

Part 1. **General**

1.1 **Standard specifications**

- A. Unless otherwise stated in the Specification the latest edition of the following standard specifications shall apply:

AASHTO T104-77	Magnesium Sulphate Soundness Test
BS 8110: 1985	Structural Use of Concrete
BS 812:	Testing Aggregates
BS 882: 1983	Aggregates from Natural Sources for Concrete
BS 1377: 1990	Soil Testing
BS 12: 1988	Specification for Portland Cement
BS 4027: 1980	Sulphate-Resisting Cement
BS 3148: 1980	Testing of Water for Concrete
BS 4449: 1988	Carbon Steel Reinforcing Bars for Concrete
BS 4482: 1985	Cold Reduced Steel Wire for Reinforcement for Concrete
BS 970: Parts 1&4	Valve Steels
BS 4483: 1985	Steel Fabric for Reinforcement
BS 1521: 1972	Waterproof Building Paper
BS 1881:	Testing concrete
BS 8666: 2000	Reinforcement Bending Dimensions
BS 8007: 1987	Design of Concrete Structures for Retaining Aqueous Liquids
BS 1305	Batch Type Concrete Mixers
BS 3963	Mixing Performance of Concrete Mixers
BS 5328	Concrete
BS 146	Cement
BS 729	Galvanising

1.2 **Concrete grades**

- A. Concrete grades in this specification, e.g. grade 7,10 etc. are defined in Section 03300

Part 2. **Products**

2.1 **Materials Generally**

- A. Materials, articles, samples and test certificates may conform with standards other than the British Standards referred to in this Specification provided the alternative standard is at least equivalent. In the event of a conflict of interpretation between the alternative standard and the British Standard, then the requirements of the British Standard shall prevail.

- B. Materials used in the works shall be new, of the qualities and kinds specified herein and equal to approved samples. Delivery shall be made sufficiently in advance to enable further samples to be taken and tested if required. No materials shall be used until approved, and materials not approved shall be immediately removed from the site.
- C. Materials shall be transported, handled and stored on the site or elsewhere in such a manner as to prevent damage, deterioration or contamination.

Part 1. **General**

1.1 **Scope**

- A. Formwork including all temporary or permanent forms required for forming the concrete, together with all temporary construction required for its support.

1.2 **Quality assurance**

- A. Formwork shall be fixed in its correct position and securely braced to withstand, without appreciable displacement; deflection or movement of any kind, the loading from the construction and the movement of persons, materials and plant including any effects of vibrating the concrete.
- B. All formwork shall be so constructed that there shall be no loss of material from the concrete, and all joints shall be sufficiently tight to prevent leakage of cement grout and to avoid the formation of fins or other blemishes. After hardening, the concrete shall be in the position and of the shape, dimensions and surface finish described in the contract.
- C. When requested by the Architect, a statement of method and design calculations shall be submitted for approval not less than 7 days prior to any formwork erection.

Part 2. **Products**

2.1 **Surface finishes**

- A. The surface finishes for formed surfaces shall be as specified on the drawings to the following requirements:

Type	Quality
FI	This finish shall be obtained by the use of properly designed formwork or moulds of closely jointed sawn boards or sheet ply. The surfaces may be imprinted with the grain of the sawn boards or sheet ply and their joints. In addition, small blemishes caused by entrapped air or water will be accepted, but the surface shall be free from voids, honeycombing and other large blemishes.
F2	This finish shall be obtained by the use of properly designed forms of closely jointed wrought boards or film faced ply. The surfaces may be imprinted with the slight grain of the timber and their joints. Small blemishes caused by entrapped air or water will be accepted, but

the surface shall be free from voids, honeycombing and other large blemishes.

- F3 The finish shall be achieved only by the use of high quality concrete and by using properly designed forms having a hard, smooth surface. The concrete surfaces shall be smooth, with true clean arrises. Only very minor surface blemishes will be accepted and there shall be no staining nor discolouration from the release agent.
- F4 This finish shall be obtained by first producing a type F2 finish on thoroughly compacted high quality concrete, cast in properly designed forms. The surface shall then be improved by carefully removing all fins and other projections, thoroughly washing down and then filling the most noticeable surface blemishes with a cement and fine aggregate paste. Every effort shall be made to match the colour of concrete. The Contractor shall ensure that the finished concrete surface is not permanently stained nor discoloured by the choice of the release agent used.
- F5 This finish shall be obtained by first producing a type F3 finish and then, while the concrete is still green, filling all surface blemishes with a fresh, specially prepared cement and fine aggregate paste. Every effort shall be made to match the colour of the concrete. After the concrete has been properly cured, the faces shall be rubbed down to produce a smooth and even surface.
- F6 This finish shall be achieved by lining the formwork with the material specified by the Architect to achieve the specified finish. This material shall leave no stain on the concrete and shall be so jointed and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source through anyone structure. The Contractor shall make good any imperfections in the resulting finish as required by the Architect Internal ties and embedded metal parts will only be allowed with the specific approval of the Architect.

