GENERAL SPECIFICATION FOR CIVIL ENGINEERING WORKS

2006 Edition

AMENDMENT NO. 2/2010 (March)

VOLUME 1

SECTION 1 GENERAL

(a) Clause No. 1.02(1) **Add note to the abbreviation for** "CD" **as follows:-**

CD	Chart Datum (0.146 m below Principal Datum)

(b) Clause No. 1.02(1) **Delete the abbreviation** "CS"**.**

(c) Clause No. 1.02(1) **Add the following abbreviations:-**

CS1	Construction Standard CS1: 1990 Testing Concrete
CS2	Construction Standard CS2: 1995 Carbon Steel Bars for the Reinforcement of Concrete
CSF	Condensed Silica Fume
GGBS	Ground Granulated Blastfurnace Slag
QSPSC	Quality Scheme for the Production and Supply of Concrete

APPENDIX 1.1 STANDARDS

(d) New reference **Add the following standard after BS 144: 1990**:-

BS 146: 2002	Specification for blastfurnace cements with strength properties outside the scope of BS EN 197-1

(e) New reference **Add the following standard after BS 1740: Part 1: 1971 (1990)**:-

BS 1881: Part 124: 1988	Testing concrete. Methods for analysis of

hardened concrete

(f) New reference **Add the following standard after BS 4232: 1967**:-

BS 4246: 1996	Specification for high slag blastfurnace cement

(g) New reference **Add the following standard after BS 5589: 1989**:-

BS 5606: 1990	Guide to accuracy in building

(h) New reference **Add the following standard after BS 6681: 1986**:-

BS 6699: 1992	Specification for ground granulated blastfurnace slag for use with Portland cement

(i) New reference **Add the following standards after BS EN 755: Part 9: 2001**:-

BS EN 934: Part 2: 2009	Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labeling
BS EN 934: Part 4: 2009	Admixtures for concrete, mortar and grout. Admixtures for grout for prestressing tendons. Definitions, requirements, conformity, marking and labelling

(j) New paragraph **Add the following new paragraph 1.1.16**:-

1.1.16 CANADIAN STANDARD

CSA-A23.5-M86	Supplementary Cementing Materials

VOLUME 2

SECTION 21 MARINE WORKS

(k) Clause 21.07 **Replace the clause with following:**

Concrete shall comply with Appendix 21.2 entitled “Specification for Reinforced Concrete in Marine Environment” to address the corrosion of reinforced concrete for marine structures and also shall comply with Section 16 in general.

(l) Clause 21.08 **Replace the clause with following:**

Joints in concrete in seawalls shall comply with Section 16 and shall also comply with Appendix 21.2 entitled “Specification for Reinforced Concrete in Marine Environment”.

(m) New appendix **Add new Appendix 21.2**

Add new Appendix 21.2 as attached.

Quality Management & Standards Unit
Civil Engineering and Development Department
9 March 2010

APPENDIX 21.2

SPECIFICATION FOR REINFORCED CONCRETE IN MARINE ENVIRONMENT (TO BE READ IN CONJUNCTION WITH SECTION 16 AND THE AMENDMENTS)

PART 1: CONCRETE WORKS

MATERIALS

Mix constituents

21.2.1 Clause 16.03 – Sub-clause (1) is replaced by (1) below: -

(1) Cementitious content is the combined mass of cement and the dry mass of CSF and the mass of either PFA or GGBS per cubic metre of compacted concrete. PFA, GGBS and CSF are referred to as supplementary cementitious materials in this Specification.

Cement

21.2.2 Clause 16.06 – Sub-clause (1) is replaced by the following: -

(1) All cement and supplementary cementitious materials shall comply with the following standards:-

Portland-blast furnace cement	:	BS 146
Low heat Portland-blast furnace cement	:	BS 4246
Ground Granulated Blastfurnace Slag (GGBS)	:	BS 6699
Condensed Silica Fume (CSF)	:	CSA-A23.5-M86 (Canadian Standard)

Clause 16.06 – Sub-clause (3) is added below:-

(3) The Contractor shall nominate the source of any of the materials mentioned in sub-clause (1) above proposed to be used in each concrete mix.

