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SANS 2001-CC1:2007

Edition 1

SOUTH AFRICAN NATIONAL STANDARD

Construction works

Part CC1: Concrete works (structural)

standards SouthAfrica
(a division of SABS)

SANS 2001-CC1:2007
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Table of changes

Change No.	Date	Scope

Acknowledgement

Standards South Africa wishes to acknowledge the input of the Joint Structural Division of the South African Institution of Civil Engineering and the Institution of Structural Engineers and the Cement and Concrete Institute in the development of this part of SANS 2001.

Foreword

This South African standard was approved by National Committee StanSA TC 5120.61, *Construction standards*, in accordance with procedures of Standards South Africa, in compliance with annex 3 of the WTO/TBT agreement.

This part of SANS 2001 was published in April 2007. This edition cancels and replaces

SANS 1200 G (SABS 1200 G:1982),

SANS 1200 GA (SABS 1200 GA:1982),

SANS 1200 GB (SABS 1200 GB:1984),

SANS 1200 GE (SABS 1200 GE:1984), and

SANS 1200 GF (SABS 1200 GF:1984).

SANS 2001 consists of a number of parts in various stages of preparation, under the general title *Construction works*.

Annex A forms an integral part of this part of SANS 2001. Annex B is for information only.

Introduction

The different parts of SANS 2001 each address a specific component of construction works. The prime purpose in the production of these standards is to create a set of standards that are generally applicable to construction works, and which can be readily modified to make them applicable to particular works.

The SANS 2001 family of standards provides technical descriptions of the standard of materials and workmanship that will be used in the works that are executed or in the performance of the works when completed (or both). These standards do not make reference to the actions of those responsible for executing the works or the parties to a contract, i.e. to the constraints relating to the manner in which contract work is to be performed. Neither do they deal with the commercial arrangements of such contracts. These standards are suitable for use in any “in-house” construction work or in all types of engineering and construction works contracts, for example, design by employer, design and build, develop and construct, construction management or management contracts.

Standard requirements pertaining to the manner in which works are constructed can be found in the SANS 1921 family of standards.

Construction works

Part CC1:
Concrete works (structural)

1 Scope

This part of SANS 2001 covers concrete works related to the structural use of concrete in buildings and structures where the design and supervision of plain, reinforced, prestressed (by means of pre-tensioning or post-tensioning) and precast concrete are under the direct control of appropriately qualified engineers and technologists.

It does not cover the structural use of concrete in piles, harbour and marine works, and underground works in mines.

NOTE 1 This part of SANS 2001 is suitable for the construction of concrete work designed in accordance with the requirements of SANS 10100-1. SANS 10100-2 provides guidance on how to specify aspects of concrete works and how to comply with particular requirements.

NOTE 2 This part of SANS 2001 may be used as an alternative to SANS 2001-CC2 to construct concrete works designed in accordance with the standard designs contained in national standards, for example, SANS 10400 and parts of SANS 2001.

NOTE 3 Appropriate modifications to this part of SANS 2001 are required to extend the applicability to structures excluded from the scope of this part of SANS 2001.

2 Normative references

The following referenced documents are indispensable for the application of this document. All normative documents are subject to revision and, since any reference to a normative document is deemed to be a reference to the latest edition of that document, parties to agreements based on this document are encouraged to take steps to ensure the use of the most recent editions of the normative documents indicated below. Information on currently valid national and international standards can be obtained from Standards South Africa.

ASTM C 156, *Standard test method for water retention by concrete curing materials*.

ASTM C 260, *Standard specification for air-entraining admixtures for concrete*.

ASTM C 309, *Standard specification for liquid membrane-forming compounds for curing concrete.*

ASTM C 494/C 494M, *Standard specification for chemical admixtures for concrete*.

BS 4486, *Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete.*

BS 5896, *Specification for high tensile steel wire and strand for the prestressing of concrete.*

EN 1008, *Mixing water for concrete – Specifications for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.*

EN 13391, *Mechanical tests for post-tensioning systems*.

SANS 121/ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.*

SANS 282, *Bending dimensions and scheduling of steel reinforcement for concrete.*

SANS 794 (SABS 794), *Aggregates of low density.*

SANS 878, *Ready-mixed concrete*.

SANS 920, *Steel bars for concrete reinforcement*.

SANS 967, *Unplasticized poly(vinyl chloride) (PVC-U) soil, waste and vent pipes and pipe fittings*.

SANS 1024, *Welded steel fabric for reinforcement of concrete*.

SANS 1083, *Aggregates from natural sources – Aggregates for concrete.*

SANS 1431, *Weldable structural steels*.

SANS 1491-1, *Portland cement extenders – Part 1: Ground granulated blast-furnace slag*.

SANS 1491-2, *Portland cement extenders – Part 2: Fly ash.*

SANS 1491-3, *Portland cement extenders – Part 3: Silica fume*.

SANS 2001-CC2, *Construction works – Part CC2: Concrete works (minor works).*

SANS 2001-CS1, *Construction works – Part CS1: Structural steelwork.*

SANS 5836 (SABS SM 836), *Effect of fine and coarse aggregate on the shrinkage and expansion of cement: aggregate mixes (mortar prism method).*

SANS 5850-2 (SABS SM 850-2), *Sulfates content of fines in aggregates – Part 2: Acid-soluble sulfates in fines in aggregates.*

SANS 5856, *Bulking of fine aggregates*.

SANS 5860, *Concrete tests – Dimensions, tolerances and uses of cast test specimens.*

SANS 5861-2, *Concrete tests – Sampling of freshly mixed concrete.*

SANS 5861-3, *Concrete tests – Making and curing of test specimens.*

SANS 5862-1, *Concrete tests – Consistence of freshly mixed concrete – Slump test*.

SANS 5862-2, *Concrete tests – Consistence of freshly mixed concrete – Flow test.*

SANS 5863, *Concrete tests – Compressive strength of hardened concrete*.

SANS 5865 (SABS SM 865), *Concrete tests – The drilling, preparation, and testing for compressive strength of cores taken from hardened concrete.*

SANS 6085, *Concrete tests – Initial drying shrinkage and wetting expansion of concrete*.

SANS 6252, *Concrete tests – Air content of freshly mixed concrete – Pressure method*.

SANS 10100-1 (SABS 0100-1), *The structural use of concrete – Part 1: Design.*

SANS 10100-2 (SABS 0100-2), *The structural use of concrete – Part 2: Materials and execution of work.*

SANS 10403, *Formatting and compilation of construction procurement documents*.

SANS 50196-2/EN 196-2, *Methods of testing cement – Part 2: Chemical analysis of cement*.

SANS 50197-1/EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements.*

3 Definitions

For the purposes of this document, the definitions given in SANS 10403 and the following apply.

3.1 General

3.1.1
accredited testing laboratory
laboratory that has been accredited by the South African National Accreditation System (SANAS)

3.1.2
admixture
material, other than a cement extender, that is used as an ingredient of concrete or mortar to modify the properties of concrete or mortar in the fresh or hardened state

3.1.3
cementitious binder
common cement that complies with the requirements of SANS 50197-1, and blends of certain types of common cement and cement extenders that comply with the requirements of SANS 1491-1, SANS 1491-2 or SANS 1491-3

3.1.4
concrete cover
thickness of concrete between the face of the concrete, as cast, and the outer face of reinforcing steel, prestressing steel, steel used for binding the reinforcing, or any embedded steel nearest to this face

3.1.5
deviation
difference between the actual (i.e. measured) dimension or position and the specified dimension or position

3.1.6
extender
material which, when mixed with portland cement, has a cementing property and is used as a portion of the cement in a concrete mix for economic reasons or for the chemical or physical properties (or both) that it gives to the concrete mix

3.1.7
falsework
temporary works required to support concrete while it is being cast and until it becomes self-supporting

3.1.8
fixture
item such as a bolt, anchorage, bearing or the like, that is cast or grouted into concrete

3.1.9
formwork
all the temporary aids and material required to support concrete (i.e. falsework), and to provide the shape of the concrete in a structure (while the concrete is in the fresh state)

3.1.10
permissible deviation
pd
specified limit(s) of deviation within which a dimension or position lies

3.1.11
specification data
data, provisions and variations that make this part of SANS 2001 applicable to a particular contract or works (see annex A)

3.1.12
suitable
capable of fulfilling or having fulfilled the intended function, or fit for its intended purpose

3.1.13
tolerance
range between the limits within which a dimension or position lies

3.2 Weather

3.2.1
adverse weather
cold weather or a combination of a high ambient temperature, low relative humidity and high wind velocity or driving rain, which might impair the quality of fresh or hardening concrete, or otherwise cause undesirable properties in hardened concrete

3.2.2
cold weather
weather in which the minimum ambient temperature is 5 °C or less

3.2.3
cool weather
weather in which the minimum ambient temperature is higher than 5 °C, but less than 15 °C

3.2.4
hot weather
weather in which the maximum ambient temperature is higher than 32 °C

3.2.5
normal weather
weather in which the maximum ambient temperature is greater than 15 °C, but not greater than 32 °C

3.3 Concrete — General characteristics

3.3.1
breeze concrete
concrete made from graded inorganic aggregates of low density, including any type of furnace residue

3.3.2
consistency
extent (usually measured by slump or flow tests) to which fresh concrete flows or can be deformed

3.3.3
grade of concrete
identifying number for a particular concrete, which is numerically equal to the characteristic strength of such concrete at 28 d, expressed in megapascals

3.3.4
no-fines concrete
concrete composed of prescribed proportions of cementitious binder and aggregate of a designated single size

3.3.5
plain concrete
concrete that is not reinforced

3.3.6
precast concrete
concrete that consists of units cast and cured in a position other than their final position, and placed in position to form an integral part of a structure

3.3.7
prescribed-mix concrete
concrete for which mix proportions have been specified

3.3.8
prestressed concrete
structural concrete in which effective internal stresses have been induced by means of tendons

3.3.9
ready-mixed concrete
concrete that complies with the relevant requirements of this part of SANS 2001 and SANS 878, and that is delivered on site in a fresh state

3.3.10
sample of concrete
minimum volume of uncompacted freshly mixed concrete required in terms of SANS 5861-2 for a designated test (for example, 16 dm^3 for the compressive strength test for 3 cubes of nominal size 150 mm)

3.3.11
slump
measured value for the consistency of concrete at the point of delivery to ensure compliance with the consistency specified

3.3.12
workability
property of fresh concrete that determines the ease of placing and compacting the concrete without segregation of its constituent materials

3.4 Concrete — Strength characteristics

3.4.1
characteristic strength
value for the compressive strength of concrete at 28 d, below which not more than 5 % of the valid test results obtained on cubes of concrete of the same grade fall

3.4.2
specified strength
required characteristic strength (or the strength corresponding to the required grade of concrete)

3.4.3
strength concrete
concrete designed primarily for strength considerations and designated by its characteristic strength in conjunction with the maximum nominal size of stone used in its manufacture

NOTE Strength concrete is designated by its characteristic strength followed by the size of stone used in its manufacture, for example, 30 MPa/19 mm refers to a grade 30 mix made with 19 mm stone.

3.4.4
valid test result
average result obtained from three test cubes of concrete that have been tested in accordance with SANS 5860, SANS 5861-2 and SANS 5863 and where the range does not exceed 15 % of the average strength

3.5 Prestressing

3.5.1
anchorage
device used to anchor a tendon to the concrete member

3.5.2
coil
one continuous length of finished strand or wire wound in closely packed concentric rings

3.5.3
coupler
device designed to transfer the prestressing force from one tendon to another

3.5.4
post-tensioning
method of prestressing in which tendons are tensioned after the concrete has attained its initial minimum specified strength

3.5.5
prestress
stress induced in concrete by tendons

3.5.6
pre-tensioning
method of prestressing in which tendons are tensioned before concrete placement

3.5.7
pull-in
elastic shortening of a tendon caused by movement of the tendon within the anchorage or coupler components due to seating and gripping action during or immediately after transfer

3.5.8
sheath
conduit that encloses a tendon and temporarily or permanently allows some movement between the tendon and the surrounding concrete

3.5.9
sheathing
enclosure in which tendons intended to be post-tensioned are encased, to prevent bonding during concrete placement

3.5.10
strand
number of wires of the same nominal diameter spun together in helical form round a core wire of slightly larger diameter

3.5.11
tendon
assemblage of steel elements (for example, wire, bar or strand) used to impart prestress to concrete when the assemblage is tensioned

3.5.12
transfer
action of transferring force from a tendon to the concrete

NOTE It may cover work carried out both on site and also during the manufacture of prestressed concrete units.

3.5.13
vent
opening in a sheath that can be adjusted to control the release of air, the drainage of water or the injection or release of grout

3.5.14
wire
cold-drawn wire produced from a suitably treated hot-rolled rod

NOTE The surface of a wire is initially smooth but the wire may subsequently be indented or crimped by a mechanical process and given a final stress-relieving treatment.

4 Requirements

4.1 General

4.1.1 Precast concrete shall comply with the relevant requirements of 4.2 to 4.8 (inclusive). The requirements of 4.8 shall take precedence over any requirements specified in 4.2 to 4.7.

4.1.2 Prestressed concrete shall comply with the relevant requirements of 4.2 to 4.9 (inclusive). The requirements of 4.9 shall take precedence over any requirements specified in 4.2 to 4.8.

4.2 Materials

4.2.1 Cementitious binders

4.2.1.1 Cementitious binders shall, unless otherwise specified in the specification data (see annex A), be common cements that comply with SANS 50197-1 or be blends of certain common cements and extenders that comply with SANS 1491-1, SANS 1491-2 or SANS 1491-3.

4.2.1.2 Separate storage facilities shall be provided on site for each type of cementitious binder used. Cementitious binders shall be stored in weatherproof conditions and in such a manner that the oldest binder is used first and, where stored in bulk, the cementitious binder drawn for use is measured by mass and not by volume.

4.2.1.3 Cement shall not be kept in storage on site for longer than eight weeks.

4.2.2 Water

Water shall be clean and free from injurious amounts of acids, alkalis, organic matter, and other substances that could impair the strength or durability of the concrete or metal embedded in the concrete and, where required in terms of the specification data, shall comply with the requirements of EN 1008.

4.2.3 Aggregates

4.2.3.1 Unless otherwise specified in the specification data or the scope of work,

a) both the coarse aggregate (stone) and the fine aggregate (sand) shall comply with the relevant requirements of SANS 1083, and

b) the coarse aggregate shall have a nominal size of either 13,2 mm or 19 mm.

4.2.3.2 Pea gravel shall have 100 % of particles passing a test sieve of nominal aperture 9,5 mm, between 95 % and 100 % passing 4,74 mm and between 0 % and 5 % passing 2,35 mm.

4.2.3.3 Clinker for breeze concrete and no-fines concrete shall be clean, dry furnace clinker that complies with the applicable requirements of SANS 794.

4.2.3.4 In plain concrete of thickness at least 300 mm, hard, clean, stone "plums" of mass 15 kg to 55 kg may, if permitted in terms of the specification data, be used to displace concrete to a maximum of 20 % of the volume of the concrete, provided that

a) such plums are clean, durable and inert and have no adhering films or coatings;

b) no plum has a dimension less than 150 mm or greater than 500 mm or one-third of the smallest dimension of the concrete element, whichever is the lesser; and

c) the strength of the rock that makes up the plums (as indicated by the aggregate crushing value or the 10 % fines aggregate crushing test) is at least that specified for coarse aggregate in SANS 1083.

4.2.3.5 Where required in terms of the specification data,

a) The drying shrinkage of both the fine and coarse aggregate, when tested in accordance with SANS 5836, shall not exceed the following limits:

   1) For use in prestressed concrete, concrete bridge decks and slender columns, the shrinkage of both fine and coarse aggregate shall not exceed 130 % of that of the reference aggregate.

   2) For use in other reinforced concrete members, the shrinkage of the fine aggregate shall not exceed 175 % of that of the reference aggregate and the shrinkage of the coarse aggregate shall not exceed 150 % of that of the reference aggregate.

   3) For use in mass concrete substructures and unreinforced concrete head walls and wing walls, the shrinkage of both the fine and coarse aggregate shall not exceed 200 % of that of the reference aggregate.

b) The drying shrinkage of concrete shall not exceed 0,040 %, when tested in accordance with the requirements of SANS 6085.

c) The flakiness index of the stone as determined by SANS 1083, shall not exceed 35.

d) Where there is any danger of a particular combination of aggregate and cement giving rise to a harmful alkali-aggregate reaction, that particular combination shall be tested and, where the result points to such reaction, either the aggregate or the cement (or both) shall be replaced so that the combination will not give rise to a harmful alkali-aggregate reaction.

4.2.3.6 Aggregates of different nominal sizes shall be stored separately and in such a way that

a) segregation of particles of the same size is minimized,

b) contamination by foreign matter is prevented, and

c) intermixing of aggregates is minimized.

