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## SERIES 700

### CONCRETE

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### CONCRETE

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#### **NOTE: New European Standards**

It is recognised that the BSI withdrew BS5328, BS3148 and many parts of BS1881 on 1<sup>st</sup> December 2003, in favour of new European Standards.

However whilst reference has been made to the new European Standards where appropriate, this document has not generally been updated to reflect these Standards. Therefore references to products and properties may remain in accordance with the withdrawn British Standards.

## **701 Constituent Materials**

### **Cement**

- 1 Cement shall comply with one of the following:
  - (i) Portland cement complying with BS EN 197-1 (includes rapid hardening, also to BS EN 197-1);
  - (ii) Portland blast furnace cements complying with BS 146;
  - (iii) Sulphate-resisting Portland cements complying with BS 4027;
  - (iv) A mixture of Portland cement (to BS EN 197-1) and pulverised-fuel ash for use in structural concrete (to BS 3892: Part 1), provided that the amount of pfa is not less than 15% and not more than 35% by weight of the total cement;
  - (v) A mixture of Portland cement (to BS EN 197-1) and ground granulated blast furnace slag for use with Portland cement [ggbs] (to BS 6699), provided that the amount of ggbs is not more than 65% by weight of the total cement.
- 2 Different cements may not be mixed, other than where allowed under Sub-clauses 701(1)(iv) and (v).
- 3 The use of rapid hardening cements by the Contractor, shall be subject to approval by the Engineer.

### **Aggregates**

- 4 Unless otherwise specified or agreed by the Engineer, aggregates shall comply with one of the following British Standards, as appropriate:
  - (i) Aggregates from natural sources for concrete complying with BS 882/BS EN 12620;
  - (ii) Air-cooled blast furnace slag coarse aggregate for concrete complying with BS 1047: 1983/BS EN 12620;
  - (iii) Sands (i.e. fine aggregates) complying with BS 1199 and BS 1200.
- 5 For concrete Grade 40 or higher the ten per cent fines value of the coarse aggregate, determined in accordance with BS 812: Part 111, shall be not less than 100 kN and for other grades not less than 50 kN. The test sample shall be in a soaked condition at the time of test.
- 6 The preferred nominal maximum sizes of aggregate for use in concrete are 40mm and 20mm, but if a smaller size is necessary it should be either 14mm or 10mm.

### **Water**

- 7 If water for the Works is not available from a water company's supply, the Engineer's approval shall be obtained regarding the source of supply and the manner of its use. When required by the Engineer the Contractor shall arrange for tests of the water to be carried out in accordance with BS EN 1008. Water from the sea or tidal rivers shall not be used.

## **Admixtures**

- 8** Unless otherwise approved by the Engineer, admixtures shall comply with one of the following:
- (i) Pigments for Portland cement and Portland cement products complying with BS EN 12878;
  - (ii) Concrete admixtures, except chloride-based admixtures, complying with BS EN 480 & BS EN 934.
- 9** In all cases, the Contractor shall provide the following information for the Engineer's approval:
- (i) The quantity of the admixture to be used, in terms of either, millilitres per kilogram of cement and ml per cubic metre of concrete for liquid-based products, or, kilograms per 50 kilograms of cement and kilograms per cubic metre of concrete for solid-based products;
  - (ii) The detrimental effects of adding a greater or lesser quantity to (i) above;
  - (iii) The chemical name(s) of the main active ingredient;
- 10** The quantity and method of using admixtures shall be in accordance with the manufacturer's recommendations and in all cases shall be strictly subject to the prior approval of the Engineer. Where admixtures are proposed by the Contractor, the Engineer may ask the Contractor to provide trial mixes of the modified concrete. The trial mixtures should contain representative constituents intended for the Permanent Works. The Engineer shall be satisfied that the admixture is compatible with all other constituents of the concrete mix and ascertain whether it causes acceleration or retardation of the setting time, and whether there is any loss of workability.
- 11** Only in exceptional circumstances such as hot weather conditions shall retarding admixtures be used, and only then after the Engineer's approval, in accordance with this Clause.
- 12** Accelerating admixtures may be used, but only after the Engineer's approval, in accordance with this Clause.
- 13** Other than for foamed concretes for Reinstatements (FCRs), air entrainment of concrete and structural concrete is not permitted under any circumstance.