B. The surface finishes for unformed surfaces shall be as specified on the drawings to the following requirements:

Type	Quality
U1	The concrete shall be uniformly leveled, tamped or screeded to produce a plain or ridged surface as described on the drawings or elsewhere. No further work shall be applied to the surface unless it is used as the first stage for a Type U2 or U3 finish.
U2	After the concrete has hardened sufficiently the concrete Type U1 surface shall be floated by hand to produce a uniform surface free from screed marks.
U3	When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Type U1 surface shall be power-floated and power-toweled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.
U4	The concrete shall be finished to U3 level and then brushed to produce permanent non-slip ridges.

- C. Any remedial treatment to surfaces shall be agreed with the Architect following inspection immediately after removing the form work and shall be carried out without delay.
- D. Any concrete, the surface of which has been treated before being inspected by the Architect, shall be liable to rejection.
- E. In no cases shall any concrete finishes be of a lower standard than the minimum specified in A or B above.

Part 3. **Execution**

3.1 Preparation

- A. The inside surfaces of forms shall, except for permanent formwork, be coated with an approved material to prevent adhesion of the concrete. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement. The same release agent shall be used for all concrete surfaces which will be visible on completion of the works.
- B. Immediately before concreting, all forms shall be thoroughly cleaned out. Openings for inspection of the inside of the formwork and for the escape of

water used for washing out shall be formed so that they can be conveniently closed before placing the concrete.

- C. Before placing the concrete, bolts and fixings shall be in position, and cores and other devices used for forming openings, holes, pockets, recesses and other cavities shall be fixed to the formwork. No holes shall be cut in any concrete unless approved by the Architect.
- D. Vertical props shall be supported on wedges, or other measures shall be taken whereby the props can be gently lowered vertically when commencing to remove the formwork. Props for an upper storey shall be placed directly over those in the storey immediately below and the lower prop shall bear on work sufficiently strong to carry the load.
- E. Before any concrete is placed, all formwork shall be inspected and approved by the Architect who must be notified by the Contractor 24 hours prior to concreting. Approval does not relieve the Contractor of the responsibility for the structural adequacy of formwork and supports.

3.2 Installation

- A. Connections shall be constructed to permit easy removal of the formwork and shall be either nailed, screwed, bolted, clamped, wired or otherwise secured to be strong enough to retain the correct shape during consolidation of the concrete.
- B. Where internal metal ties are permitted, they or their removable parts shall be extracted without damage to the concrete and the remaining holes filled with drypack. No permanently embedded metal parts shall have less than 2" (50mm) cover to the finished concrete surface or 3" (75mm) cover where the structure is water retaining or exposed to sea-water.
- C. If the formwork for a column is erected to the full height of the column, one side shall be left open and shall be built-up in sections as placing of the concrete proceeds.
- D. Forms for beams, slabs and similar members shall be designed and constructed so that the sides may be removed without disturbing the soffit shutters or supports thereto.
- E. Where concrete is to be placed directly against an un-excavated surface, the Contractor shall seal the face of the excavation to ensure that no water required for the hydration of the cement is drawn out of the concrete mix. The method of sealing the face of the excavation shall be subject to the approval

of the Architect. Approval does not relieve the Contractor of the responsibility for the adequacy of the method.

3.3 Removal

- A. The Architect shall be informed in advance when the Contractor intends to strike any Formwork.
- B. Formwork shall be constructed so that the side forms of members can be removed without disturbing the soffit forms, and if props are to be left in place when the soffit forms are removed, such props shall not be disturbed during striking.
- C. Formwork shall be removed by gradual easing without jarring or damage to the concrete. Formwork shall be removed only in the presence of a competent supervisor when the concrete has attained sufficient strength.
- D. Where it is intended that formwork is to be reused it shall be cleaned and made good to the satisfaction of the Architect.

3.4 Removal times

- A. The time at which the formwork is struck shall be the Contractor's responsibility, but the minimum periods between concreting and the removal of forms shall be as follows:

Type of Formwork	Minimum Period before striking
Vertical formwork to columns, walls, and large beams	12 hours
Soffit formwork to slabs	4 days
Props to slabs	10 days
Soffit formwork to beams	10 days
Props to beams	14 days

- B. Notwithstanding any approval given by the Architect, the Contractor shall be held responsible for, and shall make good any damage arising from the removal or premature removal of the formwork.

Part 1. **General**

1.1 **Galvanising**

- A. After being cut and/ or bent to the dimensions shown on the drawings or given in the bar schedules, all bar reinforcement and steel fabric unless indicated otherwise on the drawings shall be prepared and hot-dip galvanised in accordance with the requirements of BS 729 with a chromatin post-treatment. The temperature of the molten zinc bath shall not exceed 500°C. Softannealed iron tying wire shall also be hot-dip galvanised and similarly treated. Steel reinforcement shall be clean, free from loose rust and millscale at the time of galvanising. Unless instructed otherwise by the Architect, reinforcement shall not be straightened nor bent after galvanising.
- B. Steel bars to be used for reinforcement supports and spacers shall be hot-dip galvanised and treated in accordance with BS 729 as above. With the prior approval of the Architect the Contractor may cut and bend this steel on site provided 2 coats of an approved metallic zinc-rich paint is applied to the cut end of the steel and to those areas where damage occurs to the galvanising coating.

