TRANSNET LIMITED

S420 (1999)

SPECIFICATION FOR CONCRETE WORK

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1. SCOPE

This specification covers requirements for plain, reinforced and prestressed concrete.

2. INTERPRETATION

Supporting Specifications

Plain and reinforced concrete shall comply with SABS 1200 G and with the supplementary requirements contained herein. Prestressed concrete shall comply with SABS 1200 GF. In addition, the following specifications shall apply where relevant:

SABS 763 : 1988	Hot-dip (galvanised) zinc coatings
SABS 1083 : 1994	Aggregates from natural sources
SABS 0100-2 : 1992	The Structural use of concrete - Part 2 : Materials and execution of work.
SABS ENV 197-1	Cement - composition, specifications and conformity criteria. Part 1 : Common cements
SABS 1491-1 : 1989	Portland cement extenders - Part 1 : Ground granulated blast furnace slag.
SABS 1491-2 : 1989	Portland cement extenders - Part 2 : Fly ash
SABS 1491-3 : 1989	Portland cement extenders - Part 3 : Condensed Silica Fume

3. MATERIALS

3.1 Cementitious Binders

3.1.1 Cement

Common cements, complying with SABS ENV 197.1, as summarised in Annex A, shall be used for all concrete work. On no account shall masonry cements be used for concrete work, even if the strength designations are the same as for common cements.

3.1.2 Coastal Zones

In all wet applications and within one kilometre of the sea, unless otherwise specified in the project specifications, one or more of the following cementitious binders shall be used in all applications including prestressed concrete.

(i) Portland blastfurnace cement, type III/A, certified as containing not less than 40% and not more than 50% milled granulated blastfurnace slag (MGBS), or a blend of Type I Portland cement with not less than 40% and not more than 50% MGBS. MGBS shall comply with SABS 1491 Part 1.

(ii) Portland fly ash cement type II/B-V or Portland fly ash cement type II/B-W, certified as containing not less than 25% and not more than 30% fly ash shall comply with SABS 1491 Part 2.

3.1.3 Alkali Reactive Aggregate

If coarse aggregate known to be alkali reactive, are to be used in the proposed concrete, then one or more of the cementitious binders listed under (i) and (ii) above shall be used.

The equivalent Na_2O content, defined as % Na_2O = % Na_2O + (0,658%K_2O) shall be limited as follows:

Malmesbury Group metasediments	:	2,1 kg/m^3
Table Mountain Group orthoquartzite	:	2,8 kg/m^3
Cape Granite	:	4,0 kg/m^3

3.1.4 Alkali Reactive Cement

In addition to, or as an alternative to the precautions specified under 3.1.3 above, the equivalent alkali content of the Portland cement type I and the quantity of alkali per cubic metre of concrete shall be limited as directed by the Engineer. This applies to both site mixed and ready mix concrete. Certificates stating the equivalent alkali content of each delivery of cement to

site or to the ready mix depot supplying concrete to site, shall be provided by the Contractor.

3.1.5 Sulphate Resisting Cement

Where sulphate resisting Portland cement is specified, the fly ash cement specified in 3.1.2.(ii) may be used as a substitute.

3.2 Aggregates

3.2.1 Fine and coarse aggregate shall comply with the relevant clauses of SABS 1083.

3.2.2 Where aggregates have constituents which, in the opinion of the Engineer, may give rise to damage due to alkali-aggregate reactions, the provisions of 3.1.3 and 3.1.4 shall be applicable.

3.3 Curing Compound

In all cases where a concrete curing compound is specified, the curing compound shall be a clear or white pigmented membrane forming material complying with ASTM specification C 309, except that the maximum permissible water loss in the test shall be 0,40 kilogram per square metre.

Alternatively, the concrete curing compound shall be acceptable if the treated concrete retains 90% or more of its mixing water when subjected to the test set out in British Standard Specification 8110 Part 1 - Chapter 6.6.

3.4 Admixtures

Admixtures containing chlorides will not be permitted in reinforced concrete.

