

SOUTH AFRICAN BUREAU OF STANDARDS

STANDARDIZED SPECIFICATION

for

CIVIL ENGINEERING CONSTRUCTION

G : CONCRETE (STRUCTURAL)

Approved by the
COUNCIL OF THE
SOUTH AFRICAN
BUREAU OF STANDARDS
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G : CONCRETE (STRUCTURAL)

1. SCOPE

1.1 This specification covers the requirements for structural concrete work (plain and reinforced) for civil engineering and building construction. It covers the basic materials, the plant and formwork required, the quality, manufacture, and curing of the concrete, tolerances in workmanship, tests and acceptance criteria, and the methods by which the finished structure is to be measured for the purpose of payment.

1.2 This specification does not cover specialized aspects of structural concrete work, post- and prestressed work, and piles, coissons, cylinders, and harbour and marine works.

NOTE: The standards referred to in the specification are listed in Appendix A.

2. INTERPRETATIONS

2.1 SUPPORTING SPECIFICATIONS. Where this specification is required for a project, the following specifications shall, inter alia, form part of the contract document:

- a) Project specification;
 - b) SABS 1200 A or SABS 1200 AA, as applicable;
- and, in addition, SABS 1200 D or SABS 1200 DA, as applicable, may be required.

2.2 APPLICATION. This specification contains clauses that are generally applicable to structural concrete work. Interpretations and variations of the specification are set out in Portion 2 of the project specification which precedes this specification in a contract document.

2.3 DEFINITIONS. For the purposes of this specification the definitions and abbreviations given in SABS 1200 A or SABS 1200 AA (as applicable) and the following definitions shall apply:

a) General

Adverse weather. Cold weather, or weather in which

a) the ambient temperature is above 25 °C, or

b) the relative humidity is low, or

c) the wind velocity is high,

or weather in which any combination of these three conditions occurs, and which tends to impair the quality of fresh or hardened concrete or otherwise causes concrete to have abnormal properties.

Approved laboratory. A laboratory suitably equipped and staffed for purposes of concrete testing and as such approved by the Engineer.

Cold weather. Weather conditions in which the ambient temperature is 5 °C or less.

Concrete cover. The thickness of concrete between the face of the concrete and the outside of reinforcing steel nearest this face as cast.

Cool weather. Weather conditions in which the ambient temperature is higher than 5 °C but not higher than 15 °C.

Fixture. An item such as a bolt, anchorage, bearing, or the like that is cast or grouted into concrete.

Formwork. Temporary works required to support and shape the concrete for a structure.

Hot weather. Weather conditions in which the ambient temperature is higher than 32 °C.

Normal weather. Weather conditions in which the ambient temperature is higher than 15 °C but not higher than 32 °C.

b) Quality

Consistency. The extent, as measured by the slump test, to which fresh concrete resists flow or deformation.

Grade of concrete. An identifying number for the concrete, the number being numerically equal to the specified strength at 28 d expressed in megapascals (see 2.4.2).

Prescribed mix concrete. Concrete for which the Engineer has prescribed the mix proportions.

Ready-mixed concrete. Concrete complying with the relevant requirements of the specification and delivered on the Site in a plastic state.

Sample (of concrete). The minimum volume of uncompacted freshly mixed concrete required in terms of SABS Method 861 for a designated test (e.g. 16 dm³ for the compressive strength test for 3 cubes of nominal side 150 mm).

Strength concrete. Concrete designed primarily for strength.

Target slump. The average value for the slump of concrete aimed at to ensure compliance with the slump required in terms of 5.5.1.2.

Workability. The property of fresh concrete that determines the ease with which it can be placed and compacted without segregation of the constituent materials.

c) Strength

Specified strength. The required concrete strength (or the strength corresponding to the required concrete grade) stated on the drawings or in the project specification, and which in all cases represents the strength below which not more than 5 % of valid 28 d test results obtained on cubes of concrete of the same grade can be expected to fall. (NOTE: Specified strength is referred to in certain design codes as characteristic strength.)

Target strength. An average value of the strength of concrete that is higher than the specified strength and is aimed at to ensure that the specified strength is attained. (NOTE: If the standard deviation can be determined, the value of the target strength is at least equal to the specified strength + 1,64 times the standard deviation of valid 28 d test results.)

Valid test result. The average result obtained from the testing of three test cubes of concrete in accordance with SABS Method 863.

2.4 EXPLANATION OF TERMS

2.4.1 Exposure Conditions

2.4.1.1 Mild conditions. Conditions under which the concrete is protected from the weather and exposed only to air.

2.4.1.2 Moderate conditions. Conditions under which the concrete is

- a) sheltered from severe rain and is not subject to freezing when wet; or
- b) buried in non-aggressive soil; or
- c) continuously under fresh water.

2.4.1.3 Severe conditions. Conditions under which the concrete is exposed or subject to any of the following:

- a) Driving rain;
- b) alternate wetting and drying out;
- c) freezing when wet;
- d) fresh water (at the water-line);
- e) splashing or spraying with fresh water;
- f) corrosive fumes or heavy condensation of water;
- g) aggressive soil;
- h) salt-laden air.

2.4.1.4 Very severe conditions. Conditions under which the concrete is exposed to any of the following:

- a) Sea-water (below or at the water-line);
- b) sea-water spray or windborne salts;
- c) water containing sulphates or chlorides;
- d) highly corrosive fumes.

2.4.2 Strength Concrete. A strength concrete is designated by its specified strength followed by the size of stone used in its manufacture, e.g. 30 MPa/19 mm refers to a Grade 30 mix made with 19 mm stone.

2.4.3 Joints. The location of joints is controlled by design requirements and construction limitations. All joints are "construction joints" within the general meaning of the term. Joints shown on the drawings or in the schedule are "designated joints". The Engineer may, in collaboration with the Contractor, approve further joints before the casting of concrete, which joints will then become "designated joints". The terms "constructional joints", "movement joints", "contraction joints", and "expansion joints" are used to identify various types of designated joints. The term "unforeseen joint" is used to identify a joint formed during concreting when plant failure, inclement weather, or some other unforeseen event has enforced a halt in the placing of concrete and has thus created a situation in which a construction joint has to be made in a location that was neither designated nor approved before the commencement of concreting.

3. MATERIALS

3.1 APPROVAL OF MATERIALS. The Contractor shall supply in good time to the Engineer, for his approval, samples of the aggregates (and, if so ordered, of the water) that he proposes to use for the concrete and shall furnish evidence that the water and aggregates comply with the requirements of 3.3 and 3.4. Evidence shall be in the form of either

- a) a statement from an approved laboratory of the results of tests, or
- b) an authoritative report or record of previous experience.

3.2 CEMENT

3.2.1 Applicable Specifications. Subject to the provisions of 3.2.2, cement and blends of portland cement and milled granulated blastfurnace slag (see SABS 626) shall comply with the relevant requirements of the following specifications:

BS 1370	Low heat Portland cement
SABS 471	Portland cement (ordinary, rapid-hardening, and sulphate-resisting)
SABS 626	Portland blastfurnace cement
SABS 831	Portland cement 15 and rapid-hardening portland cement 15

3.2.2 Alternative Types of Cement. Any type of cement other than those referred to in 3.2.1 shall be used only when specifically authorized by the Engineer. (See 8.1.3.2 and 8.1.3.3.)

3.2.3 Storage of Cement. Separate storage facilities shall be provided on the Site for each type of cement used.

Cement that is stored on the Site shall be kept under cover that provides proper protection against moisture and other factors that may promote deterioration. Storage of cement in bulk in weather-proof silos or similar containers will be permitted provided that the cement drawn for use is measured by mass and not by volume.

3.3 WATER. Water shall be clean and free from injurious amounts of acids, alkalis, organic matter, and other substances that may impair the strength or durability of concrete.

3.4 AGGREGATES

3.4.1 Applicable Specification. Both the coarse aggregate (stone) and the fine aggregate (sand) shall comply with the relevant requirements of SABS 1083.

