

South Africa

**COTO**

Committee of Transport  
Officials

# **Standard Specifications for Road and Bridge Works for State Road Authorities**

**Committee Draft Final (CDF)**

**CHAPTER 20: QUALITY  
ASSURANCE**

**August 2019**

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Roads Coordinating Body (RCB)

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**Working Draft (WD).** When a COTO subcommittee identifies the need for the revision of existing Standard Specifications for Road and Bridge Works, a workgroup of experts is appointed by the COTO subcommittee to develop the document. This document is referred to as a Working Draft (WD). Successive working drafts may be generated, with the last being referred to as Working Draft Final (WDF). Working Drafts (WD) have no legal standing.

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## Comments

Comments on the Chapters must be provided in writing as per the format provided on the SANRAL website [www.nra.co.za](http://www.nra.co.za) and e-mailed to [cotorevision@nra.co.za](mailto:cotorevision@nra.co.za) no later than **04 October 2019**.

# Contents

<b>CHAPTER 20: QUALITY ASSURANCE</b> .....	<b>3</b>
A20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP .....	3
PART A: SPECIFICATIONS .....	3
A20.1.1 SCOPE .....	3
A20.1.2 DEFINITIONS .....	3
A20.1.3 TESTING METHODS .....	5
A20.1.4 PUBLISHED TEST METHODS .....	8
A20.1.5 UNPUBLISHED TEST METHODS .....	17
A20.1.6 SPECIAL TEST METHODS .....	39
A20.1.7 ACCEPTANCE CONTROL BY STATISTICAL JUDGEMENT PRINCIPLES .....	41
B20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP .....	53
PART B: LABOUR ENHANCED .....	53
C20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP .....	54
PART C: MEASUREMENT AND PAYMENT .....	54

# CHAPTER 20: QUALITY ASSURANCE

## A20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP

### CONTENTS

#### PART A: SPECIFICATIONS

##### A20.1.1 SCOPE

##### A20.1.2 DEFINITIONS

##### A20.1.3 TEST METHODS

##### A20.1.4 PUBLISHED TEST METHODS

##### A20.1.5 UNPUBLISHED TEST METHODS

##### A20.1.6 SPECIAL TEST METHODS

##### A20.1.7 ACCEPTANCE CONTROL BY STATISTICAL JUDGEMENT PRINCIPLES

#### PART B: LABOUR ENHANCED

#### PART C: MEASUREMENT AND PAYMENT

#### PART D: GUARANTEES AND COMPLIANCE CERTIFICATES – NOT APPLICABLE

## PART A: SPECIFICATIONS

### A20.1.1 SCOPE

During the execution of the work, control testing shall be conducted on materials and workmanship to monitor compliance with the requirements of the specifications. Tests, measurements, and inspections shall be carried out using manual, mechanical and electronic equipment on materials and workmanship before, during and after construction to ensure compliance with the quality requirements of the specifications.

This Chapter also describes the schemes that are specified to ascertain compliance with the specification of certain materials properties and workmanship. This is achieved by means of tests and measurements, and, where applicable, by applying statistical judgement plans.

These statistical acceptance control requirements, unless otherwise specified, apply to Class A, B, C and D roads, as classified in TRH 26 South African Road Classification & Access Management Manual. The acceptance control requirements for lower classes of roads shall be specified in the Contract Documentation.

### A20.1.2 DEFINITIONS

**Independent site laboratory** - This laboratory is procured by the Employer for carrying out the ordinary test required on site for both process and acceptance control testing which serves the Contractor and the Engineer. Irrespective of the requirements of Clause A20.1.3.3a)(ii)2 this laboratory operates under the auspices and systems of the main commercial laboratory which is SANAS accredited as a testing laboratory facility in terms of their accredited tests with an ISO17025 management system and with the necessary quality assurance plans. The commercial laboratory shall be responsible for frequent and regular auditing of the Independent Site Laboratory and provide reports to the Engineer of such audits and correlation tests conducted.

**Independent commercial laboratory** - This laboratory refers to a SANAS accredited testing laboratory facility in terms of their accredited test schedule and conformance with the ISO 17025 requirements. This laboratory is located away from site and conducts ordinary and special tests. The testing work is charged to whichever client places the order, at the applicable rates and tariffs.

**Engineer's laboratory** - This type of laboratory refers generally to the Independent Site Laboratory and/or a specific independent commercial laboratory nominated for certain tests by the Engineer.

**Approved laboratory/Testing authority** - An approved laboratory shall mean any locally accredited laboratory that is located away from site and has been approved by the Engineer for the testing of materials, products, elements and mixes used on site. Whenever the need exists the Engineer will also seek the consent of the Contractor.