3.5 Cover Blocks

Cover blocks used to ensure the cover to reinforcement shall be made of cement mortar. They shall be dense and have a minimum 28 day crushing strength of 50 MPa, and shall be cured in water for at least 14 days before being used. Steeldale cover blocks or similar approved proprietary items shall be used - site made blocks will not be permitted. Spacer blocks made of plastic will not be permitted.

3.6 Underwater Concrete

3.6.1 The maximum size of aggregate shall be 50mm, and the aggregates shall be well graded. To ensure a plastic, cohesive mix, at least 10% of the fine aggregate shall pass the 300µm sieve, and at least 2%, the 150µm sieve.

3.6.2 Except in the cases of concrete placed in sacks or grouted concrete the slump shall be between 140 and 200mm.

3.6.3 Sacks shall be made of jute or other porous material.

3.6.4 The requirement in clause 5.5.5.7 of SABS 1200 G for concrete placed by tremie, that the quantity of cement in the concrete mix shall be increased by 20%, shall also apply to concrete placed underwater by other means.

4. PLANT AND EQUIPMENT

4.1 Tremie

A tremie shall consist of a hopper and a watertight tube, of diameter to suit the size of aggregate. The tube shall extend from slightly below concrete level to above the water surface, and shall be constructed in sections with watertight couplings so that it can be shortened as the concrete level rises, by removing sections above the water surface. It shall be strong enough to withstand the full hydrostatic pressure, even if a partial vacuum develops in the pipe. The tremie shall be supported so as to permit rapid lowering when necessary to retard or stop the flow of concrete. If required, the discharge end of the pipe shall be equipped with a valve to allow for dewatering of the tremie and control of concrete distribution.

4.2 Underwater Buckets

Underwater buckets shall have bottom doors of the drop bottom or roller gate type. The doors shall be latched in such a way that they cannot be opened until the bucket has reached the bed upon which the concrete is to be deposited. If air is used to open the bottom doors, the air shall discharge through a pipe to the surface. The doors shall be surrounded by a steel skirt. The top of the bucket shall be fitted with double canvas flaps to protect the concrete from wash when it enters the water and descends.

5. CONSTRUCTION

5.1 Approval of aggregates

Evidence of compliance of the aggregates with the requirements of 3.2 above, shall be furnished as early as practicable. If required by the Engineer, the Contractor shall submit 40kg samples for approval at least 6 weeks before concrete construction is to be commenced. No aggregate shall be delivered for use in the works until approval is given.

5.2 Concrete Quality

5.2.1 Quality Assurance Plan

Before the start of any concrete work on site, the Contractor shall submit a quality assurance plan which will ensure compliance with specification and provide acceptable documentary proof that all specified operations have been carried out satisfactorily.

5.2.2 Potential heat Generation

Measures, subject to the approval of the Engineer, shall be applied to reduce heat development in concrete of which the minimum dimension to be placed during a single pour is larger than 600mm, provided that the cement content exceeds the following :

	Cement types I and II/ * S	Cement types II/B-V and II/B-W
	kg/m³	kg/m³
Reinforced concrete	400	450
Prestressed concrete	500	550

5.3 Batching

5.3.1 Cement

All cementitious binders shall be batched by full sack or by mass batching with approved precision weighing equipment.

5.3.2 Aggregates

(i) All aggregates shall be precisely measured by mass using approved precision weighbatching equipment, unless otherwise permitted by the Engineer:

(ii) Should any variation in the composition of the aggregate become apparent, the Engineer shall be notified and a further sample of aggregate submitted immediately for his approval.

5.4 Concrete Placing

5.4.1 Inspection of Excavation

The size, shape and depth of any excavation shall be approved by the Engineer before concrete is placed.

5.4.2 Inspection of Reinforcement

Unless otherwise permitted by the Engineer, no concrete shall be placed until the fixed reinforcement has been accepted by him.

5.5 Concrete placed under water

5.5.1 The Contractor shall furnish to the Engineer in good time for his approval, details of the method of construction that he proposes to use.