4.2.3.7 Stockpiles of sand shall be free-draining to ensure a relatively uniform moisture content throughout the stockpile.

4.2.4 Admixtures, air-entrainment agents and curing agents

4.2.4.1 Admixtures may be used in a concrete mix provided that their use is permitted in terms of the specification data. All admixtures shall comply with the requirements of ASTM C 494 and, where more than one admixture is used, shall be compatible with each other.

4.2.4.2 When an admixture is used in concrete that will contain prestressing tendons, reinforcement and embedded metal, the chloride content of the admixture, expressed as a mass fraction of chloride ions, shall not exceed 2 % of the admixture or 0,03 % of the mass of the cementitious binder.

4.2.4.3 Air-entraining agents shall comply with the requirements of ASTM C 260. Where an air-entraining agent is used, test measurements shall be carried out on site, as and when required, to determine

a) the percentage of air entrained in the concrete, and

b) the density of the concrete.

4.2.4.4 Curing agents shall be tested in accordance with ASTM C 156 and shall comply with the requirements of ASTM C 309, except that the loss of water within 72 h shall not exceed 0,40 kg/m^2.

4.2.5 Reinforcement

4.2.5.1 Reinforcing bars shall comply with the relevant requirements of SANS 920 and the requirements of the scope of work. The type of bar required shall be indicated in the drawings by the symbols R, Y or Z, in accordance with the requirements of SANS 282.

4.2.5.2 Welded steel fabric shall comply with the relevant requirements of SANS 1024, as specified in the scope of work.

4.2.5.3 A certificate issued by a government-endorsed accreditation body (for example, SANAS), confirming that the steel complies with the specified requirements, shall be supplied for each consignment of steel reinforcement delivered on site.

4.2.5.4 Steel shall be stacked off the ground so as to prevent distortion and shall be protected from aggressive environments and contamination.

4.2.5.5 The tensile properties of mechanical couplers, determined on a test sample with a maximum gauge length of 610 mm and which consists of reinforcing bars butt-jointed by means of such a device, shall comply with the following requirements, as certified by an accredited testing laboratory:

a) When tested in accordance with the relevant requirements of 5.3 of SANS 920:2005, the tensile properties of the test sample shall show an improvement of at least 10 % on the requirements of 3.7 of SANS 920:2005.

b) Where the test sample is subjected to a load equal to 58 % of the specified minimum yield force of the bar, the elongation measured on the gauge length shall not exceed the calculated theoretical elongation for a 610 mm length of the bar, based on a stress of 58 % of the specified minimum yield stress of the bar and a Young's modulus of 200 GPa.

4.2.6 Grade of concrete

The grade shall be as specified in the scope of work. Unless otherwise specified in the scope of work, the grade in precast concrete elements shall be at least grade 30.

4.2.7 Grout

Materials used for grouting shall, unless otherwise specified in the scope of work, comply with the following requirements:

a) cement shall comply with SANS 50197-1 and be of a strength class 32,5 or higher;

b) sand shall comply with the requirements of SANS 1083 for sand for concrete, except that the grading shall be such that 100 % passes through a 1,18 mm sieve; and

c) admixtures shall not contain chlorides, nitrates, sulfides or sulfites and when aluminium powder is used, the total expansion of the grout shall not exceed 10 %.

4.2.8 Tendons

4.2.8.1 Tendons shall consist of high tensile wire, strand or alloy steel bars. Wire and strand shall comply with the applicable requirements of BS 5896. Bars shall be of cold-worked high tensile steel and shall comply with the requirements of BS 4486 for hot-rolled and processed bars.

4.2.8.2 The characteristic strength of the steel shall be as specified in the scope of work.

4.2.8.3 Each consignment delivered to the site shall be accompanied by the manufacturer’s certificate stating the quality and the mechanical properties thereof.

4.2.8.4 Steel that will be bonded to the concrete as pre-tensioning reinforcement shall not be galvanized and shall be deformed either by indenting or crimping.

4.2.8.5 The storage of all prestressing steel shall be above the ground and the steel shall be fully protected from the weather.

4.2.9 Anchorages and couplers

Anchorages and couplers shall comply with the requirements of EN 13391, and be supplied with the manufacturer's test certificate(s) as evidence that the anchorages and couplers do so comply.

4.2.10 Sheaths

4.2.10.1 General

4.2.10.1.1 Sheaths for tendons shall be of a suitable type that takes into account the design friction characteristics between sheath and tendon, and shall be of metal or of any other suitable material.

4.2.10.1.2 Except for vents, each sheath shall be mortar-tight and shall be sufficiently strong to prevent puncture, damage or excessive deformation during concreting operations. A sheath may be provided with a threaded entry to permit the use of a screwed connector from the grout pump.

4.2.10.2 Sheathing for bonded tendons

4.2.10.2.1 Sheathing or duct-formers shall be of a material that will not react with the alkalis in the cement and that is strong enough to retain its shape and resist damage during construction. It shall prevent the intrusion of cement paste from the concrete. Sheathing material left in place shall not cause electrolytic action or deterioration.

4.2.10.2.2 Sheathing shall have an internal cross-sectional area at least twice that of the net steel area of the tendon, but might need to be larger, if a large number of tendons are involved.

4.2.10.2.3 Sheathing shall have injection pipes fitted at each end and vent pipes at all high points except where the curvature is small and the sheathing is relatively level, such as in continuous slabs. Drain holes shall be provided at all low points if the tendon might be subjected to freezing after placing and before grouting.

4.2.10.3 Sheathing for unbonded tendons

Sheathing shall have sufficient strength and weather resistance to prevent damage or deterioration during transportation, storage on site and installation. Sheathing shall be a continuous tube and shall continue over the unbonded length of the tendon. In the event of lubricated sheaths, sheathing shall prevent the intrusion of cement paste and loss of lubricant.

4.2.11 Joint fillers, sealants, waterstops, bearings and accessories

4.2.11.1 Joint fillers, sealants, waterstops, bearings and accessories shall comply with the requirements of the scope of work.

4.2.11.2 Bond breakers shall comprise a suitable material; polyethylene tape, coated paper, metal foil or similar material may be used where bond breakers are required.

4.2.11.3 Unless otherwise specified in the scope of work, backing material shall consist of a suitable compressible material of the correct width and shape to ensure that, after installation, it can compress by up to 50 % and allow the sealant to be formed to the specified depth. Backing materials shall be compatible with the sealant used.

NOTE Material containing bitumen or volatile material should not be used with thermosetting chemically curing sealants.

4.2.11.4 Steel cover plates shall comply with the requirements of SANS 1431 for grade 300 WA steel, unless otherwise specified in the scope of work. Galvanizing, where required in terms of the scope of work, shall comply with the requirements of SANS 121.

4.2.12 Deteriorated material

Material that has deteriorated, or that has been contaminated or otherwise damaged, shall not be used in concrete works.

4.2.13 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.

4.3 Formwork

4.3.1 General

4.3.1.1 Materials that have a deleterious effect on concrete (for example, untreated timber) shall not be used for formwork.

4.3.1.2 Forms shall have sufficient strength to withstand the pressure resulting from placement and compaction of the concrete and shall have sufficient rigidity to maintain the specified tolerances, the required shapes, finishes, positions, levels and dimensions shown in the drawings. The surfaces of forms which are to be in contact with the concrete shall be clean, free from deposits or adhering matter, ridges or spatter, that will cause irregularities and blemishes to the concrete surface, and shall also be free from indentations and warps.

4.3.1.3 Forms shall be sufficiently tight to prevent loss of cement paste.

4.3.1.4 The formwork shall be capable of being dismantled and removed from the cast concrete without shock, disturbance or damage to the concrete.

4.3.1.5 Earth cuts shall not be used as forms for vertical surfaces, unless permitted or unless so required in terms of the specification data.

4.3.1.6 Where formwork is to be erected over a road, a street or a railway, the formwork shall be so designed 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 scope of work, before commencing erection, the approval of such authority shall be obtained for the design of the formwork.

4.3.1.7 Precautions shall be taken to prevent deterioration of the foundations during the course of construction.

4.3.1.8 Formwork shall be such as to produce the surface conditions and finished concrete to the relevant sections of the work as required by the scope of the work (see table 1). Unless otherwise specified in the scope of work, the formed surfaces of sections of the works shall be as follows:

a) rough: all external surfaces more than 150 mm below ground level or concealed and internal surfaces not exposed to view;

b) smooth: all surfaces not described in (a), that are to be clad or are to receive surface coatings; and

c) smooth-special: all surfaces not described in (a) or (b).

Table 1 — Surface finishes of formed surfaces

1	2
Surface finish	**Description**
Rough	A surface formed by any material and that has a degree of accuracy III in respect of exposed surfaces (see 5.2.5). Surface defects repaired. No treatment of the surface of the concrete is required after the striking of the formwork.
Smooth	A surface formed by any material and that has a degree of accuracy specified in the specification data in respect of exposed surfaces (see 5.2.5). No treatment of the surface of the concrete is required after the striking of the formwork. Imperfections, such as small fins, bulges, irregularities, surface honeycombing and slight surface discolorations shall be made good and repaired.
Smooth-special	A surface formed by using steel forms, unless otherwise specified in the specification data, and that has a degree of accuracy specified in the specification data in respect of exposed surfaces (see 5.2.5). Surfaces formed as for smooth, but completely rubbed or treated to form a smooth finish of uniform texture, appearance and colour.
Special off-form	A surface finish that is such that no after-treatment other than the treatment of bolt-holes (which shall be placed with regularity and precision) is required. The form used is unblemished and the panels regular. Joints are a feature of the pattern and are handled with care. The finished concrete is accurate to degree of accuracy I. The finish in each portion of the work is one of the following as specified in the scope of work: **Board-marked finish:** obtained by the use of timber planks that are dressed and planned except where unplanned timber is required, in which case, the boards with the strong grain are mixed with the boards with less pronounced grain and not grouped together. **Special patterned finish:** a finish that reflects, without blemish, the surface of the patterned hardboard, rubber, thermoplastic, or other lining as specified in the specification data.
Exposed aggregate finish	A surface that exposes the aggregate in such a manner that the specified cover to the reinforcement is maintained after the aggregate has been exposed. The finish in each portion of the works is one of the following as specified in the scope of work: **Brushed and water finish:** obtained by the stripping and scrubbing of the concrete surface with a stiff wire brush where the forms can be struck at a very early stage (16 h at 20 °C) or the formwork is treated with a suitable retarding agent and care is taken to prevent the concrete, when it is deposited in the formwork, from removing such retarding agent. Water, or where this is not effective, a solution of hydrochloric acid made up of 1 part of the concentrated acid to 4 parts of water, is thoroughly and evenly scrubbed into the surface until the desired texture is obtained. When hydrochloric acid is used, the surface is then neutralized by thorough washing with water to which a small amount of ammonia has been added. **Tooled finishes:** obtained by the application of a brush-hammer, light mechanical chisels or other suitable tools that are mechanically operated when the age of the concrete is such that aggregate particles are not dislodged during such application. The final finish shows a surface of evenly distributed aggregate particles in slight relief. After tooling, the surface is scrubbed down with a stiff brush and washed with water. **Sand-blasted finishes:** obtained by sand-blasting the surface with hard sharp sand, when the age of the concrete is such that aggregate particles are not dislodged during such application. The finish produces an even, fine, clean surface in which the mortar has been cut away, leaving the aggregate exposed. **Aggregate transfer finishes:** obtained by sticking a single layer of selected aggregate onto plyboard or other suitable liners which have been cut to size and coated with a layer of water-soluble cellulose adhesive mixed with plaster sand. The thickness of this layer is slightly less than half the average least dimension of the aggregates. When the glue has set, the liners are placed in the forms, which are then concreted, taking care to protect these liners during placement and compacting of the concrete. The liners are stripped 3 d after the concrete has been placed and the adhesive and sand covering the aggregate have been removed by scrubbing and washing.

4.3.2 Design and construction of formwork and falsework

4.3.2.1 General

4.3.2.1.1 The forms shall be designed to withstand the worst combination of self-weight, wet concrete mass, concrete pressure, construction loads and wind loads, together with all incidental dynamic effects caused by placing and compacting the concrete. Cognizance shall also be taken of the redistribution of load which might occur as a result of effects such as temperature, wind force, the prestressing of curved and skewed structures, stage construction, flooding and debris.

4.3.2.1.2 To maintain the specified tolerances, the formwork shall be cambered to compensate for anticipated deflections in the formwork before the concrete hardens.

4.3.2.1.3 An assessment of the allowable bearing pressure on the foundation material shall be made. The footings and falsework shall be designed to prevent overloading, minimize differential settlement and excessive overall settlement. In assessing the allowable bearing pressure, due account shall be taken of the effect of wetting on the foundation material.

4.3.2.1.4 The design and drawings for formwork and falsework, including the design criteria and calculations, shall be submitted for review where required in terms of the specification data.

4.3.2.1.5 The formwork for bridge decks shall be erected to levels calculated from the information given on the plans for roadworks and bridges. The levels shall be adapted to make provision for the specified precamber as well as for the expected deflection and settlement of the fully loaded falsework and formwork. The levels shall be set out and checked at intervals that do not exceed 2,50 m.

4.3.2.1.6 Formwork shall not restrain any elastic shortening, deflection or camber of the structure that results from the application of the prestressing force.

4.3.2.2 Sliding formwork

4.3.2.2.1 Sliding formwork shall be designed so that

a) the formwork panels are inclined to give a small taper, the forms being slightly wider at the bottom than at the top,

b) the taper produces the specified concrete thickness at the mid-lift level of the form, and

c) the spacing of the jacks with their jack rods shall be such that the dead load of the sliding-formwork assembly, the frictional load, and the mass of materials, personnel and equipment shall be evenly distributed and within the design capacity of the jacks used.

4.3.2.2.2 Drawings of the complete sliding-formwork assembly shall be submitted for review before the fabrication of sliding formwork or bringing the sliding formwork and any additional equipment to the site. The drawings shall show full details of the forms, jacking frames, access ladders, hanging platforms, safety rails and curing skirts as well as details of the jacks and jack layouts. An instruction manual in which the sliding techniques, jacking procedure, methods of keeping the formwork level, the procedure to be adopted to prevent bonding of the concrete to the forms and a method for releasing the forms in the event of bonding, the instrumentation and monitoring of the slide casting and correcting for verticality, twisting and levelness are described in detail, shall be submitted together with the drawings.

4.3.2.2.3 Hoisting equipment for sliding formwork shall operate stepwise with upward movements of between 10 mm and 100 mm. The use of linked hydraulic jacks or pneumatic jacks is preferred, since these are reversible and driven by an electrically operated pump, and can hoist at a steady rate. The jacks shall have independent controls for regulating verticality and levelness. The jacking system shall ensure that the sliding-formwork assembly can be hoisted evenly.

4.3.2.2.4 All equipment shall be thoroughly tested and inspected before installation and shall be maintained in a good working order throughout the entire sliding operation. Sufficient back-up plant, equipment and quantities of materials shall be kept on site to ensure that the slide casting can proceed without interruption.

4.3.2.2.5 Suitable instrumentation shall be installed on the sliding platform and foundations and against the sides of the structure for monitoring the height, verticality, levelness and twisting at regular distances.

4.3.2.2.6 The verticality of the structure shall be controlled with laser alignment apparatus or optical plummets, and the levelness of the sliding forms shall be controlled with a water-level system with reference control points placed at strategic locations.

4.3.2.2.7 Height and verticality shall be monitored at intervals that do not exceed 4 h. The readings shall be plotted immediately on graphs. When the structure is more than 10 mm from the vertical datum, action shall be taken to correct the deviation.

4.3.2.2.8 Records of all readings and measurements taken shall be filed systematically and made available at all times to the persons overseeing or in control of the sliding operation.

4.3.2.2.9 During the entire period of the sliding operation, a person who is fully acquainted with the sliding technique and the methods of construction, shall be in attendance on the sliding platform and in control of the sliding operations.

4.3.3 Form accessories

4.3.3.1 The types of ties used and their position shall be such that the required finish is achieved.

4.3.3.2 Form ties and spacers left in situ shall be such that they will not impair the desired appearance or durability of the structure, for example, by causing spalling or rust staining or by allowing the passage of moisture.

4.3.3.3 After the ends or end fasteners of form ties have been removed, any embedded portion of the tie shall terminate at a distance of not less than the specified minimum cover from the formed surface of the concrete.

4.3.3.4 Runways for moving equipment during concreting shall be provided with struts and legs, shall be supported directly on the formwork or structural member, and shall not rest on the reinforcing steel.

4.3.3.5 The jack rods, which shall have a diameter of not less than 25 mm, and the base plates and couplers for sliding formwork shall be strong enough to carry the design load under all operating conditions without buckling, distorting or causing damage to the concrete. Jack rods which are to remain permanently embedded in the concrete shall be clean, free from mud, oil, grease, paint, loose rust, loose mill scale or any other substance which could have an adverse chemical effect on the steel or concrete, or which could reduce the bond.