Admixtures

21.2.3 Clause 16.10 – Sub-clauses (1) and (2) are replaced by new sub-clauses (1) to (4) below: -

(1) An admixture is defined as a constituent material of concrete other than cementitious materials, aggregates and water. The admixtures shall comply and be used in accordance with the supplier's recommendation. The admixtures shall comply with the following:-

Pigments for Portland cement and Portland cement products	:	BS 1014
Accelerating admixtures, retarding admixtures and water-reducing admixtures	:	BS 5075:Part 1
Superplasticising admixtures	:	BS 5075:Part 3

Where two or more admixtures are used in a concrete mix, the compatibility shall be verified in writing by the supplier with the following: -

BS 5075 Concrete Admixtures

(2) The use of admixtures shall only be permitted subject to the Contractor carrying out prior testing on trial mixes in accordance with this specification.

(3) The use of any admixture containing chlorides is prohibited.

(4) The Contractor shall submit relevant test data which demonstrates that the properties of concrete composed of the admixture meets the requirements of this specification.

Curing compound

21.2.4 Clause 16.11 - Sub-clause (1) is replaced by the following:

(1) Curing compound and the material and methods of applications shall be submitted for the approval of the Engineer prior to concrete placement. The use of curing compound shall be limited to the following type: -

Wax Emulsion

The curing compound shall have an efficiency index of not less than 85%. The minimum application rate shall be 0.2 litre/m^2 or the minimum stated on the certificate of compliance, whichever is greater.

CONCRETE

Concrete mix

21.2.5 Clause 16.12 – Sub-clause (3) is replaced by the following: -

(3) Admixtures for concrete shall comply with Clause 21.2.3. All-in aggregates shall not be used.

New sub-clause (7) is added below: -

(7) For reinforced concrete in marine environment:

(a) The water/cementitious ratio of the concrete mix shall not exceed 0.38.

(b) Unless otherwise permitted by the Engineer, the minimum designed slump value for designed mix concrete for reinforced elements, after the addition of superplasticiser if used, shall be 75 mm.

(c) The acid soluble sulphate content of all concrete expressed as SO_3 shall be determined in accordance with Clause 21.10.3 of CS1 and shall not exceed 4% of total weight of concrete.

Chloride content of concrete

21.2.6 Clause 16.13 (2) is added below: -

(2) For reinforced concrete in marine environment, the acid soluble chloride ion content of all concrete shall be determined in accordance with Clause 21.10.2 of CS1, and shall not exceed 0.02% of total weight of concrete.

Cementitious content of designed mix concrete

21.2.7 Clause 16.14 - Sub-clauses (1) and (2) are replaced by the following: -

(1) The minimum cementitious content of designed mix concrete of Grade 20 or above using 20 mm nominal maximum aggregate size shall be as stated in Table 16.2 in Section 16 of this GS. The minimum cementitious contents shall be increased by 40 kg/m^3 for 10 mm nominal maximum aggregate size and decreased by 30 kg/m^3 for 40 mm nominal maximum aggregate size.

(2) The maximum cementitous content of designed mix concrete for reinforced concrete in marine environment shall be 450 kg/m^3 unless otherwise approved by the Engineer. The maximum cementitious content of designed mix concrete (other than for reinforced concrete in marine environment) in, water retaining structures and water tight structures, shall be 550 kg/m^3.

New sub-clauses (6) to (8) are added below: -

(6) For reinforced concrete in marine environment, CSF and either PFA or GGBS shall be incorporated into the concrete as separate materials complying with the following requirements:

(a) The proportion of CSF replacement shall be within the 5-10% range by mass of the cementitious content.

(b) The proportion of PFA replacement shall be within the 25-40% range by mass of the cementitious content for normal applications, or if GGBS is used instead of PFA, the proportion of GGBS replacement shall be within 60-75% range by mass of the cementitious content.

(7) The Contractor shall nominate the source of any of the materials of CSF and PFA or GGBS proposed for being used in each concrete mix.

(8) Triple blending of cement, PFA and GGBS is not allowed unless approved by the Engineer.