Part 2. **Products**

2.1 **Reinforcing steel**

- A. Steel used for concrete reinforcement shall comply with the following British Standard Specifications:

BS	Bar Description
4449	Carbon Steel Bars for the Reinforcement of Concrete
4483	Steel fabric for the Reinforcement of Concrete

- B. Reinforcement shall have the following minimum specified characteristic strengths:

Hot rolled mild steel bars 250N/sqmm

High yield steel bars 410N/sqmm

- C. High yield steel reinforcement shall be Type 2 deformed bars.

Part 1. **General**

1.1 **Codes and standards**

- A. All concrete work shall be in accordance with the British Standard Code of Practice BS 8110.

1.2 **Testing and sampling**

- A. The Contractor shall be responsible for providing qualified personnel and site equipment for all testing and sampling of concrete as instructed by the Architect.
- B. Compliance with the specified characteristic compressive strength of the concrete shall be judged by tests made on 6" (150mm) cubes at an age of 28 days in accordance with BS 1881. Where the Contractor requires an early indication of the strength of the concrete, additional cubes may be taken and tested at 7 days at the option of the Contractor, and these results shall also be forwarded to the Architect

- C. The tests will require the preparation of 4 cubes, each made from a single sample taken from a randomly selected batch of concrete. Cubes shall be labeled A,B,C,D, for any particular sample and in a numerical order for the number of samples. A test result is defined as the mean compressive strength of two cubes tested at 28 days.

$$\text{i.e Test result X} = (\text{Comp strength cube A} + \text{Comp strength cube B})/2$$

$$\text{Test result Y} = (\text{Comp strength cube C} + \text{Comp strength cube D})/2$$

- D. The samples, where practicable, should be taken at the point of discharge from the mixer, or in the case of ready-mixed concrete at the point of discharge from the delivery vehicle. The samples shall be taken as representative, but not ones taken at the beginning or end of the discharge.
- E. The number, frequency and location of tests shall be decided by the Architect, but the maximum quantity of concrete that four consecutive test results shall represent shall be limited to 13 yd³ (10 m³).
- F. Compliance with the specified characteristic compressive strength shall be assumed if the following conditions are met:
1. the average strength determined from any group of four consecutive test results exceeds the specified characteristic strength by:
 - a) 3 N/ sq mm for concretes of grade 20 and above, or,

- b) 2 N/sq mm for concretes of grade 7,10 and 15.
2. the strength determined from any test result is not less than the specified characteristic strength minus:
- a) 3 N/sq mm for concretes of grade 20 and above, or,
 - b) 2 N/sq mm for concretes of grade 7,10 and 15.

If only one test result fails to meet the second requirements then that test result may be considered to represent only the particular batch of concrete from which that test was taken provided the average strength of the group satisfies the first requirement.

If more than one test result in a group fails to meet the second requirement or if the average strength of any group of four consecutive test results fails to meet the first requirement then all the concrete represented by all such samples shall be deemed not to comply with the strength requirements.

- G. All test cubes shall be labeled as described herein, and shall, approximately 24 hours after casting, be transported to the Ministry of Public Works Quarry for curing and testing. Test results shall be forwarded to the Architect.
- H. The Architect may require the testing of additional cubes for special purposes including the time at which to strike formwork and the strength of concrete under hot weather conditions. These additional cubes shall be made and tested in accordance with BS 1881, but the methods of sampling shall be varied to suit the purpose for which they are required. Sampling where possible shall be at the point of placing and the cubes shall be stored so far as possible under the same conditions as the concrete in members to which they relate. The extra cubes shall be clearly identified at the time of making and shall not be used as part of the normal quality control or compliance procedures.
- I. The cement content of any batch of concrete shall be not less than the specified minimum value minus 5% of that value, not more than the specified maximum value plus 5% of that value, unless otherwise approved by the Architect.
- J. On every- batch of concrete the workability shall be measured by either the standard slump test or the compacting factor test all in accordance with BS 1881 and shall be within the following limits:

1. Slump Test

	Specified Value	Tolerance
	3/8"(10mm)	+ 1 3/8" (+35mm)
		- 3/8" (-10mm)
	1"(25mm)	+ 1 3/8" (+35mm)
		-1" (-25mm)
	2"(50mm)	± 1 3/8" (+35mm)
	3"(75mm) and over	± (1/3 specified slump + 3/8" (10mm)
2. Compaction Factor Test		
	± 0.03 where the required value is 0.90 or more;	
	± 0.04 where the required value is less than 0.90 but more than 0.8;	
	+ 0.05 where the required value is 0.8 or less.	

The slump shall be sampled in accordance with BS 1881:Part 102. If the concrete is delivered in a mixing or agitation truck the slump is measured in a sample obtained from the initial discharge. There shall be allowed a discharge of approximately 0.4 yd³ (0.3m³) of concrete (which shall not be placed until a satisfactory- test is achieved) and then the sample shall be taken.

If the first test result fails to meet the specified limits a second set of results shall be tested. Two failures constitutes a rejection of that batch of concrete.

- K. Any additional tests required by the Architect to comply with this specification as a result of failure of routine tests shall be performed at the expense of the Contractor.