5.5.2 Underwater concrete for piles shall be placed by tremie in accordance with SABS 1200 F.

5.5.3 Underwater concrete shall not be placed in water colder than 2°C.

5.5.4 Unless otherwise permitted, the technique adopted for placing of concrete, and any cleaning of the bed, shall be designed to prevent the washing out of cement from the concrete mixture, minimise the segregation of materials and the formation of laitance, and prevent the flow of water through or over new concrete less than 24 hours old. Concrete shall not be moved after placing, e.g. by lateral movement of tremie pipes. No vibration shall be carried out until the top of the concrete is above water level.

5.5.5 Unless otherwise permitted, concreting of any element shall be continuous to completion.

5.5.6 The bed shall be cleaned of silt and loose material. No concrete shall be placed until the Engineer has approved the bed.

5.6 Concrete placed by Tremie

5.6.1 Concreting by tremie shall be done in accordance with clause 5.5.2.2 of SABS 1200 F, but with the words "bore" and "casing" replaced by "space to be filled with concrete".

5.6.2 When concrete is deposited, the tremie shall penetrate into the concrete and shall be slowly raised to discharge a uniform flow of concrete.

5.6.3 Concreting shall continue to a level such that when unsound concrete has been removed, a sound surface will be left at the specified finished level.

5.6.4 When concreting over a wide area, tremie spacing shall not exceed 5m.

5.7 Concrete place by Underwater Bucket

The bucket used in underwater concreting shall be completely filled, lowered to the bed and then raised slowly as concrete is discharged.

5.8 Concrete placed in sacks

5.8.1 Immediately prior to placing, sacks shall be filled with concrete to two-thirds capacity. The openings shall be securely tied or, when directed, sewn up.

5.8.2 The sacks of concrete shall be placed by a diver in header and stretcher bond, with their mouths away from the outside surface, so that the whole mass becomes interlocked. Where necessary, steel spikes shall be driven through the sacks after placing to hold them in position.

5.9 Grouted Concrete

5.9.1 Coarse aggregate for grouted concrete, 25mm or larger, shall first be placed and compacted in position.

5.9.2 Grout, in a colloidal state, shall be pumped into the voids through pipes which shall reach to the bottom of the aggregate. Grout pipes shall be spaced at not more than 1,5m, and shall be withdrawn in such a way that a head of at least 1m of grout is maintained above the grout outlets.

5.10 Concrete placed by pumping

The requirements of clauses 4.2, 5.4, 5.7 and 5.5.5.7 of SABS 1200 G and clause 5.5.2.2 of SABS 1200 F, for concrete placed by a tremie tube, shall also apply to concrete placed by pumping.

5.11 Construction Joints

5.11.1 Unless otherwise shown on the drawings, the exact position of horizontal construction joints shall be marked on the formwork by means of grout checks in order to obtain truly horizontal joints.

5.11.2 Stub columns, stub walls and stays on footings shall be cast integrally with the footings and not afterwards, even where another class of concrete is being used.

5.11.3 Joint lines shall be so arranged that they coincide with features of the finished work.

5.11.4 Where new concrete is to be cast against a hardened concrete surface a neat cement slurry mixed to a creamy consistency shall be brushed onto the cleaned concrete surface.

5.11.5 At contraction joints (joints having no reinforcement passing through the joint) no bond is required between casts. Contraction joints shall be smooth and shall have one coat of limewash or PVA applied to the older surface prior to casting the newer concrete.

5.12 Curing

5.12.1 Curing Compound

Unless otherwise directed by the Engineer, an approved trafficable, resin-based, white pigmented, membrane-forming curing compound shall be used on slopes flatter than 1 in 1.

On all other concrete surfaces, including beam and slab soffits, an approved clear, aesthetically acceptable membrane-forming curing compound shall be used, unless otherwise directed by the Engineer.

5.12.2 Application Rate

The total application rate shall be as specified by the Supplier, or 0,30 litres per square metre, whichever is the greater. On textured concrete surfaces e.g. concrete roads, the total application rate shall be 0,50 litres per square metre.