SUBMISSIONS

Particulars of materials for concrete

21.2.8 Clause 16.17 - The first sentence of Sub-clause (1) is deleted and replaced by:

"The following particulars of the proposed cement, PFA, aggregate, GGBS and CSF shall be submitted to the Engineer:"

Sub-clause (1) (d) is replaced by (d), (e) and (f) below: -

(d) A certificate not older than 6 months for each nominal maximum aggregate size showing the source of the aggregate and showing that the aggregate complies with the requirements stated in the Contract and including results of tests for:

- grading
- silt content
- chloride content
- flakiness index of coarse aggregate
- ten percent fines value
- water absorption
- elongation index
- Los Angeles abrasion value
- sodium sulphate soundness
- magnesium soundness

(e) A certificate not older than 6 months for GGBS showing the source of the GGBS and showing that the GGBS complies with the requirements stated in the Contract.

(f) A certificate not older than 6 months for CSF showing the source of the CSF and showing that the CSF complies with the requirements stated in the Contract.

Particulars of ready-mixed concrete supplier

21.2.9 Clause 16.19 is replaced by the following: -

"The Contractor shall arrange for the Engineer or Engineer's Representative to inspect the supplier's plant or plants if required before and/or during the period of supply. The name of the

supplier, the type of plant, and the location of each plant, including a back-up plant, from which the Contractor proposes to obtain ready-mixed concrete shall be submitted to the Engineer at least 14 days before trial mixes are made or if trial mixes are not required, at least 14 days before the ready-mixed concrete is placed in the permanent works."

Particulars of precast concrete units

21.2.10 Clause 16.21 – New sub-clauses (3) to (6) are added below: -

(3) The following particulars of the precast concrete units shall be submitted to the Engineer at least 21 days before the casting work starts:

(a) Layout of the precasting yard,

(b) Methods and sequence of casting and placing the units,

(c) Methods of testing for checking continuity of steel reinforcement before and after casting, and

(d) Methods and details of handling and storage of the precasting units.

(4) Precast concrete units shall be stored on level supports and in a manner which will not result in damage or deformation to the units or in contamination of the units. The units shall be protected from damage and any damaged units shall be replaced or repaired to the satisfaction of the Engineer.

(5) Particulars of the proposed method and devices to be used for lifting and setting of the precast concrete units shall be submitted to the Engineer for approval at least 14 days before the lifting works starts.

(6) Contact surfaces between precast concrete units shall be prepared as stated in the Contract. Dimensional tolerances shall be checked in accordance with the new Clause 16.97 in paragraph 21.2.25 of this Specification. Discrepancies in dimensions of the units shall be rectified by a method approved by the Engineer before the units are lifted into position.

HANDLING AND STORAGE OF MATERIALS

Storage of cement, PFA, GGBS and CSF

21.2.11 Clause 16.33 – New sub-clauses (3) and (4) are added below: -

(3) GGBS and CSF of different types and from different sources shall be stored in separate containers clearly marked to identify the different content of each.

(4) Cement and supplementary cementitious materials from different sources shall not be used in the same pour and may only be used in the same structure with the Engineer's prior approval.

BATCHING AND MIXING CONCRETE

Batching concrete 21.2.12 Clause 16.37 – Sub-clause (2) is replaced by the following:

(2) The quantities of cement, supplementary cementitious materials and fine and coarse aggregate shall be measured by mass except that cement supplied in bags may be measured by using a whole number of bags in each batch. The mass of aggregates shall be adjusted to allow for the free moisture content of the aggregates.

Mixing concrete 21.2.13 Clause 16.38 – New sub-clause (6) is added below: -

(6) Remixing of partially hardened concrete with or without additional cement, PFA, aggregate or water is prohibited.

TRANSPORTATION OF CONCRETE

Transportation of Concrete

21.2.14 Clause 16.39 – New Sub-clause (3) is added below: -

(3) Particulars shall be submitted to the Engineer for approval at least 14 days before placement of concrete regarding the method of transporting concrete from the production plant to the Site and the methods of handling concrete for placement on the Site.

RECORDS OF CONCRETE

Records of concrete

21.2.15 Clause 16.40 – New sub-clause (1) (k) is added below: -

(k) time of introduction of cement and supplementary cementitious materials to the mix.