3.4.2 Use of Plums. Where plums are required to be used, or are permitted, they shall

- a) be hard, clean stone of mass 15 to 55 kg;
- b) constitute not more than 20 % of the volume of the concrete;
- c) have no adhering film or coating;
- d) be such that no plum has a dimension greater than one-third of the smallest dimension of the concrete member or greater than 300 mm, whichever is less;
- e) each be surrounded by concrete of depth at least 80 mm; and
- f) have an aggregate crushing value at least equal to that specified for coarse aggregate in SABS 1083.

3.4.3 Storage of Aggregates. Aggregates of different nominal sizes shall be stored separately and in such a way that

- a) segregation is minimized; and
- b) intermixing of different materials and contamination by foreign matter is prevented.

3.5 ADMIXTURES

- 3.5.1 Approval of Admixtures Required. Admixtures shall not be used in any concrete mix without the approval of the Engineer, who may require tests to be made before they are used. To facilitate approval, the Contractor shall provide the following information:
- a) The trade name of the admixture, its source, and the manufacturer's recommended method of use;
 - b) typical dosage rates and possible detrimental effects of under-dosage and overdosage;
 - c) whether compounds (such as those containing chloride in any form as an active ingredient) likely to cause corrosion of the reinforcement or deterioration of the concrete are present and, if so, the chloride content (expressed as chloride ions or as equivalent anhydrous calcium chloride) by mass of admixture (see 5.5.1.4);
 - d) the average expected air content of freshly mixed concrete containing an admixture which causes air to be entrained when used at the manufacturer's recommended rate of dosage.

- 3.5.2 Air-Entraining Agents. If the use of an air-entraining agent is permitted by the Engineer, test measurements shall be carried out on Site by the Contractor, as and when required by the Engineer, to determine
- a) the percentage of air entrained in the concrete; and
 - b) the density of the concrete.
- The Contractor shall provide equipment to permit measurement of entrained air at such frequencies as are required by the Engineer.

- 3.6 REINFORCEMENT. Reinforcing bars shall comply with the relevant requirements of SABS 920. Welded steel fabric shall comply with the relevant requirements of SABS 1024. Steel shall be so stacked off the ground as to prevent distortion and shall be protected from aggressive environments and contamination.

- 3.7 STORAGE CAPACITY. The storage capacity provided and the amount of material stored (whether cement, aggregates, steel, or water) shall be sufficient to ensure that no interruption to the progress of the work is occasioned by lack of materials.

- 3.8 DETERIORATED MATERIAL. Material that has deteriorated, or that has been contaminated or otherwise damaged, shall not be used in concrete. Such material shall be removed from the Site without delay.

4. PLANT

- 4.1 GENERAL. All plant shall be maintained in good working order.

- 4.2 BATCHING PLANT. The Contractor shall ensure, by regular examination, calibration, and tests, that the batching system functions efficiently and accurately and that hoppers and cement containers are kept dry and clean. The batching plant shall be such that
- a) cement may be batched to an accuracy of within 2 % of the mass required;
 - b) water may be measured, by mass or by volume, to an accuracy of within 2 % of the quantity required; and
 - c) aggregate may be batched to an accuracy of within 3 % of the mass required.
- In the case of an automatic plant, the weighing scales shall be so interlocked that a new batch of materials cannot be delivered until the weighing hoppers have been completely emptied of the previous batch and the scales are in balance. Where discharge of materials from the hoppers is manually controlled, a method of signalling shall be employed to ensure that ingredients are not omitted, or are not added more than once, when a batch of concrete is being made up.

4.3 MIXING PLANT

- 4.3.1 General Requirements for Mixing Plant. The type and capacity of mixing machines shall be such that the rate of output of concrete is suitable for the rate of concreting. Each machine shall be capable of producing a uniform distribution of the ingredients throughout the batch and shall comply with the specification to which the manufacturer claims it has been manufactured. Worn or bent blades and paddles shall be replaced. The inner surfaces of the mixer shall be clean and free from hardened concrete.
- 4.3.2 Approval for Short Mixing Periods. The Contractor shall obtain the Engineer's prior approval should he wish to use any particular type of mixer in respect of which
- a) it has been established on Site, or
 - b) the manufacturer has guaranteed,
- that efficient mixing can be consistently achieved in mixing periods shorter than those specified in 5.5.3.1(e).

- 4.4 VIBRATORS. Vibrators shall be capable of fully compacting each layer of concrete where compaction by vibration is specified. At least one standby vibrator shall be available for every three (or smaller number of) vibrators necessary to maintain the rate of placing.

4.5 FORMWORK

- 4.5.1 Design. Formwork shall be so designed and constructed that the concrete can be properly placed and compacted and that, subject to the tolerances specified in 6.2.3 (a) and (b), the required shapes, finishes, positions, levels, and dimensions shown on the drawings are maintained. The formwork and joints shall be capable of resisting the dead load, including the pressure exerted by the wet concrete, wind forces, and all other superimposed loads and forces. Where formwork is to be erected over a road, a street, or a railway, the Contractor shall so design his formwork that the full clearances required for the free movement of traffic are maintained to the satisfaction of the authority controlling such road, street, or railway. Where so required in terms of the project specification, the Contractor shall, before commencing erection, obtain the approval of such authority for the design of his formwork.
- 4.5.2 Finish. The quality of formwork shall be such that the finished surface of the concrete is as scheduled or shown on the drawings or as required in terms of the project specification (see 5.2.1).
- 4.5.3 Ties. The types of ties used and their position shall be such that the required finish is achieved and will not be marred by subsequent corrosion of the ties.

5. CONSTRUCTION
5.1 REINFORCEMENT

5.1.1 Bending

5.1.1.1 Reinforcing bars shall be bent to the dimensions shown on the drawings and in accordance with SABS 82.

5.1.1.2 Except as allowed in 5.1.1.3, all bars shall be bent cold and bending shall be done slowly, a steady, even pressure being used without jerk or impact.

5.1.1.3 Subject to the approval of the Engineer and provided that the bars do not depend for their strength on cold working, bars of diameter 32 mm or more may be bent hot.

5.1.1.4 Bars that are to be bent hot shall be heated slowly to a cherry red heat (not above 840 °C) and, after bending, shall be allowed to cool slowly in air. Hot bars shall not be quenched with water.

5.1.2 Fixing. Steel shall, at the time of the placing of the concrete, be free from loose or powdery rust, scale, oil, and other coatings that may reduce the bond between steel and surrounding concrete, affect the durability of the concrete, or initiate corrosion of the reinforcement. If any substance other than water is used for lubricating the formwork, every precaution shall be taken to avoid contamination of the reinforcement by such substance.

Reinforcement shall be positioned as shown on the drawings and maintained in those positions within the tolerances given in 6.2. It shall be secured against displacement by tying at intersections with annealed wire of nominal diameter 1,6 mm or 1,25 mm, or by the use of acceptable clips or, if permitted by the Engineer, by welding. Reinforcement shall be supported in its correct position by means of hangers or saddles, and aligned by means of chairs and spacers of approved design.

Supporting steel to approved design will be added to the reinforcing schedule by the Engineer. Other supporting materials shall be subject to prior approval.

5.1.3 Cover. Unless otherwise shown on the drawings, the cover of concrete over reinforcement (other than over rail or structural steel reinforcement) for various environmental exposure conditions shall in no case be less than

- a) the applicable value given in Table 1, measured from the outside of any bar or stirrup, or
- b) the diameter of the reinforcement or stirrup to which the cover is measured, whichever is greater.

TABLE 1 - MINIMUM COVER FOR
VARIOUS EXPOSURE CONDITIONS
(mm)

1	2	3	4	5	6
Exposure conditions (See 2.4.1)	Specified strength of concrete, MPa				
	20	25	30	40	50
Mild	20	20	15	15	15
Moderate	40	40	30	25	20
Severe		50	40	40	35
Very severe				60	50

Cover over rail and structural steel reinforcement shall be at least 80 mm, unless otherwise shown on the drawings.

The cover for fire protection shall be in accordance with the relevant requirements of SABS 0144.