## **702 Mix Design**

### **General**

- 1** Concrete mixes are specified in the form of one of the following types:
- (i) Designed Mix;
  - (ii) Standard Mix.

## Designed Mixes

- 2 Designed mixes are specified by their required performance, in terms of grade (subject to any special requirements for materials), minimum or maximum cement content, free water/cement ratio and any other properties. Designed mixes are used for structural concrete, including: cabinet bases, chamber and box walls and bases and for all reinforced concrete structures or elements.

## Standard Mixes

- 3 Standard mixes are suitable for ancillary purposes, where strength testing is not required to assess conformity. Standard mixes generally provide concrete of a required characteristic strength, except where there is poor control of production, or where poor materials are used. Standard mixes are applicable for site batching, and shall be used as blinding concrete to reinforced concrete bases, backfill for structural foundations, filling of overdig, preparation of formwork and bedding and backing to precast concrete kerbs, channels, edgings and quadrants.

Environment	Reinforced Concrete					Plain Concrete				
	Nominal Max Size of Aggregate (mm)				Max free w/c ratio	Nominal Max Size of Aggregate (mm)				Max free w/c ratio
	40	20	14	10		40	20	14	10	
Extreme	320	350	370	390	0.45	320	350	370	390	0.50
Very Severe	295	325	345	365	0.45	295	325	345	365	0.50
Severe	295	325	345	365	0.50	270	300	320	340	0.50
Moderate	270	300	320	340	0.50	245	275	295	315	0.50

**Table 7/2: Minimum Cement Content (kg/m<sup>3</sup>) and Maximum Water/Cement (w/c) Ratio Required in Concrete to Ensure Durability.**

- 3 Conditions of environment indicated in Table 7/2 are classified as follows:
- (i) Extreme - Concrete surfaces exposed to abrasive action by sea water, or, water with a pH value of 4.5 or less;
  - (ii) Very Severe - Concrete surfaces directly affected by de-icing salts, or, sea water spray;
  - (iii) Severe - Concrete surfaces exposed to driving rain, or, alternate wetting and drying;
  - (iv) Moderate - Concrete surfaces above ground level and fully sheltered against rain, or, de-icing salts, or, seawater spray.
- 4 Further guidance for the minimum cement content and maximum water/cement ratios required for different sizes of aggregate and particular types of cement to provide concrete having an acceptable durability to under exposure to a particular degree of sulphite or acid attack is provided in Building Research Establishment (BRE) Digest No. BRE 363.

## Maximum Cement Content

- 5 The maximum cement content shall not exceed 550kg/m<sup>3</sup>, unless otherwise agreed by the Engineer.

### Maximum Chloride Content

- 6 The total chloride content of a concrete mix arising from the cement, aggregate, admixture (where used) and any other source shall not exceed the following appropriate limits when determined in accordance with BS 812:
- (i) 0.2 for concrete made with cements complying with BS 4027 (Sulphate-resisting Portland cement);
  - (ii) 0.3 for concrete containing embedded metals and made with cements complying with BS EN 197-1, BS 146 or combinations of BS EN 197-1 with pfa or ggbs.

Where the maximum total chloride content is expressed as a % of chloride ion by mass of cement, inclusive of pfa or ggbs when they are used as cement.

### Maximum Sulphate Content

- 7 Sulphates are present in most cements and in some aggregates. Excessive amounts can cause expansion or disruption in the concrete. The total acid-soluble sulphate content of the concrete mix, expressed as  $\text{SO}_3$ , shall not exceed 4% of the mass of the cement in the mix. The sulphate shall be calculated as the total from the various constituents of the mix.

## 703 Designed Mixes

### Concrete Grade and Class

- 1 For each grade of concrete, the specified characteristic strength in  $\text{N/mm}^2$  shall be as given in Table 7/1. The class of concrete shall be defined by its grade followed by the maximum size of aggregate allowed (eg. 30/20).

Grade	Characteristic Strength $\text{N/mm}^2$
7.5	7.5
10	10.0
15	15.0
20	20.0
25	25.0
30	30.0
40	40.0
50	50.0
60	60.0

Table 7/1: Grades of Concrete

### Minimum Cement Content and Maximum Water/Cement Ratio

- 2 Table 7/2 gives the minimum cement content required ( $\text{kg/m}^3$ ), when using a particular size of aggregate and maximum water/cement (w/c) ratio, to provide acceptable durability under the respective conditions of environment. The Contractor shall confirm with the Engineer the relevant conditions of environment, prior to mixing concrete.