PLACING AND COMPACTING CONCRETE

Placing concrete

21.2.16 Clause 16.41 – New sub-clauses (10) to (16) are added below: -

(10) All areas in which concrete is to be placed shall be clean and free from standing water immediately before the placing of the concrete, except for concrete placed under water.

(11) Unless otherwise permitted by the Engineer, rock or earth surfaces on which concrete, unless the concrete is placed by tremie, is to be placed shall be prepared after site clearance in accordance with the following requirements:-

(a) Topsoil, grass and other organic matter shall be removed.

(b) Soft spots, boulders loose/ shattered/ unsound rock fragments and other materials which in the opinion of the Engineer are unsuitable or unstable shall be removed.

(12) Concreting to structures below +2.5 m CD shall be carried out in the dry at low tides using formwork with watertight joints or an equivalent method accepted by the Engineer.

(13) On completion of concreting below +2.5 m CD, the top of the concrete shall be adequately covered to prevent washout of cement paste as the water level rises or falls.

(14) No concrete shall be placed in flowing water.

(15) The Contractor shall be responsible for setting and maintaining forms sufficiently within the tolerances, and shall ensure that the work is completed within the specified tolerances.

Concrete work falling outside the tolerances shall be remedied or replaced by and at the expense of the Contractor.

(16) The swellable waterstop shall be kept in dry conditions for at least 48 hours prior to casting the pile connection holes.

Compacting Concrete 21.2.17 Clause 16.44 – New sub-clauses (7) to (9) are added below: -

(7) Concrete shall be compacted and in its final position within 2.5 hours of the introduction of water to mixture and within 30 minutes of discharge from agitator, truck mixer and static mixer.

(8) An internal vibrator shall operate at not less than 10,000 cycles per minute.

(9) Concrete shall not be subjected to vibration between 4 hours and 24 hours after compaction.

CURING CONCRETE

Curing concrete 21.2.18 Clause 16.46 – Sub-clauses (1) and (2) are replaced by the following and sub-clauses (3) and (7) are deleted: -

(1) After final set has taken place the concrete shall be cured for at least 7 days. All exposed surfaces shall be protected from the sun and wind immediately after the initial set has occurred and the concrete shall be kept moist by light water spray or other suitable means until curing methods are applied. Surfaces from which formwork has been removed before 7 days shall be cured for the remaining period.

(2) The following curing methods are acceptable:

(a) Moist Curing

Concrete shall be covered by canvas, hessian or polyethylene sheeting and kept continuously moist. Where polyethylene sheeting is used, all edges of the sheeting shall be securely fastened so that no air circulation can occur. Concrete surfaces which have become dry shall be thoroughly wetted before the sheeting is placed. Alternatively, exposed surfaces can be cured by flooding or continuous sprinkling. Formwork left in position shall be kept continuously wet.

(b) Curing Compounds

Curing compounds shall comply with Clause 16.11 and methods of applications shall be submitted for the approval of the Engineer prior to concrete placement. The curing compound shall have an efficiency index of not less than 85%. The minimum application rate shall

be 0.2 litre/m^2 or the minimum stated on the certificate of compliance, whichever is greater.

TESTING: CONCRETE – COMPRESSIVE STRENGTH

Testing : compressive strength of concrete

21.2.19 Clause 16.59 – Sub-clause (3) is replaced by the following: -

(3) Test cubes which are cured on the Site shall be delivered to the testing laboratory as specified by the Engineer at least 36 hours before the tests are due to be carried out. The Contractor shall provide an on-site covered curing tank of internal dimension 2200 x 1200 x 900 mm deep with lock for storage of test cubes. The curing tank shall be made of galvanized steel coated with epoxy/tar paint and fitted with bottom drain, water inlet, overflow facilities and lifting lugs. The curing tank shall be thermostatically controlled within the range $27^oC \pm 3^oC$ and be completed with an impeller type circulation device of suitable design to maintain a temperature gradient of better than 0.5^oC. The temperature control mechanism shall be equipped with both heating and cooling system. All mechanisms shall be suitably protected from damage. The tank base shall be fitted with mesh racks, suitably treated to prevent corrosion, which allow water circulation beneath the cubes. The rack shall be constructed in at least 3 sections for ease of handling and removal.