Reports of each test taken shall be supplied to the Architect and shall contain the following:

1. Name of project and the position of placement.
 2. Name of supplier.
 3. Date and time of delivery- to site.
 4. Time from sampling to commencement of test.
 5. Form of slump, whether true, shear or collapse.
 6. Measured true slump.
 7. Name of person carrying out test.
- L. Should any of the results of the specified works tests be unsatisfactory, the Architect may take one of the following actions:
1. Reject the work and instruct replacement of the unsatisfactory work
 2. Instruct the Contractor to carry out additional tests and/or works to ensure the soundness of the work

- M. The Contractor shall note that the target strength for the concrete mix design shall be substantially greater (in the order of 10 N/sq mm) than the specified characteristic compressive strength. To ensure that no more than 5% of the concrete falls below this value the Architect may instruct the contractor to take one or both of the following steps in the event of test cubes failing to meet the required standard:
1. Alter his methods of making concrete and control quality to reduce variability;
 2. Alter the proportions of the concrete mix to increase the compressive strength.

1.3 Load tests of structures or parts of structures

- A. The Architect shall instruct the Contractor to make a loading test on the works if in the opinion of the Architect such a test is necessary. The test shall be in accordance with BS8110, and shall be carried out as soon as possible after the expiry of 28 days from the time of placing the concrete.
- B. The test loads to be applied shall be specified by the Architect and shall be equal to the characteristic imposed load and shall be maintained in place for 24 hours. If any of the final dead load is not in position on the structure, compensating loads shall be added as directed.
- C. During the tests, struts and bracing strong enough to support the whole load should be placed in position leaving a gap under the members to be tested, and adequate precautions should be taken to safeguard persons in the vicinity of the structure.
- D. Measurements of deflection and crack width shall be taken immediately after the application of load, at the end of the 24 hour loaded period, after removal of the load and after a 24 hour recovery period.
- E. The maximum permissible deflection measured immediately after application of the test load shall be as specified by the Architect, which for members spanning between two supports shall be not more than 1/500 of the effective span.
- F. If, within 24 hours of the removal of the test load the part of the works under test does not show a recovery of at least 85% of the maximum deflection shown during the 24 hours under load, the loading shall be repeated. The structure shall be considered to have failed to pass the test if the recovery after the second loading is not at least 85% of the maximum deflection shown during the second loading.

- G. If the result of any test is not satisfactory, the Architect shall instruct that the part of the works concerned shall be taken down or cut out and reconstructed to comply with the Specification, or that other measures shall be taken as directed. The Contractor shall conduct the test and shall take down or cut out and reconstruct the defective work or shall execute remedial measures as directed.
- H. On completion of the works, including plastering if required, all water retaining structures constructed shall be tested for water tightness with potable water in accordance with BS 8007. After the expiry of a minimum 28 days from completion of the tank, all inlets and outlets shall be sealed and the tank slowly filled with fresh water. When filled, the water shall stand for 7 days to allow for absorption. At the end of 7 days, the tank shall be deemed to be water tight if the total drop in surface level does not exceed 1/2" (13mm) in 7 days.
- I. If the structure does not satisfy the conditions of the test, and the daily drop in water level continues, the period of test may be extended for a further 7 days at the discretion of the Architect. The Contractor shall execute any remedial measures as required by the Architect.

Part 2. **Products**

2.1 **Cement**

- A. Unless otherwise noted, cement shall comply with BS 12 and BS 146 or equal approved.
- B. Neither masonry cement nor high alumina cement shall be used in structural concrete.
- C. All cement shall be fresh when delivered to the site, and unless delivered in bulk, shall be in the original sealed bags or drums of the manufacturers. It shall be stored in a suitable weatherproof building of ample size, with raised floors giving adequate protection against the effects of moisture from any source. Manufacturers' certificates shall be submitted to the Architect on request.
- D. Cements of different types shall not be mixed and consignments shall be used in the order of delivery.
- E. Cements shall be delivered in quantities that ensure there is no suspension nor interruption of the work of concreting at any time.

- F. If in the opinion of the Architect any cement has become injuriously affected by damp or other causes, it shall at once be removed from the site. All cement shall remain stored at the sole responsibility of the Contractor.

2.2 Aggregates

A. Generally:

1. Materials used as aggregate shall be obtained from a source known to produce aggregates satisfactory for concrete and shall be chemically inert, strong, hard, durable, of limited porosity, and free from adhering coatings, clay lumps, residues and organic or other impurities that may cause corrosion of the reinforcement or may impair the strength or durability of the concrete. Aggregates shall be natural gravels or crushed stone complying with BS 882 or as specified by the Architect.

B. Fine aggregate:

1. Fine aggregate shall be natural sand, excluding beach sand, or sand derived by crushing gravel or stone. It shall be clean, sharp, free from coagulated lumps without any admixtures of clay or other foreign matter.
2. Sand derived from stone unsuitable for coarse aggregate shall not be used as fine aggregate.
3. The grading of fine aggregate shall be such that not more than 10% shall exceed 3/16" (5mm). For a natural sand or crushed gravel not more than 10%, and for crushed stone not more than 20% shall pass BS sieve No. 100. Between these limits the grading shall conform to the grading for either Zones 1,2 or 3 (BS 882) or Zone 4 if so instructed.