5.1.4 Splicing. Splices or joints in reinforcing bars shall be made only as and where shown on the drawings or as otherwise approved.

5.1.5 Protection of Exposed Bars. If left exposed for future bonding of extensions to the Works, reinforcement shall be protected from corrosion as directed.

5.2 FORMWORK

5.2.1 Classification of Finishes. Formwork will be classified in accordance with the surface condition required on the finished concrete. Such surface conditions are classified as follows and will be so scheduled:

a) Rough. No treatment of the surface of the concrete will be required after the striking of the formwork. The finish of the concrete need not be more accurate than Degree of Accuracy III as defined in terms of Clause 6.

b) Smooth. Imperfections such as small fins, bulges, irregularities, surface honeycombing, and slight surface discolorations shall be made good and repaired by approved methods. The finish of the concrete shall be accurate to Degree of Accuracy II as defined in terms of Clause 6 (see also 5.5.10.3).

c) Special. Special finishes shall be as specified in the project specification.

5.2.2 Preparation of Formwork. Forms shall be erected with joints tight enough to prevent leakage of cement mortar.

Surfaces of forms (regardless of the material of which they are made) that are to be in contact with fresh (wet) concrete shall be treated with a coat of non-staining mineral oil or other approved material or, only in the case of timber forms, by thorough wetting of the surfaces with water, so as to ensure easy release and prevent adhesion of the formwork during stripping.

5.2.3 Re-use of Formwork. Before re-use, all formwork shall be reconditioned, and all form surfaces that are to be in contact with the concrete shall be thoroughly cleaned.

5.2.4 Openings. Where necessary for the proper placing of the concrete, temporary openings for cleaning, inspection, or placing purposes shall be provided and, subsequently, so closed as to provide the finish specified and to conform to the applicable tolerances given in 6.2.3(b).

5.2.5 Removal of Formwork

5.2.5.1 Formwork shall not be removed before the concrete has attained sufficient strength to support its own weight and any loads that may be imposed on it.

5.2.5.2 For this purpose and except as allowed in 5.2.5.3, the formwork shall remain in place, after placing of the concrete, for the appropriate minimum period of time given in Table 2.

TABLE 2 - REMOVAL OF FORMWORK (MINIMUM TIMES IN DAYS (24 h))

1	2	3	4	5	6	7	8	9	10
Type of structural member or formwork	Type of cement used								
	Portland cement and portland cement 15			Rapid-hardening portland cement* and rapid-hardening portland cement 15			Portland blast-furnace cement		
	Weather								
	Hot or normal	Cool	Cold	Hot or normal	Cool	Cold	Hot or normal	Cool	Cold
a) Beam sides, walls, and unloaded columns	0,75	+	1,5	0,5	+	1	2	+	4
b) Slabs with props left underneath	4	+	7	2	+	4	6	+	10
c) Beam soffits with props left underneath, and ribs of a ribbed-floor construction	7	+	12	3	+	5	10	+	17
d) Slab props) including	10	+	17	5	+	9	10	+	17
e) Beam props) cantilevers	14	+	21	7	+	12	14	+	21

* Shorter periods may be used for sections of thickness 300 mm or more.

+ In cool weather (see 2.3(a)), stripping times shall be determined by interpolation between the periods specified for normal and cold weather.

- 5.2.5.3 If the Contractor can prove to the satisfaction of the Engineer that a period shorter than the appropriate minimum given in Table 2 is sufficient to enable the concrete to comply with the requirement given in 5.2.5.1, the formwork may be removed after such shorter period.
- 5.2.5.4 Formwork shall be removed carefully so that shock and damage to the concrete are avoided.
- 5.2.5.5 Notwithstanding the provisions of 5.2.5.2 and 5.2.5.3, the Contractor shall be responsible for making good any damage to the concrete arising from the removal of formwork and its supports.
- 5.3 HOLES, CHASES, AND FIXING BLOCKS. No holes or chases, other than those shown on the drawings or approved by the Engineer, shall be cut or otherwise formed in the concrete. The manner of attaching fixtures to be embedded in the concrete shall be subject to approval.
- 5.4 PIPES AND CONDUITS. No pipes or conduits, other than those so shown on the drawings, shall be permanently embedded in the concrete without prior approval.
- 5.5 CONCRETE
- 5.5.1 Quality
- 5.5.1.1 General. Concrete shall comply with the requirements for strength concrete (see 5.5.1.7) or for prescribed mix concrete (see 5.5.1.6), as applicable. The types of aggregates and cement shall not be altered during the currency of the contract without prior approval.
- 5.5.1.2 Consistency. The slump, measured in accordance with SABS Method 862, shall be within the limits given in Table 3 appropriate to the type of construction, or within such other limits as are laid down
- a) in the project specification;
- b) by the Engineer in respect of prescribed mix concrete; or
- c) by the Engineer after receipt of the Contractor's design for strength concrete, if any, in terms of 5.5.1.7.

TABLE 3 - SLUMP LIMITS (mm)

1	2	3	4	5
Type of construction	Hand-placed		Vibrated	
	Max.	Min.	Max.	Min.
Paving and precast units ...	70	50	50	30
Heavy mass construction ...	70	30	50	20
Reinforced foundation walls and footings	120	50	80	30
Slabs, beams, columns, and reinforced walls	120	50	80	30
Slabs and industrial floors on ground	120	70	80	50
Plain footings, caissons, and substructure walls ...	100	30	60	20
Heavy duty industrial floors	-	-	80	50

- 5.5.1.3 **Workability.** The concrete shall be of such workability that it can be readily compacted into the corners of the formwork and around reinforcement without segregation of the materials or excessive bleeding of free water at the surface.
- 5.5.1.4 **Chloride content.** Except where a lower value is required in terms of the project specification, the amount of chloride ion in concrete expressed as a percentage by mass of the cement shall not exceed the applicable value given in Table 4.

TABLE 4 - MAXIMUM CHLORIDE CONTENT
(As Cl^- , % (m/m))

1	2	3	4	5	6	7
Type of concrete						
Mass concrete		Reinforced and post-tensioned concrete			Prestressed concrete (Pretensioned)	
Efflorescence acceptable	Efflorescence not aesthetically acceptable	Not subject to marine exposure	Efflorescence not aesthetically acceptable	Exposed to marine environment	Wire of diam. over 5 mm	Stressing strands and wire of diam. 5 mm and less
2,0	0,30	0,60	0,30	0,20	0,08	0,05

- 5.5.1.5 **Durability.** For each grade of concrete the Engineer will, notwithstanding strength considerations, specify the water/cement ratio appropriate to the exposure conditions indicated in Table 5 or as required in the project specification.

TABLE 5 - MAXIMUM WATER/CEMENT RATIOS FOR DIFFERENT
CONDITIONS OF EXPOSURE

1	2	3	4	5
Type of structure	Exposure conditions			
	Mild	Moderate	Severe	Very Severe
Thin sections; reinforced piles; all sections with less than 25 mm cover to reinforcement	*	0,53	0,48	0,40
Moderate sections; retaining walls, piers, beams	*	*	0,53	0,43
Exterior portions of mass concrete	*	*	0,53	0,43
Concrete slabs laid on ground	*	0,53	0,48	*
Concrete protected from the weather, inside buildings, or in ground below frost level	*	*	*	*

* In these cases the ratio will be based on strength for workability desired.

- 5.5.1.6 **Prescribed mix concrete.** The Engineer will be responsible for the design of prescribed mix concrete and for determining the proportions of the constituent materials. The Contractor shall provide, on the Site, concrete of the specified materials and in the proportions given by the Engineer. The Engineer will specify the sources of supply of the materials in such concrete and will make available, at the time of tendering, samples of each aggregate together with information on their origin. He will also specify the following in respect of prescribed mix concrete for each section of the work:
- The maximum nominal size of coarse aggregate, in millimetres, and its proportion in the mix;
 - the proportion of fine aggregate in the mix;
 - the type and proportion of cement in the mix;
 - the slump, in millimetres, or the w/c ratio.
- 5.5.1.7 **Strength concrete.** The Contractor shall be responsible for the design of strength concrete, and the submission of test cubes to an approved laboratory, and for the measurement of the constituent materials to produce concrete that complies with the requirements specified by the Engineer. The Engineer will specify the following in respect of strength concrete for each section of the work:
- The grade of concrete and position on the Works;
 - the maximum nominal size of coarse aggregate, in millimetres.

