the Engineer's opinion is not thoroughly compacted shall be classed as defective.

5.12 Curing

5.12.1 MAINTENANCE OF CONCRETE TEMPERATURE

Maintain the temperature of the concrete at not less than 5◦C for at least forty eight hours after casting, unless otherwise approved. Obtain approval of proposed methods of maintaining concrete temperatures.

Contractor to implement a thermal monitoring regime utilising thermocouples for deep pours (>600mm). System to be reviewed with the Engineer. The amount and position of thermocouples shall be adequate to confirm design temperature assumptions.

5.12.2 NOMINATED CURING PERIODS

Unless otherwise declared by the Engineer curing periods shall be a minimum of Class 2 to EN 13670. Strength development curves (at 20°C) shall be confirmed with the concrete supplier as being –

Rapid: $r \geq 0.50$,

Medium: $0.50 > r \geq 0.30$, or

Slow: $0.3 > r \geq 0.15$.

The minimum curing period shall be in compliance with Table 5.17

5.12.3 ALTERNATIVE CURING CLASSES

Where an alternative curing class has been approved by the engineer the minimum curing in number of days and corresponding temperatures deemed to satisfy may be taken from:

Table 5.18 – Curing Class 3

Table 5.19 – Curing Class 4

5.12.4 CURING METHOD

Obtain approval for curing methods proposed for vertical and horizontal surfaces before the works are commenced. If a curing agent is proposed it shall not affect finishes and this shall be confirmed in writing by the manufacturers of the curing agent.

5.12.5 PROTECTION OF FLOOR FINISH

Where a spray on damp proof membrane is specified the Contractor is to make provision for its application or other suitably approved membrane which is compatible with the applied finish and adhesive. The contractor shall also mitigate the risk associated with a floor finish on a floor that has not dried out or achieved appropriate moisture content in time for the Contractors programme.

Table 5.17 *Minimum Curing Period for Curing Class 2 – Corresponding to a surface concrete strength equal to 35% of the specified characteristic strength (Table F.1 I.S. EN 13670)*

Surface Concrete Temperature (t), ˚C	Minimum Curing Period, Days [a]		
	Concrete Strength Development [c, d]		
	$(f_{cm}2/f_{cm}28) = r$		
	Rapid r≥0. 50	Medium 0.50 > r ≥ 0.30	Slow 0.30 > r≥0.15
t ≥ 25	1.0	1.5	2.5
25 > t ≥ 15	1.0	2.5	5
15 > t ≥ 10	1.5	4	8
10 > t ≥ 5 [b]	2.0	5	11

[a] Plus any period of set exceeding 5 h.

[b] For temperatures below 5˚C, the duration should be extended for a period equal to the time below 5˚C.

[c] The concrete strength development is the ratio of the mean compressive strength after 2 days to the mean compressive strength after 28 days determined from initial tests or based on known performance of concrete of comparable composition (see EN 206-1).

[d] For very slow concrete strength development, special requirements should be given in the execution specified.

Table 5.18 *Minimum Curing Period for Curing Class 3 – Corresponding to a surface concrete strength equal to 50% of the specified characteristic strength (Table F.2 I.S. EN 13670)*

Surface Concrete Temperature (t), ˚C	Minimum Curing Period, Days [a]		
	Concrete Strength Development [c, d]		
	$(f_{cm}2/f_{cm}28) = r$		
	Rapid r≥0. 50	Medium 0.50 > r ≥ 0.30	Slow 0.30 > r≥0.15
t ≥ 25	1.5	2.5	3.5
25 > t ≥ 15	2.0	4	7
15 > t ≥ 10	2.5	7	12
10 > t ≥ 5 [b]	3.5	9	18

[a] Plus any period of set exceeding 5 h.

[b] For temperatures below 5˚C, the duration should be extended for a period equal to the time below 5˚C.

[c] The concrete strength development is the ratio of the mean compressive strength after 2 days to the mean compressive strength after 28 days determined from initial tests or based on known performance of concrete of comparable composition (see EN 206-1).

[d] For very slow concrete strength development, special requirements should be given in the execution specified.