4.3.3.6 Under no circumstances shall bent jack rods be used in the works.

4.3.4 Temporary openings

Temporary openings shall be provided at the base of column forms and wall forms and at other points where necessary to facilitate cleaning and observation immediately before the concrete is placed. Subsequently, the openings shall be so closed as to provide the specified finish and to conform to any applicable tolerances.

4.3.5 Void formers

4.3.5.1 Void formers used in permanent work shall be suitable for the purpose and comply with the requirements of the scope of work, if any. They shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on precast concrete blocks or rigid welded steel cradles. The ties securing the void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or supported on the reinforcement.

4.3.5.2 Void formers shall be manufactured from material which will not leak, tear or be damaged during the course of construction and shall be of such tight construction as to prevent undue loss of the mortar component of the concrete through leakage. The units shall be sufficiently rigid so as not to deform during handling or under the pressure of the wet concrete.

4.3.5.3 For mild-steel spiral-lock-formed void formers, the metal thickness shall be as follows, unless otherwise specified in the scope of work:

a) unbraced void formers:

1) 0,6 mm for diameters of up to 600 mm;

2) 0,8 mm for diameters exceeding 600 mm and up to 800 mm; and

3) 1,0 mm for diameters exceeding 800 mm and up to 1 000 mm.

b) internally braced void formers:

1) 0,6 mm for diameters of up to 800 mm;

2) 0,8 mm for diameters exceeding 800 mm and up to 1 000 mm; and

3) 1,0 mm for diameters exceeding 1 000 mm and up to 1 200 mm.

4.3.5.4 Internally braced void formers shall be braced at intervals that do not exceed 2,0 m and that are not further than 1,0 m from the end of each unit. Timber cross braces shall consist of members with cross-sectional dimensions of at least 50 mm × 50 mm.

4.3.5.5 All hollow void-former units shall be provided with a 12 mm diameter drainage hole at each end.

4.3.6 Preparation of formwork

4.3.6.1 All matter that could contaminate the concrete, including rubble and dust, shall be removed from the interior of the forms before the concrete is placed.

4.3.6.2 Surfaces that are to be in contact with fresh (wet) concrete shall be clean and covered with a suitable coating material that will effectively prevent absorption of moisture, will prevent bond with the concrete, and will not stain the concrete surfaces.

4.3.6.3 Release agents shall be applied strictly in accordance with the manufacturer's instructions, and every precaution shall be taken to avoid the contamination of the reinforcement, prestressing tendons and anchorages. In the selection of release agents, due regard shall be given to the necessity for maintaining a uniform colour and appearance throughout on the exposed concrete surfaces.

4.3.7 Reuse of formwork

Before reuse, all formwork shall be reconditioned, and all form surfaces that are to be in contact with the concrete shall be thoroughly cleaned.

4.3.8 Removal of formwork

4.3.8.1 Forms and shoring in the formwork shall remain in place until the concrete has reached at least the strength necessary to prevent plucking of the surface during removal of the formwork and to support its own mass and any loads that might be imposed on it. In the absence of any qualitative data, the periods before striking formwork shall be not less than those given in table 2.

NOTE It might be possible to remove formwork within periods shorter than normal if the early strength of the concrete is assessed. This strength may be assessed by tests on cubes of equal maturity, and cured, as far as possible, at the same temperature as the concrete in the element (see SANS 10100-2).

4.3.8.2 Due regard shall be given to the curing methods to be employed before formwork is removed. If formwork is part of the curing system, the time of its removal shall be taken into account.

4.3.8.3 On continuously reinforced concrete structures, the falsework and supporting formwork shall not be removed before the concrete of the last pour has reached the appropriate minimum age given in table 2 or the appropriate minimum strength. Where the structure is constructed in stages, the falsework and supporting formwork shall be removed as specified in the specification data.

4.3.8.4 On prestressed-concrete structures, the falsework and supporting formwork shall be removed after the full prestressing force relating to the particular stage of construction has been applied, unless otherwise specified in the specification data.

4.3.8.5 Formwork shall be carefully removed so that shock and damage to the concrete are avoided.

NOTE The sudden removal of wedges is equivalent to an impact load on the partially hardened concrete.

Table 2 — Minimum time before removal of formwork (in days[a])

1	2	3	4	5	6	7	8	9	10
Formwork to structural member	**Strength class of cement**								
	42,5 R or higher			**CEM I and CEM II A-S, D, P, Q, V, A, W, T, L, LL, M and blends of CEM I with 20 % or less ground granulated blast-furnace slag or fly ash**			**CEM II B-S,P, Q, V, W, T, L, LL, M; CEM III, CEMIV and CEM V and blends of CEM I with more than 20 % ground granulated blast-furnace slag or fly ash**		
	Minimum time before removal of formwork d								
	Weather								
	Hot or normal	**Cool**	**Cold**	**Hot or normal**	**Cool**	**Cold**	**Hot or normal**	**Cool**	**Cold**
Beam sides, walls and unloaded columns	0,5	0,75	1	0,75	1,25	1,5	2	3	4
Slabs with props left underneath	2	3	4	4	5,5	7	6	8	10
Beam soffits with props left underneath and ribs with a ribbed floor construction	3	4	5	7	9,5	12	10	13,5	17
Slab props including cantilevers	5	7	9	10	13,5	17	10	13,5	17
Beam props including cantilevers	7	9,5	12	14	17,5	21	14	17,5	21
NOTE In cool weather stripping times may be determined by interpolation between the periods specified for normal and cold weather.									
[a] A day is taken as 24 h.									

4.4 Reinforcement

4.4.1 Bending

4.4.1.1 Reinforcing bars shall be bent to the dimensions shown in the construction drawings and in accordance with SANS 282. Grade 250 reinforcement protruding from concrete elements may be bent, provided that the radius of bend is not less than that specified in SANS 282.

4.4.1.2 Except as allowed in 4.4.1.3, all bars shall be bent cold and bending shall be done slowly, using a steady, even pressure without jerking or impact.

4.4.1.3 If so permitted in terms of the specification data, and provided that the bars do not depend on cold working for their strength, bars of diameter 32 mm or more may be bent hot.

4.4.1.4 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.

4.4.1.5 Reinforcement shall not be subjected to mechanical damage, rough handling, dropping from a height, or shock loading.

4.4.1.6 Where protruding bars are exposed to the elements for an indefinite period, the bars shall be suitably protected against corrosion and damage and shall be properly cleaned before being permanently encased in concrete.

4.4.2 Fixing

4.4.2.1 All reinforcement, at the time of placing of the concrete, shall be free from rust, scale, oil and other coatings that might reduce the bond between the steel and surrounding concrete, or initiate corrosion of the reinforcement. The reinforcement shall not be contaminated by any substance used as a release agent for the formwork.

4.4.2.2 Reinforcement shall be positioned as shown in the construction drawings and maintained in those positions. Reinforcement shall be secured at sufficient intersections to avoid displacement of bars, by

a) tying at intersections with annealed wire of nominal diameter 1,6 mm or 1,25 mm or by the use of suitable clips, or

b) if permitted in terms of the specification data, welding between crossing or lapping reinforcement, or between bars and other steel elements by means of metal-arc welding or electric-resistance welding.

Reinforcement shall be supported in its correct position by means of hangers or saddles, and aligned by means of suitable chairs and spacers fixed securely to retain the critical position of the reinforcement and which are sufficiently robust to support, amongst others, temporary loads due to construction activities.

4.4.2.3 Spacers required for ensuring that the specified cover is obtained shall be of a suitable material, shape and design. Spacers shall be durable, shall not lead to corrosion of the reinforcement and shall not cause spalling of the concrete cover. Concrete spacer blocks made on the construction site shall not be used unless they are made and suitably cured under strictly controlled conditions. Ties cast into spacer blocks shall not extend deeper into the spacer block than half the depth of the spacer block. The concrete cover over the projecting ends of ties or clamps shall comply with the concrete cover requirements for reinforcement.

NOTE Concrete spacer blocks are typically made with aggregate of size 6,7 mm (maximum), and of the same strength and material source as those of the surrounding concrete. The blocks are formed in specially manufactured moulds and the concrete is compacted on a vibratory table and cured under water for a period of at least 14 d.

4.4.2.4 Welded wire fabric for slabs shall extend to within 100 mm of the concrete edge. Welded wire fabric shall be suitably supported during the placing of the concrete, to assure proper positioning in the slab.

4.4.2.5 Laps and joints of reinforcing bars shall be formed only as and where shown in the construction drawings. Bars left exposed for bonding of future extensions to the structure shall be well protected from corrosion, using suitable means. Laps shall be constructed in such a way that the cover is not reduced below the limits specified in the scope of work.

NOTE SANS 10144 contains recommendations for the spacing of spacers and chairs.

4.4.2.6 Connections between reinforcing bars using proprietary connectors, where required in terms of the scope of work, shall be made strictly in accordance with the manufacturer's instructions.

4.4.2.7 In members that are formed with sliding formwork, spacer ladders for placing and fixing the wall reinforcement shall be used at suitable intervals or those indicated in the construction drawings. The spacer ladders shall consist of two bars, 3,7 m in length with ties, 4 mm in diameter, welded to them to resemble a ladder. The ties shall be spaced at multiples of the horizontal bar spacing in the wall, and shall be used to secure the horizontal reinforcement. The laps in the horizontal reinforcement shall be staggered to ensure that no part of two laps in any four consecutive layers lies in the same vertical plane.

4.4.3 Cover

4.4.3.1 Unless otherwise specified in the scope of work, 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 3 for the exposure conditions, 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.

4.4.3.2 Cover over rail and structural steel reinforcement shall be at least 80 mm, unless otherwise specified in the scope of work.

4.4.3.3 The cover shall be increased by the expected depth of any surface treatment, for example, when concrete is bush hammered or when rebates are provided.

4.5 Holes, chases and fixing blocks

4.5.1 No holes or chases, other than those shown in the construction drawings, shall be cut or otherwise formed in the concrete. The manner of attaching fixtures that are to be embedded in the concrete shall be as specified in the scope of work.

4.5.2 The clear space between such pipes or between such pipes and any reinforcing steel shall be at least 40 mm or the maximum size of the aggregate plus 5 mm, whichever is the greater. The thickness of the concrete cover over pipes and fittings shall be at least 25 mm.

4.5.3 The ends of all ferrules used for bracing formwork shall be neatly finished off to the details shown in the drawings. Where no details are given in the drawings, ferrules shall be cut back to a depth of at least the specified cover, and the holes shall be filled in with mortar and finished off flush with the concrete surface.

Table 3 — Cover for various exposure conditions

1	2	3	4	5	6	7
Exposure condition	**Description of member/surface to which the cover applies**	**Minimum cover** mm				
		Class of concrete				
		20	**25**	**30**	**40**	**50**
Moderate: concrete surfaces above ground level and protected against alternately wet and dry conditions caused by water, rain and sea water	Surfaces protected by the superstructure, such as the sides of beams and the undersides of slabs and other surfaces not likely to be moistened by condensation	50	45	40	30	25
	Surfaces protected by a waterproof cover or permanent formwork not likely to be subjected to weathering or corrosion					
	Enclosed surfaces					
	Structures or members which are permanently submerged					
	Surfaces in contact with ballast from railway lines	NA	55	50	50	45
Severe: concrete surfaces exposed to hard rain and alternately wet and dry conditions	All exposed surfaces	NA	50	45	40	35
	Surfaces on which condensation takes place					
	Surfaces in contact with soil					
	Surfaces permanently under running water					
	Surfaces in contact with ballast from railway lines	NA	55	50	50	45
	Cast-in-situ piles:					
	a) wet cast against casings	50	50	50	50	50
	b) wet cast against soil	75	75	75	75	75
	c) dry cast against soil	75	75	75	75	75
Very severe: concrete surfaces exposed to aggressive water, sea-water spray or a saline atmosphere	All exposed surfaces of structures within 30 km from the sea	NA	NA	NA	60	50
	Surfaces in rivers polluted by industries	NA	NA	NA	60	50
	Cast-in-situ piles, wet cast against casings	NA	NA	NA	80	80
Extreme: concrete surfaces exposed to the abrasive action of sea water or very aggressive water	Surfaces in contact with sea water or industrially polluted water	NA	NA	NA	65	65
	Surfaces in contact with marshy conditions					
NA = not applicable.						

4.6 Embedded items

4.6.1 General

Expansion joint material, waterstops, pipes and conduits, and other embedded items shall be positioned accurately and supported against displacement. Voids shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

4.6.2 Waterstops

4.6.2.1 The material and design of waterstops and their location in joints shall be as specified in the scope of work. Each piece of premoulded waterstop shall be of maximum practicable length in order to keep the number of end joints to a minimum.

4.6.2.2 Joints at intersections and at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall

a) develop effective watertightness fully equal to that of the continuous waterstop material,

b) permanently develop at least 50 % of the mechanical strength of the parent section, and

c) permanently retain their flexibility.

4.6.3 Pipes, conduits and ducts

4.6.3.1 No pipes or conduits, other than those shown in the construction drawings, shall be permanently embedded in the concrete. Such pipes and conduits shall be free from rust, scale and oil.

4.6.3.2 The pipes and fittings to be used for the construction of the ducting shall be rigid PVC pipes and fittings with flexible rubber joints which comply with the requirements of SANS 967. Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt, concrete, etc., from entering the ducts. Two strands of 2,5 mm diameter galvanized steel wire shall be threaded through each duct. The strands shall extend 2 m beyond each end and be wedged firmly into position with the wooden stoppers. Inspection eyes for the ducts shall be constructed in accordance with the details shown in the construction drawings.

4.6.3.3 The interior surface of drainage pipes shall, on completion, be smooth and clean.

4.6.4 Weepholes

Weepholes shall not be placed within 40 mm of any reinforcement and shall be carefully cleaned and kept clean.

4.7 Quality of concrete

4.7.1 General

4.7.1.1 Concrete shall comply with the requirements for strength concrete or, where required in terms of the specification data or in the case of no-fines concrete and breeze concrete, a prescribed-mix concrete. The types of aggregate and cementitious binder for strength concrete shall not be altered for the duration of the works specified in the scope of work, unless the relevant tests are conducted to ensure that all requirements are complied with.

4.7.1.2 Unless otherwise specified in the specification data, the cementitious binder content for any class of concrete shall not exceed 500 kg/m^3 of concrete.

4.7.2 Consistency

4.7.2.1 Unless otherwise specified in the specification data, the slump shall be as given in table 4 or 4.7.2.2.

4.7.2.2 The slump of concrete may be up to 150 mm, should the method of sliding so require.

Table 4 — Slump limits

1	2	3	4	5
Type of construction	**Slump limits**			
	Hand-placed mm		**Vibrated** mm	
	Max.	**Min.**	**Max.**	**Min.**
Paving and precast units	70	50	50	30
Heavy mass concrete	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 the ground	120	70	80	50
Plain footings and substructure walls	100	30	60	20

4.7.3 Workability

4.7.3.1 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.

4.7.3.2 Where pumping of the concrete is permitted in terms of the specification data, the concrete mix to be pumped shall be so designed that

a) the slump shall not exceed 125 mm,

b) graded aggregate and suitable admixtures are used, wherever necessary, with a view to improving the pumpability of the mix, and

c) its shrinkage capacity shall not be more than 10 % higher than that of ordinary concrete mixes.

4.7.4 Chloride and sulfate content

4.7.4.1 Except where a lower value is required in terms of the scope of work, the amount of chloride ion in concrete expressed as a mass fraction (%) of the cement shall not exceed the applicable values given in table 5.

4.7.4.2 Where required in terms of the specification data, the total water soluble sulfate content of the concrete mix, expressed as SO_3, shall not exceed a mass fraction of 4 % of the cementitious binder content of the mix.

Table 5 — Maximum chloride content (CL^{-1}, % (mass fraction))

1	2
Type of concrete	**Maximum chloride content CL^{-1}** % (mass fraction)
Mass concrete	
Efflorescence acceptable	2,0
Efflorescence not aesthetically acceptable	0,30
Reinforced and post-tensioned concrete	
Not subject to marine exposure	0,60
Efflorescence not aesthetically acceptable	0,30
Exposed to marine environment	0,20
Prestressed concrete (pre-tensioned)	
Wire of diameter over 5 mm	0,08
Stressing strands and wire of diameter 5 mm and less	0,05
NOTE The specification data should indicate whether or not efflorescence is acceptable.	

4.7.5 Durability

4.7.5.1 Where required in terms of the specification data, concrete that has an air-dry density in the range 2 000 kg/m^3 to 2 600 kg/m^3 shall contain entrained air and conform to the air-content limits given in table 6, as determined in accordance with SANS 6252. The water:binder ratio shall have a mass fraction of not more than 0,53.