- 5.5.2 **Batching**
- 5.5.2.1 **Cement.** The mass of cement supplied in a standard sack shall be assumed to be 50 kg. All cement taken from bulk storage containers and from partly used sacks shall be batched by mass to an accuracy of within 2 % of the mass required.
- 5.5.2.2 **Water.** Mixing water for each batch shall be measured. The amount of water measured shall be adjusted to allow for the moisture content of the aggregates (see 4.2(b)).
- 5.5.2.3 **Aggregates.** If batching is by mass, the mass of the aggregate of each size shall be determined and a correction made for the moisture content of the aggregates. If batching is by volume, the fine and the coarse aggregates shall be measured separately in suitable measuring boxes of known volume and of such capacity that the quantities of aggregates for each batch are suitable for direct transfer into the mixer. Bulking tests on the fine aggregate shall be conducted regularly in accordance with SABS Method 856 and the results used for adjustment of the batch volume of fine aggregate to give the true volume required. The Engineer shall be permitted to require additional tests for bulking to be done after rain has fallen or if, in his opinion, any other cause of variation in the moisture content of the aggregate has arisen.
- 5.5.3 **Mixing**
- 5.5.3.1 **Mixing at construction site.** The following requirements shall apply to the mixing of concrete at the construction site:
- Mixing of materials for concrete shall be conducted by an experienced operator.
 - The sequence of charging the mixing plant shall have been approved before mixing commences and, unless otherwise directed, the approved sequence shall be maintained.
 - The total volume of material per batch shall not exceed the rated capacity of the mixer.
 - Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete shall be removed. A slurry of cement, sand, and water containing cement and sand in the ratio 1:2 and in sufficient quantity to cover the entire inside surface of the mixer shall be produced in the clean mixer and discharged immediately before the charging of the mixer with materials at the commencement of each concrete production run.
 - The period of mixing shall be measured from the time when all the materials are in the drum or pan to the commencement of discharge. Subject to the provisions of (f) below, the mixing period for each batch of 1,5 m³ or less shall be at least 1,5 min and 1 min for drum-type and pan-type mixers respectively, and shall be increased by 20 s and 15 s respectively for each additional cubic metre or part thereof. During this period, the drum or pan shall be rotated at the speed recommended by the manufacturer of the mixer. The maximum continuous mixing times at the recommended mixing speeds shall not exceed 10 min and 6 min per batch for drum-type and pan-type mixers respectively.
 - The Engineer will permit mixing periods to be reduced where he has approved the use of a mixer that complies with the requirements of 4.3.2 and the Contractor's site control is rated as good.
 - In the event of delay in the concreting operations, concrete may be retained in the mixer for a maximum period of 2 h provided that the slump is checked frequently and that only enough water to maintain the target slump is added to the mixer. During this period the mixer shall be restarted and run for about 2 min every 15 min. The Engineer may order that the period of 2 h be reduced if, in his opinion, the ambient temperature, or any other factor, will tend to produce early setting.
 - Discharge shall be so carried out that there is no segregation of the materials in the mix. The mixer shall be emptied completely before it is recharged. If the mixer has been out of use for longer than 30 min, it shall be thoroughly cleaned out, particular attention being paid to the removal of any build-up of materials in the drum, in the loader, and around the blades or paddles.
- 5.5.3.2 **Ready-mixed concrete.** The Engineer will advise whether the production of concrete at a central concrete production facility other than on the construction site is permitted and whether the test results obtained by such a production facility as part of its quality control system are acceptable when the results of tests are evaluated in terms of 7.3. Where concrete is delivered to the Site ready-mixed (see 2.3), the requirements of SABS 878 shall apply.
- 5.5.4 **Transportation.** Mixed concrete shall be discharged from the mixer and transported to its final position in such a manner that segregation, loss of ingredients, and adulteration are prevented and that the mix is of the required workability at the point and time of placing.
- 5.5.5 **Placing**
- 5.5.5.1 The Contractor shall give the Engineer adequate notice of his intention to place concrete. The concrete shall be placed within 1 h of the time of its discharge from the mixer. Concrete shall not be retempered by the addition of water or any other material. The forms to be filled shall be clean internally. All excavations and other surfaces of an absorbent nature that are to come into contact with the concrete shall be dampened with water. There shall be no free water on the surfaces against which concrete is to be placed.
- 5.5.5.2 Wherever possible, the concrete shall be deposited vertically into its final position to avoid segregation and displacement of reinforcement and other items that are to be embedded.
- 5.5.5.3 Deposited concrete shall not be so worked (whether by means of vibrators or otherwise) as to cause it to flow laterally in such a way that segregation occurs. Where possible, the concrete shall be brought up in horizontal layers of compacted thickness not exceeding 450 mm and heaping shall be avoided.
- 5.5.5.4 Where a chute is used to convey the concrete, its slope shall be such as will not cause segregation, and a suitable spout or baffles shall be provided for the discharge of the concrete.
- 5.5.5.5 Concrete shall not be allowed to fall freely through a height of more than 3 m, unless otherwise approved.
- 5.5.5.6 When closed circuits are being concreted, work shall commence at one or more points in the circuit and proceed in opposite directions at the same time so that on completion of the circuit the junction or junctions are formed with freshly placed concrete.
- 5.5.5.7 Placing of concrete under water will be permitted only under exceptional circumstances when it is, in the opinion of the Engineer, not practicable to dewater before placing. No concrete shall be placed in flowing water. When the placing of concrete under water is permitted, it shall be placed by means of a tremie. During placing, the lower end of the tremie shall be continuously immersed in the concrete being deposited. To maintain the desired properties of the concrete the quantity of cement in the concrete mix shall be increased by 20 %. Full details of the method proposed and of the adjusted concrete mix proportions shall be submitted to the Engineer for his approval before placing commences.
- 5.5.5.8 During and after concreting under water, pumping or dewatering operations in the immediate vicinity shall be suspended should there be, in the opinion of the Engineer, any danger that such operations will interfere with the freshly placed concrete before it has set and gained adequate strength.
- 5.5.5.9 The placing of concrete by pumping in any section of the Works shall be subject to the written approval of the Engineer. The Contractor shall furnish the Engineer with full details regarding the mix proportions of concrete that he intends to place by pumping.

5.5.6 Compaction

- 5.5.6.1 The concrete shall be fully compacted by approved means during and immediately after placing. It shall be thoroughly worked against the formwork and around reinforcement and other embedded items without displacing them.
- 5.5.6.2 The concrete shall be free from honeycombing and planes of weakness. Successive layers of the same lift shall be thoroughly worked together. To achieve this, the compaction tool shall penetrate through the new layer to the lower layer which shall still be sufficiently plastic to permit interknitting.
- 5.5.6.3 Compaction shall be carried out by mechanical vibration or (if approved) by spading, rodding, or forking. Over-vibration resulting in segregation, surface laitance, or leakage, or any combination of these, shall not be permitted.
- 5.5.6.4 The rate of concrete placing shall be commensurate with the available compaction equipment and only skilled operators shall be permitted to undertake compaction by vibration.