Table 5.19 *Minimum Curing Period for Curing Class 4 – Corresponding to a surface concrete strength equal to 70% of the specified characteristic strength (Table F.3 I.S. EN 13670)*

Surface Concrete Temperature (t), ˚C	Minimum Curing Period, Days [a]		
	Concrete Strength Development [c, d]		
	$(f_{cn2}/f_{cm28}) = r$		
	Rapid r≥0. 50	Medium 0.50 > r ≥ 0.30	Slow 0.30 > r≥0.15
t ≥ 25	3	5	6
25 > t ≥ 15	5	9	12
15 > t ≥ 10	7	13	21
10 > t ≥ 5 [b]	9	18	30

[a] Plus any period of set exceeding 5 h.

[b] For temperatures below 5˚C, the duration should be extended for a period equal to the time below 5˚C.

[c] The concrete strength development is the ratio of the mean compressive strength after 2 days to the mean compressive strength after 28 days determined from initial tests or based on known performance of concrete of comparable composition (see EN 206-1).

[d] For very slow concrete strength development, special requirements should be given in the execution specified.

5.13 Bonding to Cast Concrete

5.13.1 SURFACE PREPARATION OF CAST CONCRETE

Remove all laitance and loose material to expose, but not disturb, the coarse aggregate. Use wire brushing, sand blasting, high pressure water jet or needle gunning. Do not hack or hammer.

5.13.2 CASTING PREPARATION SURFACES

The face of the cast concrete shall be clean and damp when placing new concrete against it.

5.14 Finishes – Quality Control

5.14.1 STAINING

Care shall be taken to prevent the staining and disfiguring of finished work such as fair faced concrete, coated steelwork, and brickwork.

5.14.2 SURFACE FINISH

Formwork shall be designed to give the surface finish as specified by the Engineer. If no specific finish is required by the Engineer the finish shall be "plain" in accordance with the definition in I.S. EN 13670.

Unless otherwise noted or dictated by the architect, where concrete is to be exposed for architectural/aesthetic purposes the finish shall be "special" in accordance with the definition in I.S.EN 13670

Surface finish shall be in compliance with Table 5.20

Table 5.20 *Types of surface finish (Table F.4 I.S. EN 13670)*

TYPE	NORMAL APPLICATION	I.S. EN 13670 DESCRIPTION	BS 8110 DESCRIPTION
Formed Surfaces			
Basic Finish	Where no particular requirement is needed.	Foundations	
Ordinary Finish:	Where visual effect is of little importance.	Areas were applied render finish or unseen surfaces such as inside ducts or lift shafts.	Type A Finish
Plain Finish:	Where visual effect is of some importance.	Areas seen occasionally and areas which are prepared, direct painted areas where there are some particular requirements.	Type B Finish
Special Finish:	Where special requirements have to be given.	Areas where surface regularity and/or colour are important.	Type C Finish
Unformed Surfaces			
Basic Finish	A closed uniform surface produced by levelling. No further work is required.	Area to receive a screeded finish or other applied finishes.	N/A
Ordinary Finish	A level uniform surface produced by floating or similar process.	Area for false floor and other applied floorings.	N/A
Plain Finish	A dense smooth surface produced by trowelling or similar	Normal warehouses and factories, areas of plant rooms and work areas without other finish than paint.	N/A
Special Finish	A surface where special requirements have to be given for further working of another finish.	Areas of warehouse floors for special trafficking.	Type C Finish

5.14.3 QUALITY

The Contractor shall not proceed with cladding, rendering, rubbing down or making good of concrete surfaces until he receives the Engineer's permission to do so and he shall not under any circumstances apply cement slurry or any other coating to the concrete surface as struck from the shuttering or do anything else which would hinder the proper inspection of the concrete surfaces by the Engineer. Failure to comply with the clause shall classify the concrete as defective.

5.14.4 SAMPLES FOR FINISHES

Provide samples of finish for approval in accordance with requirements.

Retain samples for an approval period and remove when instructed.