PART 2: JOINT IN CONCRETE

MATERIALS

Waterstops

21.2.20 Clause 16.80 is replaced by the following: -

Swellable waterstop shall be a proprietary type approved by the Engineer and shall:

(a) be a water swellable hydrophilic waterstop and made from a preformed elastomeric strip,

(b) be free from rubber, bentonite or other inclusions,

(c) have an unrestrained volumetric expansion of not less than 170%,

(d) not deteriorate under prolonged wet/dry cycling,

(e) be able to withstand a hydrostatic head of 50 m.

(f) be in form of 10 mm x 20 mm rectangular section elastomeric strips, and

(g) be in good serviceable conditions under a temperature range of -30^{o}C to +70^{o}C.

The swellable waterstop shall be installed in strict accordance with the manufacturer's instructions and shall be kept in dry conditions for at least 48 hours prior to casting.

CONTROL OF ALKALI-SILICA REACTION IN CONCRETE

Measures to prevent alkali-silica reaction(ASR) in concrete

21.2.21 New Clause 16.93 is added below: -

(1) Measures to prevent the occurrence of alkali-silica reaction (ASR) in concrete structures shall be the control of reactive alkali content of the concrete using the framework as depicted in Sections H2.4 and H3.3 of Appendix H of GEO Report No. 167 entitled "The 2004 Review on Prevention of Alkali Silica Reaction in Concrete" published by the Geotechnical Engineering Office of Civil Engineering and Development Department. Alternative measures may be submitted to the Engineer for approval. The Engineer is not obliged to accept any alternative measures, especially if a measure could limit the performance or use of the structure, or necessitate follow-up actions such as monitoring.

(2) The reactive alkali content of concrete expressed as the equivalent oxide (Na_2O) content per cubic metre of concrete shall be obtained in accordance with clauses 16.94 and 16.95 below.

Equivalent sodium oxide (Na_2O) content

21.2.22 New Clause 16.94 is added below: -

(1) The equivalent sodium oxide (Na_2O) content of the concrete shall be calculated from the following expression:

Equivalent $Na_2O = A + B + C$

Where A is the sum of the acid-soluble alkalis (expressed as equivalent Na_2O) of cement, admixtures and water.

B is equal to 1/6 the total alkalis of PFA (expressed as equivalent Na_2O).

C is equal to 0.76 times the chloride ion ($C1^-$) of the aggregate.

(2) The acid-soluble alkali content of the cement shall be determined in accordance with BS EN 196-21:1992 and shall be taken as the average of the latest 25 daily determinations of equivalent sodium oxide plus twice the standard deviation of the results.

(3) The acid-soluble alkali content of admixtures shall be determined in accordance with BS1881: Part 124:1988.

(4) The acid-soluble alkali content of water shall be determined in accordance with BS EN 1008:2002.

(5) The total alkali content or the pulverised-fuel ash shall be determined in accordance with BS EN 196-21:1992 and shall be taken as the average of 25 weekly determinations plus twice the standard deviation of the results.

(6) The equivalent sodium oxide content of the coarse and fine aggregates shall be calculated from the quantity of chloride ion present which shall be measured in accordance with BS 812-117: 1988.

Submission

21.2.23 New clause 16.95 is added below: -

(1) The following particulars of the proposed concrete mix shall be submitted to the Engineer:

(a) HOKLAS endorsed test certificates not older than 6 months giving the results of tests required in above Clauses 16.94(2) to (6).

(b) Calculation of the reactive alkali of the proposed mix.

(c) A system to control the active alkali content in the concrete and evidence that the control system is covered by the QSPSC certification of the concrete production plant.

(2) Within five working days of any instance of the active alkali content in the concrete supplied having been found to have exceeded, the calculation shall be submitted to the Engineer together with supporting HOKLAS endorsed test certificates.

(3) The HOKLAS endorsed test certificates giving the results of tests required in Clause 16.94(2) to (6) in this Specification shall be submitted at quarterly intervals unless agreed otherwise by the Engineer. The certificates shall be accompanied by any necessary calculations to demonstrate that the mix continues to comply with the limit on reactive alkali content.