**Contractor's satellite laboratory** - A laboratory established by the Contractor on site or at manufacturing plants for asphalt and concrete. The Contractor's satellite laboratory also carries out process control on materials stockpiles and bulk binder storage, as well as during the manufacture of asphalt and concrete mixes. All tests and procedures are undertaken in terms of a quality control plan.

**Ordinary tests** - Ordinary tests refer to the range of tests that are routinely carried out as part of process and acceptance control.

**Special tests** - Special tests refer to tests that require the use of specialised equipment and expertise not normally available in an independent site laboratory, unless otherwise provided for. These tests are applicable to certain products, structural elements, drainage, and in the design of special mixes. The use thereof, in terms of conformance to the requirements and obligations of the Contract and the cost of such testing, shall, unless otherwise specified, be included in the Contractor's rates.

**Lot** - A lot is a sizeable portion of work or quantity of material that is assessed as a unit for the purposes of acceptance control and selected to

present material or work produced by essentially the same process and from essentially the same materials.

**Random sampling** - A random sample is a group of "n" test measurements at "n" separate test positions or on "n" sample portions obtained from the lot in an unbiased manner following tables of random numbers published in TMH5 or any other random number generating tool as approved on condition that there are no other causes for rejection as described in Clause A20.1.7.5.

**Stratified sampling** - This involves the subdivision of the "lot" to be assessed into uniform strata equal to the selected number of "n" tests. These sub-lots may be in the form of truckloads, batches or subdivisions of a "lot" of pavement layers.

**Stratified random sampling** - This is a combination of random and stratified sampling as a means of eliminating clustering in the position or portion of samples within the "lot".

**Sample mean ( $\bar{x}_n$ ):**

$\bar{x}_n$  is the arithmetic mean of a set of "n" test results constituting the sample, i.e.  $(x_1 + x_2 + x_3 + \dots + x_n) / n$

$$\bar{x}_n = \sum x/n$$

where

x is individual test result

n is the number of individual test results or measurements

**Sample standard deviation (S)** - The sample standard deviation S is defined by:

$$S = \sqrt{(\sum x^2 - n\bar{x}_n^2) / (n - 1)}$$

Where  $\bar{x}_n$  is the sample mean

x is the value of an individual sample portion, i.e. an individual test result or measurement.

n is the sample size, i.e. the number of individual test results or measurements.

**Specification limit (L<sub>s</sub>)** - This is the limit value of the property of any product outside which not more than a certain specified percentage (Ø) of the population of values representing an acceptable product property is allowed to lie. The specification limit may be a single lower limit L<sub>s</sub>, or a single upper limit L'<sub>s</sub> or a double limit consisting of a lower limit L<sub>s</sub> and an upper limit L'<sub>s</sub>.

**Acceptance limit (L<sub>a</sub>)** - This is the limit value of the sample mean within which the lot will be accepted. For a lower-limit specification this acceptance limit is denoted by L<sub>a</sub>. For an upper-limit specification this acceptance limit is denoted by L'<sub>a</sub>. For a double limit specification, the lower and upper limits are denoted by a L<sub>a</sub> and L'<sub>a</sub> respectively.

**Conditional acceptance** - This is the acceptance of a lot at reduced payment in lieu of rejection. Conditional acceptance shall be subject to the provisions of Clause A20.1.7.6.

**Rejection limit (L<sub>r</sub>)** - This is the limit value of the sample mean outside which conditional acceptance cannot be considered. It may be a lower limit L<sub>r</sub> or an upper limit L'<sub>r</sub>.

**Payment reduction factor (fr)** - This is the factor by which payment at contract rates shall be multiplied for calculating the payment for conditionally accepted work subject to the provisions of Clauses A20.1.7.6a) and A20.1.7.6b) (i), (ii) and (iii).

**Outliers** - Where, in a sample, one or more test results differ significantly from the other values obtained, this difference could be ascribed to an assignable cause in which case further investigations must be carried out. To determine whether or not a test result is a possible outlier, the methods and procedures given in Clause A20.1.7.3 shall be followed.

**Factors ka, kad, kr and krd** - These factors are used for calculating the various judgement limits, as follows:

**a) Acceptance limits (L<sub>a</sub> and L'<sub>a</sub>)**

k<sub>a</sub> is used for determining the acceptance limits for single-limit specifications.

k<sub>ad</sub> is used for determining the acceptance limits for double-limit specifications.

**b) Rejection limits (L<sub>r</sub> and L'<sub>r</sub>):** The rejection limits shall be determined in accordance with the provisions of Table A20.1.7-14.

**Ø (%)** - Ø is the maximum percentage of a statistical population of values of a product property permitted to lie outside the specification limits where the product may still be regarded as being acceptable.