5.14.5 PREPARATION OF SAMPLES FOR FINISHES

Prepare all samples using the proposed method of construction and using the equipment, formwork, release agent, aggregate, concrete mix, reinforcement, curing methods and method of obtaining finish to be used in the construction.

5.14.6 SURFACE REGULARITY ON HORIZONTAL SCREEDS

Notwithstanding all provisions given in the OCSC Concrete Screeding specification, the surface regularity shall, as a minimum, comply with classification SR2 in compliance with BS 8204-1, unless a deviation is agreed by the Engineer and

written confirmation has been provided. Any surface regularity requirement exceeding this classification, as required in the contract documents, shall be complied with.

5.15 Finishes to Ground Floor Slabs

5.15.1 APPLIED

Surface regularity and abrasion resistance shall be as specified on the drawings and reference to OCSC Ground Floor Slab Specification.

Concrete surfacing required to accept floor finish to be reviewed with supplier. Refer also to clause 5.11 of this document.

Joints to be finished as per Architects/Engineers Specification.

6 Watertight Concrete

6.1 General

6.1.1 CODE OF PRACTICE

The work shall be carried out in accordance with EN 1992-3:2006 Eurocode 2 – Design of Concrete Structures – Part 3: Liquid Retaining and Containment Structures and BS 8102:2009 Code of Practice for protection of below ground structures against water from the ground.

6.1.2 WATERTIGHT CONSTRUCTION

Where the description of a concrete mix is qualified by the phrase "watertight construction" the Contractor shall give such special care and attention to the work at all stages that will ensure a watertight structure. Should the work fail in this respect it shall be made watertight at the Contractor's expense. Unless otherwise noted on the drawings, this section specifies requirements not covered elsewhere for work in connection with basements, pits, water tanks, reservoirs, podium decks and other structures where the concrete must be water resistant without the assistance of an impermeable membrane.

6.1.3 BEST PRACTICE

The design mix for underground structures should be based on the following best practice principals:

a. Minimise cement content where reasonable to reduce heat of hydration. This will require a balanced approach to the depth of cover to achieve the same durability performance. Notwithstanding, the strength performance shall not be compromised.

b. Minimise water/cement ratio to reduce shrinkage properties and increase durability properties.
c. Provide adequate compaction and curing in accordance with the specification.
d. All watertight construction joints are to be inspected and photographed in full prior to placing of concrete.
e. Installers of proprietary waterproof systems shall be registered Contractors with the system manufacturer.
f. Concreting shall only proceed following sign-off of all pre-pour checks by designated and approved inspectors

6.1.4 TANKING

Tanking to walls and slabs shall be provided as shown on the drawings and shall be laid and protected, temporarily and permanently, strictly in accordance with the manufacturers printed instructions. Particular attention is needed in the weather protection of bentonite clay membranes that rely on expansion after the concrete is placed to generate waterproofing qualities.

The installation and application of all proprietary tanking membranes and products shall be inspected and signed off by an approved and competent inspector. Evidence and records of this sign-off shall be submitted to the Engineer.

6.1.5 TIES

No through ties shall be installed in watertight walls.

6.1.6 WATER-LOGGED GROUND

In water-logged ground the site shall be kept free from water until the concrete has thoroughly set and the construction has advance sufficiently to preclude flotation.

6.2 Joints Generally

6.2.1 GENERAL

In watertight construction external water-bars shall be used in all construction joints and movement joints in accordance with the manufacturer's instructions. The Contractor shall obtain approval for the methods to be used to maintain them in their correct locations while the concrete is being placed and during or after the removal of the formwork.