4.7.5.2 Where required in terms of the specification data, concrete made to have an air-dry density that does not exceed 2 000 kg/m^3 shall contain 6 % ± 2 % total air when the nominal maximum size of aggregate exceeds 9,5 mm, or 7 % ± 2 % total air when the nominal maximum size is 9,5 mm or less. Proportions shall be so selected that a characteristic strength of 20 MPa or more is attained.

Table 6 — Total air content for various sizes of coarse aggregate for normal-density concrete

1	2
Nominal maximum size of coarse aggregate mm	**Total air content as a volume fraction** %
9,5	6 to 10
13,2	5 to 9
19	4 to 8
37,5	3 to 6

4.7.6 Prescribed-mix concrete

4.7.6.1 The mix proportions shall be as specified in the scope of work.

4.7.6.2 The prescribed proportions of

a) coarse aggregate of the specified maximum nominal size (in millimetres) and where required, sourced from a source specified in the specification data,

b) fine aggregate, and

c) cementitious binder of the type specified in the specification data,

shall be mixed to produce concrete with the specified slump or water:cement ratio for each section of the work (see table 4).

4.7.7 Batching

4.7.7.1 Cementitious binder

The mass of cementitious binder supplied in a standard bag shall be assumed to be the mass indicated on the bag. All cementitious binder taken from bulk storage containers and from partly used bags shall be batched by mass to an accuracy of within 2 % of the mass required.

4.7.7.2 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 and the water used in mixing the admixtures.

4.7.7.3 Aggregates

4.7.7.3.1 The mass of the aggregates of each size shall be determined and a correction made for the moisture content of the aggregates.

4.7.7.3.2 If a mix is prescribed 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 SANS 5856 and the results used for adjustment of the batch volume of fine aggregate to give the true volume required.

4.7.7.3.3 Additional tests for bulking might be required after rain has fallen or if any other cause of variation in the moisture content of the aggregate has arisen.

4.7.8 Mixing

4.7.8.1 Mixing at the construction site

4.7.8.1.1 The following requirements shall apply to the mixing of concrete at the construction site:

a) Mixing of materials for concrete shall be conducted by an experienced operator.

b) The sequence of charging the mixing plant shall be maintained.

c) The total volume of material per batch shall not exceed the rated capacity of the mixer.

d) Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete shall be removed. Immediately before the mixer is charged with materials at the commencement of each concrete production run, a slurry of cement, sand and water that contains cement and sand in the ratio 1:2 and in sufficient quantities to cover the entire inside surface of the mixer shall be produced in the clean mixer and discharged.

e) 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 requirements of (f), the mixing period for each batch of 1,5 m^3 or less shall be at least 1,5 min and at least 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.

f) 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, and particular attention shall be paid to the removal of any build-up of materials in the drum, in the loading pan and around the blades or paddles.

4.7.8.1.2 Concrete shall only be mixed in quantities required for immediate use. Concrete that has set shall be discarded. In the event of a delay in the concreting operations, concrete may be retained in the mixer for a maximum period of 2 h, provided that the water:cement ratio is not increased to above the maximum limit permissible for strength and durability and the maximum slump is not exceeded. During this time, the mixer shall be restarted and run for about 2 min every 15 min. The period of 2 h shall be reduced if the ambient temperature, or any other factor, tends to produce early setting. Alternatively, if concrete is being cast under cold conditions, this time may be extended. Any addition of water in excess of that permitted by the limitation on the water:cement ratio shall be accompanied by a quantity of cement sufficient to maintain the proper water:cement ratio.

4.7.8.2 Ready-mixed concrete

Ready-mixed concrete shall, unless otherwise specified in the specification data, be mixed in accordance with the requirements of SANS 878.

4.7.8.3 Breeze concrete

Breeze concrete shall consist of 12 parts clinker to 1 part cement. The fine fraction of the clinker shall be mixed with the cement first to make a mortar, after which the coarse fractions shall be added and thoroughly incorporated.

4.7.8.4 No-fines concrete

4.7.8.4.1 No-fines concrete shall be composed of coarse aggregate of a single-size, cement and water. The cement and aggregate shall be mixed in a suitable mechanical mixer with just enough water to form a smooth grout that will completely coat each particle of aggregate and will be fluid enough to flow together to form a fillet at each point of contact of the aggregate particles. Not more than 20 L of water per 50 kg of cement shall be used. The aggregate shall be moist or wetted before the cement is added.

4.7.8.4.2 The aggregate shall, in addition to complying with the applicable requirements of SANS 1083 and SANS 794, be of a nominal size not greater than 20 % of the thickness of the no-fines concrete to be placed and shall be measured by volume in suitable measuring boxes. The proportions of aggregate and cement binder shall be as follows:

a) 0,33 m^3 stone aggregate of nominal single size 38 mm to 50 kg cement;

b) 0,30 m^3 stone aggregate of nominal single size 19 mm to 50 kg cement;

c) 0,27 m^3 stone aggregate of nominal single size 13 mm to 50 kg cement; or

d) 6 parts clinker aggregate to 1 part cement binder.

4.7.8.4.3 Small quantities of no-fines concrete may be mixed by hand in accordance with the requirements of SANS 2001-CC2.

4.7.8.4.4 Reinforcement, if any, shall be pre-coated with cement slurry which shall be allowed to dry before the concrete is placed.

4.7.8.4.5 No-fines concrete shall be placed within 30 min of mixing. It shall be so worked that it fills the space to be concreted and that adjacent particles are in contact with each other. No-fines concrete shall not be vibrated.

4.7.8.4.6 The removal of formwork for no-fines concrete shall comply with 4.3.8, but the minimum curing period shall be 2 d longer than that required at the applicable ambient temperature in terms of 4.7.13.

4.7.9 Transportation of concrete

4.7.9.1 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.

4.7.9.2 Concrete may only be conveyed through pipes made with materials that are non-reactive with cement. Aluminium pipes shall be suitably protected.

4.7.9.3 The capacity of conveying equipment shall be sufficient to ensure that placed concrete does not set before adjacent concrete of the same pour and, as a result, cold joints are formed.

4.7.9.4 Conveying equipment shall be cleaned at the end of each operation or work day.

4.7.10 Placing

4.7.10.1 The forms to be filled shall be clean internally. All excavations and other surfaces of an absorbent nature that will 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.

4.7.10.2 Placing shall be carried out at such a rate that fresh concrete is not integrated with concrete that has partially set.

4.7.10.3 Concrete shall be placed within 1 h of the time of its discharge from the mixer, unless a permitted retarding admixture has been used. Concrete shall not be reworked by the addition of water or any other material.

4.7.10.4 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.

4.7.10.5 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 that does not exceed 450 mm and heaping shall be avoided.

4.7.10.6 Vibrators shall not be used to move concrete laterally within forms.

4.7.10.7 Where a chute is used to convey the concrete, its slope shall be such as not to cause segregation, and a suitable spout or baffles shall be provided for the discharge of the concrete.

NOTE Generally, the chute should be at an angle that exceeds 30° to the horizontal.

4.7.10.8 Concrete shall, in general, not be allowed to fall freely through a height of more than 3 m.

4.7.10.9 Placing of concrete in an element that is supported shall not be commenced until the concrete previously placed in supporting elements (columns, walls or beams) is no longer plastic and has been in place for at least 2 h. When elements that are supported and supporting elements are placed in one operation, the concrete in the vicinity of the junction between these elements shall be revibrated shortly before it sets.

NOTE This procedure is necessary to eliminate defects such as cracks caused by the settlement of solids in the fresh concrete. This is also relevant for horizontal reinforcement in deep sections and in slabs.

4.7.10.10 Unless otherwise specified in the specification data, the entire thickness of a bridge deck shall be placed in one pass so as to avoid the layering of concrete. Fresh concrete shall not be placed against concrete which has been in position for more than 30 min unless a construction joint has been formed or unless a retarding additive has been used in the concrete.

4.7.10.11 In plain concrete with a thickness of not less than 300 mm, plums may, if permitted in terms of the specification data, be included to displace concrete for up to 20 % of the total volume, provided that

a) the plums are spread evenly throughout the concrete;

b) no plum laid shall have a dimension that exceeds one-third of the smallest dimension of the concrete in any plane; and

c) each plum is surrounded by at least 75 mm of concrete.

4.7.10.12 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.

4.7.10.13 Concrete shall not be placed under water unless permitted in terms of the specification data. 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 so that the fresh concrete enters the mass of previously placed concrete from within, causing water to be displaced with minimum disturbance at the surface of the concrete. To maintain the desired properties of the concrete, the quantity of cementitious binder in the concrete mix shall be increased by 20 %.

4.7.10.14 During and after concreting under water, pumping or dewatering operations in the immediate vicinity shall be suspended should there be any danger that such operations will interfere with the freshly placed concrete before it has set and gained sufficient strength.

4.7.10.15 Concrete may be placed by pumping if so permitted in terms of the specification data.

4.7.10.16 No-fines concrete shall be placed in its final position within 15 min of mixing.

4.7.10.17 Where sliding formwork is used, the following additional requirements shall apply:

a) All necessary measures to ensure the continuity of operations shall be taken, including the provision of all the necessary lighting and standby equipment for mixing, hoisting, placing and compacting and the availability of all the materials on site required for completing each structure before casting commences.

b) Concrete shall be cast in uniform layers in the formwork so that the level of the top surface of the concrete differs by no more than 250 mm between any two points in the formwork. In addition, the top level of the concrete shall not be so low down in the formwork as to cause structural instability in the formwork. The working platform shall be kept clean and no concrete which has dried out in part shall be swept into the formwork.

c) The concrete shall be compacted during and immediately after placing. Care shall be taken not to damage or disturb previously placed concrete. To ensure the proper bonding of successive layers, not more than 1 h shall elapse between the placing of successive layers except where a suitable retarding additive has been applied, in which case an appropriate delay is permissible.

4.7.11 Compaction

4.7.11.1 The concrete shall be fully compacted by suitable means during and immediately after placing. It shall be thoroughly worked against the formwork and around reinforcement and other embedded items without displacing them, and into corners of formwork to form a solid void-free mass that has the required surface finish.

NOTE Internal vibrators should be capable of operating at more than 10 000 cycles per minute and external vibrators at more than 3 000 cycles per minute. Sufficient standby vibrators should be kept available in case of breakdowns.

4.7.11.2 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.

4.7.11.3 Compaction shall be carried out by mechanical vibration or, if permitted in terms of the specification data, by spading, rodding or forking. The concrete shall not be over-vibrated, which results in segregation, surface laitance, or leakage, or any combination of these.

NOTE Vibration should be applied continuously during the placing of each batch of concrete until the expulsion of air has virtually ceased. Immersion vibrators should be inserted vertically into the concrete to be compacted, at regular intervals that do not exceed 0,6 m or 10 times the diameter of the vibrator, whichever is the lesser. As soon as a water sheen is visible on the surface, the vibrator should be slowly withdrawn from the concrete, care being taken to avoid the formation of voids.

4.7.11.4 Contact with reinforcement and formwork shall, as far as is practicable, be avoided when internal vibrators are used.

4.7.11.5 When external vibrators are used, the design of formwork and the disposition of vibrators shall be such as to ensure efficient compaction and to avoid surface blemishes.

4.7.11.6 No-fines concrete shall be worked sufficiently to ensure that it will completely fill the space to be concreted and that adjacent aggregate particles are in contact with one another. Excessive tamping shall be avoided and the no-fines concrete shall not, in any circumstances, be vibrated.

4.7.11.7 The rate of concrete placing shall be commensurate with the available compaction equipment and only skilled operators shall undertake compaction by vibration. The number of vibrators used shall be compatible with the rate at which concrete is placed. Standby vibrators shall be made available.

4.7.11.8 Concrete shall not be subjected to disturbance by vibration within 4 h to 24 h of it having been compacted.

NOTE Special attention should be given to the compaction of concrete in the anchorage zones and behind the anchor plates, and in all places where high concentrations of reinforcing steel or cables occur.

4.7.12 Joints

NOTE The location of joints is controlled by design requirements and construction limitations. Joints shown in drawings are "designated joints". The terms "construction 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 caused 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 planned as such ahead of concreting.

4.7.12.1 Construction joints

4.7.12.1.1 Except as allowed in 4.7.12.1.2, concreting shall be carried out continuously up to the locations where joints are shown in the construction drawings or up to pre-planned locations. Unless otherwise constructed (see 4.7.12.3), joints shall be constructed in accordance with

a) the details shown in the drawings, or

b) the applicable requirements of the scope of work.

4.7.12.1.2 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.

4.7.12.1.3 The method adopted for forming joints (including unforeseen joints) shall be one of those contained in table 7, appropriate to the circumstances.

4.7.12.1.4 Proprietary bonding compounds may be used between old and new concrete, if permitted in terms of the specification data.

4.7.12.2 Filled and unfilled joints

4.7.12.2.1 Wherever material susceptible to damage is used for forming joints, it shall be lined with a hard surface on the side to be concreted. The hard surface shall be sufficiently resilient to ensure that the joint and surfaces can be formed free from defects.

4.7.12.2.2 Filled joints shall be accurately formed to the dimensions shown and with the filler material specified in the construction drawings. The filler shall be secured in position so as not to be displaced during concreting or thereafter if the filler is to remain permanently in the joint. Where the removal of the filler is required, it shall be done before the installation of the proprietary joint.

4.7.12.2.3 Unfilled joints shall be accurately formed to the dimensions given in the construction drawings, and all external corners chamfered or rounded for at least 5 mm. The concrete face against which the fresh concrete is placed shall be treated with a suitable bond breaker.

4.7.12.3 Proprietary joints

Proprietary joints shall be installed strictly in accordance with the manufacturer's instructions.

4.7.12.4 Sealing the joints

The sealing of joints shall be undertaken in accordance with the requirements of the scope of work.

Table 7 — Methods of forming construction joints

1	2	3
Method number	**Conditions under which method shall be applied**	**Methodology**
1	Construction joints when concrete is not more than 24 h old	The surface of the concrete shall be brushed with a steel wire brush until the aggregate is 'shining' and the face is clean before new mortar and concrete are placed in accordance with the requirements of method 2.
2	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 and swept clean so that the aggregate is 'shining' and the face is clean. Thereafter, the face shall be 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.
3	Construction joints when concrete is more than 3 d old	The procedure associated with method 2 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.
4	Construction joints at tops of columns	The appropriate procedures for brushing or cleaning associated with methods 1 and 2 shall be followed before the steel reinforcement of the slab or floor to be cast on the columns is placed in position.

4.7.13 Curing and protection

4.7.13.1 All concrete shall be protected from contamination, erosion by rain and flowing water, frost, mechanical damage, and vibration and movement that could disrupt the concrete and interfere with its bond to the reinforcement.

4.7.13.2 As soon as it is practicable (including the period before the formwork is removed), all concrete shall be protected from moisture loss for the period necessary for hydration of the cement and hardening of the concrete by one or more of the following methods, except in the case of sliding formwork and no-fines concrete:

a) ponding the exposed surfaces with water, except where the temperature is below 5 °C;

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; or

e) the use of a suitable curing compound applied in accordance with the manufacturer's instructions.

NOTE Some curing compounds, such as toppings, plasters or paints, applied to the hardened concrete, inhibit the bonding of the finishes. The compound used should therefore be suitable for the intended finish.

4.7.13.3 Concrete in sliding formwork shall be cured by means of a fog spray to keep it wet constantly throughout the curing periods or until a curing compound is applied. Wetting the concrete by spraying shall be done by means of a fixed spraybar along the full length of the sliding formwork. The spraybar shall be connected to a suitable high-pressure water supply. Wetting shall be discontinued when the ambient air temperature drops below 5 °C, and care shall be taken by the contractor to ensure that the water does not erode the surface of the fresh concrete.

4.7.13.4 Whatever method of curing is adopted, its application shall not cause permanent staining, contamination or marring of the surface of the concrete. The water used shall comply with the requirements of 4.2.2.

4.7.13.5 Curing shall continue for at least the appropriate period of time given in table 8.

Table 8 — Minimum curing periods

1	2	3
Strength class of cement	**Minimum curing period** d	
	Ambient temperature	
	15 °C and higher	**5 °C and lower**
42,5 R or higher	3	6
CEM I and CEM II A-S, D, P, Q, V, A, W, T, L, LL, M and blends of CEM I with 20 % or less ground granulated blast-furnace slag or fly ash	7	14
CEM II B-S, P, Q, V, W, T, L, LL, M, CEM III, CEM IV, CEM V and blends of CEM I with more than 20 % ground granulated blast-furnace slag or fly ash	10	20
NOTE When the ambient temperature is between 5 °C and 15 °C, the curing period shall be determined by interpolation between the given periods.		

4.7.13.6 When sliding formwork is used, the concrete shall be protected against the weather and rapid drying out by means of a 4 m wide skirt attached to the lower perimeter of the formwork and hanging over the working platform. The skirt shall consist of hessian in the summer months, but of canvas or other suitable material in winter. The skirt shall be weighted at the bottom to prevent it flapping around in windy conditions.