**First submission** - The submission of a lot for approval will be classified as a first submission when submitted for the first time or when submitted for a second time on the basis of a second set of test values to be regarded as a first submission in terms of Clause A20.1.7.4 because the properties of the first and the second sets of test values differ significantly.

**Resubmission** - The submission of a lot for approval for a second time shall be classified as a resubmission should it be regarded as a resubmission in terms of Clause A20.7.4 because the properties of the first and second sets of test values do not differ significantly.

**Repair and rehabilitation work** - Quality control of non-continuous repair and rehabilitation work in small lots, portions and sections shall be carried out as specified in the Contract Documentation.

## **A20.1.3 TESTING METHODS**

### **A20.1.3.1 General**

All time related implications, brought about by the testing regime as specified herein, are deemed to be included in the contract rates and the Contractor's programme, and no Contractor's claims whatsoever to that effect will be entertained.

All sampling, testing measurements, etc. shall be performed and recorded by competent staff in terms of ISO 17025 and facilities accepted by the Engineer.

The responsibility to deliver the product in terms of the specification shall always remain the obligation of the Contractor in terms of the contract.

### **A20.1.3.2 Standard Methods**

All tests shall be conducted in accordance with the standard methods specified in the following list, in order of precedence, unless indicated otherwise in the other Chapters:

- a) South African National Standards (SANS) codes of practice and coordinating specifications (CKS) as published by the South African Bureau of Standards (SABS)
- b) Relevant TMH methods
- c) British Standards Institute Specifications (abbreviated as BS)
- d) European standards maintained by CEN (European Committee for Standardization) (abbreviated as EN)
- e) The methods/specifications of the American Society for Testing and Materials (abbreviated as ASTM).
- f) The methods/specifications of the American Association of State Highway and Transportation Officials (abbreviated as AASHTO).
- g) The standard methods of testing of the South African Bitumen Association (abbreviated as Sabita)
- h) The standard methods of testing of the International Union of Laboratories and Experts in Construction Materials, Systems and Structures (abbreviated as RILEM).
- i) The Asphalt Academy

In addition to the above standard methods of testing, standard specifications or test methods of other bodies may also be referred to in these specifications, or test methods as described in the Contract Documentation where no acceptable standard methods exist.

Note: In all cases the latest amendment or revision current at the closing date of the tender is implied when reference is made to one of the above standards in the specification.

### **A20.1.3.3 The Costs of Testing**

#### **a) Material and workmanship for quality control**

- (i) *The cost of testing may be borne by the Contractor and Employer in several ways, as specified in the Contract Documentation, i.e.:*
  1. Process and acceptance control testing are carried out by the Contractor. The cost of the testing is deemed to be included in the rates, or
  2. Process control testing is carried out by the Contractor, and acceptance control testing by the Engineer. The cost of process control testing is borne by the Contractor and the cost of acceptance control testing is borne by the Employer, or
  3. All materials testing, including process and acceptance control testing is carried out by an independent site laboratory. The Contractor shall contribute to the costs of such laboratory under the pay items under Section C20.1.
- (ii) *When the testing is undertaken by an independent site laboratory, the Employer stipulates that:*
  1. The Contractor accepts the test results of the laboratory. Should there be any doubts or disputes regarding certain test results, this shall be settled by another independent SANAS accredited testing laboratory facilities mutually agreed upon that shall retest the work in question. The cost in such cases shall be to the account of the party at fault by means of the aggregate results obtained by all test facilities.
  2. The Contractor accepts that the Engineer will be in charge of the independent site laboratory.
  3. The total estimated cost of the independent site laboratory for the contract period is reflected in the Contract Documentation.
  4. A negative pay item representing the Contractor's monthly contribution to be deducted from the Contractor's interim payment certificates has been provided under Section C20.1.
  5. The monthly contribution by the Contractor shall be a negative amount for all process control testing, excluding acceptance control and other testing ordered by the Engineer, as a portion of the total cost (per month).

### **A20.1.3.4 Compliance Certificates and Testing**

Where the properties of materials or manufactured products are required in these specifications to comply with specifications published by a standards authority, the Contractor shall produce, when called upon to do so, certificates from the manufacturer confirming that the materials or products supplied comply with the relevant specifications. The cost of providing such certificates shall be borne by the Contractor. Where it is specified that a product shall comply with SABS specifications, it means that the product shall have been tested and evaluated in accordance with the requirements of the relevant SABS specification. Where a SABS mark is specified, a certificate will be required.