C. Coarse aggregate

1. Coarse aggregate shall be crushed or uncrushed gravel or crushed stone. It shall be clean and free from any clay admixtures and other foreign matter. The pieces shall be angular, or, except for concrete surfaces subject to abrasion, rounded in shape and shall have granular or crystalline or smooth (but no glossy), non-powdery surfaces. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities that do not adversely affect the strength and durability of the concrete.
2. After 24 hours immersion in water, a previously dried sample of the coarse aggregates shall not have gained in weight more than 10% or not more than 5% if for use in impermeable construction.
3. The grading of coarse aggregate is such that not more than 5% is larger than 3/4" (19mm) and not more than 10% is smaller than

3/1611 (5mm) and not less than 25% nor more than 55% is smaller than 3/811 (10mm).

D. All-in aggregate

1. All-in aggregate shall only be used for concrete grade 15 or below, unless the Architect gives written approval otherwise. All-in aggregate shall comply in all respects except grading with the requirements for fine and coarse aggregates, and except for grading tests shall be separated into two groups: material smaller than 3/ 1611 (5mm) and material of 3/16" (5mm) and over. These materials shall be considered as fine and coarse aggregates respectively.
2. The grading of all-in aggregate shall be such that not more than 5% shall exceed 1- 1/2" (38mm) and not more than 6% shall pass B.S. sieve No. 100, and not less than 45% nor more than 75% is smaller than 3/411 (19mm) and not less than 25% or more than 45% is smaller than 3/1611 (5mm).

E. Storage of aggregates

1. Aggregates shall be handled and stored to minimise segregation and contamination. They shall be stored to size separately on hard standings or timber platforms, and kept clean and well drained and free from surface water in order that the materials are not be contaminated before use.

F. Testing of aggregates

1. Aggregates shall be tested in accordance with BS 812 and the results of such tests shall comply with the requirements of B,C,D, & E the percentages being by weight.

2.3 Water

- A. Water shall be potable, clean, fresh and free from organic and inorganic matter in solution or suspension in the concrete. Water shall be obtained from an approved source and must not be obtained from a well, excavation, underground source or the sea.
- B. Only water of approved quality shall be used for washing out formwork, curing concrete, and similar purposes. Water for making concrete shall be tested in accordance with BS 3148.

2.4 Admixtures

- A. Suitable admixtures may only be used in structural concrete mixes with the prior approval of the Architect. The amount added and the method of use shall be to the strict instructions of the manufacturer and the approval of the Architect.

2.5 Building paper

- A. Building paper shall comply with BS 1521.

Part 3. Execution

3.1 Concrete grades

- A. The concrete grade designations are given in Table C.1 below:

Grade	Characteristic strength		Lowest grade for compliance with use
	N/mm ²	psi	
7	7.0	1015	Blinding concrete
10	10.0	1450	Mass concrete
15	15.0	2175	Plain, unreinforced concrete
20	20.0	2900	Reinforced concrete
25	25.0	3625	Marine concrete

TABLE C.1- CONCRETE GRADE DESIGNATIONS

- B. The characteristic strength of concrete is that 28 day cube strength below which not more than 5% of the test results may be expected to fall.

3.2 Quality of concrete mixes

- A. For the specified grade of concrete the Contractor shall design the mix in accordance with BS 8110 and within the limits indicated in Table C.2 below:

Grade	Max. size aggregate	Min. cement content	Max. free W/C ratio	Characteristic strength (150mm cube)
	mm (in)	kg/m ³ (pcy)	by weight	N/mm ² (psi)
7	14 (9/16)	290 (490)	0.55	7 (1015)
10	20 (3/4)	330 (557)	0.55	10 (1450)
15	20 (3/4)	330 (557)	0.55	15 (2175)
20	20 (3/4)	340 (574)	0.50	20 (2900)
25	20 (3/4)	360 (607)	0.50	25 (3625)

TABLE C.2 -CONCRETE MIXES

- B. The cement content of the mix shall not exceed 500 kg/m³ (844 pcy) without the approval of the Architect.
- C. The total chloride content of the concrete mix shall not exceed 0.35% of chloride ion by weight of cement for concrete made with ordinary Portland cement. The chloride content shall be measured in accordance with BS 1881.
- D. The total sulphate content of the mix shall not exceed 4.0% of sulphur trioxide by weight of cement. The sulphate content shall be measured in accordance with BS 1881.
- E. The Contractor shall demonstrate to the Architect's satisfaction that the proposed mix will develop the required strength prior to the commencement of concreting, by either submitting a history of test results for the mix or by carrying out trial mixes in accordance with Part 3.4. G, H and I of this Section.

3.3 Workability

- A. The workability of the fresh concrete should be such that the concrete is suitable for the conditions of handling and placing so that after compaction it surrounds all reinforcement and fills the formwork, subject to the approval of the Architect.
- B. The workability of the mix may be improved by the use of an admixture if approved by the Architect.