## 704 Standard Mixes

### General

- 1 Concrete mixes, referred to in the Contract as ST followed by a number, shall apply to standard concrete mixes, and shall be used only for ancillary purpose.
- 2 Concrete for ancillary purposes shall be a standard mix complying with BS 5328/BS 8500/BS EN 206-1 and with the requirements of this Clause.

### Standard Mixes and Related Strengths

- 3 The standard mix, relating to characteristic compressive strengths, shall be selected from Table 7/3.

Standard Mix Reference	Characteristic Strength
	N/mm <sup>2</sup>
ST1	7.5
ST2	10.0
ST3	15.0
ST4	20.0
ST5	25.0

**Table 7/3: Grades of Concrete**

- 4 The standard mix proportions shall be selected from Table 7/4.

Standard Mix	Constituent	Nominal Aggregate Size = 20 mm Slump = 75mm
ST1	Cement (kg/m <sup>3</sup> )	210
	Total Aggregate (kg/m <sup>3</sup> )	1940
ST2	Cement (kg/m <sup>3</sup> )	240
	Total Aggregate (kg/m <sup>3</sup> )	1920
ST3	Cement (kg/m <sup>3</sup> )	270
	Total Aggregate (kg/m <sup>3</sup> )	1890
ST4	Cement (kg/m <sup>3</sup> )	300
	Total Aggregate (kg/m <sup>3</sup> )	1860
ST5	Cement (kg/m <sup>3</sup> )	340
	Total Aggregate (kg/m <sup>3</sup> )	1830
ST1	Fine aggregate (percentage by mass of total aggregate)	35 to 50%
ST2		
ST3		
ST4		
ST5		
	Grading Limit Coarse	35 to 45%
	Grading Limit Medium	30 to 40%
	Grading Limit Fine	25 to 35%

**Table 7/4: Mix Proportions for Standard Mixes**

### Allowable Use of Standard Mixes

- 5 The standard concrete mix used for each purpose shall be as described in Table 7/5.

Purpose	Standard Mix
Footings for fence posts, traffic sign posts.	ST2
Blinding Concrete, backfill for chamber and box foundations and backfilling of overdig for chamber and box foundations.	ST1
Bedding and backing to precast concrete kerbs, channels, edgings and quadrants.	ST1

**Table 7/5: Allowable Use of Standard Mixes for Ancillary Purposes**

## 705 Production

### Storage of Constituent Materials

- 1 Different cements shall be stored in separate silos. Alternatively, these materials may be stored in bags in dry weatherproof sheds. Any cement that has become contaminated by damp or other causes shall be removed immediately.
- 2 Sand (i.e. fine aggregate), single-sized coarse and graded aggregates which are to be used shall be stored in separate hoppers, or different stacks which shall be separated from each other. All aggregates shall be kept free from contact with deleterious matter with adequate provision for drainage, and shall be stored and handled so as to void segregation.

### Batching and Mixing - Off-Site Ready Mix Concrete

- 3 The quantities of cement, sand (i.e. fine aggregate) and the various sizes of course aggregates shall be measured by machine unless otherwise agreed by the Engineer. Separate weighing machines shall be used for cementitious materials and aggregates. Alternatively, cementitious materials may be measured by using a whole number of bags (of verified weight) in each mix.
- 4 The quantity of water adjusted for the natural free moisture content of the aggregate(s) shall be measured. Any admixture to be added shall be measured and, if solid, measured by weight.
- 5 Different types of cement shall not be mixed, other than where allowed under Clause 701(2).
- 6 Ready mixed concrete shall be carried in purpose-made agitators, operating continuously, or truck mixers. The concrete shall be compacted and in its final position within 2 hours of the introduction of cement to the aggregate, unless a longer time is agreed by the Engineer. The time of such introduction shall be recorded on the delivery note together with the weight of the constituents of each mix.
- 7 When concrete is transported in a truck mixer, water shall be added under supervision either at the Site or at the central batching plant as agreed by the Engineer, but in no circumstances shall water be added in transit.

### Batching and Mixing - On-Site Hand or Mechanically Mixed Concrete

- 8 The Contractor shall submit proposals to ensure accuracy of mix proportions and concrete strength for the Engineer's approval, prior to mixing on site.