The Engineer shall be entitled to take samples of and order tests to be made on products and materials in respect of which certification of compliance are required. The Contractor shall be paid at the appropriate rates if the costs of such tests are itemised in the pricing schedule and if no appropriate rates exist, such tests shall be classed as an extra works order, provided that such tests indicate compliance with the specifications, otherwise the cost shall be borne by the Contractor.

### **A20.1.3.5 Taking and submitting samples**

The method of taking samples shall be as specified in the appropriate sampling and testing methods. The sampling methods described in TMH5, SABS, SANS and AASHTO shall apply where relevant. If no sampling method is specified, the sampling methods described in TMH5 and in SABS method 5827 shall take precedence.

Where the Contractor is required in these specifications to submit samples of materials or mixtures to the Engineer for approval prior to their being used in the works, the use of these materials or mixtures without the Engineer's written approval shall constitute default on the part of the Contractor, who shall be liable for the consequence of such default, including resultant time delays. All samples shall be submitted in sufficient time for proper testing.

The Engineer's approval of any sampled materials shall in no way relieve the Contractor's obligation to provide materials, mixtures and workmanship that comply with the specification.

All samples for testing shall be taken in a random pattern, or in any position, as prescribed by the Engineer. Where specified or required by the Engineer, stratified random sampling methods shall be followed. For the testing of layer work stratified random sampling methods shall be used for obtaining all the sample positions and for determining the locations for in-situ tests.

The Engineer shall have full access to the works for the purpose of taking samples. The Contractor shall render any assistance necessary for taking the samples and shall be responsible for the reinstatement to the specified standards of pavement layers or other structures at the position where the samples have been taken. Full compensation for time delays and for rendering assistance with sampling and for reinstatement where samples have been taken shall be deemed to be included in the rates tendered for the various items of work tested and no additional payment will be made in this respect.

Table A20.1.3-1 provides guidelines for submitting materials with regard to the time and quantity of material required for testing, approval and mix designs. As the time stated in this table does not make any allowance for possible rejection and the resubmission of alternative materials, the Contractor shall submit any materials of marginal quality at an early stage or together with alternative materials in order to minimise any delays in final approval.

The Contractor shall note that any samples submitted direct to the Engineer for approval shall be properly marked and shall be accompanied by a covering letter with all the required information and countersigned by the Engineer's representative upon delivery.

**Table A20.1.3-1: Schedule showing quantities and times for submitting the materials for approval and mix designs**

Material submitted	Proposed use	Submission for quality approval only		Submission for quality approval and mix design	
		Minimum time to be allowed for testing and approval	Minimum quantity to be submitted	Minimum time to be allowed for testing, approval and mix design	Minimum quantity to be submitted
Crushed stone	Coarse aggregate for concrete	2 weeks	50 kg of each type and size of aggregate	8 weeks for structures and concrete pavements	150 kg of each size of aggregate for each class of concrete
	Bituminous seals	2 weeks *1	50 kg of each type and size of aggregate	2 weeks	50 kg of each size of aggregate
	Asphalt mix design Marshall Method	2 weeks *1	50 kg of each type and size of aggregate	8 weeks *2	100 kg of each size of aggregate as well as proposed binder *2
	Asphalt mix design Level 1	4 weeks *1	50 kg of each type and size of aggregate	10 weeks *2	100 kg of each size of aggregate as well as proposed binder *2
	Asphalt mix design Level 2	6 weeks *1	50 kg of each type and size of aggregate	12 weeks *2	100 kg of each size of aggregate as well as proposed binder
	Asphalt mix design Level 3	8 weeks *1	50 kg of each type and size of aggregate	16 weeks *2	100 kg of each size of aggregate as well as proposed binder *2
	Crushed-stone base or subbase	3 weeks	50 kg	8 weeks (stabilisation)	200 kg
Fine aggregate	Fine aggregate for concrete	2 weeks	50 kg of each type and size of aggregate	10 weeks	150 kg of each type proposed for use for each class of concrete
	Asphalt mix design Marshall Method	2 weeks *1	50 kg of each type and size of aggregate	8 weeks *2	150 kg of each type proposed for use *2
	Asphalt mix design Level 1	4 weeks *1	75 kg of each type and size of aggregate	10 weeks *2	150 kg of each size of aggregate as well as proposed binder *2
	Asphalt mix design Level 2	6 weeks	50 kg of each type and size of aggregate	12 weeks *2	150 kg of each size of aggregate as well as proposed binder *2
	Asphalt mix design Level 3	8 weeks	50 kg of each type and size of aggregate	16 weeks *2	150 kg of each size of aggregate as well as proposed binder *2
	Slurry or sand seal	2 weeks	50 kg of each type proposed for use	6 weeks	50 kg of each type proposed for use as well as proposed binder
Gravel	Subbase and/or base	4 weeks	200 kg of each type	8 weeks (stabilisation)	200 kg as well as stabilising agent
Binders	Asphalt	2 weeks	5 ℓ	4 weeks	10 ℓ
	Surface treatments	2 weeks	5 ℓ	4 weeks	10 ℓ
	Bituminous stabilised materials	2 weeks	5 ℓ	4 weeks	10 ℓ