6.2.2	JOINTS POSITION	The contractor shall submit for approval drawings indicating the positions of joints and details of water bars to be used for all watertight construction. Details shall include scheduling for all special function pieces to be used.
6.2.3	WATERPROOFING	Waterproofing shall comply with BS 8102 Code of Practice for protection of below ground structures against water from the ground. The waterproofing membrane shall be compatible with the gas exclusion properties required for radon, methane, carbon monoxide etc. as required. Waterproofing systems shall be supplied from one company only. Hydrophilic strips may be used in locations with congested reinforcement subject to the approved of the Engineer.
6.2.4	CERTIFICATION OF JOINT MATERIAL	All waterproofing and waterproofing jointing material shall have a certified Declaration of conformity/performance in compliance with the Construction Products Regulations. All watertight construction joints shall be inspected by competent personnel to ensure quality of workmanship.
6.2.5	SURFACE PREPARATION	Preparation of surfaces and jointing of waterbars and hydrophilic strips along with robust fixing to withstand the pouring process are key elements to achieving watertight joints.
6.2.6	SLAB AND WALL JUNCTIONS	At slab and wall junctions, a continuous up stand section of the wall shall be cast at the same time as and integrally with the floor slab unless otherwise noted on the drawings. This section shall not be less than 150mm in height above the slab, and not less than 150mm above a splay where used.
6.2.7	SLAB/WALL INTERACTION	A concrete slab adjacent to a wall shall be cast against a top horizontal form or other suitable arrangement shall be made so that the junction of the base slab and wall will be cast in one.
6.2.8	SLAB/WALL SERVICE PENETRATIONS	Where possible, all slab and wall service penetrations shall be made with a proprietary puddle flange with a waterbar as required. Where puddle flanges are not feasible or appropriate, the Contractor shall submit details for review to the Engineer. All details shall have a fitness for use compatible with the end use of the building and

their performance shall be guaranteed by the Contractors supplier.

7 Cast Insitu Work – Tolerances For Finished Work

7.1 General

7.1.1 TOLERANCE STANDARD

Tolerance for placement of concrete shall be in accordance with EN 13670. Tolerance limits shall be based on Class 1 as adjusted by the Engineer as appropriate.

7.1.2 CONTRACTOR RESPONSIBILITY

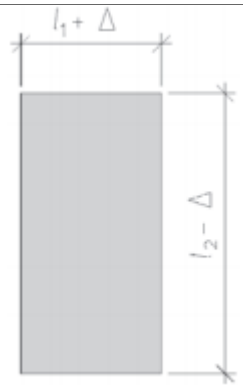
It is the Contractor's responsibility to check that the above mentioned tolerances are sufficient to accommodate fittings, prefabricated items, window frames, lift shafts etc… and he/she shall work to reduce tolerances when required for these items.

7.2 Section Dimension Tolerances

7.2.1 PERMITTED TOLERANCES

The dimensions of cross section, the cover and position of reinforcement and prestressing reinforcement shall comply with Table 7.1

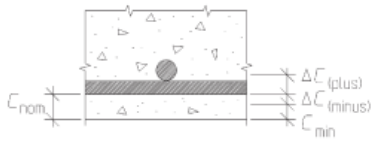
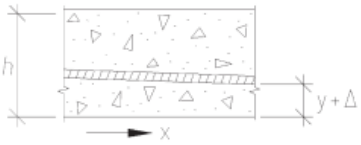
Table 7.1 *Tolerances for cross-section dimensions (Figure 4 & Figure G.4 I.S. EN 13670)*

No	Type of deviation	Description	Permitted deviation Δ	
			Tolerance Class 1	**Tolerance Class 2**
A		Cross-sectional dimensions Applicable to beams, slabs and columns For ℓ_i < 150mm ℓ_i = 150mm ℓ_i ≥ 150mm with linear interpolation for intermediate values	± 6mm ± 10mm ± 15mm	± 5mm ± 10mm ± 15mm
	NOTE 1 For foundations, permitted plus-deviations shall be stated in the executing specification, if required. Minus-deviations are as stated.			
	NOTE 2 Tolerances for special geotechnical concrete members cast directly into the ground we are not covered by this standard, e.g., slurry-walls, bored piles, etc. However, ordinary, normal foundations cast directly onto the ground are covered (i.e., blindings etc.)			
B		Orthogonality of a cross-section Note: a = length of cross-sectional dimension	The larger of ± 0,04 a or ± 10mm But not more than ± 20mm	

7.2.2 PERMITTED TOLERANCES

The cover and position of reinforcement and prestressing reinforcement shall comply with Table 7.2