MISCELLANEOUS

Blinding concrete 21.2.24 New clause 16.96 is added below: -

Blinding concrete shall be grade 10/20 and shall be cast in bays with vertical joint properly formed.

Construction tolerances 21.2.25 New Sub-clause 16.97 is added below: -

(1) Unless otherwise specified, the dimensional tolerances for concrete construction shall comply with BS 5606:1990. Verification of tolerances shall be made by measurement made as close as practicable to 28 days after casting the appropriate element of structure for in situ construction or at the time of incorporation into the Works in the case of precast units.

(2) Unless otherwise specified, the tolerances for insitu concrete in the finished work shall be :

(a) Variation from plumb in any 3 m: 6 mm
Variation from plumb in any 12 m: 18 mm

(b) Variation of level or lateral position of any point from its level or lateral position indicated or completed: 12 mm

(c) Variation in slab and wall thickness: +6 mm, -3 mm

(d) Variation of level or lateral position of any point, for machinery installation, from its level or lateral position indicated or completed: +5 mm, -12 mm

(3) Unless otherwise specified, the tolerances for precast concrete construction in the completed work shall be:

(a) Length

Up to 2 m	±6 mm
2 m to 6 m	±9 mm
Over 6 m	±12 mm

(b) Cross section width or height

Up to 2 m	±4 mm
2 m to 6 m	±6 mm
Over 6 m	±8 mm

(c) Cross section thickness or depth

Up to 0.5 m	±6 mm
Above 0.5 m	±8 mm

(d) Straightness or bow (deviation from intended line)

Up to 3 m	±6 mm
3 m to 6 m	±8 mm

(e) Length

Up to 1.2 m	±6 mm
1.2 m to 1.8 m	±9 mm

Over 1.8 m	±12 mm

(f) Gap

The gaps between adjacent units shall not exceed 15 mm ±5 mm.

(4) Discrepancies in dimensions of the concrete construction works shall be rectified by methods approved by the Engineer. If the said concrete construction works cannot be rectified to the satisfaction of the Engineer, the concrete construction works shall be removed and reconstructed. Any additional expenses incurred thereon shall be borne by the Contractor.

Use of displacers 21.2.26 New Sub-clause 16.98 is added below: -

"Where their use is approved, displacers shall be clean and dry and carefully placed into the concrete as pouring proceeds. There shall be at least 225 mm between any two pieces, or between the displacers and the face of the concrete. The mass of displacers in any one pour of concrete shall not exceed 20% of the total mass of that pour."

GROUT

Grout 21.2.27 New Sub-clause 16.99 is added below: -

"Where directed by the Engineer, cement mortar or concrete used for grouting in bolts, pipes, etc. shall be supplied with an expandable compound additive to provide a non-shrink grout. The additive shall in no case affect the durability performance, and aesthetics of the structure. Such additive shall be submitted to the Engineer for approval and be applied in accordance with the manufacturer's recommendations."

Marine Grout 21.2.28 New Sub-clause 16.100 is added below: -

(1) Marine grout shall be a proprietary non-shrink cementitious grout for underwater application approved by the Engineer and shall be a cement based product which is iron and chloride free.

(2) It shall be mixed with clean water at a water/powder ratio of 0.22 and not exhibit bleed or segregation. A volumetric expansion of up to 4% (by means of a gaseous system) shall occur while the grout is in a plastic state.

(3) The grout shall contain admixtures to minimise wash-out in underwater applications.

(4) The compressive strength of the grout must exceed 30 N/mm^2 at 7 days and 50 N/mm^2 at 28 days.

(5) The storage, handling, mixing and placement of the grout must be in strict accordance with the manufacturer's instructions.

REINFORCED CONCRETE IN MARINE ENVIRONMENT

Reinforced Concrete in Marine Environment

21.2.29 New Sub-clause 16.101 is added below: -

"For avoidance of doubt, concrete of Grade 45/20 or above in a marine works contract is regarded as Reinforced Concrete in Marine Environment and the specification contained in this Appendix shall apply."