4.7.13.7 All no-fines concrete shall be protected from the elements and loss of moisture by one or more of the following methods:

a) retaining formwork in place;

b) covering exposed surfaces with sacking or other suitable material that is kept continuously wet; or

c) covering exposed surfaces with plastic sheeting.

4.7.14 Adverse weather

4.7.14.1 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, all reasonable steps shall be taken 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 (or both) 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.

4.7.14.2 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 0 °C or is expected to fall below 0 °C during the curing period (see 4.7.13), water shall not be used for curing. All surfaces shall be protected from ice or frost damage.

4.7.14.3 No-fines concrete placed during cold weather shall be suitably protected against frost for at least 3 d.

4.7.14.4 During sliding operations in cold weather, the water only, or the water and the aggregate, shall be heated to ensure that the concrete temperature will not drop below 10 °C until it has attained a strength of 5 MPa.

4.7.14.5 During cold weather the rate of sliding shall be suitably decreased to ensure sufficient strength in the concrete which leaves the bottom of the formwork.

4.7.14.6 Concrete shall not be placed during periods of heavy or prolonged rain, unless the materials, plant and the concreting operation are well covered.

4.7.15 Concrete surfaces

4.7.15.1 Exposed surfaces of concrete that are not finished against forms (such as horizontal or slightly sloping surfaces) shall be brought up to a plane, uniform surface with suitable screed boards. Unless otherwise specified in the scope of work, the surface finish of concrete which

a) will receive asphalt, concrete surfacing or screeds, or which will be covered by backfilling material, shall be screeded off with a template to the required cross section and tamped with a tamping board to compact the surface thoroughly and to bring mortar to the surface, so as to leave the surface slightly rough but generally at the required elevation;

b) is exposed or will be tiled or surface-coated, shall be wood-floated to a uniform surface free from trowel marks after the concrete has hardened sufficiently; and

c) forms bearing areas or the tops of walls and columns, shall be steel-floated to a smooth surface after the concrete has hardened sufficiently and, if necessary, rubbed down with carborundum stone after the concrete has hardened.

4.7.15.2 Where exposed surfaces are not finished against forms and are required, in terms of the scope of work, to have a non-skid surface, the surface shall be given a broom finish. The corrugations so produced shall be approximately 1 mm deep, uniform in appearance and width and shall be perpendicular to the centre line of the slab.

4.7.15.3 Finished concrete shall have a neat, smooth, even and uniform finish that is free from any honeycombing. If the finish of any formed or floated concrete surface is not suitable and does not conform to that specified, such surface shall be

a) rubbed down while the concrete is still green;

b) ground down with carborundum or other suitable material when it has hardened; or

c) rectified using any other suitable remedial measures to give the specified finish.

4.7.15.4 Surfaces of permanently exposed concrete shall be protected from rust marks, spillage and stains of any description, and other damage during construction.

4.7.16 Watertight concrete

Each section of the works that is required, in terms of the scope of work, to hold or exclude water, shall be watertight, and special care, particularly at construction joints, shall be taken to ensure watertightness. Such concrete shall be tested in accordance with the requirements of 5.1.6.

4.7.17 Concrete in wet ground

Wherever concrete is to be placed in wet ground, shallow drains filled with broken stone and connected to suitably placed sumps, shall be excavated below the ground formation. A concrete carpet, the top of which will form the foundation level for the structural concrete, shall then be laid.

4.7.18 Grouting

4.7.18.1 All relevant concrete surfaces shall first be prepared by scabbling and cleaning where

a) holding-down bolts are to be grouted, or

b) grout is to be placed under column bases or bedplates for mechanical or other equipment.

4.7.18.2 Grouting of supports to structural steelwork shall be in accordance with the requirements of SANS 2001-CS1.

4.7.18.3 The mortar grout for holding-down bolts shall consist of a mixture of 1 part cementitious binder to 2 parts sand, water and, where necessary, an admixture, or be a proprietary grout ready mixed in sealed packets as supplied by the manufacturer and mixed and placed in accordance with the manufacturer's instructions.

The mortar grout shall be so placed into each holding-down bolt pocket or under each base or bed plate (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 plate or a bed plate, that the grout projects beyond the base plate or bed plate.

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 plate or bed plate and the trimmed edge wood-floated to a neat finish.

4.7.18.4 Dry-packed grout shall comprise a mixture of the following:

a) where the clearance between bed plate and foundation is 25 mm or less: 1 part cementitious binder and 2 parts sand suitable for concrete; or

b) where the clearance between bed plate and foundation exceeds 25 mm: 1 part cementitious binder, 1 part sand suitable for concrete and 1 part pea gravel.

4.7.18.5 The quantity of water added to dry-packed grout shall be kept to a minimum, consistent with placing conditions. Dry-packed grout shall be well rammed.

4.7.19 Defects

4.7.19.1 The concrete shall be homogeneous and free from honeycombing, interstices, planes of weakness and cracks formed in the plastic state. If, after the removal of the forms, the concrete shows any defect, patching or remedial work shall be carried out.

4.7.19.2 Surface defects, such as small areas of honeycombing, cavities produced by form ties, large isolated blow-holes, broken corner edges, etc., shall be repaired with mortar that has a cement to sand ratio equal to that of the concrete being repaired.

4.7.19.3 Suitable methods and techniques, such as pneumatically applied mortar, pressure grouting, epoxy bonding agents, etc., may be used for the repair of large or deep areas of honeycombing and defects.

4.7.19.4 Where the extent of the honeycombing or defects is such that doubt exists about the effectiveness of repair work, a full-scale load test shall be performed in accordance with SANS 10100 to prove that the structural safety of the repaired member has not been compromised, failing which, the structure shall be rebuilt in part or in full.

4.7.19.5 Where the concrete has been damaged by adhesion to the formwork panel, the cracked and loose concrete shall be removed. Where the fresh concrete has lifted off at construction joints, the crack shall be scraped out immediately on both sides of the vertical surface to a depth of at least 50 mm. The cavities so formed shall then be repaired as described in 4.7.19.2 and 4.7.19.3.

4.7.20 Rubbing down of concrete surfaces

4.7.20.1 The surface shall be saturated with water for at least 1 h. Initial rubbing shall be done with a medium-coarse carborundum stone, where a small amount of mortar, that has a sand to cement ratio equal to that of the concrete being repaired, is used on the surface.

4.7.20.2 Rubbing shall be continued until all form marks, projections and irregularities have been removed and a uniform surface has been obtained. The paste produced by the rubbing shall be left in place.

4.7.20.3 The final rubbing shall be carried out with a fine carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth, even texture and is uniform in colour. The surface shall then be washed with a brush to remove surplus paste and powder.

4.7.21 The use of sliding formwork

4.7.21.1 General

4.7.21.1.1 The jacking frame shall be constructed with sufficient clearance between the underside of the cross members and the top of the formwork to allow the horizontal reinforcement and embedded items to be correctly installed. A control procedure shall be put in place to ensure that all the reinforcement is placed. There shall be horizontal reinforcement above the level of the top of the formwork panel at all times.

4.7.21.1.2 Guides shall be provided to ensure that the vertical reinforcement can be correctly placed and the specified concrete cover over the reinforcement can be maintained.

4.7.21.1.3 Where the jack rods are to be recovered, suitable precautions shall be taken in respect of their removal, so that the concrete is not damaged.

4.7.21.1.4 Where jack rods occur at openings or wall chases, suitable lateral support shall be provided to prevent their buckling.

4.7.21.1.5 Equipment and material shall be so distributed on the working platforms that the load will be evenly distributed over the jacks.

4.7.21.1.6 Guard plates shall be provided at the tops of the forms to the outside walls to prevent the concrete from falling down the outside.

4.7.21.1.7 The framework, forms and platforms shall be regularly cleared and the accumulation thereon of redundant concrete shall be prevented.

4.7.21.1.8 All precautions shall be taken to prevent contamination of the concrete by leaking oil or other causes.

4.7.21.2 The sliding process

4.7.21.2.1 Sliding shall not commence before the sliding-formwork assembly is fully operative and the complete stock of all materials required for the slide casting, as well as back-up plant and equipment, are on site.

4.7.21.2.2 The rate of sliding shall be such that the concrete at the bottom of the formwork has obtained sufficient strength to support itself and all loads which might be placed on the concrete at the time, and does not adhere to the sides of the forms.

4.7.21.2.3 The slide-casting operation shall be continuous, without any interruptions, until the full height of the structure has been reached, and shall be geared and organized so as to maintain an average sliding rate of 350 mm/h.

4.7.21.3 Interruptions

When the sliding operations are delayed for more than 45 min, the adhesion of the setting concrete to the formwork panels shall be prevented by easing the forms or moving them slightly every 10 min, or alternatively, where reversible jacks are used, by lowering the forms by 10 mm to 25 mm. Wherever interruptions occur, emergency construction joints shall be formed and treated in accordance with 4.7.12. Before concreting is restarted, the form shall be adjusted to fit snugly onto the hardened concrete so as to prevent steps from being formed on the exposed concrete surface. When slide casting is recommenced, care shall be taken to prevent the fresh concrete from being lifted off from the old concrete.

4.7.21.4 Surface treatment

Where the concrete surfaces formed by sliding formwork require treatment to achieve the surface finish specified for the member, the concrete shall, as soon as the surfaces under the formwork are exposed, be floated with rubber-lined floats to the desired finish.

4.7.22 Records

Written records that provide the following information shall be maintained:

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; and

c) the nature of the samples of concrete, the dates on which they were taken and identification by which the results of tests on such samples of concrete may be correlated with the section of work to which they pertain.

4.7.23 Demolition and removal of existing structural concrete

4.7.23.1 Where partial demolition is required for extension work to existing structures, the contact face shall be cut to predetermined lines and levels, any loose and fragmented material shall be removed, and the projecting steel shall be cleaned and bent as necessary. Care shall be taken to ensure that the reinforcement required to tie in the extension work is not cut off or damaged in the demolition process. Where partial demolition is not required, but only extension work, the contact surface shall be roughened and cleaned of all dirt and loose particles.

4.7.23.2 If dowels are required, they shall be installed in holes drilled into the existing structure, in accordance with the details shown in the construction drawings, and secured by means of a suitable type of epoxy-resin grout.

4.7.23.3 Fresh concrete shall be bonded to the old concrete in accordance with the relevant requirements of 4.7.12.1.

4.7.23.4 Only hand-operated breaking equipment shall be used for the demolition of concrete where extension work is required.

4.8 Precast concrete

4.8.1 Casting beds, moulds and formwork

All casting beds shall be properly aligned and levelled. The layout shall be such that work being carried out on any unit(s) does not interfere with, or adversely affect, adjacent operations. Suitable protection against the elements shall be provided should this be necessary to achieve the specified standard. Moulds and formwork shall be such that the concrete surfaces and arrises can comply with 4.8.5.

4.8.2 Concrete mixers

The concrete mixers used shall be specially suited to the production of low slump concrete. Particular attention shall be paid to matching the mixer capacity to the required output.

4.8.3 Vibrating equipment

Vibrating equipment, whether in the form of a vibrating table, an external vibrator attached to a mould, or an immersion vibrator, shall have a frequency that is suitable for the compaction of low slump concrete, and shall have a capacity that exceeds the output of the concrete mixer with which it is used.

4.8.4 Handling, lifting and stacking

Suitable equipment for handling, lifting and stacking shall be provided so that precast units do not become discoloured and are protected from permanent damage due to stresses induced during handling or stacking or due to the use of slings, chains and hooks.

4.8.5 Placing and vibrating of concrete

Concrete shall be so placed in moulds and vibrated that concrete surfaces are smooth and even and all arrises are true and clean.

4.8.6 Units that have architectural finishes

4.8.6.1 Samples of concrete

Where required in terms of the specification data, samples of precast concrete units that have architectural finishes shall be prepared to establish a standard for quality and colour before full-scale production is commenced.

4.8.6.2 Construction and manufacture

4.8.6.2.1 In the case of a unit that is required to have an architectural finish, particular care shall be taken to ensure that the facing is thick enough to comply with the architectural requirements, but is not so thick as to moderate the strength of the unit. Care shall also be taken to ensure complete homogeneity between the finished facing and the concrete backing.

4.8.6.2.2 Where an exposed aggregate finish is scheduled or required in terms of the construction drawings, care shall be taken to ensure that the retarder used does not weaken the bond between the exposed stone and the concrete backing.

4.8.6.2.3 Where a mosaic finish is required in terms of the scope of work, before the sheets of mosaic are laid and backing concrete is poured into the moulds, the bottom of each mould in which the concrete is to be cast shall be cleared of foreign matter, such as stones or pebbles, that might create irregularities in the finished face. The concrete shall be so placed that the mosaic is fully bonded to the concrete backing.

4.8.6.3 Erection

4.8.6.3.1 The design and shape of each unit with architectural finishes and the devices cast in for fixing the unit shall be such that the unit is held firmly and permanently in its intended position. Particular care shall be taken not to chip corners or edges or to otherwise damage the exposed faces of the units while erecting and fixing them.

4.8.6.3.2 Damaged units may be repaired where it can be demonstrated that suitably bonded patches of matching colour and texture will not, after curing and drying, be or become apparent.

4.8.7 Reinforcement in precast concrete

Where practicable, reinforcement in precast concrete work shall be preformed into rigid cages. For this purpose the spot welding of mild steel reinforcement and high tensile reinforcement shall only be carried out by skilled and experienced welders.

4.8.8 Curing of precast concrete works

4.8.8.1 Curing at ambient temperature

Curing in accordance with the requirements of 4.7.13 at ambient temperature shall start not earlier than 6 h after the concrete has been placed.

4.8.8.2 Steam curing

Provided that the curing temperature does not exceed 60 °C, and that the rate of increase or decrease of the curing temperature does not exceed 20 °C/h, precast concrete may be steam cured at atmospheric pressure or curing may be accelerated by casting the concrete in heated moulds.

4.8.8.3 Demoulding

Precast concrete units shall not be moved from casting beds until the concrete from which they have been made has gained sufficient strength to ensure that the units are capable of resisting, without permanent damage, all stresses induced during such movement.

4.9 Prestressed concrete

4.9.1 Apparatus

4.9.1.1 The tensioning apparatus shall be capable of applying to a tendon a controlled force that can be increased gradually in stages and in such a way that no significant secondary stresses are induced in the tendon, anchorage or concrete.

4.9.1.2 The force in the tendons during tensioning shall be measured by direct-reading load cells or obtained indirectly from gauges of minimum diameter 150 mm fitted into the hydraulic systems to determine the pressure in the jacks. When pressure gauges are used, they shall be calibrated

together with the jack to allow for jack friction. Facilities shall be provided for the measurement of the extension of the tendon and of any movement of the tendon in the anchorage devices. The force measuring device shall be calibrated to an accuracy of ± 2 % (or better) and checked at intervals not greater than 6 months. Elongation of the tendon shall be measured to an accuracy of at least 2 % or 2 mm, whichever is the more accurate.

4.9.1.3 The grout-pumping equipment shall be capable of developing and maintaining a pressure of at least 0,7 MPa. Each pump shall be fitted with a pressure gauge and with a controlling device that will effectively prevent the build-up of excessive pressure.

4.9.1.4 Piping to the grout pump shall have a minimum of bends, valves and changes in diameter, and connections shall be air-tight. All baffles to the pump shall be fitted with sieve strainers of aperture size 3 mm. All equipment, especially piping, shall be thoroughly flushed with clean water after every series of operations and more frequently, if necessary. Intervals between washings shall not exceed 3 h.

4.9.2 Tendons

4.9.2.1 Surface condition

4.9.2.1.1 All prestressing tendons and internal and external surfaces of sheaths shall, at the time of incorporation of the tendons and sheaths in the structural unit, be free from pitting, loose mill scale, loose rust, paint and oil, grease, soap and other lubricants, and any other harmful matter. A tendon may be cleaned by wire brushing or by passing the tendon through a pressure box containing carborundum powder. Solvent solutions for cleaning shall not be used unless otherwise specified in the specification data.

4.9.2.1.2 Any prestressing steel or sheath which is excessively rusty or otherwise unsuitable, shall be removed from the site and not incorporated in the works.

4.9.2.2 Straightness

4.9.2.2.1 Wire and strand shall be in coils of such diameter that the curvature of the uncoiled wire or strand complies with the applicable requirements for curvature given in BS 5896.

4.9.2.2.2 Prestressing bars, as delivered, shall be straight, except that where small adjustments will achieve straightness, such adjustments may be made by hand on site under the supervision of a person who is qualified by virtue of his experience and training to perform such a task.

4.9.2.2.3 Straightening of bars shall be carried out at ambient temperature. If the ambient temperature is less than 5 °C, any heating required to raise the temperature of the bars above 5 °C shall be done by means of steam or hot water.