Table 7.2 *Reinforcement tolerances (Figure 4 I.S. EN 13670)*

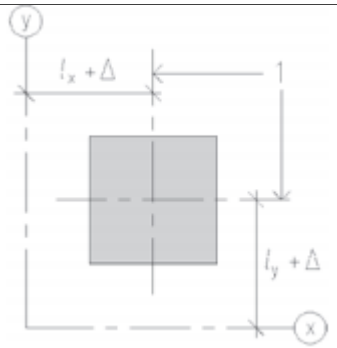
No	Type of deviation	Description	Permitted deviation Δ	
			Tolerance Class 1	Tolerance Class 2
A	 Requirement: $C_{nom} = \Delta C_{(plus)} > c > C_{nom} - \lvert\Delta C_{(minus)}\rvert$	Location of ordinary reinforcement Δc(plus) $h \leq 150$ mm $h = 400$ mm $h \geq 2500$ mm with linear interpolation for intermediate values	 + 10 mm + 15 mm + 30 mm[b]	 + 5 mm + 10 mm + 30 mm
	C_{min} = required minimum cover C_{nom} = nominal cover = $C_{min} + \lvert\Delta C_{(minus)}\rvert$ c = actual cover ΔC= permitted deviation from C_{nom} h = height of cross-section	$\Delta C_{(minus)}$	ΔC_{dev}[a]	ΔC_{dev}[a]
	[a] Δc_{dev} – Can be found in national annex to EN 1992-1-1. Unless otherwise specified, Δc_{dev} = 10mm. The execution specification may state if a statistical approach allowing a certain percentage of values with covers less than c_{min} is permitted. [b] Permitted plus-deviations for cover to reinforcement for foundations and concrete members in foundations may be increased by 15mm. The given minus-deviations apply.			
B		Lap-joints ℓ = Lap Length	-0,06 ℓ	
C		Location of prestressing reinforcement[a] For $h \leq 200$m For $h >$ 200mm Concrete cover measured to sheath $\Delta c_{(minus)}$	 ±6mm The smaller of ± 0,03 h or ± 30 mm Δc_{dev}[b]	
	[a] The values given apply to thickness and transverse direction. For transverse direction h is the width of the element. For tendons in slabs larger deviations than ± 30mm may be permitted if necessary to avoid small openings, ducts, chases and inserts. The tendon profile of such deviations shall be smooth. [b] Permitted minus-deviation Δc_{dev} as for ordinary reinforcement, see case A.			

7.3 Base Supports

7.3.1 PERMITTED TOLERANCES

Permitted deviations for the position of base supports shall comply with Table 7.3

Table 7.3 *Tolerances base support dimensions (Figure G.1 I.S. EN 13670)*

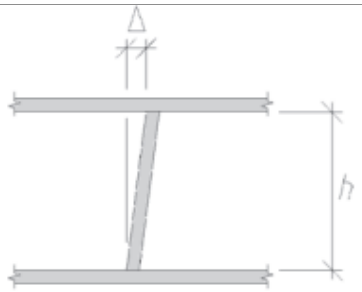
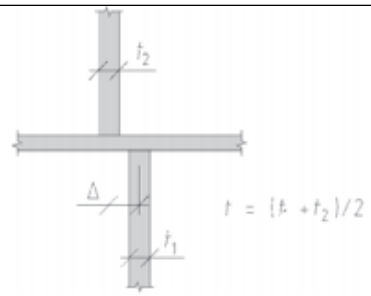
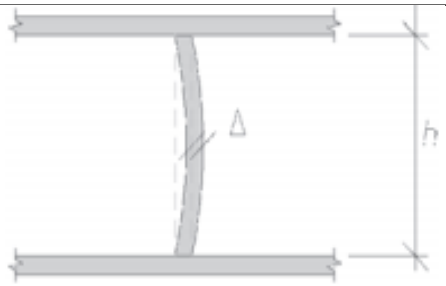
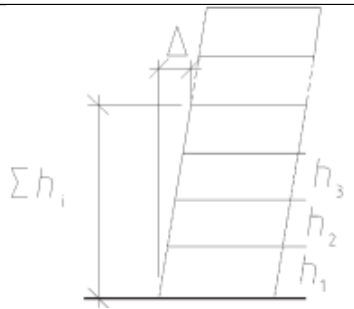
No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A		Position in plane of a base support relative to the secondary lines Note: 1 - column centre lines (horizontal section) y - secondary line in the y - direction x - secondary line in the x - direction	± 25mm
B		Position in vertical direction of a base support relative to the secondary level Note: 1 – secondary level (vertical section) h – intended distance to base from secondary level	± 20mm