5.5.7 Construction Joints

- 5.5.7.1 Except as allowed in 5.5.7.2, concreting shall be carried out continuously up to the locations where joints are shown on the drawings or up to approved locations. Unless otherwise constructed (see 5.5.7.3), joints shall be constructed in accordance with
- a) the details shown on the drawings, or
- b) the applicable requirements of the project specification.
- 5.5.7.2 If, because of an emergency (such as a breakdown of the mixing plant or the occurrence of unsuitable weather), concreting has to be interrupted, concrete shall be finished off at the place of stoppage in the manner that will least impair the durability, appearance, and proper functioning of the concrete.
- 5.5.7.3 The method adopted for forming joints not covered by 5.5.7.1 and unforeseen joints (see 2.4.3) shall be one of the following:
- a) Construction joints when concrete is not more than 24 h old. The surface of the concrete shall be brushed with a steel wire brush before new mortar and concrete are placed as specified in (b) below.
- b) Construction joints when concrete is more than 24 h but not more than 3 d old. The surface of the concrete shall be sand-blasted or chipped with a light hammer, swept clean, and thoroughly wetted and covered with a 10 mm thick layer of mortar composed of cement and sand mixed in the same ratio as the cement and sand in the concrete mixture. This mortar shall be freshly mixed and placed immediately before the new concrete is placed.
- c) Construction joints when concrete is more than 3 d old. The procedure specified in (b) above shall be followed, except that the old surface shall be prepared and kept continuously wet for at least 24 h before the mortar and new concrete are placed.
- d) Construction joints at tops of columns. The procedure for brushing or cleaning specified in (a) or (b) above, as applicable, shall be followed before the steel reinforcement of the slab or floor to be cast on the columns is placed in position.

- 5.5.8 Curing and Protection. After formwork has been removed (see 5.2.5) and as soon as it is practicable in the opinion of the Engineer, all concrete shall, subject to the provisions of 5.5.9.1, be protected from contamination and loss of moisture by one or more of the following methods:

- a) Ponding the exposed surfaces by means of water;
- b) covering the concrete with sand, or mats made of a moisture-retaining material, and keeping the covering continuously wet;
- c) continuously spraying the exposed surfaces with water;
- d) covering the concrete with waterproof or plastics sheeting firmly anchored at the edges;
- e) the use of an approved curing compound applied in accordance with the manufacturer's instructions. Whatever method of curing is adopted, its application shall not cause staining, contamination, or marring of the surface of the concrete. Water used shall comply with the requirements of 3.3.
- When the ambient temperature is 5 °C and higher, the curing period shall be at least 5 d for concrete made with portland cement, at least 2 d for concrete made with rapid-hardening portland cement, and at least 7 d for concrete made with portland blastfurnace cement. When the ambient temperature is below 5 °C, the curing periods shall be extended by 72 h, 36 h, and 72 h, respectively.

5.5.9 Adverse Weather Conditions (see 2.3(a))

- 5.5.9.1 Under adverse cold weather conditions, effective measures shall be taken to ensure that the temperature of the concrete, from the time of placing until it has hardened (i.e. about 24 h), is maintained at not less than 5 °C. If the atmospheric temperature in the vicinity of the concrete is below 2 °C or is expected to fall below 2 °C during the curing period (see 5.5.8), water shall not be used for curing. All surfaces shall be protected from ice or frost damage.
- 5.5.9.2 When the ambient temperature is above 32 °C, the temperature of the concrete when deposited shall not be allowed to exceed 32 °C. Under adverse hot weather conditions, the Contractor shall take all reasonable steps to reduce to a minimum the placing temperature of the concrete. Stockpiles of aggregates and all metal surfaces in contact with aggregates and concrete shall be shielded from the direct rays of the sun or cooled by being sprayed with water, and windbreaks shall be erected, if necessary, to prevent the initial rapid drying-out of concrete which would otherwise occur before normal curing procedures can be undertaken.

- 5.5.9.3 Concrete shall not be placed during periods of heavy or prolonged rainfall.

5.5.10 Concrete Surfaces

- 5.5.10.1 Exposed surfaces of concrete not finished against forms (such as horizontal or slightly sloping surfaces) shall be brought up to a plane, uniform surface with suitable screed boards.
- 5.5.10.2 Where a wood-floated or steel-floated or power-floated finish or a screed topping or granolithic finish is required in terms of the project specification, the concrete shall, unless otherwise stated in the project specification, be finished to the tolerances specified for Degree of Accuracy II in terms of 6.2.3(d).
- 5.5.10.3 Finished concrete shall have a neat, smooth, even, and uniform finish free from any honeycombing. If the finish of any formed or floated concrete surface is, in the opinion of the Engineer, unsatisfactory and does not conform to that specified, the Contractor will be required, at his own expense, to rub down such surface while it is still green, or, alternatively, to grind it down with carborundum or other suitable material when it has hardened or to take other approved remedial measures to give the specified finish.
- 5.5.11 Watertight Concrete. Each section of the Works that is required, in terms of the project specification, to hold or exclude water shall be watertight, and special care, particularly at construction joints, shall be taken by the Contractor to ensure watertightness. Should any such section of the Works fail to pass the tests for watertightness as required in terms of the project specification or as ordered, or show any sign of water leakage or penetration after being taken into use, it shall be deemed defective and the provisions of 5.5.14.2 shall apply.

- 5.5.12 Concrete in Wet Ground. Wherever concrete is to be placed in wet ground, shallow drains shall be excavated below the ground formation, filled with broken stone, and connected to suitably placed sumps. A concrete carpet, the top of which will form the foundation level for the structural concrete, shall then be laid. The layout and dimensions of the dry-stone drainage channels and the thickness of the carpet will be determined by the Engineer in every case, whether or not these details are given on the drawings. Unless such drains are scheduled separately, their construction will be dealt with as daywork.
- 5.5.13 Grouting. Where he is required to grout holding-down bolts, or to place grout under column bases or bedplates for mechanical or other equipment, the Contractor shall first prepare the relevant concrete surfaces by scabbling and cleaning them. The mortar grout shall consist of an approved mixture of cement, sand, water, and admixture, and shall be so rammed into each HD-bolt pocket or under each base or bedplate (as applicable) that all voids and pockets are completely filled around the bolt or between the top of the concrete and the underside of the metalwork, and, in the case of a base or a bedplate, that the grout projects beyond the base or bedplate. After the void has been completely filled, the edges of the mortar grout shall be trimmed at an angle of 45° outward from the bottom edges of each base or bedplate and the trimmed edge wood-floated to a neat finish.
- 5.5.14 Defects
- 5.5.14.1 The concrete shall be homogeneous and free from honeycombing, interstices, and planes of weakness. If, after the removal of the forms, the concrete shows any defect, the Contractor shall immediately report such defect to the Engineer, and he shall not carry out any patching or remedial work until authorized to do so by the Engineer.
- 5.5.14.2 After thorough inspection and investigation of the quality and strength of the defective work and after due consideration of the possible consequences of such defect, the Engineer will either specify the extent and method of repair or order the demolition and reconstruction of the whole of the defective work to the extent that he considers necessary. The cost of all such investigation, repair, and remedial work and of any demolition and reconstruction of defective work shall be borne by the Contractor and all repair, remedial, and reconstruction work shall be executed to the satisfaction of the Engineer.
- 5.5.15 Records. The Contractor shall maintain written records that provide the following information:
- a) The date on which each section was concreted, the time taken to place the concrete, and the position of the section in the Works;
 - b) the daily weather conditions;
 - c) the nature of samples, the dates on which they were taken, and identification by which the results of tests on such samples may be correlated with the section of work to which they pertain.
6. TOLERANCES
- 6.1 BASIS OF MEASUREMENT
- 6.1.1 General. Permissible deviations appropriate to the degree of accuracy required will be applied to linear dimensions, position, verticality, level, squareness, and bow. The degree of accuracy may be one of the following:
- a) Degree of Accuracy III for use where a high degree of accuracy is unnecessary, e.g. mass foundations;
 - b) Degree of Accuracy II for what is commonly called "good work";
 - c) Degree of Accuracy I where the use of special, as opposed to normal, methods or materials (or both) is warranted despite the probability of higher costs than are caused by the use of Degree of Accuracy II. This may apply where, for example, prefabricated units (windows, precast panels) are required to fit in position.
- 6.1.2 Methods of Measurement of Deviations. Certain deviations will be measured as set out below:
- a) Any deviation from flatness of a plane surface will be measured as the maximum deviation of the surface from any straight line of length 3 m joining two points on the surface, determined by means of a straight-edge the ends of which are supported on identical blocks of suitable thickness placed over each of the points.
 - b) Any abrupt change in a continuous surface, including a local depression or peak in a floor or wall and any abrupt change caused by a joint in formwork will be measured as specified in (a) above.
 - c) Out-of-squareness of a corner or an opening or an element such as a column will be measured by taking the longer of two adjacent sides as the base line, and determining any departure from the perpendicular of the side at either end of the base line.
- 6.2 PERMISSIBLE DEVIATIONS
- 6.2.1 General. The Contractor shall construct each of the various parts of the Works within the limits of the applicable permissible deviation set out in 6.2.3 appropriate to the degree of accuracy specified in the project specification or shown on the drawings. If no degree of accuracy is specified, Degree of Accuracy II shall apply.
- 6.2.2 Concrete Surfaces. Any departure from flatness and the height or depth of any irregularity of a finished plane concrete surface shall not exceed the applicable maximum value given in (d) (7) and (8) below. The specified accuracy shall be achieved without any treatment except the rubbing down of hardened surfaces with carborundum blocks.
- 6.2.3 Specified PDs