4.9.2.2.4 Bars that are bent in the threaded part shall be rejected.

4.9.2.3 Cutting

4.9.2.3.1 The cutting to length and trimming of ends shall be done by means of

a) a high-speed abrasive cutting wheel, friction saw or any other suitable mechanical method, or

b) an oxy-acetylene cutting flame, and excess oxygen shall be used to ensure a cutting rather than a melting action, the cutting shall be so done that neither the flame nor splashes come into contact with the anchorage or with other tendons.

4.9.2.3.2 In the case of post-tensioning systems, cutting shall be done as specified in 4.9.2.3.1(a), the heating effect on the tendon shall be kept to a minimum such that the temperature of the tendon adjacent to the anchorage does not exceed 200 °C .

4.9.2.3.3 The tendons or the elements of the tendons, as relevant, shall be cut or released in the order that will produce the least lateral eccentricity of prestress at any stage.

4.9.2.4 Positioning of tendons and sheaths

4.9.2.4.1 Tendons and sheaths shall be accurately located and their vertical and horizontal positions accurately maintained as shown in the construction drawings. The method of supporting and fixing the tendons (or the sheathing) in position shall be such that they will not be displaced by heavy or prolonged vibration, by pressure of the wet concrete, by workmen or by construction traffic. These supports shall not unnecessarily increase the friction when they are being tensioned.

4.9.2.4.2 The assembly of post-tensioning tendons shall be done on raised platforms or tables that are fully protected from the weather.

4.9.2.4.3 Sheaths shall be handled carefully to avoid their being damaged and in order to ensure that they retain their cross section and profile. When preparing the tendons, wires and strands shall be laid out in parallel and maintained in position by metal or PVC spacers before insertion into the sheath.

4.9.2.4.4 Joints in sheathing shall be securely taped and water-tested to prevent penetration of the sheath by concrete or cement paste, and the ends of sheaths shall be sealed and protected after the stressing and grouting operations. Joints in adjacent sheathing shall be staggered at least 300 mm.

4.9.2.4.5 As damage might occur during the concreting operation, and if the tendon is to be inserted later, the sheath shall be water-tested before the concreting operation to ensure a clear passage for the tendon.

4.9.2.4.6 Where possible, all wires or strands to be stressed in one operation shall be taken from the same batch of prestressing steel. Each tendon shall be tagged with its number and the coil number(s) of the steel used. Tendons shall not be kinked or twisted and individual wires and strands shall be readily identifiable at each end of a member. A strand that has become unravelled shall not be used.

4.9.2.4.7 Tendons shall be clearly marked at each end so that extensions, slips or other movements that occur can be accurately measured.

4.9.2.5 Tensioning procedure

4.9.2.5.1 All tendons shall be free to move in the ducts before being tensioned. The sequence of prestressing shall be such that the permissible stresses in the unit or structure, as specified in the prestressing force diagram provided in the scope of work, are not exceeded. Tensioning shall be carried out by personnel who are suitably qualified, and under constant supervision of a person who is qualified by virtue of his experience and training to perform such a task

4.9.2.5.2 Immediately after concreting has been completed, the sheaths shall be flushed with water and the water expelled by compressed air. Unless the sides of a unit are outward sloping in such a direction that uplift will not be impeded, side forms shall be removed before the unit is stressed.

4.9.2.5.3 Tensioning shall be so carried out that the stress in the tendons increases gradually and at a steady rate. Tensioning shall not be carried out while the ambient temperature is below 0 °C.

4.9.2.5.4 Except where load cells are used, allowance shall be made during stressing for friction losses in the jack and in the anchorage.

4.9.2.5.5 Tendons shall be stressed to the specified force. Sufficient measurements shall be taken to complete a force-extension diagram. The measurement of extension shall be corrected for any pull-in of the tendon that occurs at the non-jacking end, and for any slack in the tendon.

4.9.2.5.6 Where two or more wires or strands are stressed simultaneously, they shall be parallel and of approximately equal length between the anchorage points at the datum of force and extension measurement. The degree of variation in individual extensions shall be small in comparison with the expected extension.

4.9.2.5.7 The actions taken to rectify faults where the full stress cannot be attained in a unit because of breakage, slippage or blockage of a sheath, and replacement of that unit is not practicable, shall be such that the structural safety and structural serviceability performance of the structure is not compromised.

4.9.2.5.8 In the case of curved tendons, or tendons made up of a number of components, or tendons loaded in stages, the order of loading and the magnitude of the load for each component of the tendon shall be as specified in the scope of work.

4.9.2.5.9 During the period between stressing the tendons and covering them with grout, concrete or other permanent protection, the tensioned tendons and their anchorages and sheaths shall be protected from corrosion. The ends and vents of all such sheaths shall be plugged.

4.9.2.5.10 In the case of post-tensioning, the tendons shall not be stressed until the concrete strength has been found, by valid test results, to be at least equal to the specified strength for the stage concerned.

In the case of pre-tensioning, transfer shall not take place until the concrete strength has been found, by valid test results, to be at least equal to the specified strength for the stage concerned.

4.9.2.5.11 Records shall be kept of every stressing operation. Such records shall include the date, the coil number, the stressing force, the extension, the unit number or position, the concrete cube strength at the time of stressing, and any other relevant information.

4.9.2.5.12 The final stage of tensioning will be deemed to have been satisfactorily accomplished when the tendons comply with all of the following requirements:

a) each tendon shall have been tensioned to the required force;

b) the measured extension on individual tendons shall be within 6 % of the theoretical extension;

c) the average of the measured extensions of all the tendons in a unit shall not deviate from the theoretical extension by more than 3 %; and

d) the release or pull-in (or both) as relevant, shall, in the case of each tendon, be within 2 mm of the designated value.

4.9.2.5.13 Should any individual tendon or group of tendons fail to comply with any of the applicable requirements, the remedial action shall be such that the design intent with respect to structural safety and structural serviceability is not compromised. In the event of the friction of any tendon being too high, a suitable water-soluble lubricant may be injected into the sheath after having first released the tension in the tendon.

4.9.2.5.14 The part of the tendons projecting beyond the anchorages may be cut after the tensioning has complied with all requirements. The projecting part of tendons may be cut before grouting is carried out.

4.9.3 Grouting of sheaths

4.9.3.1 General

4.9.3.1.1 The stressed tendons shall be protected and an efficient bond shall be achieved between the stressed tendons and the concrete of the unit when the sheaths of prestressed concrete units are being grouted by

a) using efficient equipment;

b) providing a good quality of workmanship under careful supervision of a person who is qualified by virtue of his experience and training to perform such a task;

c) ensuring that the grout is mixed with a water:cement (w:c) ratio of between 0,38 and 0,43;

d) ensuring that the grout has good fluidity and low sedimentation (i.e. a low tendency to bleed) and is injected in the plastic state;

e) ensuring that the grout forms a suitable bond with the tendons and the sides of the sheaths; and

f) adopting methods that can effectively and reasonably easily be carried out on site.

4.9.3.1.2 When so specified in the specification data, bleeding tests or grouting trials (or both) shall be undertaken.

4.9.3.2 Sheaths

4.9.3.2.1 A vent shall be provided and used at each crest in the case of a profiled sheath, and at intervals of not more than 15 m, in the case of a straight sheath.

4.9.3.2.2 Before grouting is carried out, all sheaths shall be thoroughly cleaned by thorough flushing with water immediately before grouting.

4.9.3.3 Grout

A suitable plasticizer shall be used in the grout. The grout shall be such that, when it is tested in accordance with 5.1.5.5.1, bleeding does not exceed 2 % after 3 h, or 4 % max. when bleeding is complete, and the bleed water shall be re-absorbed fully after 24 h.

4.9.3.4 Grout mix design

At least one month before the commencement of grouting on site, tests shall be carried out to determine whether the grout complies with the requirements of this part of SANS 2001 for fluidity, bleeding and strength. After establishing a grout mix design that yields a grout that complies with the said requirements, the mix design shall not be altered unless trial mixes of any altered mix are made and tested.

4.9.3.5 Mixing

When grout is mixed, first water shall be added to the mixer and then the cement. Only after the water and cement have been thoroughly mixed shall any admixture or sand be added. Mixing shall then be continued until a uniform consistency is obtained but, in any event, for at least 2 min. The water:cement ratio of the mix shall be as low as possible within the mass fraction range 0,35 to 0,5, and the mix shall have the required fluidity. Mixing shall not be done by hand.

4.9.3.6 Injection of grout

4.9.3.6.1 Grouting shall be carried out as soon as is practicable after the tendons have been stressed, but not before the stressing records have been analysed for compliance with the requirements of this part of SANS 2001.

4.9.3.6.2 The method of injecting grout shall be continuous and slow enough to avoid segregation of the components of the grout and to ensure complete filling of the sheaths and complete encasement of the tendons. The pump suction intake shall at all times during the grouting operation be kept below the surface of the grout. Grout shall be allowed to flow successively from each intermediate vent and from the free end of a sheath until the consistency of the effluent grout is equivalent to that of the grout injected, whereupon the inlet opening as well as all intermediate vents, shall be firmly closed off, one after the other, following the direction of the flow.

4.9.3.6.3 Further injections shall be carried out as necessary to fill any cavities that are found.

4.9.3.6.4 When the injection of grout has been completed, the injection tube shall be sealed off under pressure, which shall be maintained until the grout has set. The vents (if any) shall be opened 24 h after the injection of the grout, and any voids that might be present shall be filled with grout poured in under gravity.

4.9.3.7 Grouting during cold weather

4.9.3.7.1 When the weather at the site is cold, accurate temperature records shall be kept stating the maximum and minimum air temperatures and the temperatures (at the time of grouting) of the units to be grouted.

4.9.3.7.2 Materials in which snow, frost or ice is present shall not be used. Sheaths and equipment shall be completely free of snow, frost and ice.

4.9.3.7.3 Except where the unit is so heated as to maintain the temperature of the grout above 5 °C for at least 48 h after the grout has been placed, no grout shall be placed when the temperature of the unit is below 5 °C or is likely to fall below 5 °C during the next 48 h. Except when the heating of sheaths is accompanied by a general external heating of the unit or structure, sheaths shall not be heated in any way. Grout materials shall be maintained at a temperature of at least 5 °C.

4.9.3.8 Compressive strength of grout

Cubes (of sides 100 mm) made of the grout used, and cured at a temperature of 22 °C to 25 °C and a relative humidity of at least 90 % for the first 24 h, and then kept in water at 22 °C to 25 °C, shall have a compressive strength that exceeds 20 MPa at 7 d.

4.9.4 Permanent protection and bonding of external tendons

4.9.4.1 After having been tensioned, external tendons in structures such as circular structures for water storage, shall receive permanent protection against mechanical damage and corrosion. Such tendons shall be so encased in a dense concrete, mortar or grout that suitable durability and density with low shrinkage are developed in the hardened state and a suitable bond is formed with the tendons and with the parent concrete. The encasement material may be applied by means of compressed air or by any other means that can effectively and reasonably easily be used on site. A suitable plasticizer may be incorporated in the grout mix.

4.9.4.2 When so required in terms of the specification data, preliminary tests shall be undertaken on the proposed encasement materials, to obtain a mix design that will yield a concrete, mortar or grout that complies with the requirements for durability, density, shrinkage and bonding. Once a suitable mix design has been determined, the design shall not be altered unless trial mixes have been made and tested for the use of the altered mix.

4.9.4.3 Protection and bonding of the tendons shall be effected within 7 d after final tensioning of the tendon(s), or as specified in the specification data.

4.9.4.4 After the encasement or bonding has been completed, the anchorages shall be encased in concrete or grout, or completely coated with a corrosion-resistant material. The protection provided shall be such that it prevents the ingress of water and aggressive agents.

4.9.5 Pre-tensioning

4.9.5.1 General

Where pre-tensioning methods are used, positive means shall be used to maintain the full pre-stressing force during the period between tensioning and transfer. The force shall be transferred slowly to minimize shock, which would adversely affect the transmission length.

4.9.5.2 Straight tendons

4.9.5.2.1 In the long-line method of pre-tensioning, sufficient locator plates shall be distributed along the length of the bed to ensure that the wires or strands are maintained in their proper position during concreting. Where a number of units are made in line, they shall be free to slide in the direction of their length and thus permit transfer of the prestressing force to the concrete along the whole line.

4.9.5.2.2 In the individual mould system, the moulds shall be made sufficiently rigid to accommodate the reaction to the prestressing force without distortion.

4.9.5.3 Deflected tendons

4.9.5.3.1 Where practical, the mechanisms for holding down or holding up tendons shall be such that the part in contact with the tendon is free to move in the line of the tendon in order to eliminate frictional losses. If, however, a system is used that develops a frictional force, this force shall be determined by testing, and due allowance shall be made for the applied force.

4.9.5.3.2 For a single tendon, the deflector in contact with the tendon shall have a radius of at least 5 times the tendon diameter for wire, or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15°.

4.9.5.3.3 The transfer of the prestressing force to the concrete in conjunction with the release of hold-down and hold-up forces shall be so effected that any tensile stresses in the concrete that result during the process, do not exceed the permissible limits.

4.10 Handling and erection of precast concrete units

4.10.1 Handling and transportation

4.10.1.1 Prestressed units shall not be removed from casting beds until the units have been sufficiently stressed to ensure that they resist, without permanent damage, all stresses induced during such movement.

4.10.1.2 The lugs, slots, holes, etc., provided for handling precast units and moving them from the point of manufacture to the place where they are erected, shall be suitable and shall be so arranged that excessive stresses do not occur in any unit during handling, movement or erection.

4.10.1.3 The position of lifting and supporting points, the method of lifting, and the type of equipment and transport used shall be as specified in the scope of work.

4.10.1.4 Indelible identity, location, and orientation marks shall be placed on each unit, as and where necessary.

4.10.1.5 Packing pieces shall be such that they do not discolour or otherwise permanently damage the units.

4.10.1.6 Units shall be so stacked that

a) the accumulation of trapped water and dirt is prevented, and

b) in the case of small units, deformation is minimized during the curing process, and

c) large units, such as bridge beams (particularly prestressed beams) have complete freedom of movement during the curing process.

4.10.2 Assembly and erection

The method of assembly and erection specified in the scope of work shall be adhered to on site. Immediately after a unit is in position and before the lifting equipment is removed, temporary supports or temporary connections between units shall be provided, as necessary. The final structural connections shall be completed as soon as is practicable.

4.10.3 Temporary supports during construction

4.10.3.1 Temporary supports shall be so designed and arranged that account is taken of

a) all construction loads (including wind loads) likely to be encountered during the completion of the joints between any combination of precast and cast-in-situ concrete structural units,

b) when appropriate, movements, including those due to shrinkage of concrete and any tensioning,

c) the need to prevent any local collapse from becoming progressive if a unit breaks accidentally and strikes against another during erection, and

d) proper finishing and curing of any cast-in-situ concrete, mortar or grout.

4.10.3.2 Temporary supports shall not be removed or released until the specified strength is attained in the cast-in-situ portion of a construction and until structural integrity is achieved.

4.10.4 Forming structural connections

4.10.4.1 Each precast unit shall be inspected to ensure that

a) the structural connection complies with the design requirements specified in the scope of work,

b) the location of reinforcement and structural steel sections in the ends of precast units is accurate, and

c) any additional reinforcement needed to complete a connection is introduced.

4.10.4.2 Each precast unit shall be free from irregularities of such size and shape as to lead to stress concentrations that could be damaging.

4.10.4.3 The contact surfaces of each precast unit shall be suitably prepared to provide the specified bond between the unit and cast-in-situ concrete or to develop the specified frictional resistance at a bearing.

4.10.4.4 The packing of joints shall be carried out in accordance with the assembly instructions.

4.10.4.5 Tests shall be carried out when joints between units, particularly the horizontal joints between successive vertical lifts, are load-bearing and packed with mortar or concrete, to prove that the material is suitable for the purpose and that the proposed method of filling will result in a solid joint.

4.10.4.6 The cast-in-situ material shall be thoroughly compacted.

5 Compliance with the requirements

5.1 Testing

5.1.1 General

5.1.1.1 When concrete of a particular grade is being placed, samples of concrete shall be taken in accordance with SANS 5861-2, as close as is practicable to the start of placing and at appropriate intervals thereafter, or from one particular batch and then from subsequent batches chosen at appropriate intervals.

5.1.1.2 Slump shall be measured in accordance with SANS 5862-1. Flow shall be measured in accordance with SANS 5862-2.

5.1.1.3 Concrete cubes shall be cast and cured in accordance with SANS 5861-3. Cubes cured on site shall be cured in water at a temperature between 22 °C and 25 °C.

5.1.1.4 Cubes shall be tested in accordance with SANS 5863 to obtain valid test results. Three cubes shall be tested to obtain valid results.