7.4 Columns & Walls

7.4.1 PERMITTED TOLERANCES VERTICAL SECTIONS

Values for permitted structural deviations from the vertical for columns and walls shall comply with Table 7.4.

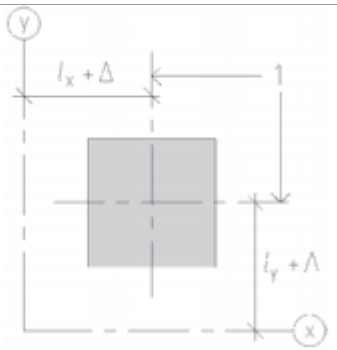
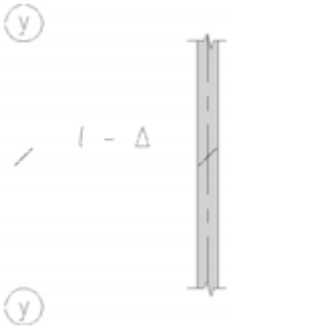
Table 7.4 *Tolerances for vertical deviation of columns & walls (Figure 2 I.S. EN 13670)*

No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A		Inclination of a column or wall at any level in a single or a multi-storey building $h \leq 10m$ $h > 10m$ Note: *h* = free height	The larger of 15mm or *h*/400 25mm or *h*/600
B		Deviation between centres	The larger of *t*/30 or 15mm But not more than 30mm
C		Curvature of a column or wall between adjacent storey levels	The larger of *h*/300 or 15mm But not more than 30mm
D		Location of a column or a wall at any storey level, from a vertical line through its intended centre at base level in a multi-storey structure. *n* is the number of storey, where $n > 1$	The smaller of 50mm or $\sum h_i (200\ n^{1/2})$

7.4.2 PERMITTED TOLERANCES HORIZONTAL SECTIONS

Values for permitted structural deviational for horizontal sections shall comply with Table 7.5.

Table 7.5 *Tolerances for horizontal sections of columns & walls (Figure G.2 I.S. EN 13670)*

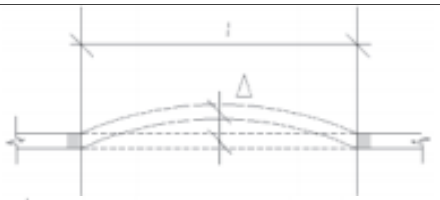
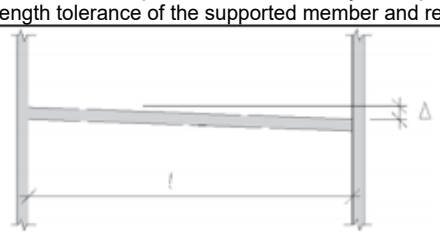
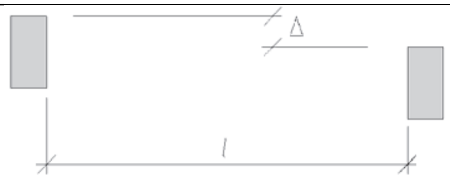
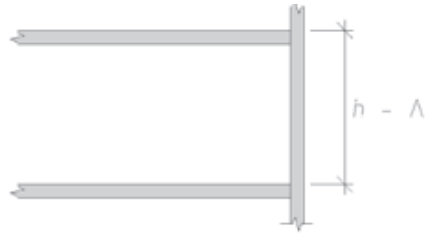
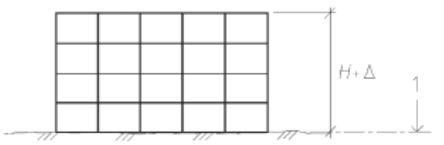
No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A		Position in plane of a column relative to the secondary lines Note: 1 - column centre lines (horizontal section) y - secondary line in the y - direction x - secondary line in the x - direction	± 25 mm
B		Position in plane of a wall relative to the secondary line	± 25 mm
C		Free space between adjacent columns or walls	The larger of[a] ± 20 mm ± l/600 But not larger than 60 mm