- 9 Concrete shall be mixed thoroughly either by hand or mechanically until its colour and consistency are uniform. The constituent materials shall be accurately gauged, allowance being made for bulking of all aggregates.
- 10 Hand mixed concrete - constituent materials shall be repeatedly turned in a dry state on a mixing board until a uniform colour is achieved. Water shall then be added using the rose of a watering can and the turning of the mix continued until thoroughly mixed. The mixing board shall be sufficiently large to allow the ingredients to be turned over from one place to another and shall not allow liquid cement to escape through holes, joints or overlaps.
- 11 Machine mixed concrete - constituent materials shall be added to the machine in dry form without prior mixing. The water may be inserted before or after the ingredients have been added to the machine.
- 12 On-Site mixed concrete shall be made in small quantities only as and when required. On-Site mixed concrete, which has been mixed for a period of more than 1 hour, shall be discarded.
- 13 Under no circumstances may chambers be constructed using on-site hand mixed concrete. Chambers may in exceptional circumstances be constructed using on-site machine mixed Concrete but only following the specific approval of the Engineer, and subject to the necessary approvals required by this Clause.

## **706 Compliance of Concrete**

### **Testing - General**

- 1 The methods of Sampling and testing of fresh and of hardened concrete shall comply with BS1881/BS EN 12350.
- 2 The testing required under the Specification is intended to achieve a good balance between the risk of incorporating concrete that does not meet the strength requirements and the risk of rejecting satisfactory concrete.

### **Strength**

- 3 Compliance with the specified characteristic strength shall be based on tests made on cubes at an age of 28 days unless there is evidence, satisfactory to the Engineer, that a particular testing regime is capable of predicting the strength at 28 days of concrete tested at an earlier age.
- 4 Unless otherwise instructed by the Engineer, the rate of sampling shall be one sample per 20m<sup>3</sup> for reinforced concrete, or one sample per 50m<sup>3</sup> for unreinforced, mass or plain concrete. However, other than with the agreement of the Engineer, not less than one sample shall be taken on each day that concrete of that grade is used.
- 5 Two cubes shall be made from a sample taken from a randomly selected batch of concrete. Samples shall be taken at the point of discharge from the delivery vehicle, or at the mix source for on-site mixed concrete. The cubes shall be tested and the mean of the two results shall be taken as the test result. When the difference between the results divided by their mean exceeds 15%, the test result shall be deemed invalid.
- 6 For compliance purposes:
  - (i) the average strength determined from any group of four consecutive test results shall exceed the specified characteristic strength by not less than 0.5 times the 'current margin'; and

- (ii) each individual test result shall be greater than 85% of the specified characteristic strength.

The 'current margin' shall be taken as two thirds of the specified characteristic strength for concrete up to Grade 15, or 15 N/mm<sup>2</sup> for concrete of Grade 20 or above, unless a smaller margin is agreed by the Engineer.

- 7 If only one test result fails to meet the second requirement (ii), then that result shall be considered to represent only the particular batch of concrete from which those cubes were taken.

If the average strength of any group of four consecutive test results fails to meet the first requirement (i), then all the concrete in all the batches represented by all such results shall be deemed not to comply with the strength requirements. For the purposes of this Clause the batches of concrete represented by a group of four consecutive test results shall include the batches from which samples were taken to make the first and the last pairs of cubes in the group of four, together with all the intervening batches.

- 8 The Engineer may, as a result of inspection or rebound hammer tests, condemn any chamber or concrete structure, or require new, or additional cores to be taken and tested. The cores shall be examined by an approved independent laboratory and tested in accordance with BS EN 12504-1 to ascertain the quality and crushing strength.

The Contractor shall be provided with a copy of the test report as soon as it is available and, if this indicates that the quality of the concrete in the structure is unsatisfactory, the jointing chamber shall not be accepted and the Contractor will be required to effect remedial measures or fresh works.

#### **Workability**

- 9 The workability of fresh concrete shall be such that the concrete is suitable for the conditions of handling and placing, so that after compaction, it surrounds all reinforcement, tendons and ducts and completely fills the formwork.
- 10 Workability shall be measured for each batch or at such times as directed by the Engineer using the slump test in accordance with BS 1881/BS EN 12350-2. The required slump shall be 50mm  $\pm$  25mm.

### **707 Compliance of Surface Finish**

#### **Control of Colour**

- 1 Aggregates shall be free of any impurities that may cause staining.