- a) Reinforcement
- 1) Spacing between two adjacent bars
- 2) Longitudinal location of bends and ends of bars
- 3) Cover to reinforcement (see (e) below)
- b) Formwork. Formwork shall be so constructed as to ensure that the position of the finished work will be as specified, subject to the relevant permissible deviation given in (c) or (d) below, as applicable.

Permissible deviation, Degree of accuracy		
III mm	II mm	I mm
+25	+20	+15
+40	+30	+20
-0+20	-0+20	-0+10

c) Foundations : Mass and reinforced concrete

- 1) Position on plan of any edge or surface measured from the nearest grid line or agreed centre line
- 2) Linear dimension on plan cast against excavation sides
- 3) Linear dimension on plan cast against formwork
- 4) Level of underside of concrete
- 5) Surface level (i.e. top of foundation) (excluding floor slabs) ...

d) Elements or components above foundations (including floor slabs)

- 1) Position on plan of any edge or surface measured from the nearest grid line or agreed centre line
- 2) Linear (other than cross-section) dimensions
- 3) Cross-section dimensions
- 4) Level (deviation from designed level with reference to the nearest transferred datum (TD) of the upper or lower surface, as may be specified, of any slab or other element or component)
- 5) Verticality, per metre of height
- 6) Out-of-squareness of a corner or an opening or an element such as a column (see 6.1.2(c)) for short side of length
 - i) Up to and including 0,5 m
 - ii) over 0,5 m up to and including 2 m
 - iii) over 2 m, up to and including 4 m

7) Exposed concrete surface:

- i) Flatness of plane surface
- ii) Abrupt changes in a continuous surface

8) Exposed concrete surface to be plastered:

- i) Flatness of plane surface
- ii) Abrupt changes in a continuous surface

e) Cover to reinforcement. No deviation from the minimum cover of concrete over reinforcement specified in 5.1.3(a) will be permitted.

f) Location of holding-down bolts

- 1) the centre line of a holding-down bolt from its designated location in plan
- 2) the top of the bolt from its designated elevation

g) Constituents in concrete mix (including water)

- PD of quantities from approved or designated or prescribed mix, as applicable

- Tolerances not stated and those for bow, camber, and twist, and for slipform concrete and precast concrete will be stated in the project specification where applicable.

Permissible deviation, Degree of accuracy		
III	II	I
mm	mm	mm
+50	+35	+20
+60	+40	+20
+30	+20	+10
-40+20	-30+15	-20+10
-30+15	-20+10	-10+5
+25	+15	+5
+30	+20	+10
-10+20	-5+15	+5
-20+10	-15+5	-10+0
5	5	2
70	50	30
+10	+ 5	+ 3
+20	+15	+10
+25	+20	+15
10	5	3
10	5	2
15	10	*
10	5	*
*	+ 3	*
*	-3+5	*
±	±	±
+ 5	+ 5	+ 5

7. TESTS

7.1 FACILITIES AND FREQUENCY OF SAMPLING

7.1.1 Facilities. For the purposes of taking samples and carrying out tests, the Engineer shall have free access to the Works, and the Contractor shall render any assistance necessary. If so required, the Contractor shall provide storage and protection for such samples on the Site. In addition, the Contractor shall provide slump cones and the moulds required for compressive strength testing in accordance with SABS Method 863 in sufficient quantities to enable the frequency of sampling and testing required in terms of 7.1.2 and 7.2 to be achieved.

7.1.2 Frequency of Sampling

- 7.1.2.1 Subject to the requirements of 7.1.2.4, while concrete of a particular grade and in sufficient quantity is being placed under the same conditions, sets of samples (each sample (see 2.3) being sufficient for 3 cubes, beams, cylinders, or prisms, as relevant) shall be taken until 30 valid test results have been obtained. The sets of samples shall be taken in accordance with SABS Method 861, for example, as close as is practicable to the start of placing and at appropriate intervals after that, or from one particular batch and then from subsequent batches chosen at appropriate intervals.
- 7.1.2.2 At least one set of samples shall be taken from each day's casting and from at least every 50 m³ of concrete of each grade placed.
- 7.1.2.3 Frequency of sampling shall, with due regard to the importance of the work and the eventual assessment of test results, be programmed on the basis of considerations such as whether a test pertains to a particular section of work only or to the overall quality of concrete in the structure.
- 7.1.2.4 Only one sample shall be drawn from any one batch of concrete, and, except where otherwise ordered, no sample shall be taken of any grade until at least 3 batches of such grade have been mixed and discharged.

7.2 TESTING

- 7.2.1 General. All testing shall be carried out in accordance with the methods referred to in the specification or in accordance with such other method or methods as are specified in the project specification.
- 7.2.2 Site Testing. The Contractor shall ensure that Site testing is carried out by a competent technician or by a person deemed by the Engineer to be sufficiently experienced.
- 7.2.3 Laboratory Testing. The Contractor shall ensure that laboratory testing is carried out by a recognized testing institution or an approved laboratory or a firm approved by the Engineer.