[a] Note Stricter position tolerance may be required for columns and walls supporting precast elements depending on the length of the supported member and required support length

7.4.3 PERMITTED TOLERANCES LINE & LEVEL

Values for permitted structural deviations for line and level at beams and slabs shall comply with Table 7.6.

Table 7.6 *Tolerances for line and level of beams & slabs (Figure G.3 I.S. EN 13670)*

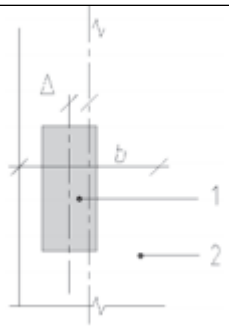
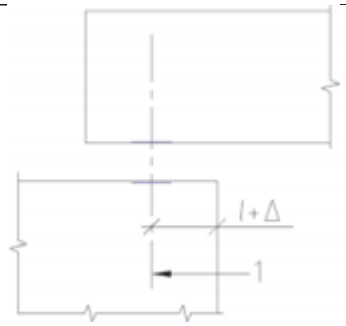
No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A		Horizontal straightness of beams	± ℓ/600 But ± 20mm maximum
B		Distance between adjacent beams, measured at corresponding points	The larger of [a] ± 20mm or ± ℓ/600 But not more than 40mm
	[a]NOTE: Stricter position tolerances may be required for beams supporting precast elements depending on the length tolerance of the supported member and required support length.		
C		Inclination of a beam or a slab	± (10 + ℓ/500) mm But not greater than 25mm
D		Level of adjacent beams, measured at corresponding points	± (10 + ℓ/500) mm But not greater than 25mm
E		Levels of adjacent floors at supports	± 20mm
F		Level of upper floor measured relative to the secondary system $H \leq 20m$ $20m < H$	± 20 ± 0,5 (H + 20) But not more than 50mm

7.5 Beams & Slabs

7.5.1 PERMITTED TOLERANCES LOCATION

Values for permitted structural deviations for location of beams and slabs shall comply with Table 7.7.

Table 7.7 *Tolerances for horizontal sections of beams & slabs (Figure 3 I.S. EN 13670)*

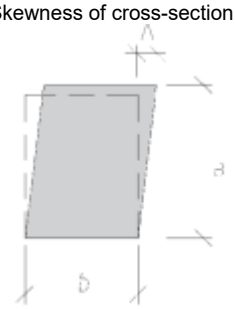
No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A		Location of beam-to-column connection measured relative to the column *b* – dimension of column in the same direction as Δ Notes: 1 – beam, section 2 – column, elevation	The larger of ± *b*/30 Or ± 20 mm
B		Position of bearing axis of support when structural bearings are used. ℓ = Intended distance from edge. Note: 1 – actual bearing of support	The larger of ± *l*/20 Or ± 15 mm

7.6 Surfaces and Edge Straightness

7.6.1 PERMITTED TOLERANCES

Values for permitted structural deviational for surfaces and edge straightness shall comply with Table 7.8. (For ground floor slabs please refer to TS13 and the drawings for floor level and flatness criteria)

Table 7.8 *Tolerances for surfaces & edge straightness (Figure G.5 I.S. EN 13670)*