3.4 Batching and mixing

- A. The weighing and water-dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in

- BS 1305 and checked against accurate weights and volumes when required by the Architect
- B. The weights of cement and each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of $\pm 2\%$ of the respective weights per batch agreed by the Architect. The weights of the fine and coarse aggregates shall be adjusted to allow for the free water contained in them. The water added to the mix shall be reduced by the quantity of free water contained in the fine and coarse aggregates, which shall be determined by the Contractor by a method approved by the Architect immediately before mixing begins, and further as the Architect requires.
- C. Concrete shall be mixed in a batch type mixer manufactured in accordance with BS 1305 or in a batch type mixer that has been tested in accordance with BS 3963 and has a mixing performance within the limits of Table 6 of BS 1305.
- D. The cement and aggregates shall be thoroughly mixed in the required proportions and the water shall not be admitted to the drum of the mixer until all the cement and aggregate constituting the batch are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged before the materials for the succeeding batch are fed into the drum. No partly set or re-tamped concrete shall be used. Partly set or excessively wet concrete shall not be used on the works and shall be immediately removed.
- E. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Unless otherwise agreed by the Architect the first batch of concrete through the mixer shall then contain only two-thirds of the normal quantity of coarse aggregate. Mixing equipment shall be thoroughly cleaned before changing types of cement.
- F. 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.
- G. Trial mixes: where trial mixes are required, three separate batches of concrete shall be made using materials likely to be typical of the proposed supply and preferably under full scale production conditions. If circumstances make this inconvenient, the batches may be mixed in a laboratory unless this is specifically precluded by the Architect. Sampling and testing should be in accordance with BS 1881 and BS 5328.

- H. The workability of each of the trial batches should be determined and three cubes made from each batch for test at 28 days. A further three cubes from each batch shall be made for testing at an earlier age if required. The trial mix proportions should be approved if the average strength of the nine cubes tested at 28 days exceeds the specified characteristic strength by 10 N/sq mm or the nine tests at a earlier age indicate that is likely to be exceeded by this amount
- I. During production the Architect may require trial mixes to be made before a substantial change is made in the materials or in the proportions of the materials to be used.

3.5 Ready-mixed concrete

- A. Ready mixed concrete as defined in BS 5328, batched off the site, may be used only with the agreement of the Architect and shall comply with all requirements of the Specification and Contract.
- B. The concrete shall be carried in purpose made agitators operating continuously, or truck mixers. The concrete shall be compacted and in its final position within 1 1/2 hours of the introduction of cement to the aggregates, unless a longer time is agreed by the Architect. The time of such introduction shall be recorded on the Delivery Note together with the weight of the constituents of each mix, water/cement ratio strength admixtures and any other pertinent information. The following information shall be added to the delivery ticket on site; the time of completion of discharge; the location in the works of the batch of concrete, and the quantity of any water added to the mix on site and the name of authorising officer. Copies of all Delivery Notes for each days work are to be bound and delivered to the Architect to form part of his site records.
- C. When truck mixed concrete is used, no water may be added to the mix at the site, without the express approval of the Architect, and in no circumstances shall water be added in transit.
- D. Mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.
- E. Any ready-mix truck containing concrete which has been rejected by the Architect for whatever reason shall be removed from the site and deposited elsewhere. Under no circumstances will any addition of material such as cement, aggregate or water and remixing of the original batch be allowed.

3.6 Transporting concrete

- A. Concrete shall be transported in such a manner as to avoid the contamination, segregation or loss of constituent materials. The method of transporting shall be subject to the approval of the Architect.

3.7 Placement of concrete

- A. Mixing and distributing equipment shall be clean before commencing mixing and distribution of the concrete and such equipment shall be kept free from set concrete. The method of placing concrete shall be to the approval of the Architect.
- B. Before proceeding to place the concrete, the formwork shall be realigned, if necessary, and all formwork, and reinforcement contained in it, shall be clean and free from standing water.
- C. Concrete shall not be placed in any part of the structure until the approval of the Architect has been given. A minimum of 24 hours notice shall be given prior to any concrete placement.
- D. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Architect. Concreting shall then proceed continuously over the area between construction joints or to the approved extent. If stopping of concrete placing is unavoidable elsewhere, a construction joint shall be formed where the work stopped. Fresh concrete shall not be placed against in-situ concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with Part 3.10. of this Section. When in-situ concrete has been placed for more than 4 hours no further concrete shall be placed against it for a further 20 hours.
- E. Concrete, when deposited, shall have a temperature of not less than 41 ° F (5° C) and no more than 86° F (30° C). It shall be compacted in its final position within 30 minutes of discharge from the mixer.
- F. Except where otherwise agreed by the Architect, concrete shall be placed in a single operation to the full thickness of slabs, beams and similar members. Concrete shall be placed directly in its permanent position and shall not be worked along the forms to that position.
- G. Concrete shall not be dropped into place from a height exceeding 3' (1.0m). When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation. In general, trunking or chutes shall not be more than 20° from vertical.