Material submitted	Proposed use	Submission for quality approval only		Submission for quality approval and mix design	
		Minimum time to be allowed for testing and approval	Minimum quantity to be submitted	Minimum time to be allowed for testing, approval and mix design	Minimum quantity to be submitted
Bituminous stabilised materials	Bituminous stabilised mixes	2 weeks	50 kg of each type of aggregate and reclaimed asphalt (RA)	4 weeks	100 kg of each type of aggregate and RA
Other materials e.g. paint, cement, additives, Concrete, Additives, etc.	As specified	As prescribed by the Engineer			

\*1 In the event of PSV and Soundness testing an additional 2 weeks shall be allowed for.

\*2 In the event of "check only" mix designs the minimum time and quantities can be reduced, depending upon the properties to be validated, and shall be agreed with the Engineer after the submission of the original mix design.

### A20.1.3.6 Classifying the tests for costing and payment purposes

For the purposes of this Chapter tests are classified as follows:

#### a) Ordinary tests

Ordinary tests are tests that are constantly conducted by the Contractor on a regular basis in terms of his obligations. These tests, for which no specified pay items have been provided, include, inter alia:

- (i) Tests for determining the properties of all natural materials such as, inter alia, sand, stone, water, soil and gravel, provided by the Contractor for use in the works.
- (ii) Tests on processed natural materials such as aggregate for concrete, asphalt and seals, purchased or produced on the site by the Contractor.
- (iii) Tests for determining the properties of products such as concrete and asphalt, etc, produced specially for use on the works by the Contractor or purchased from commercial producers or sub-Contractors.
- (iv) Tests on completed elements of construction such as fills, pavement layers, concrete structures, concrete pavements, etc, for establishing compliance with the specified properties.

Payment for ordinary tests shall be included in the rates tendered by the Contractor for the items of work to which the ordinary tests relate.

#### b) Special test

Special tests that have to be conducted by the Contractor only at the specific request of the Engineer include the following:

- (i) Tests on commercial products such as cements, lime, paint, bituminous products, pipes, valves, cranes and bridge bearings. The requirements are specified as a whole or in part by reference being made to the specifications of a standards organisation such as the SABS.
- (ii) Special tests on structures or elements of structures to determine their efficacy, for the payment of which clear provision has been made in the specifications and the schedule of quantities, unless otherwise specified.
- (iii) Any test requested by the Engineer purely for purposes of acceptance control, acceptance of products and mix designs. With reference to Clause A20.1.3.3a)(i), points 1 and 2, only the cost of testing for acceptance control will be paid for.
- (iv) Such tests, however, will not be classified as a special test if the test is requested because the Contractor has neglected to conduct sufficient or proper tests in terms of Clause A1.2.8.1 of Chapter 1 and with a view to submit the result to the Engineer for his approval of the completed works.

The payment of special tests required by the Engineer shall be borne by the Employer for which provision is made in Section C20.1, provided that such tests indicate compliance with the specifications.

## A20.1.4 PUBLISHED TEST METHODS

The test methods listed in this section are contained in the standard test methods referred to in Clause A20.1.3.2. These include the following test methods:

### A20.1.4.1 Testing of aggregates

#### SANS 3001-AG1

Civil Engineering test methods Part AG1: Particle size analysis of aggregates by sieving

#### SANS 3001-AG2

Civil Engineering test methods Part AG2: Determination of the average least dimension of aggregates by direct measurement

#### SANS 3001-AG3

Civil Engineering test methods Part AG3: Determination of the average least dimension of aggregates by computation

#### SANS 3001-AG4

Civil Engineering test methods Part AG4: Determination of the flakiness index of coarse aggregate

**SANS 3001-AG5**

Civil Engineering test methods Part AG5: Sand equivalent value of fine aggregates

**SANS 3001-AG9**

Civil Engineering test methods Part AG9: Determination of the Treton impact values for aggregates and gravels

**SANS 3001-AG10**

Civil Engineering test methods Part AG10: ACV (aggregate crushing value) and 10 % FACT (fines aggregate crushing test) values of coarse aggregates

**SANS 3001-AG11**

Civil Engineering test methods Part AG11: Determination of the Polished Stone Value of Aggregates

**SANS 3001-AG12**

Civil Engineering test methods Part AG12: Soundness of aggregates (magnesium sulfate method)