5.12.3 Additional Coats

In the case of concrete surfaces with run-off problems, it may be necessary to apply more than one coat of membrane forming curing compound to obtain the specified total or cumulative application rate.

5.12.4 Application

Curing in accordance with SABS 1200 G shall commence on all concrete surfaces as soon as it is practicable in the opinion of the Engineer. For unformed surfaces the compound shall be applied after finishing and as soon as the free water on the surface has disappeared and no water sheen is visible, but not so late that the liquid curing compound will be absorbed into the concrete. For formed surfaces, when forms are removed, the exposed concrete surface shall be wet with water immediately and kept moist until the curing compound is applied. Immediately prior to application, the concrete shall be allowed to reach a uniformly damp appearance with no free water on the surface. Application of the compound should then begin at once. The compound should be applied at a uniform rate with two applications at right angles to each other to ensure complete coverage, and may be applied by hand or power sprayer. Pigmented compounds must be adequately stirred to assure even distribution of the pigment during application, unless the formulation contains a thixotropic agent which prevents settlement.

5.12.5 Windy Conditions

When the wind velocity exceeds 5 m/s and/or the ambient temperature is above 25 °C and/or the relative humidity is below 60%, the initial 24 hour curing of concrete surfaces not covered by formwork shall be carried out by ponding, covering with constantly wetted sand or mats, or continuous spraying in accordance with SABS 1200 G, unless otherwise permitted by the Engineer.

If plastic shrinkage cracks occur, the concrete, while still plastic, shall be re-vibrated and floated. Thereafter it shall be re-coated with curing compound as if no curing has previously taken place.

5.12.6 Marine Structures

For reinforced concrete marine structures moist curing methods shall be used except as otherwise permitted in writing by the Technical Officer. Only fresh, clean water shall be used for curing. The use of seawater shall not be permitted under any circumstances.

5.12.7 Curing Time

The curing period for concrete containing CEM I only shall be 7 days. The curing period for concrete's containing CEM I plus cement extenders (GGBS, FA) shall be 10 days. The period will start on completion of the concrete pour and for formed surfaces shall include the time for which forms are still in place after the pour.

5.12.8 Steam Curing

Steam curing under atmospheric pressure will be permitted, subject to approval by the Technical Officer. Steam curing shall not commence sooner than 5 hours after completion of concrete placement. Temperatures shall be raised to between 60 and 70°C at a rate not exceeding 20°C per hour. The rate of cooling shall also not exceed 20°C per hour.

Records of temperatures recorded on an hourly basis at sufficient locations to ensure that the prescribed temperatures and rates of heating are not exceeded at any point shall be provided to the Technical Officer on a daily basis.

5.13 **Records**

The Contractor shall maintain the following daily records for every part of the concrete structure and shall make these available at all times during the progress of the work for inspection by the Engineer :

(i) The date and times during which concrete was placed.
(ii) Identification of the part of the structure in which the concrete was placed.
(iii) The mix proportions and specified strength
(iv) The type and brand of cement.
(v) The slump of the concrete
(vi) The identifying marks of test cubes made
(vii) Curing procedure applied to concrete placed
(viii) The times when shuttering was stripped and props were removed.
(ix) The date of despatch of the cubes to the testing laboratory
(x) The test results.

The records shall be delivered to the Engineer each week except in the case of sub-standard concrete, when the Engineer shall be informed immediately.

6. TOLERANCES

Deviations shall be within the limits listed in SABS 1200 G for Degree of Accuracy II unless otherwise specified in the project specification.

7. TESTING

7.1 Frequency of Sampling

Frequency of sampling and testing shall be as specified in SABS 1200 G.

(i) If the quantity from which these samples were taken exceeds 40 m^3, it shall be subject to the testing of a minimum of 3 sets of samples per day from each grade of concrete placed in each independent structure.

(ii) If the quantity from which these samples were taken is less than 40 m^3, it shall be subject to the testing of a minimum of 2 sets of samples per day.