#### **Release Agents**

- 2 Release agents for the formwork shall be to the approval of the Engineer and shall enable the formwork to be removed without damage to the concrete surface. There shall be no adverse residual effect from the release agent on the concrete surface. Where a concrete surface is to be permanently exposed, only one agent shall be used throughout the entire area. Release agents shall be applied evenly and shall not be permitted to come into contact with reinforcement, or other metalwork.
- 3 The release agent shall also not leave any residue that is detrimental to the surface impregnation of the concrete.
- 4 Where the concrete is to receive an applied finish, or surface impregnation, the release agent shall be compatible.

## Surface Finishes for Concrete

### 5 Formed Surfaces - Classes of Finish

Formwork shall be capable of producing the following finishes where required in the Works:

Class F1 No extra requirement.

Class F2 The irregularities in the finish shall be no greater than those obtained from the use of wrought thickened square edged boards arranged in a uniform pattern. The finish is intended to be left as struck but imperfections such as fins and surface discolouration shall be made good to the approval of the Engineer.

Permanently exposed concrete surfaces to all Classes of finish other than F1 shall be protected from rust marks and stains of all kinds.

### 6 Unformed Surfaces - Classes of Finish

Surfaces to exposed (unformed) surfaces shall be of the following finishes where required in the Works

Class U1 The concrete shall be levelled and screeded to produce a uniform surface to the profile shown on the Drawings. No further work shall be applied to the surface unless it is used as a first stage for another class of finish.

Class U2 After the concrete has hardened sufficiently, the Class U1 finish shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

Class U3 When the moisture has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 finish shall be steel trowelled under firm pressure to produce a dense, smooth uniform surface, free from trowel marks.

## 708 General Construction

### Construction Joints

- 1 The position of construction joints shall be as agreed with the Engineer before the concrete is placed. When concrete is placed in vertical members, walls, columns and the like, the lifts of concrete shall finish level or, in sloping members, at right angles to the axis of the members, and the joint lines shall match features of the finished work, if possible, or be formed by grout checks. Kickers shall be constructed integrally with the lift of concrete below.
- 2 Concreting shall be carried out continuously up to construction joints.
- 3 Construction joints shall be prepared in either of the following ways:
  - (i) When the concrete is self-supporting but still sufficiently green, the formwork shall be removed, as necessary to expose the construction joint, subject to the requirements of Sub-Clauses 708(23) and 708(24). The concrete surface shall be sprayed with a fine spray of water or brushed with a stiff brush, just sufficiently to remove the outer mortar skin and expose the larger aggregate without disturbing it. Alternatively where this preparation proves impracticable the hardened surface skin and laitance shall be removed by grit blasting or a needle gun. Hardened surfaces shall not be hacked.
  - (ii) By the use of proprietary steel open-mesh permanent formwork with the approval of the Engineer.

- 4 Retarding agents shall not be used unless approved by the Engineer.
- 5 The joint surface shall be clean and damp but free of standing water immediately before any fresh concrete is placed against it.

#### **Formwork**

- 6 Subject to compliance with the drawings as regards dimensions, the Contractor shall be at liberty to adopt any arrangement he may think fit for the make-up of shuttering, it being understood that on completion of the chamber, the whole of the material shall be withdrawn through the entrance to the chamber.
- 7 The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and for the appropriate method of placing and compacting.
- 8 The formwork shall be so arranged as to be readily dismantled and removed from the cast concrete without shock, disturbance or damage. Where necessary, the formwork shall be so arranged that the soffit form, properly supported on props only, can be retained in position for such period as may be required by maturing conditions.
- 9 Where it is intended to re-use formwork it shall be thoroughly cleaned and made good to the approval of the Engineer.
- 10 The faces of the forms in contact with the concrete shall be clean and treated with a suitable release agent.
- 11 Projecting reinforcement and fixing devices. Where holes are needed in forms to accommodate projecting reinforcement or fixing devices, care shall be taken to prevent loss of grout when concreting or damage when striking forms.