**SANS 3001 AG13**

Civil Engineering test methods Part AG13: Determination of the soundness of mudrock aggregates (Venter test)

**SANS 3001-AG14**

Civil Engineering test methods Part AG14: Determination of the ethylene glycol durability index for rock

**SANS 3001 AG15**

Civil Engineering test methods Part AG15: Determination of rock durability using 10 % FACT (fines aggregate crushing test) values after soaking in ethylene glycol

**SANS 3001-AG16**

Civil Engineering test methods Part AG16: Determination of the durability mill index for aggregates

**SANS 3001-AG20**

Civil Engineering test methods Part AG20: Determination of the bulk density, apparent density and water absorption of aggregate particles retained on the 5 mm sieve for road construction materials

**SANS 3001-AG21**

Civil Engineering test methods Part AG21: Determination of the bulk density, apparent density and water absorption of aggregate particles passing the 5 mm sieve for road construction materials

**SANS 3001-AG22**

Civil Engineering test methods Part AG22: Apparent density of crushed stone base

**SANS 3001-AG23**

Civil Engineering test methods Part AG23: Particle and relative densities of aggregate

**SANS 195: 2006**

Sampling of aggregates

**SANS 197: 2006**

Preparation of test samples of aggregates

**SANS 202**

Chloride content of aggregates

**SANS 5831: 2006**

Presence of chlorides in aggregates

**SANS 5832: 2006**

Organic impurities in fine aggregates

**SANS 5833: 2006**

Detection of sugar in fine aggregates

**SANS 5834: 2006**

Soluble deleterious impurities in fine aggregates (limit test)

**SANS 5835**

Estimation of the effect of fine aggregate on the water requirement of concrete

**SANS 5837**

Low density materials content of aggregates

**SANS 5836**

Effect of fine and coarse aggregate on the shrinkage and expansion of cement: aggregate mixes (mortar prism method)

**SANS 5840**

Shell content of fine aggregates

**SANS 5843**

Water absorption of aggregates

**SANS 5844**

Particle and relative densities of aggregates

**SANS 5845**

Bulk densities and voids content of aggregates

**SANS 5846**

Abrasion resistance of coarse aggregate (Los Angeles machine method)

**SANS 5849**

Total water-soluble salts content of fines in aggregates

**SANS 5850-1**

Sulfates content of fines in aggregates Part 1: Water soluble sulfates in fines in aggregates

**SANS 5850-2**

Sulfates content of fines in aggregates Part 2 Acid-soluble sulfates in fines in aggregates

**SANS 5855**

Free water content of aggregates

**SANS 5856**

Bulking of fine aggregates

**SANS 6242**

Acid insolubility of fine aggregate

**SANS 6243: 2008**

Deleterious clay content of the fines in aggregate (methylene blue adsorption indicator test)

**SANS 6245: 2006**

Potential reactivity of aggregates with alkalis (accelerated mortar prism method)

**AASHTO T-19**

Standard method of test for bulk density and voids in aggregate

**ASTM C142-97**

Percentage clay lumps and friable particles

**ASTM D3398**

Standard Test Method for Index of Aggregate Particle Shape and Texture

**BS 812**

Tests on active filler

**FNB 22-67 (2008)**

Determination of Aggregate Finger Value and Aggregate Pliers Value : Published by Dr F Netterberg ([Frank.Netterberg@gmail.com](mailto:Frank.Netterberg@gmail.com))

**A20.1.4.2 Testing of cement, extenders and admixtures****SANS 50197**

Testing of cement

**SANS 50450**

Testing of fly ash

**SANS 53263**

Testing of silica fume

**SANS 55167**

Testing of GGBS

**SANS 50934 4-6**

Testing of admixtures

## **SANS 1083**

Testing of aggregates

### **A20.1.4.3 Testing of concrete**

#### **SANS 5861-1:2006 (SANS 3001-CO1-1)**

Concrete tests — Mixing fresh concrete in the laboratory

#### **SANS 3001-CO1-2**

Concrete tests — Sampling of freshly mixed concrete

#### **SANS 5862-1:2006 (SANS 3001-CO1-3)**

Concrete tests — Consistence of freshly mixed concrete — Slump test

#### **SANS 5862-3:2006 (SANS 3001-CO1-4)**

Concrete tests — Consistence of freshly mixed concrete — Vebe test

#### **SANS 3001-CO1-5**

Concrete tests — Consistence of freshly mixed concrete — Compacting factor and compaction index