5.1.1.5 Site testing shall be carried out by a person who is qualified by virtue of his experience and training to perform such a task. Laboratory testing shall be carried out by an accredited testing laboratory.

5.1.1.6 The relevant test methods given in BS 5896 and BS 4486 shall apply to steel wire, strand and bars used for stressing.

5.1.1.7 Unless otherwise specified in the specification data, test results that form part of the quality control system of a ready-mix production facility shall not be accepted as valid test results when the strength of the concrete is evaluated in terms of 5.1.2.

5.1.1.8 The test for the percentage of alkali-aggregate shall be as specified in the specification data.

5.1.2 Acceptance of strength concrete

5.1.2.1 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 shall be deemed not to comply with the requirements of this part of SANS 2001.

5.1.2.2 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. Where the value of the age (in days) of such consecutive tests is at least equal to the value of the specified strength (in MPa), the concrete yielding such result shall be accepted but the mix design and standard of control shall be reviewed and adjusted if necessary to comply with the requirements of table 9.

Table 9 — Required average strength

1	2
Number of tests	**Required average strength**
4	Specified characteristic strength + 3 MPa
5	Specified characteristic strength + 4,5 MPa
6	Specified characteristic strength + 5,0 MPa
10	Specified characteristic strength + 6,0 MPa
20	Specified characteristic strength + 7,0 MPa

5.1.2.3 Where a concreting operation is of such magnitude or the sampling is of such frequency that 30 or more valid test results have become available within three months, and if permitted or required in terms of the specification data, the results shall be assessed statistically instead of in terms of 5.1.2.2, as relevant. In such case, the average of all the test results of a specific grade at any stage shall exceed the specified strength by at least 1,64 standard deviations. If the average of such test results fails to comply with this requirement, the mix design shall be adjusted to ensure compliance with this criterion.

5.1.2.4 If, after evaluation of the test results in terms of 5.1.2.1 and 5.1.2.2 or 5.1.2.3, as relevant, an examination of the concrete in the structure is indicated, one or more of the following procedures, in the sequence given, may be adopted to determine the structural adequacy, durability or performance 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 (for example, impact hammers and ultrasonic testing), subject to similar concrete of proved quality being available in comparable members in the same construction as a reference, as well as apparatus that have previously been calibrated;

c) the testing of drilled cores in accordance with SANS 5865 with the test results being interpreted in accordance with the requirements of SANS 10100; and

d) full-scale load tests in accordance with SANS 10100.

5.1.2.5 Core holes shall be filled with low-slump concrete or mortar.

5.1.3 Frequency of sampling

5.1.3.1 Subject to the requirements of 5.1.3.3, while concrete of a particular grade and in sufficient quantity is being placed under the same conditions, sets of samples of concrete (each sample being sufficient for three cubes, beams, cylinders or prisms, as relevant) shall be taken for each testing age.

5.1.3.2 Unless otherwise specified in the specification data, at least one set of samples of concrete shall be taken from each day's casting and from at least every 50 m^3 of concrete of each grade placed.

5.1.3.3 Only one sample of concrete shall be drawn from any one batch of concrete and no sample of concrete shall be taken of any grade until at least three batches of such grade have been mixed and discharged.

5.1.4 Individual load tests on precast units and prestressed units

5.1.4.1 General

Where so required and in the manner specified in the specification data, carry out the load tests given in 5.1.4.2 to 5.1.4.3. Apply and remove the test loads incrementally.

5.1.4.2 Non-destructive (service) test

5.1.4.2.1 Support the unit at its designed points of support and load the unit for 5 min with a load equal to the sum of the characteristic dead load plus 1,25 times the characteristic imposed load, and record the deflection. Check the maximum deflection measured after application of the load for compliance with the applicable requirements specified in the specification data.

5.1.4.2.2 Measure the recovery 5 min after the removal of the applied load and then re-impose the load. Ensure that the percentage recovery after the second loading is at least equal to that determined after the first loading and at least 90 % of the deflection recorded during the second loading. Ensure that at no time during the test there is any sign of weakness or faulty construction in the unit(s) under test.

5.1.4.3 Destructive (ultimate) test

Support the unit at its design points of support, and load the unit to its ultimate design load as specified in the specification data. Ensure that the unit does not fail within 15 min after the application of the ultimate design load. Regard a deflection that exceeds 1/40 of the span as failure of the unit.

5.1.4.4 Special tests

For very large units or units not amenable to the tests given in 5.1.4.2 or 5.1.4.3, such as columns, the precast parts of composite beams, and units designed for continuity of fixity, ensure that the details of the testing arrangements are as specified in the specification data.

5.1.5 Tests on prestressed structures

5.1.5.1 Age at test

5.1.5.1.1 Where particular tests on structures or on parts of structures are required in terms of the specification data, carry out the tests as soon as possible after a period of 28 d that commences at the time of the placing of the concrete. When a test is required for a reason other than that the quality of the concrete in the structure has to be assessed, the test may be carried out earlier than the end of the said 28 d period, provided that the concrete has already reached its specified strength.

5.1.5.1.2 When prestressed concrete is tested, make allowance for the fact that the effective prestress at the time of testing will be greater than the value that will prevail during the working life of the structure.

5.1.5.2 Test loads

5.1.5.2.1 Apply test loads incrementally and as follows:

a) Ensure that the test loads to be applied for the determination of the limit states of deflection and local damage are the characteristic dead and imposed loads. When the ultimate limit state is being considered, ensure that the test load maintained for a period of 24 h is the greater of

   1) the sum of the characteristic dead load and 1,25 times the characteristic imposed load, or

2) 1,125 times the sum of the characteristic dead and imposed loads.

b) Where only part of a structure will be tested, take special precautions to ensure that all the units actually under test are subjected to the full test load, making proper allowance for load sharing between units.

5.1.5.2.2 Add compensating loads as necessary, should any part of the characteristic dead load not be in position on the structure.

5.1.5.3 Measurements during tests

Take measurements of deflection and crack width immediately after the application of each incremental load. In the case of the 24 h sustained load test, take the measurement of deflection and crack width at the end of the 24 h period of loading, after removal of the load and after the 24 h recovery period. Take sufficient measurements to enable side effects to be taken into account. Record temperature and weather conditions during the test.

5.1.5.4 Acceptance criteria

Subject to due allowance being made for the possible effects on a structure or part of a structure of variations in temperature and humidity during the period of the test, the following acceptance criteria shall apply:

a) Cracks in the concrete shall be in accordance with the acceptance criteria given in table 10 for the class of prestressed concrete structure specified in the specification data, or if not so specified, the most appropriate exposure given in table 10.

b) For units that span two supports, the deflection measured immediately after application of the test load for deflection shall not exceed 1/500 of the effective span.

c) For units that are cantilevered, the deflection measured immediately after application of the test load for deflection shall not exceed the value as specified in the specification data.

d) If the maximum deflection in millimetres, occurring during a period of 24 h under the test load, is less than 40 L^2/d, where L is the effective span in metres and d the overall depth of construction in millimetres, it is not necessary for the recovery to be measured and the criteria of (e) and (f) shall not apply.

e) If the maximum deflection is equal to or more than 40 L^2/d (see (d)) and if, within 24 h of the removal of the test load for the ultimate limit state calculated in accordance with 5.1.5.2, a class 3 prestressed concrete structure does not show a recovery of at least 75 % of the maximum deflection that occurred during the 24 h under load, repeat the loading. Unless there is a recovery of at least 75 % of the maximum deflection that occurred during the second loading, the structure shall be regarded as having failed to pass the test.

f) If, within 24 h of the removal of the test load for the ultimate limit state calculated in accordance with 5.1.5.2, a class 1 or class 2 prestressed concrete structure does not show a recovery of at least 85 % of the maximum deflection that occurred during the 24 h under load, repeat the loading. The structure shall be regarded as having failed to pass the test if the recovery after the second loading is not at least 85 % of the maximum deflection that occurred during the second loading.

Table 10 — Acceptance criteria for crack widths

1	2	3
Class of prestressed structure	**Typical condition of exposure**	**Acceptance criteria**
1	**Moderate:** concrete surfaces above ground level and protected against alternately wet and dry conditions caused by water, rain and sea water	No visible cracks shall occur on application of the test load for local damage.
2	**Severe:** concrete surfaces exposed to hard rain and alternately wet and dry conditions	
3	**Very severe:** concrete surfaces exposed to aggressive water, sea-water spray or a saline atmosphere	The maximum width of any crack measured immediately on application of the test load for local damage shall not exceed 0,07 mm and the width of any such crack shall not exceed 0,13 mm.
	Extreme: concrete surfaces exposed to the abrasive action of sea water or very aggressive water	As specified in the specification data.

5.1.5.5 Tests on grout

5.1.5.5.1 Bleeding

Place a sample of the grout in a covered graduated cylinder of diameter approximately 100 mm and fitted with a thermometer. Ensure that the height of the grout in the cylinder is 100 mm. Keep the temperature of the grout at 20 °C ± 2 °C and check the bleeding for compliance with 4.9.3.3.

5.1.5.5.2 Compressive strength

Take a sample of the grout in accordance with SANS 5861-2. Test the grout in accordance with SANS 5863. Check compressive strength for compliance with 4.9.3.8.

5.1.6 Tests for watertightness

5.1.6.1 Clean the structure and initially fill it, at a uniform rate of not more than 2,0 m in 24 h, to the normal maximum level with water or any other liquid as specified in the specification data. When first filled, maintain the liquid level by the addition of further liquid for the stabilizing period specified in the specification data while absorption and autogenous healing take place.

After the stabilizing period, record the level of the liquid surface at 24 h intervals for a test period of 7 d. During this 7 d period, the total permissible drop in level, after allowing for evaporation and rainfall, shall not exceed the value specified in the specification data.

5.1.6.2 Test the roofs of liquid-retaining structures, where practical, upon completion, by flooding the roof to a minimum depth of 25 mm for 24 h or longer. Where it is impractical, because of roof falls or otherwise, to contain a 25 mm depth of water, apply water continuously by a hose or sprinkler system to provide a sheet flow over the entire area of the roof for a period of not less than 6 h. In either case, no leaks or dampness shall be visible on the soffit.

5.1.6.3 Should any such section of the concrete works fail to pass the tests for watertightness, or show any sign of water leakage or penetration after being taken into use, it shall be deemed defective.

Carry out any necessary remedial treatment of the concrete, cracks or joints, wherever practicable, from the surface which is in contact with the liquid face. Ensure that remedial linings applied to inhibit leakage at a crack have suitable flexibility and have no reaction with the stored liquid.

Test the repaired structure in accordance with the requirements of 5.1.6.1 or 5.1.6.2, as relevant.

5.1.7 Test for sulfate content

Calculate the total sulfate content from the various constituents of the mix as follows:

a) cementitious binder: use SANS 50196-2

b) aggregates: use SANS 5850-2

5.2 Tolerances

5.2.1 General

5.2.1.1 Permissible deviations appropriate to the degree of accuracy specified in the scope of work shall be applied to linear dimensions, position, verticality, levelness, squareness and bow. If no degree of accuracy is specified, degree of accuracy II shall apply.

NOTE 1 Degree of accuracy III is suitable for use where a high degree of accuracy is unnecessary, for example, mass foundations, concrete elements in buildings, such as reinforced foundations, frames, walls, columns and beams that are normally plastered, painted or hidden from view.

NOTE 2 Degree of accuracy II is suitable for work where a reasonable degree of accuracy is required.

NOTE 3 Degree of accuracy I is suitable where the use of special, as opposed to normal, methods or materials (or both) is warranted despite the probability of higher costs than those caused by the use of degree of accuracy II. This may apply where, for example, prefabricated units (windows and precast panels) are required to fit in position.

NOTE 4 Where precast units are to fit on or between cast-in-situ concrete units, the tolerances applicable to the cast-in-situ concrete should be compatible with the tolerances applicable to the precast units.

5.2.1.2 Where a wood-floated or steel-floated or power-floated finish or a screed topping or granolithic finish is required in terms of the scope of work, the concrete shall, unless otherwise specified in the specification data, be finished to a degree of accuracy II.

5.2.1.3 Any deviation from flatness of a plane surface or any abrupt change in a continuous surface shall 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.

5.2.1.4 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, shall be measured in accordance with 5.2.1.3.

5.2.1.5 Out of squareness of a corner or an opening or an element, such as a column, shall 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.

5.2.1.6 The straightness or bow in precast concrete beams shall be measured from the intended line on a part, or on the overall length, of the beam.

5.2.2 Accuracy of the concrete works

5.2.2.1 The various parts of the concrete works shall, unless otherwise specified in the scope of work, be constructed within the limits of the applicable permissible deviation set out in table 11.

5.2.2.2 Where precast units are to fit on or between cast-in-situ concrete units, the tolerances applicable to the cast-in-situ concrete shall be compatible with the tolerances applicable to the precast units.

5.2.2.3 In addition to 5.2.2.2, precast beams shall be constructed within the limits of permissible deviation set out in table 12.

5.2.3 Accuracy of cover to concrete

The cover of concrete over reinforcement specified in 4.4.3 shall not be reduced and shall take precedence over any permissible deviation given in table 11 or 12, for example, where a reinforcing steel bar is bent to the maximum length permitted in terms of SANS 282, the permissible deviation applicable to the relevant dimension of the concrete structure shall be such that the specified cover is obtained.

5.2.4 Accuracy of concrete surfaces

Any departure from flatness and the height or depth of any irregularity of an exposed finished plane concrete surface shall not exceed the applicable maximum value given in table 11 or 12, as revelant. The specified accuracy shall be achieved without any treatment except the rubbing down of hardened surfaces with carborundum blocks.

5.2.5 Accuracy of formwork

Formwork shall be so constructed that the permissible deviations of the finished foundations and elements or components above foundations are in accordance with the requirements of table 11 or 12, as relevant.

5.2.6 Accuracy of constituents in prescribed mix

The permissible deviation from the quantities of a prescribed mix shall be ± 5 %.

5.2.7 Accuracy in the batching of admixtures

Admixtures shall be batched in solution in the mixing water to within 5 % of the required quantity.

5.2.8 Accuracy of prestressing tendons

Prestressing tendons and sheathing shall, unless otherwise specified in the scope of work, be placed and maintained in position within the limits of the permissible tolerances set out in table 13.

Table 11 — Accuracy in concrete work

1	2	3	4
Item	**Permissible deviation (pd)** mm		
	Degree of accuracy		
	III	**II**	**I**
Reinforcement			
1) Spacing between two adjacent bars	± 25	± 20	± 15
2) Longitudinal location of bends and ends of bars	± 40	± 30	± 20
3) Cover to reinforcement	0, +20	0, +20	0, +20
Foundations: mass and reinforced concrete			
1) Position on plan of any edge or surface measured from the nearest grid line or agreed centre line	± 50	± 35	± 20
2) Linear dimensions on plan cast against excavation sides	± 60	± 40	± 20
3) Linear dimensions on plan cast against formwork	± 30	± 20	± 1
4) Level of underside of concrete	+20, −40	+15, −30	+10, −20
5) Surface level (i.e. top of foundation) (excluding floor slabs)	+15, −30	+10, −20	+5, −10
Elements or components above foundations			
1) Position on plan of any edge or surface measured from the nearest grid line or agreed centre line	± 25	± 15	± 5
2) Linear (other than cross-sectional) dimensions	± 30	± 20	± 10
3) Cross-sectional dimensions	+20, −10	+15, −5	+5, −5
4) Level (deviation from designated level with reference to the nearest transferred datum (TD) of the upper or lower surface, as might be specified, of any slab or other element or component)	+10, −20	+5, −15	0, −10
5) Verticality, per metre of height, subject to a maximum of	5 70	5 50	2 30
6) Out-of-squareness of a corner or opening or element such as a column for short side of length			
a) ≤ 0,5 m	± 10	± 5	± 3
b) > 0,5 m; ≤ 2 m	± 20	± 15	± 10
c) > 2 m; ≤ 4 m	± 25	± 20	± 15
7) Exposed concrete surfaces:			
a) flatness of plane surface	10	5	3
b) abrupt changes in a continuous surface	10	5	2
8) Exposed concrete surface to be plastered:			
a) flatness of plane surface	15	10	[a]
b) abrupt changes in a continuous surface	10	5	[a]
Location of holding-down bolts			
1) The centre line of a holding-down bolt from its designated location on plan	[a]	± 3	[a]
2) The top of the bolt from its designated elevation	[a]	+5, −3	[a]

[a] Tolerances not stated. Those for bow, camber and twist, and for slipform concrete and precast concrete shall be specified in the scope of work.