- 7.2.4 **Early-Strength Testing.** Whereas the criteria for concrete strength in the specification are based on samples tested at the age of 28 d only, any plan for early-strength testing shall be as agreed between the Contractor and the Engineer. Correlation between early-strength test results and expected strength at 28 d shall be based on sufficient evidence obtained through continuous testing at the different ages and on variations in curing regimes if curing is not strictly controlled. Early-strength test results may be used for early remedial measures such as the changing of the mix design, if necessary, but shall not be used for assessment of strength in terms of 7.3.
- 7.3 **ACCEPTANCE CRITERIA FOR STRENGTH CONCRETE**
- 7.3.1 **Strength more than 3 MPa Below Specified Value.** Should any valid test result obtained on concrete of a specific grade show that the strength is more than 3 MPa below the specified strength, the concrete yielding such result will be deemed not to satisfy the requirements of the specification. Should an examination carried out in accordance with 7.3.4 satisfy the Engineer that the structural adequacy and durability of the part of the structure in which the concrete has been used is not impaired, the concrete shall be accepted and the mix design and other factors influencing the quality shall be reviewed in order to ensure that further concrete cast will be of acceptable quality.
- 7.3.2 **Criteria for Three Valid Test Results.** The following criteria shall apply where three consecutive valid test results are obtained:
- a) The average of any three consecutive valid test results obtained on concrete of a specific grade shall exceed the specified strength by at least 2 MPa.
 - b) If the criterion given in (a) above is not met but the said average is at least equal to the specified strength, the concrete cast shall be accepted but the mix design and standard of control shall be reviewed and adjusted as necessary.
- Should the said average result be less than the specified strength, the Engineer will investigate, in accordance with 7.3.4, the part of the structure in which concrete represented by such result has been used.
- 7.3.3 **Provision for Statistical Assessment.** Should a concreting operation be of such magnitude or the sampling of such frequency that 30 or more valid test results have become available within 3 months, the Contractor may choose, at the discretion of the Engineer, to have results assessed statistically instead of in terms of 7.3.2. In such case, the average of all the test results of a specific grade of concrete at any stage shall exceed the specified strength by at least 1,7 standard deviations. If the average of such test results fails to meet this requirement, the mix design shall be adjusted to ensure compliance with this criterion.
- 7.3.4 **Procedure for Examination of Concrete.** If, after evaluation of the test results in terms of 7.3.1 and 7.3.2 or 7.3.3, as relevant, an examination of the concrete in the structure is indicated, one or more of the procedures in the sequence given below may be adopted at the discretion of the Engineer to determine the acceptability or otherwise of concrete in particular sections of the structure:
- a) An assessment of the stress level in the structure concerned in relation to the test result obtained;
 - b) non-destructive testing, subject to similar concrete of proved acceptable quality being available in comparable members in the same construction as a reference (impact hammers and ultrasonic testing are two examples of such test techniques that may be used, provided that the apparatus has been previously calibrated);
 - c) the testing of drilled cores in accordance with the relevant SABS standard methods;
 - d) full-scale load tests in accordance with SABS 0100 under terms and conditions agreed upon between the Engineer and the Contractor.
- 7.3.5 **Replacement or Strengthening of Concrete.** Where load tests are, in the opinion of the Engineer, unsuitable or impractical, and if an examination in terms of 7.3.4 does not show the concrete strength to be acceptable, or if a portion of the structure fails to pass the tests, the Contractor shall, on the instructions and directions of the Engineer, either replace or strengthen by approved means
- a) each section that failed or contains concrete that failed, as relevant; and
 - b) any other section, irrespective of strength, the functional purpose of which is affected by the section or concrete referred to in (a) above.
- The Contractor shall bear the cost of any replacement or strengthening referred to in this subclause as well as any other remedial measures that may be ordered to restore the durability of the concrete to that achievable by concrete of the strength required in terms of the specification.
8. **MEASUREMENT AND PAYMENT**
- 8.1 **MEASUREMENT AND RATES**
- 8.1.1 **Formwork**
- 8.1.1.1 Formwork, other than formwork covered by 8.1.1.2, will be measured as the net area of the face of the concrete to be supported during the deposition of concrete. No deduction will be made for fillets and splays of size up to 50 mm x 50 mm or for openings of diameter up to 0,7 m or of area up to 0,5 m².
- 8.1.1.2 Formwork in continuous lengths of narrow widths and of fillets or splays over 20 mm x 20 mm will be measured by length, the width or range of widths being stated in the schedule. Boxing-out, the forming of holes, and other such operations will be measured by number, basic dimensions, perimeters, or drawing references, as stated in the schedule.
- 8.1.1.3 Separate items will be scheduled
- a) for each class of finish required on the formed concrete;
 - b) for the different angles of inclination of formwork given below:

Description of formwork	Angle of inclination from the vertical
Horizontal	Exceeding 85 ° and not exceeding 95 °
Sloping	Exceeding 10 ° and not exceeding 85 °
Battered	Not exceeding 10 °
Vertical	0 °

- c) for each inclination of each type of structural element, such as walls and beams, and for different prop heights for beams and slabs, and for formwork to curved (single and double curvature), curved in plan only, arched, domical, specially moulded, and other types of work;
- d) for depths of openings required in the formed concrete, as follows:
- 1) Not exceeding 0,5 m,
 - 2) exceeding 0,5 m but not exceeding 1,0 m,
 - 3) exceeding 1,0 m but not exceeding 1,5 m,
 - 4) exceeding 1,5 m but not exceeding 2,0 m,
 - 5) exceeding 2,0 m,
- measured perpendicular to the surface; and
- e) for large and small voids classified as follows:

Description	Maximum cross-section	
	Circular voids, diameter, m	Other voids, area, m ²
Large	Exceeding 0,35 and not exceeding 0,7	Exceeding 0,1 and not exceeding 0,5
Small	Not exceeding 0,35	Not exceeding 0,1

- 8.1.1.4 Where a special smooth finish is specified and scheduled such that it requires more extensive operations to be carried out after striking than are specified in 5.2.1(b), payment will become due when the finish has been achieved as specified.
- 8.1.1.5 Where a special finish (see 5.2.1(c)) is specified and scheduled, payment will become due when the finish has been achieved as specified.
- 8.1.1.6 The unit rate shall cover the cost of all parts of formwork in contact with the concrete (including forming fillets or splays up to 20 mm x 20 mm) and the necessary bearers, struts, and other supports plus the labour and plant necessary to erect and strike such formwork.
- 8.1.2 Reinforcement
- 8.1.2.1 Steel for normal reinforced concrete will be measured net by mass of all bars, including supporting steel detailed on the reinforcing schedules. The mass will be computed from the nominal bar size and the nominal mass per unit length. No allowance will be made for cutting, waste, spacer devices (materials other than steel bars), or binding wire.
- Separate items will be scheduled for:
- a) Each steel section where rails and other steel sections are used; and
 - b) steel to be fixed in different parts of the work where this could materially influence the pricing of the work.
- Steel reinforcement for precast concrete units will not be measured unless so scheduled (see 8.6).
- Welded mesh will be measured by area as shown on the drawings, no allowance being made for cutting, waste, laps, or deductions for end cover. The areas measured will be those of the concrete floor or slab reinforced by means of mesh. In the case of continuous units partly reinforced by mesh, the area will be computed from the outside dimensions of the area covered by mesh regardless of whether additional reinforcing steel is present in the same area.
- Steel offcuts resulting from the cutting and bending of reinforcement in accordance with the bending schedule shall be deemed to be the property of the Contractor.
- 8.1.2.2 a) The total mass of all round and square steel bars will be scheduled as bars of nominal size 25 mm (diameter or side, as relevant) for the purpose of obtaining a basic contract price, and the bars of all sizes actually used will be subject to the terms of the conditions of contract covering valuation of variations.
- The quantities (or percentages) of all other sizes of steel bars that may be required will be scheduled as provisional quantities that are subject to a stated clause in the Special Conditions of Contract, and the contract prices for these will be fixed regardless of the magnitude of variations (if any) of quantities.
- b) Welded mesh will be scheduled separately for each type and mass per square metre of mesh.
- 8.1.2.3 a) The unit rates for steel bars of nominal size 25 mm shall cover the cost of supply, cutting, bending, placing in position, and fixing of the reinforcing and supporting steel scheduled, and the provision of all spacer devices and binding wire, as well as the cost of tests in terms of SABS 920.
- b) The extra-over rates for bars of all nominal sizes other than 25 mm shall cover any differences in cost arising from any or all of the operations set out in (a) above in respect of bars of such other sizes.
- c) The unit rate for welded mesh shall cover the supply, cutting, and placing of mesh, and the cost of all waste due to laps.
- 8.1.3 Concrete
- 8.1.3.1 a) Concrete will be measured net to the dimensions shown on the drawings or to the dimensions cast, whichever are the smaller. Structural elements that are undersized will be measured for payment only if they are accepted by the Engineer.
- b) No allowance will be made for concrete required to make up overbreak in soft excavation, but payment will be made for additional concrete or formwork, ordered in writing by the Engineer to replace unsuitable material or overbreak in hard rock or in intermediate excavation (see (d) below).