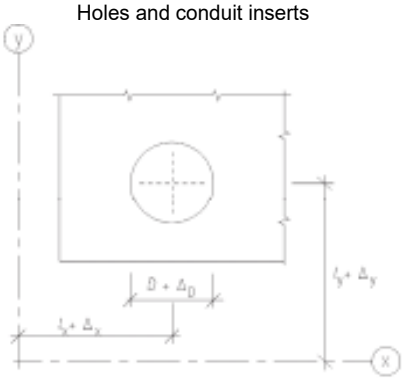
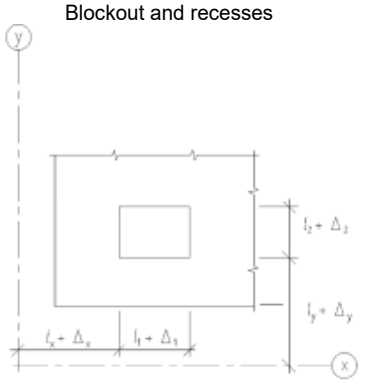
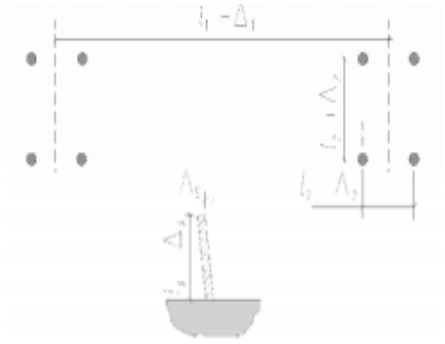
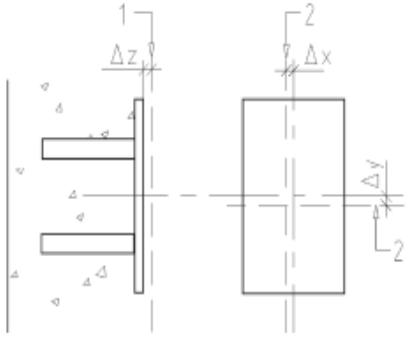
No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A	Flatness of moulded or finished surface 	Global: ℓ ≥ 2.0m Local: ℓ = 0.2m	Global = 9mm Local = 4mm (Note: for an unfinished surface limits reduce to 15mm and 6mm respectively)
B	Skewness of cross-section 		The greater of ± *a*/25 or ± *b*/25, But not more than ± 30mm
C	Edge straightness 	For Lengths: ℓ < 1m ℓ > 1m	 ± 8mm ± 8mm/m But not more than ± 20mm

7.7 Holes and Inserts

7.7.1 PERMITTED TOLERANCES

Permitted values for holes and inserts shall comply with Table 7.9.

Table 7.9 Tolerances *for holes and inserts (Figure G.6 I.S. EN 13670)*

No	Type of deviation	Description	Permitted deviation Δ (Tolerance Class 1)
A	Holes and conduit inserts 	Δ_x and Δ_y = deviation from secondary line in x- and y-direction Δ_D = deviation on diameter	**± 25mm** **± 10mm**
B	Blockout and recesses 	Δ_x, Δ_y, = deviation from secondary line in x- and y-direction Δ_1, Δ_2 = deviation on block-out (alternatively measured to centrelines as in Figure Table 7.1 A)	± 25mm
C	Anchor bolts and similar inserts 	Placing of bolts and centre of a bolt group	Δ_1 = ± 10mm
		Internal distance between bolts in a group	Δ_2 = ± 3mm
		Protrusion	Δ3 = + 25mm -5mm
		Inclination Notes: l_1 = distance between bolt groups l_2 = distance between bolts in group l_3 = free length of bolt	Δ5 = the greater of 5mm or ℓ_3/200
D	Anchoring plates and similar inserts 	Deviation in plane Deviation in depth Notes: 1 = nominal position in plane 2 = nominal position in depth	Δx, Δy = ± 20mm Δz = ± 10mm

7.8 Deformation Tolerances

7.8.1 DEFLECTION (SPAN ≤ 10M)

For spans not greater than 10m the deflection is limited to span/250 for total load in the quasi-permanent state.

In addition, deflections caused by variable actions alone are limited to span/500 (after application of cladding and finishes). The design of cladding, finishes and partitions are to be design to a limit also of span/500.

7.8.2 DEFLECTION (SPAN > 10M)

For spans greater than 10m the deflection limits must be agreed individually with the Engineer/Architect.