Table 12 — Accuracy in precast concrete beams

1	2
Item	**Permissible deviation**
Straightness or bow	
1) Deviation from intended line	
a) length ≤ 3 m	± 3 mm
b) length ≤ 4 m	± 4 mm
c) length ≤ 5 m	± 5 mm
d) length ≤ 6 m	± 6 mm
e) length ≤ 7 m	± 7 mm
f) length ≤ 8 m	± 8 mm
g) length ≤ 9 m	± 9 mm
h) length ≥ 10 m	± 10 mm
2) The rate of deviation from the intended line	≤ 1:300
Camber in the case of beams for a bridge deck Difference in level at any point of the soffits of adjacent beams placed side by side on the bridge deck	≤ 10 mm
Length of precast beams before stressing	± 0,1 % of the total length, subject to a minimum of 5 mm and a maximum of 20 mm.

Table 13 — Permitted tolerances in location of tendons and sheathing

1	2	3	4
Depth of member *d* mm	**Vertical tolerance** mm	**Width of beam** mm	**Horizontal tolerance** mm
< 200 200 to 1 000 > 1 000	± *d* /40 ± 5 ± 10	< 200 200 to 1 000 > 1 000 (incl. slabs)	± 5 ± 10 ± 30

Annex A
(normative)

Preparation of specification data associated with this part of SANS 2001 for inclusion in the scope of work

Specification data form an essential part of this part of SANS 2001; without such data, requirements are incomplete.

The format for the specification data has been developed to be compatible with the requirements in table D.1 of SANS 10403:2003. The specification data should be incorporated in the scope of work as shown in table A.1.

NOTE In the development of a scope of work, it might be necessary to address the items discussed in annex B as these are not covered in this part of SANS 2001.

Table A.1 — Incorporating this part of SANS 2001 in the scope of work

<table>
<tr><td>1</td><td>2</td><td>3</td></tr>
<tr><td>TOPIC</td><td>ASPECT</td><td>COMMENTARY</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE WORKS</td></tr>
<tr><td colspan="3">CONSTRUCTION</td></tr>
<tr><td rowspan="3">Works specifications</td><td>Applicable part(s) of SANS 2001</td><td>The following parts of SANS 2001 and associated specification data are applicable:
1) SANS 2001 …..
2) SANS 2001 …..

The associated specification data are as follows:
<table><tr><td rowspan="3">Specification data pertaining to SANS 2001…</td><td>Essential data:
The requirements for ……. are .....
The requirements for ……. are .....</td></tr><tr><td>Variations:
1) .....
2) .....</td></tr><tr><td>Additional clauses:
1) .....</td></tr></table></td></tr>
<tr><td>Applicable national and international standards</td><td></td></tr>
<tr><td>Particular/generic specifications</td><td></td></tr>
</table>

Develop the specification data based on the contents of table A.2.

Table A.2 — Specification data associated with this part of SANS 2001

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
Cementitious binders shall be common cements that comply with SANS 50197-1.	4.2.1.1	Omit if default requirements shall apply. Amend if cementitious binders shall be limited to common cements or specify what shall apply. Refer to SANS 10100-2 for guidance on the selection of cementitious binders for sulfate-resisting concrete or where the combination of cement and aggregate might give rise to a harmful alkali-aggregate reaction.
Water shall comply with the requirements of EN 1008.	4.2.2	Omit if not a requirement.
Aggregates shall comply with the following requirements: …….....	4.2.3.1	Omit if default requirements shall apply.
The coarse aggregate shall have a nominal size of ……..... mm.	4.2.3.1	Omit if default requirements shall apply. The nominal maximum size of coarse aggregate should not exceed: a) one-quarter of the minimum thickness of the concrete cross section, and b) the specified cover over reinforcement. In elements with closely spaced reinforcement, the use of a nominal size of 9,5 mm or 13,2 mm should be considered.
Plums are permitted in plain concrete.	4.2.3.4 4.7.10.11	Omit if plums are not permitted.
The following tests are required: a) drying shrinkage on fine and course aggregates; b) drying shrinkage of concrete; c) flakiness index of the stone; d) alkali-aggregate reaction.	4.2.3.5	Omit if not a requirement. Reduce list as necessary.
Admixtures are permitted, provided that the results of trial tests which demonstrate their suitability and the following are made available: a) the trade name of the admixture, its source and the manufacturer's recommended method of use; b) typical dosages and possible detrimental effects of underdosages and overdosages; c) whether compounds likely to cause corrosion of the reinforcement or deterioration of the concrete (such as those containing chloride, in any form, as an active ingredient) are present and, if so, the chloride content of admixtures, expressed as a mass fraction of chloride	4.2.4	Omit if admixtures are not permitted. Adjust wording as required. (SANS 10100-2 requires that such information be furnished.)

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
ions or expressed as an equivalent mass fraction of anhydrous calcium chloride; and d) the average expected air content of freshly mixed concrete containing an admixture that causes air to be entrained when the admixture is used at the manufacturer's recommended dosage.		
The grade of concrete shall be as follows:…..	4.2.6	State grade if not shown in the construction drawings or specified elsewhere in the scope of work and the default mix of grade 30 is not appropriate.
The material requirements for grout shall be as follows:.....	4.2.7	State requirements if different to the default requirements.
The characteristic strength of the steel in the tendons shall be not less than …..	4.2.8.2	State the characteristic strength of the tendons if not specified elsewhere in the scope of work.
Joint fillers, sealants, waterstops, bearings, and accessories shall comply with the following requirements: …….	4.2.11	State requirements for joint fillers, sealants, waterstops, bearings and accessories if not specified elsewhere in the scope of work.
Backing material is …….....	4.2.11.3	State backing requirements if default requirements shall not apply or where requirements are not specified elsewhere in the scope of work.
Steel cover plates shall comply with .....……. Galvanizing of cover plates is required.	4.2.11.4	State requirements for cover plates if steel is different to the default type and if galvanizing is required. Omit if galvanizing is not required or if requirements are specified elsewhere in the scope of work.
Earth cuts may be used as forms for vertical surfaces.	4.3.1.5	Omit if not permitted.
Approval of the authority controlling the service is required before commencing the design of formwork over the road/street/railway.	4.3.1.6	Omit if not a requirement or requirement specified elsewhere in the scope of work. Amend as necessary.
The formed surfaces shall be as follows: ……	4.3.1.8	State formed surface requirements in terms of table 1 if not specified elsewhere in the scope of work.
State degree of accuracy for formed surfaces	4.3.1.8	State degree of accuracy. (Default value is II).
The following special off-form surface finishes/ exposed aggregate finishes are required: ……	4.3.1.8	State requirements as necessary if not specified elsewhere in the scope of work. (See table 1).
The design and drawings for formwork and falsework shall be submitted for review.	4.3.2.1.4	Omit if not a requirement.
The thickness of mild-steel spiral-lock-formed void formers shall be as follows:…….	4.3.5.3	Omit if default thicknesses shall apply or if specified elsewhere in the scope of work.
The falsework and supporting formwork on continuously reinforced concrete structures shall be removed as follows:…….	4.3.8.3	Describe the manner in which falsework and supporting formwork shall be removed where the structure is constructed in stages.

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
The falsework and supporting formwork on prestressed-concrete structures shall be removed after …….....	4.3.8.4	Describe the manner in which the falsework and supporting formwork in prestressed structures shall be removed if not after the full prestressing force relating to the particular stage of construction has been applied.
Bars may be bent hot.	4.4.1.3	Omit if bars shall not be bent hot.
Welding of bars is permitted.	4.4.2.2	Omit if welding of bars is not permitted.
The cover shall be as follows:	4.4.3.1	Omit if default cover shall apply or if specified elsewhere in the scope of work.
The cover over rail and structural steel reinforcement shall be at least .....… mm.	4.4.3.2	Omit if default cover shall apply or if specified elsewhere in the scope of work.
Fixtures to be embedded in the concrete shall be attached as follows:	4.5.1	State requirement, as necessary. Omit where requirements are specified elsewhere in the scope of work.
Prescribed-mix concrete is required.	4.7.1.1	Omit if strength concrete is required or the requirements for a prescribed mix are specified elsewhere in the scope of work.
The cementitious binder content for any class of concrete shall not exceed …..... kg/m^3 of concrete.	4.7.1.2	Omit if default value of 500 kg/m^3 is not appropriate.
The slump of the concrete shall be …..... mm.	4.7.2.1	Omit if default slump values shall be used.
Pumping of concrete is permitted.	4.7.3.2 4.7.10.15	Omit if pumping is not permitted.
The maximum chloride ion content shall be	4.7.4.1	Omit if default values shall be used or where requirements are specified elsewhere in the scope of work.
Efflorescence is not acceptable/acceptable.		State whether or not efflorescence is acceptable.
The total water soluble sulfate content of the concrete mix, shall not exceed a mass faction of 4 % of the cementitious binder content of the mix.	4.7.4.2	Omit if not a requirement.
Concrete that has an air-dry density in the range 2 000 kg/m^3 to 2 600 kg/m^3 shall contain entrained air that conforms to the limits given in table 6.	4.7.5.1	Omit if not a requirement.
Concrete made to have an air-dry density that does not exceed 2 000 kg/m^3 shall contain 6 % ± 2 % or 7 % ± 2 % total air.	4.7.5.2	Omit if not a requirement. Where required, select appropriate option depending on nominal maximum size of aggregate.
The mix proportions for the prescribed mix shall be as follows: ……..	4.7.6.1	State mix proportions where a prescribed mix is required. (SANS 2001-CC2 contains a generic prescribed mix.)
The coarse aggregate for the prescribed mix shall be sourced from ……	4.7.6.2	State the source of coarse aggregate, if necessary.

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
Ready-mixed concrete shall not be permitted. OR Ready-mixed concrete shall be mixed as follows: …….	4.7.8.2	Omit if ready-mixed concrete in accordance with the requirements of SANS 878, shall be used.
The bridge deck may be cast in more than one pass.	4.7.10.10	Omit if bridge deck shall be cast in one pass.
Concrete may be placed under water.	4.7.10.13	Omit if concrete shall not be placed under water.
Compaction may be carried out by spading, rodding or forking.	4.7.11.3	Omit if concrete shall only be compacted by means of mechanical vibration.
Construction joints are required. OR Construction joints shall not be formed at the following locations: …….....	4.7.12.1.1	State requirements, if any, or if not specified elsewhere in the scope of work.
Proprietary bonding compounds between old and new concrete may be used.	4.7.12.1.4	Omit if proprietary bonding compounds shall not be used between old and new concrete.
Joints shall be sealed with ……..……..	4.7.12.4	State joint sealing requirements, if any, or if not specified elsewhere in the scope of work.
Exposed surfaces of concrete not finished against forms shall have the following surface finishes:…….....….	4.7.15.1	State surface finish if not specified elsewhere in scope of work, or where a different finish to the default finish is required.
Non-skid surfaces are required in the following areas:…….	4.7.15.2	Omit if non-skid finishes are not required or where requirements for non-skid finishes are specified elsewhere in the scope of work.
The following structures shall be watertight: …..	4.7.16	Omit if not a requirement or requirement is specified elsewhere in the scope of work.
Samples of precast concrete units that have architectural finishes shall be prepared.	4.8.6.1	Omit if such samples of concrete are not required to establish a standard for quality and colour before full-scale production is commenced.
A mosaic finish is required.	4.8.6.2.3	Omit if not a requirement or requirement is specified elsewhere in the scope of work.
Solvents may be used for cleaning.	4.9.2.1.1	Omit if solvents for cleaning are not permitted.
The prestressing force diagram is contained in sketch ……..	4.9.2.5.1	Indicate where prestressing diagram shall be found, if not in the construction drawings.
The order of loading and the magnitude of the load for each component of the tendon shall be as follows: ……	4.9.2.5.8	State requirements, if not specified elsewhere in the scope of work.
Bleeding tests and grouting trials are required.	4.9.3.1.2	Omit if bleeding tests and grouting trials are not required.
Preliminary tests shall be undertaken on the proposed encasement materials.	4.9.4.2	Omit if preliminary tests shall not be undertaken on the proposed encasement materials.
The protection and bonding of the tendons shall be effected within .....… d after final tensioning of the tendon(s).	4.9.4.3	State time period if default value shall not be used.

Table A.2 (*continued*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
The position of lifting and supporting points, the method of lifting, and the type of equipment and transport used shall be as follows: ……..	4.10.1.3	Omit if requirements are specified elsewhere in the scope of work.
The method of assembly and erection shall be as follows: ……	4.10.2	Omit if requirements are specified elsewhere in the scope of work.
The design requirements for the structural connections shall be follows: ……..	4.10.4.1	Omit if requirements are specified elsewhere in the scope of work.
The test results from a ready-mix production facility, as part of its quality control system, shall be used.	5.1.1.7	Omit if the test results from a ready-mix production facility, as part of its quality control system, shall not be used.
The test for the percentage of alkali-aggregate shall be ……	5.1.1.8	State requirements for test if required.
The test results may be assessed statistically.	5.1.2.3	Omit if the test results shall not be assessed statistically.
Sets of samples of concrete shall be taken as follows: ……..	5.1.3.2	Omit if at least one set of samples of concrete shall be taken from each day's casting and from at least every 50 m^3 of concrete of each grade placed. Specify requirements as necessary.
The following load tests shall be carried out: ….	5.1.4.1	Omit if not a requirement. State requirements.
The maximum deflection is .....……..	5.1.4.2.1	State deflection requirements for non-destructive (service) test.
The ultimate design load is .....…….	5.1.4.3	State ultimate design load for destructive (ultimate) test.
The following special tests are required:……	5.1.4.4	State requirements for special tests.
The particular test requirements for prestresssed structures are …….	5.1.5.1.1	State particular test requirements for prestressed structures.
The acceptance criteria for class 3 prestressed structures in extreme exposure conditions are.....……..	5.1.5.4 and table 10	State acceptance criteria.
The class of the prestressed structure is …..	5.1.5.4(a)	State the class of the prestressed structure.
The deflection measured immediately after application of the test load for deflection shall not exceed .....……	5.1.5.4(c)	State deflection limits, if applicable.
.....… shall be used as the liquid for test purposes.	5.1.6.1	State requirements, as relevant. State type of liquid if other than water.
The stabilizing period is ….....… d.		State the stabilizing period – usually 7 d for a maximum design crack width of 0,1 mm and 21 d for a crack width of 0,2 mm.
The total permissible drop in level is .....…..		State total permissible drop – usually 10 mm or 1/500th the average water depth.
The degree of accuracy is .....……..	5.2.1.1	State degree of accuracy required, if not specified elsewhere in the scope of work.

Table A.2 (*concluded*)

1	2	3
Specification data associated with this part of SANS 2001	**Guidance notes**	
	Clause number	**Consideration**
Essential data		
The tolerances for bow, camber and twist in slipform/precast concrete are as follows:	Table 11	State tolerances for slipform concrete and precast concrete, as necessary.
The degree of accuracy for floated finishes shall be	5.2.1.2	State accuracy required (I or II) for floated finishes, if not degree of accuracy II.
Variations		
1 Replace ..... with the following: …. 2 The requirements of ….... do not apply.		State variations as required.
Additional clauses		
1 2		State additional requirements, if any.

Annex B
(informative)

Items that might need to be considered when preparing the scope of work for a particular project

The following might have to be addressed in the construction and management section of the scope of work when compiling that section for a particular project (see annex D of SANS 10403:2003):

a) The allocation of design responsibilities.

b) Requirements for quality assurance systems.

c) The submission of test certificates issued by an accredited, independent testing authority to confirm that the respective materials comply with the specified requirements, or a certificate by the patent holder or designer, certifying that the manufactured item complies in all respects with relevant product specifications.

d) Approval procedures for the acceptance of mix designs.

e) Procedures for the review of the design and drawings for formwork and falsework, including the design criteria and calculations, and the drawings of the complete sliding-formwork assembly.

f) Requirements for batch plants and mixers.

g) Requirements for the submission of samples of materials.

h) Approval procedures for the casting of concrete, the formation of construction joints, supporting steel or other supporting materials (or both), the splicing or joints in reinforcing bars other than as shown in the drawings, shorter times for removal of formwork, for changes in materials suppliers and sources, the proposed method of placing concrete, proposed mix proportions for placing concrete by pumping, acceptability of repairs and remedial measures, a plan for early-strength testing, correlations between early-strength test results and expected strength at 28 d, a programme indicating the sequence in which prestressing will be carried out, etc.

i) The indemnification of the employer against all claims for or on account of infringement of patent rights, design or trade marks in respect of any precast system used in connection with the works and the payment of any royalties due, or that might become due, as a result of the use of such a system.

j) Health and safety requirements.

k) Lighting requirements and times when concrete may be cast.

l) It should be noted that SANS 1921-1 establishes

   1) a design services and activity matrix,

   2) general requirements for quality assurance systems, and

   3) requirements for the submission of materials and samples and basic equipment for concrete batching plants and mixing machines.

Bibliography

SANS 1921-1, *Construction and management requirements for works contracts: Part 1 – General engineering and construction works.*

SANS 10144 (SABS 0144), *Detailing of steel reinforcement for concrete*.

SANS 10400 (SABS 0400), *The application of the National Building Regulations*.