#### **Transporting, Placing and Compacting**

- 12 The Engineer should receive from the Contractor details of the method of transporting and placing concrete.
- 13 Concrete should be transported from the mixer to the formwork as rapidly as practicable by methods that will prevent the segregation or loss of any of the ingredients and maintain the required workability. It should be deposited as near as practicable to its final position to avoid rehandling.
- 14 Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur. Concrete shall not be placed in any part of the Works until the Engineer's approval has been given.
- 15 Concrete when deposited shall have a temperature of not less than 5°C or not more than 30°C.
- 16 No concrete shall be placed in flowing water.
- 17 Concreting operations shall not be permitted to displace reinforcement, anchorages or formwork, or to damage the faces of formwork.
- 19 Unless agreed with the Engineer (Sub-Clause 708(21) of this Clause), concrete shall be thoroughly compacted by vibration during the operation of placing, and thoroughly worked around the reinforcement, embedded fixtures and into corners of the formwork to form a solid mass free from voids. When vibrators are used to compact the concrete, vibration shall be applied continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation of the ingredients.

- 20 A sufficient number of vibrators in serviceable condition shall be on site to ensure that spare equipment is always available in the event of breakdowns. Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided as far as is practicable.
- 21 Other methods of compaction, such as hand tamping, shall only be adopted with the agreement of the Engineer.
- 22 The mix should be such that there will not be excess water on the top surface on completion of compaction.

### Striking of Formwork

- 23 The time at which formwork is struck is influenced by a number of factors, including concrete strength, early stresses in the concrete and methods of curing. Formwork shall therefore be removed in a manner not to damage the concrete, and at times to suit the requirements for its curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep. The formwork should be removed slowly, as the sudden removal of stressed tie-bars, wedges and the like, can be equivalent to a shock load on the partly hardened concrete.
- 24 For ordinary structural concrete made with Portland cement (PC) only, in the absence of control cubes, the period before striking of formwork shall be in accordance with the minimum periods given in Table 9/1, unless otherwise instructed, or agreed with the Engineer.

	Minimum Period before Striking		
	Surface Temperature of Concrete		
	16°C	7°C	t°C (any temperature between 0°C and 25°C)
Vertical formwork to columns, walls and large beams	12 hours	18 hours	<u>300 hours</u> (t + 10)
Soffit Formwork to slabs	4 days	6 days	<u>100 days</u> (t + 10)

**Table 9/1: Minimum Period Before Striking Formwork (PC Concrete)**

### **Curing of Concrete**

- 25** Curing usually consists of maintaining the formwork in place and covering the concrete with a material such as polythene sheet or a curing compound or with an absorbent material that is kept damp for a period of time.
- 26** Immediately after compaction and thereafter for the curing time, except where elevated temperature curing is used, concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes, frost, and from drying out, particularly under hot weather conditions. The method of curing shall provide a suitable environment for the concrete to mature and prevent harmful loss of moisture.
- 27** The use of accelerated curing methods for concrete containing other types of cement or any admixture shall be subject to the Engineer's approval.

### **Cold Weather Work**

- 28** Unless agreed by the Engineer, subject to the provisions of this Clause, concrete for any structural works shall not be mixed, or placed, when the air temperature is below 2°C. Concrete already laid shall be protected from freezing when the air temperature falls, or is likely to fall below 2°C at any time during the period before removal of shuttering.
- 29** Where agreed in exceptional circumstances by the Engineer, when concrete is placed at air temperatures below 2°C, the following requirements shall be met:
- (i) The aggregates and water used in the mix shall be free from snow, ice and frost;
  - (ii) The surface temperature of the concrete at the time of placing shall be at least 5°C and shall not exceed 30°C;
  - (iii) The surface temperature of the concrete shall be maintained at not less than 5°C until the concrete reaches a strength of 5 N/mm<sup>2</sup>;
  - (iv) Before placing concrete, the formwork, reinforcement and any surface with which the fresh concrete will be in contact shall be free from snow, ice and frost;
  - (v) Cement shall not be allowed to come into contact with water at a temperature greater than 60°C.
- 30** In accordance with the requirements of Sub-Clause 708(12) of this Clause, the Engineer should receive from the Contractor details of the proposed method for raising and maintaining the temperature of the concrete. As guidance, the raising of the temperature of the concrete may be achieved in a number of acceptable ways including the following:
- (i) By heating the mixing water and aggregate; if the water is heated above 60°C, it is advisable to mix the water with the aggregate before adding the cement;
  - (ii) By covering the top face of slabs and beams with adequate insulating material;
  - (iii) By providing wind breaks to protect newly placed concrete from cold winds;
  - (iv) By using a heated enclosure, completely surrounding the freshly placed concrete or using heated formwork panels.
- 31** Formwork should be left in place as long as possible to provide thermal insulation; timber formwork provides better insulation than steel.