- H. Should the Contractor require to place concrete by pumping he shall first obtain permission from the Architect and shall submit complete details of the proposal for approval.
- I. All cement slurry and other material used to lubricate pump pipes shall be run to waste and not deposited in the works.
- J. Should continuous pumping of concrete be suspended, all concrete remaining in the pump and pipes for longer than 30 minutes shall be run to waste and not deposited in the works.
- K. No concrete shall be placed in flowing water. Underwater concrete shall be placed in position by tremies, or by pipeline from the mixer. Full details of the method proposed shall be submitted to the Architect and his approval obtained before placing begins. Where the concrete is placed by a tremie, its size and method of operation shall be in accordance with (U.K.) Civil Engineering Code of Practice , "Foundations". Forms shall be provided in all faces of concrete placed between tides, the top face being closed immediately after completion of placing and before subsequent submersion. During and after concreting underwater, pumping or dewatering operations in the immediate vicinity shall be suspended until the Architect permits them to be continued.

3.8 Effects of the weather

- A. 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. Alternatively the Contractor may incorporate in a mix a plasticiser of a make and in a proportion which has been shown by laboratory tests and full scale trial to be to the satisfaction of the Architect, to eliminate detrimental effects of high temperature without introducing any other detrimental effect, and for which he takes full responsibility in these two respects.
- B. The following may be used to keep the temperature of concrete below the above limitations:
 - 1. Chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water is free from ice at the time of entry into the mixer;
 - 2. Cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled is uniform;
 - 3. Reclaiming of aggregate from stockpiles by the tunnel method to avoid using the surface layer of the stockpile, with shade and wind protection of conveyor elevating to batching plant;

4. Night work provided that 1,2 and 3 are proved inadequate or unsatisfactory in their results and provided also that the Architect has no other reason for refusing permission for night work and subject to Section 01010 Part 1.5.
- C. The Architect shall have the power to order the suspension of concrete production and/or laying when the shade temperature exceeds 86°F (30°C) if he is not satisfied that the precautions being taken or intended by the Contractor are adequate to:
1. Prevent the temperature of the concrete rising above 86° F (30° C) or;
 2. Avoid any detrimental effect in the use of a plasticiser. This power of the Architect shall not relieve the Contractor of his responsibilities.
- D. Concrete shall not be laid during heavy or prolonged rain. Suitable protection shall be readily available to protect the concrete after placement during adverse weather conditions.

3.9 Compaction

- A. All concrete shall be compacted to produce a dense homogenous mass. Unless otherwise agreed by the Architect, it shall be compacted with the assistance of immersion (poker) vibrators. Vibration shall continue until all the air bubbles have dispersed and the tone of the vibrator becomes constant and in a manner that does not promote segregation. Sufficient vibrators in serviceable condition shall be on site so that spare equipment is always available in the event of breakdowns.
- B. Immersion vibrators shall be capable of producing not less than 10,000 cycles per minute, and in the opinion of the Architect be of suitable diameter to deliver an effective radius of action.
- C. Vibration shall not be applied by way of the reinforcement and contact with all reinforcement and inserts shall be avoided, so far as is practicable.
- D. Concrete shall not be subjected to vibration between 2 and 24 hours after compaction.

3.10 Construction joints

- A. Construction joints shall be square and shall be vertical or horizontal, as required, except that in an inclined or curved member the joint shall be at right angles to the axis of the member.

- B. The position and detail of any construction joints not described in the contract shall be subject to the approval of the Architect, and shall be arranged to minimise the possibility of the occurrence of shrinkage cracks.
- C. Construction joints not shown on the drawings and elsewhere shall with the approval of the Architect be in accordance with the following:-
1. A joint shall be formed horizontally at the top of a foundation and 3" (75mm) below the lowest soffit of the beams meeting at the head of a column. A joint shall be formed in the rib of a large "T" or "L" beam 1" (25mm) below the soffit of the slab. Concrete in a haunch or a splay on a beam or a brace, and in the head of a column where beams meet, shall be placed without a joint at the same time as that in the beam or beams and brace. Concrete in the splay at the junction of a wall and a slab shall be placed without a joint at the same time as that in the slab. Concrete in an upstand, or starter, at the bottom of a wall or at the bottom of a lift of a column shall, if so shown on the drawings, be placed at the same time as the slab or other work from which the upstand projects.
 2. Concrete in a beam shall be placed without a joint, but if the provision of a joint is unavoidable, the joints shall be vertical and within the middle third of a span. A joint in a slab shall be vertical and parallel to the principal reinforcement.
- D. The upper surface of lifts of concrete walls and columns shall be horizontal and if the formwork extends above the joint on the exposed face it shall be cleaned of adhering concrete before the next lift is placed. The concrete placed immediately above a horizontal construction joint shall contain only two-thirds the normal quantity of coarse aggregate, shall not be the first batch through the mixer, and shall be thoroughly compacted and worked against the existing concrete.
- E. Where sections of the work are carried out in lifts, the reinforcement projecting above the lift being cast shall be adequately supported to prevent movement of the bars during the casting and setting of the concrete.
- F. All laitance, loose material and cement paste shall be removed by wire brushing while the concrete is still green, to expose, but not dislodge, the coarse aggregate, and no further roughening shall then be required. Where this is not possible, it shall be removed by mechanical means without damaging the aggregates, provided the concrete has been in position for more than 24 hours. The roughened surface shall then be washed with clean water and a 1:1 slurry of cement and concretes and shall, wherever possible, be well worked in immediately before the fresh concrete is placed.