- c) Subfoundation carpets and blinding layers will be measured to the plan size of the concrete structure resting on the carpet, or the plan size of the excavation where additional excavation is provided to facilitate erection of forms. Where the concrete is scheduled by volume it will be measured on the mean thickness as cast, provided that the Engineer is satisfied that the excavation has not at any point been taken deeper or wider than necessary (see (b) above).
- d) Where concrete is placed directly against the sides or bottoms of excavations in hard rock or in intermediate excavation, an item may be included in the schedule of quantities for any additional concrete placed in overbreak. Such additional concrete will be measured on the basis of the superficial area of the sides or bottom, or both, as applicable, of the theoretical net excavation in rock that is overbroken and in contact with the concrete.
- 8.1.3.2 Separate items will be scheduled, as applicable, for each type and each grade of concrete, for each type of cement and each type of aggregate, and for each unit of the Works or each element of a structure, where these could materially influence the pricing of the work and where the cost of depositing concrete is affected by its position in the Works or by the conditions of placing, such as
- a) slabs that are sloping, conical, or horizontal, and those of different thicknesses;
- b) concrete deposited under water or between tides, the levels of demarcation being stated;
- c) small quantities each less than $0,5 \text{ m}^3$ of formed concrete; and
- d) different surface finishes (other than striking-off and levelling) such as wood-floated or steel-floated finishes and granolithic or mortar screeds.
- 8.1.3.3 a) The unit rates shall cover the cost of the design of the mix in the case of strength concrete, the provision of concrete (made with ordinary portland cement unless otherwise scheduled), mixing, testing, placing, compacting, the forming of stop-ends and unforeseen construction joints, striking-off or levelling as applicable, and curing and repairing where necessary.
- b) Floor slabs, where placed on subfoundation carpets or directly on the prepared ground surface, will be measured to the net thickness dimensioned on the drawings.
- c) Concrete in a column supporting a reinforced concrete beam or slab structure will be measured between the top surface of the foundation, beam, or slab on which the foot of the column is standing and the underside of the beam or slab supported by the column.
- d) No deduction or addition will be made for nosings, bolt holes, chamfers or splays of size up to $50 \text{ mm} \times 50 \text{ mm}$, grooves or chases not exceeding $0,015 \text{ m}^3$ each in volume, or holding-down bolts, rails, steel sections, and reinforcement cast in the concrete.
- 8.2 SCHEDULED FORMWORK ITEMS
- 8.2.1 Rough Unit: m^2
The surfaces to be so formed will be identified in the schedule.
- 8.2.2 Smooth Unit: m^2
The surfaces to be so formed will be identified in the schedule.
- 8.2.3 Special Smooth, Repaired and Rubbed Unit: m^2
The surfaces to be so formed will be identified in the schedule.
- 8.2.4 Special Off-Form Unit: m^2
The surfaces to be so formed will be identified in the schedule.
- 8.2.5 Narrow Widths (up to mm wide) Unit: m
The constant width, if in excess of 300 mm, or the range of widths if up to 300 mm, or width and depth in the case of grooves or chases, will be stated.
- 8.2.6 Box Out Holes/Form Voids. Items will be scheduled as set out below:
- a) Small, circular, of diameter up to and including 0,35 m
- | Over | and | up to and including | Unit: | No. |
|----------|-----|---------------------|-------|-----|
| 1) - | | 0,5 m deep | | |
| 2) 0,5 m | | 1,0 m deep | | |
| 3) 1,0 m | | 1,5 m deep | | |
| 4) 1,5 m | | 2,0 m deep | | |
| 5) 2,0 m | | - deep | | |
- b) Small, other than circular, of area up to and including $0,1 \text{ m}^2$ Unit: No.
Depths as in (a) above.
- c) Large, circular, of diameter over 0,35 m up to and including 0,7 m Unit: No.
Depths as in (a) above.
- d) Large, other than circular, of area over $0,1 \text{ m}^2$ and up and including to $0,5 \text{ m}^2$ Unit: No.
Depths as in (a) above.
- 8.3 SCHEDULED REINFORCEMENT ITEMS
- 8.3.1 Steel Bars Unit: t
The type of steel (mild, high-tensile, or other) will be stated.
- 8.3.2 High-Tensile Welded Mesh Unit: m^2
The type reference will be stated.
- 8.3.3 Rails or other Steel Sections used as Reinforcement Unit: t
- 8.4 SCHEDULED CONCRETE ITEMS
- 8.4.1 Prescribed Mix Concrete Unit: m^3
The proportions and the positions or elements in the Works will be stated.
- 8.4.2 Blinding layer in Concrete
Either of the following will be stated:
- | | Unit: | No. |
|--|--------------|-----|
| Minimum thickness and proportions or grade | m^2 | |
| Proportions or grade | m^3 | |
- 8.4.3 Strength Concrete, Grade Unit: m^3
The grade and positions or elements in the Works will be stated. Except where ordinary portland cement is required, the type of cement will be stated.

- 8.4.4 Unformed Surface Finishes Unit: m^2
Where better than rough surface finishes are required, items will be scheduled for each class or type of finish, i.e.:
a) Wood-floated finish,
b) steel-floated finish,
c) power-floated finish, or
d) other special finish.
- 8.4.5 Aggregate (where measured separately) Unit: m^3
The rate shall cover the cost of supplying and using the aggregate in the manner specified.
- 8.4.6 Cement (where measured separately) Unit: t
The rate shall cover the cost of supplying and using the cement in the manner specified.
- 8.5 JOINTS Unit: m
Separate items will be scheduled for contraction and expansion joints of different types and sizes and involving different types, sizes, and qualities of water bars, soft board, sealers, etc.
The unit rate shall cover the cost of all materials and labour for the construction of each joint as specified or shown on the drawings, including the cost of formwork, testing, and making good.
- 8.6 MANUFACTURE (OR SUPPLY) AND ERECT PRECAST ELEMENTS Unit: No. or m^3
Separate items will be scheduled for:
a) Different qualities of concrete;
b) different types and sizes of units;
c) small units not exceeding $0,5 m^3$ of formed concrete;
d) different positions of units for erection purposes.
Except where separate items are scheduled for specific operations or materials, the rates shall cover the cost of supply of all materials, plant, and labour for the concrete and reinforcement in the elements including the cost of moulds for forming the element, special finishes, curing, transport, handling to site, erecting or building in or fixing, and grouting.
- 8.7 GROUTING
a) Under bases (or beds) Unit: m^3
Grouting under structural steel column bases or members or under pumps, motors, or other machinery will be measured by the volume of grout (before the edges are trimmed at 45° from the bottom edges of bedplates) necessary to fill the voids and pockets between the underside of the metalwork and the top of the concrete. No deduction will be made for bolts, packers, and baseplate shear keys protruding into the grout space.
b) HD bolts, etc. (see 8.8). Unit: t or No.
Separate items will be scheduled for HD bolts or pockets, as applicable, of different diameters, lengths, and types, and for bearings and miscellaneous metal work of different types. The quantity will be measured by the volume of grout necessary to fill the voids in the concrete. No deduction will be made for bolts and packers protruding into the grout space.
The rates for (a) and (b) above shall cover the cost of scabbling, cleaning, and preparing the concrete surfaces, providing an approved grout, placing and ramming it solidly into all voids and pockets, and mitring the outside edges to a true wood-floated surface. Formwork, if any, will be measured separately in terms of 8.2.
- 8.8 HD BOLTS AND MISCELLANEOUS METAL WORK Unit: t
Whether to be supplied by the Contractor or by others will be stated. Separate items will be scheduled as specified in 8.7(b).
The rate shall cover the cost of supplying and delivering or taking delivery (as applicable), fixing or casting into concrete, and all cleaning, preparation, and finishing.

APPENDIX A. APPLICABLE STANDARDS

Reference is made to the latest issues of the following standards:

BS 1370	Low heat Portland cement
SABS 82	Bending dimensions of bars for concrete reinforcement
SABS 471	Portland cement (ordinary, rapid-hardening, and sulphate-resisting)
SABS 626	Portland blastfurnace cement
SABS 831	Portland cement 15 and rapid-hardening portland cement 15
SABS 878	Ready-mixed concrete
SABS 920	Steel bars for concrete reinforcement
SABS 1024	Welded steel fabric for concrete reinforcement
SABS 1083	Aggregates from natural sources
SABS 1200 A	Civil engineering construction : General
SABS 1200 AA	Civil engineering construction : General (small works)
SABS 1200 D	Civil engineering construction : Earthworks
SABS 1200 DA	Civil engineering construction : Earthworks (small works)
SABS 0100	Structural use of concrete
SABS 0144	Detailing of steel reinforcement for concrete
SABS Methods	856, 861, 862, 863