- 32 The Contractor shall also seek the approval of the Engineer for the mixing and placing of concrete for non-structural purposes when the air temperature is below 2°C. Such concrete already laid shall also be protected from freezing when the air temperature falls, or is likely to fall below 2°C at any time during the following 48 hours.

#### **Hot Weather Work**

- 33 During hot weather the Contractor shall ensure that the constituent materials of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position. Concrete shall be placed in a smooth, continuous operation, to avoid the formation of 'cold joints' which may occur if concrete has stiffened too much, before the next layer of concrete is placed on it or next to it. Where they occur, 'cold joints' shall be treated and prepared as construction joints, as indicated in Sub-Clauses 708(1) - 708(5).
- 34 Only in exceptional circumstances shall retarding admixtures be used, and only then after the Engineer's approval.
- 35 The method of curing to provide a suitable environment for the concrete to mature and prevent harmful loss of moisture shall be agreed with the Engineer, prior to the placing of concrete in hot weather.

#### **Wet Weather Work**

- 36 In wet situations the Engineer may direct the Contractor to implement such methods as are deemed necessary to prevent damage to freshly placed concrete or mortar and to ensure a waterproof jointing chamber. These methods may include an independent sump, or the use of heavy duty polyethylene sheet or other suitable material, or drainage beneath the concrete floor.

### **709 Reinforcement**

#### **Hot Rolled and Cold Worked Bars**

- 1 Hot rolled and cold worked steel bars shall comply with BS 4449 except that no bar shall contain a flash weld. The characteristic strengths of reinforcement are given in BS 4449.

#### **Steel Fabric**

- 2 Steel fabric reinforcement shall comply with BS 4483 and shall be delivered into the Site in flat mats or pre-bent.

#### **Bond Strength**

- 3 The classification of deformed bars as Type 1 or 2 for bond strength shall be in accordance with BS 4449.

#### **Bar Schedule Dimensions - Cutting and Bending**

- 4 The bar schedules are based on the dimensions of the concrete and the nominal cover to the reinforcement shown on the Drawings. The reinforcement shall be cut and bent within the tolerances given in BS 4466 but this shall not relieve the Contractor of his responsibility for the correct fit of the reinforcement and the achievement of the required cover.
- 5 Where the Contractor opts to cut and bend reinforcement on site, the Contractor shall provide details to the Engineer, in order to ensure that the radii of site bends are not less than those specified in BS 4466, and to allow the Engineer to inspect site-bent reinforcement for signs of fracture.

- 6 Steel fabric in accordance with Sub-Clause 709(2), may be used as an alternative to cut and bent bars where appropriate, at the agreement of the Engineer.

#### **Fixing of Reinforcement**

- 7 Reinforcement shall be secured against displacement. The actual concrete cover shall be not less than the required nominal cover minus 5 mm.
- 8 Cover blocks shall be of comparable strength, durability and appearance to the surrounding concrete. They shall ensure that the reinforcement is correctly positioned and shall be as small as possible consistent with their purpose. They shall be fixed such that they will not overturn or be displaced when the concrete is poured.
- 9 Other types of cover blocks may be used only with the approval of the Engineer. Pieces of wood, metal, tile or porous material shall not be used as cover blocks.
- 10 Tying wire to reinforcement shall be 1.6mm diameter annealed iron wire.

#### **Surface Condition**

- 11 Immediately before concrete is placed around it, reinforcement shall be free from mud, oil, paint, retarder, release agent, loose rust, loose mill scale, snow, ice, grease or any other substance that can be shown to have an adverse chemical effect on the steel or concrete, or to reduce the bond. Normal handling prior to embedment in the concrete is usually sufficient for the removal of loose rust and scale from reinforcement, but this does not relieve the Contractor of the requirement of this Sub-Clause.

#### **Laps and Joints**

- 12 Laps and joints shall be made only where shown on the Drawings or agreed by the Engineer.

#### **Welding**

- 13 Welding reinforcement, other than steel fabric reinforcement, shall not be incorporated in the Permanent Works without the written approval of the Engineer. The Contractor shall demonstrate to the approval of the Engineer that at each location the fatigue life, durability and other properties of the member are not adversely affected by the proposal.

#### **Inspection**

- 14 The Contractor shall provide access to enable the Engineer to carry out an inspection of the fixed-in-place reinforcement, prior to any concrete being placed.