3.11 Structure joints

- A. Expansion joints, contraction joints, hinges or other permanent structure joints shall be provided in the positions and of the form described in the drawings or elsewhere in the documents.

3.12 Protection of concrete

- A. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion, deleterious groundwater, mixing with earth or other materials, flotation and other influences that may impair the strength and durability of the concrete.

3.13 Finish to floor slabs

- A. All areas of internal floor slabs shall be power-floated and power -toweled to provide a durable and smooth surface, unless otherwise indicated on the drawings.
- B. Power-toweling shall not be started until surface moisture has evaporated and the concrete is firm enough to take the weight of the machine. Sufficient machines shall be provided to ensure that the whole of the area laid is finished before the concrete becomes unworkable.
- C. The tolerance on surface regularity shall be 1/8" (3mm) under a 10' (3m) straight edge. Notwithstanding this requirement, the slabs shall be finished to provide a surface which is visually smooth to the satisfaction of the Architect

3.14 Lintels

- A. Unless otherwise stated, lintels shall be a minimum of 8" (200mm) deep and shall have a minimum bearing of 8" (200mm) on each side of the opening below them and shall be reinforced as follows:

WIDTH	CLEAR SPAN		
	Up to 4ft (1.2m)	4ft - 6ft (1.2m to 1.8m)	6ft- 8ft (1.8m to 2.4m)
4" (100mm)	1x16mm Bottom	n.a.	n.a.
6" (150mm)	2x10mm Bottom	n.a.	n.a.
8" (200mm)	2x12mm Bottom	2x12mm Bottom	2x12mm Bottom 2x10mm Top
10" (250mm)	2x12mm Bottom	2x12mm Bottom	2x16mm Bottom 2x10mm Top
12" (300mm)	2x12mm Bottom	2x12mm Bottom	2x16mm Bottom 2x10mm Top

- B. The ends of the bottom reinforcement bar shall be hooked and 8mm diameter stirrups at 6" (150mm) centres shall be provided for spans over 6ft (1.8m).
- C. These lintels are to be used only when the block work height over the opening is greater than or equal to the opening width. Where additional loads from floors, roofs, beams, etc., are within this height, purpose designed lintels are to be used.

3.15 Early loading

- A. Concrete shall at no time be subjected to loading, including its own weight, which will produce a compressive stress in it exceeding 1/3 of the compressive strength at the time of loading.
- B. The strength of the concrete and the stresses produced by the loads shall be assessed only by the Architect Materials and plant shall not be stacked on any newly constructed floor without the permission of the Architect
- C. If the imposition of a load is anticipated, which in the opinion of the Architect exceeds the design load, props shall be provided in an approved manner after removal of the formwork and before the imposition of the load. Props for an upper storey shall be placed directly over those in the storey immediately below and the lowest prop shall bear on work sufficiently strong to carry the load.

3.16 Equipment loading

- A. If it is proposed to use climbing tower cranes, or any type of plant or equipment which places any load on the reinforced concrete structure, then the Contractor shall submit full details of such plant or equipment to the Architect for approval before installation.
- B. The loads from such plant or equipment shall be imposed on completed sections of the structure where the concrete has attained the minimum 28-day crushing strength.
- C. If necessary and acceptable, the Architect may agree to strengthening the structure to take loadings imposed by plant or equipment. The Contractor shall be responsible for reinstating all damage caused.

3.17 Fixtures, indentations and voids

- A. No openings, chases, holes or voids other than those indicated on the drawings shall be formed in the concrete without the approval of the Architect.
- B. Details of any fixtures to be permanently built into the concrete shall be submitted to the Architect for his approval. Fixing lugs, Lewis bolts, timber plugs and all other fixtures must comply with the requirements of the Architect and must be of a character and size to avoid any weakening or chemical contamination of the structural concrete.

Part 1. **General**

1.1 **Curing generally**

- A. Notwithstanding the provision for special sequences. of casting as directed by the Architect, the Contractor shall at all times ensure proper curing of the works.
- B. Immediately after compaction, concrete shall be protected from the sun, wind and rain, and be prevented from drying out by one of the following methods for a period of at least 4 days:
 - 3. Water spraying or ponding.
 - 4. Wet coverings of hessian or sand.
 - 5. Covering with waterproof paper or polythene sheet
 - 6. Applying an approved coloured curing compound in strict accordance with the manufacturer's instructions.
- C. If the concrete being cured is exposed to the sun, the curing compound shall be a proprietary product containing white pigment or be an aluminised compound. The curing compound shall be kept clear of any construction joint surfaces and be compatible with floor finishes, adhesives for tiles, etc.

Part 1. **General**

1.1 Precast members

- A. A detailed method statement, drawings and method of manufacture shall be submitted to the Architect for approval two weeks before work is started. When the method has been approved no changes shall be made without the consent of the Architect.
- B. The Contractor shall inform the Architect before commencement of manufacture and casting of each type of member.
- C. A copy of all 28 day cube test results relating to members cast off the site shall be sent to the Architect as soon as they become available. Where the Architect requires tests to be carried out, no members to which the tests relate shall be dispatched to the site until the tests have been satisfactorily completed.
- D. Members shall be lifted or supported only at points shown on the drawings or approved by the Architect and shall be handled and placed without impact.