7.2 Acceptance Criteria

7.2.1 If the Contractor disputes the results of the tests on concrete cubes, the concrete represented by the cubes will be considered acceptable if the Contractor, at his own cost, proves to the satisfaction of the Engineer that the estimated actual strength of cores taken from the structure, determined in accordance with SABS Method 856, is not less than the specified strength.

7.2.2 If the strength of concrete fails to meet the acceptance criteria stipulated, the Engineer may in his sole discretion and in addition to the options listed in SABS 1200 G:

(i) accept the concrete subject to approved remedial measures being undertaken by the Contractor; or
(ii) permit the concrete to remain subject to the payment of a penalty.

7.3 Penalty

The penalty referred to in 7.2.2 (ii) will be determined as follows:

Penalty = V x R x F
where

V = Volume (in the opinion of the Engineer) of concrete of unsatisfactory strength represented by the test result.

R = Relevant scheduled rate.

$$F = 1 - \sqrt{\frac{\text{Average strength of unsatisfactory concrete}}{\text{Specified strength} + 6\ \text{MPa}}}$$

when the relevant scheduled rate (R) includes the cost of formwork or

$$F = 1 - \frac{\text{Average strength of unsatisfactory concrete}}{\text{Specified strength} + 6\ \text{MPa}}$$

when the relevant scheduled rate (R) excludes the cost of formwork or where no formwork was involved.

7.4 Underwater Concrete

In view of the 20% additional cement added in accordance with 3.6.5, replace the words "specified strength" by "specified strength plus 10 MPa" in clauses 7.3.1 to 7.3.3 of SABS 1200 G.

8. MEASUREMENT AND PAYMENT

8.1 Unless otherwise provided for in the schedules of quantities, only permanent work will be measured for payment. The cost of temporary work shall be included in the rates tendered.

8.2 If the drawings and/or specifications provide for any item which is not separately listed in the schedules of quantities, such item shall be considered as an integral portion of the structure, and its cost shall be included in the rates for related items listed in the schedules of quantities.

8.3 All costs arising out of compliance with 3.2.2 including removal of unsatisfactory materials, shall be borne by the Contractor.

ANNEX A

Extract from SABS Specification ENV 197-1

CEMENT : STANDARDS AND SELECTION

In 1996 South Africa adopted new specifications for cement. These ready-to-use, Portland based cements used in building and construction are divided by the specifications into two broad categories: "common" cement intended for use in concrete, although some may be suitable for mortar and plaster mixes, and "masonry" cements intended for beddingmortars and plasters.

"Common" cement types and compositions by mass[1]

Cement Type	Description	Notation	Clinker K	Granulated Blastfurnace Slag S	Silica Fume D[3]	Fly ash		Limestone L	Minor additions & constituents [2]
						Siliceous V	Calcareous W		
I	Portland cement	I	95-100						0-5
II	Portland slag cement	II/A-S	80-94	6-20					0-5
		II/B-S	65-79	21-35					0-5
	Portland silica fume cement	II/A-D	90-94		6-10				0-5
	Portland fly ash cement	II/A-V	80-94			6-20			0-5
		II/B-V	65-79			21-35			0-5
		II/A-W	80-94				6-20		0-5
		II/B-W	65-79				21-35		0-5
	Portland limestone cement	II/A-L	80-04					6-20	0-5
		II/B-L	65-79					21-35	0-5
	Portland composite cement	II/A-M	80-94	6-20[4]					
		II/B-M	65-79	21-35[4]					
III	Blastfurnace cement	III/A	35-64	36-65					0-5
		III/B	20-34	66-80					0-5
		III/C	5-19	81-95					0-5
IV	Pozzolanic cement	IV/A	65-89		11-35				0-5
		IV/B	45-64		36-55				0-5
V	Composite cement	V/A	40-64	18-30		18-30			0-5
		V/B	20-39	31-50		31-50			0-5

NOTES:

[1] The values in the table refer to the cement nucleus, excluding calcium sulphate and any additives.
[2] Minor additional constituents may be filler or may be one or more of the main constituents unless these are included as main constituents in the cement.
[3] The proportion of silica fume is limited to 10%.
[4] The proportion of filler is limited to 5%.