#### **SANS 5862-2:2006 (SANS 3001-CO1-6)**

Concrete tests — Consistence of freshly mixed concrete — Flow test

#### **SANS 6250:2006 (SANS 3001-CO1-7)**

Concrete tests — Density of compacted freshly mixed concrete

#### **SANS 6252:2006 (SANS 3001-CO1-8)**

Concrete tests — Air content of freshly mixed concrete — Pressure method

#### **SANS 3001-CO1-9 (EN 12350-8)**

Self-compacting concrete — Slump-flow test

#### **SANS 3001-CO1-10 (EN 12350-9)**

Self-compacting concrete — V-funnel test

#### **SANS 3001-CO1-11 (EN 12350-10)**

Self-compacting concrete — L box test

#### **SANS 3001-CO1-12 (EN 12350-11)**

Self-compacting concrete — Sieve segregation test

#### **SANS 3001-CO1-13 (EN 12350-12)**

Self-compacting concrete — J-ring test

#### **SANS 5860:2006 (SANS 3001-CO2-1)**

Concrete tests — Dimensions, tolerances and uses of cast test specimens

#### **SANS 5861-3:2006 (SANS 3001-CO2-2)**

Concrete tests — Making and curing of test specimens for strength tests

#### **SANS 5863:2006 (SANS 3001-CO2-3)**

Concrete tests — Compressive strength of hardened concrete

#### **SANS 5864:2006 (SANS 3001-CO2-5)**

Concrete tests — Flexural strength of hardened concrete

#### **SANS 6253:2006 (SANS 3001-CO2-6)**

Concrete tests — Tensile splitting strength of hardened concrete

#### **SANS 6085:2006 (SANS 3001-CO2-7)**

Concrete tests — Initial drying shrinkage and wetting expansion of concrete

#### **SANS 6251:2006 (SANS 3001-CO2-8)**

Concrete tests — Density of hardened concrete

#### **SANS 6255 (SANS 3001-CO2-9)**

Mortar tests – Compressive strength of mortar

#### **SANS 6254 (SANS 3001-CO2-10)**

Mortar tests – Initial drying shrinkage and wetting expansion of mortar

**SANS 3001-CO3-1**

Concrete tests — DURABILITY INDEX Tests - Part 1: Preparation of test specimens

**SANS 3001-CO3-2**

Concrete tests — DURABILITY INDEX Tests - Part 2: Oxygen permeability test

**SANS 3001-CO3-3**

Concrete tests — DURABILITY INDEX Tests - Part 3: Chloride conductivity test

**SANS 5865:2006 (SANS 3001-CO3-5)**

Concrete tests - The drilling, preparation, and testing for compressive strength of cores taken from hardened concrete

**ASTM C232**

Determining the bleeding of fresh concrete

**SANS 51008**

Mixing water for concrete – Specification for sampling, testing and assessment for suitability of water, including water recovered from processes in the concrete industry, as mixing water in concrete.

**AASHTO T 132**

Determination of the tensile strength of hydraulic cement mortars

**BS EN13391**

Tests on structural concrete

**A20.1.4.4 Testing soils, gravel and crushed stone for earthworks and pavement layers****SANS 3001-AG16**

Civil Engineering test methods Part AG16: Determination of the durability mill index for aggregates

**SANS 3001- GR1**

Civil Engineering test methods Part GR1: Wet preparation and particle size analysis

**SANS 3001- GR2**

Civil Engineering test methods Part GR2: Dry preparation and dry particle size analysis of gravels and sands

**SANS 3001 GR3**

Civil Engineering test methods Part GR3: Particle size analysis of material smaller than 2 mm (hydrometer method)

**SANS 3001 GR5**

Civil Engineering test methods Part GR5: Wet preparation and air-drying of samples for plasticity index and hydrometer tests

**SANS 3001-GR10**

Civil Engineering test methods Part GR10: Determination of the one-point liquid limit, plastic limit, plasticity index and linear shrinkage

**SANS 3001-GR11**

Civil Engineering test methods Part GR11: Determination of the liquid limit with the two-point method

**SANS 3001-GR12**

Civil Engineering test methods Part GR12: Determination of the flow curve liquid limit

**SANS 3001-GR20**

Civil Engineering test methods Part GR20: Determination of the moisture content by oven drying

**SANS 3001-GR30**

Civil Engineering test methods Part GR30: Determination of the maximum dry density and optimum moisture content

**SANS 3001-GR31**

Civil Engineering test methods Part GR31: Determination of the maximum dry density and optimum moisture content of laboratory mixed cementitious stabilized materials

**SANS 3001-GR35**

Civil Engineering test methods Part GR35: Determination of in-place dry density (sand replacement)

**SANS 3001-GR40**

Civil Engineering test methods Part GR40: Determination of the California bearing ratio

**SANS 3001-GR41**

Civil Engineering test methods Part GR41: Determination of the California bearing ratio of lime treated materials

**TMH 1: A21T**

Determination of the Electrical Conductivity of a saturated soil paste and water

#### **TMH 6**

Draft TMH6-ST11: Determination of the in-situ density of material containing very large grains (Rondavel Method)

### **A20.1.4.5 Tests of bituminous stabilised materials**

#### **SANS 3001 BSM1**

Civil Engineering test methods Part BSM1: Determination of foamed bitumen characteristics

#### **SANS 3001 BSM2**

Civil Engineering test methods Part BSM2: Preparation of bitumen stabilized samples for testing

#### **SANS 3001 BSM3**

Civil Engineering test methods Part BSM3: Vibratory hammer compaction of test specimens of bitumen stabilized material

#### **SANS 3001 BSM4**

Civil Engineering test methods Part BSM4: Determination of indirect tensile strength of bitumen stabilized material

#### **SANS 3001 BSM5**

Civil Engineering test methods Part BSM5: Determination of the shear properties of bitumen stabilized material (triaxial test)

### **A20.1.4.6 Testing with nuclear gauges**

#### **SANS 3001 NG1**

Civil Engineering test methods Part NG1: Administration, handling and maintenance of a nuclear density gauge

#### **SANS 3001 NG2**

Civil Engineering test methods Part NG2: The validation of standard calibration blocks

#### **SANS 3001 NG3**

Civil Engineering test methods Part NG3: Calibration of a nuclear density gauge

#### **SANS 3001 NG4**

Civil Engineering test methods Part NG4: Verification of a nuclear density gauge

#### **SANS 3001-NG5**

Civil Engineering test methods Part NG5: Determination of in-situ density using a nuclear density gauge

### **A20.1.4.7 Testing of bituminous binders**

#### **SANS 4001-BT1**

Civil Engineering test methods Part BT-1: Penetration grade bitumen

#### **SANS 4001-BT2**

Civil Engineering test methods Part BT2: Cutback bitumen

#### **SANS 4001 BT3**

Civil Engineering test methods Part BT3: Anionic road emulsion

#### **SANS 4001 BT4**

Civil Engineering test methods Part BT4: Cationic road emulsion

#### **SANS 4001 BT5**

Civil Engineering test methods Part BT5: Inverted road emulsion

#### **SANS 4001-BT10**

Civil Engineering test methods Part BT-10: Performance grade bitumen

#### **AASHTO-102**

N Heptane xylene (spot test)

#### **SABITA PG1 –Series on modified binders**

### **A20.1.4.8 Testing of asphalt**

#### **SANS 3001-AS1**

Civil Engineering test methods Part AS1: Making of asphalt briquettes for Marshall tests and other specialized tests

#### **SANS 3001-AS2**

Civil Engineering test methods Part AS2: Determination of Marshall stability, flow and quotient

#### **SANS 3001-AS3**

Civil Engineering test methods Part AS3: Gyrotory compaction of asphalt briquettes

**SANS 3001-AS4**

Civil Engineering test methods Part AS4: Determination of indirect tensile strength of asphalt

**SANS 3001-AS5**

Civil Engineering test methods Part AS5: Determination of dynamic creep of bituminous mixtures

**SANS 3001-AS10**

Civil Engineering test methods Part AS10: Determination of bulk density and void content of compacted asphalt

**SANS 3001-AS11**

Civil Engineering test methods Part AS11: Determination of the maximum void-less density of asphalt mixes and the quantity of binder absorbed by the aggregate

**SANS 3001-AS20**

Civil Engineering test methods Part AS20: Determination of the soluble binder content and particle size analysis of an asphalt mix

**SANS 3001-AS21**

Civil Engineering test methods Part AS21: Determination of the bitumen content of an asphalt mix by ignition

**SANS 3001-AS22**

Civil Engineering test methods Part AS22: Determination of binder content of mixtures used in bituminous slurry seals

**SANS 3001-AS23**

Civil Engineering test methods Part AS23: Determination of moisture in asphalt

**SANS 3001-AS25**

Recovery of binder from mixed asphalt

**SANS 3001 PD1**

Civil Engineering test methods Part PD1: MMLS3 testing of asphalt mixtures

**BS 812**

BS 812 1995 Part 2: Testing of aggregates: Methods of determination of density

**EN 12697 :2004**

EN 12697 :2004: Test methods for hot mix asphalt: Permeability of specimen

**AASHTO T324**

Hamburg wheel tracking test for permanent deformation

**AASHTO T321**

Four-point beam fatigue test

**AASHTO TP79**

Dynamic modulus/stiffness of asphalt

**AASHTO T331**

Corelok method for bulk relative density of asphalt

**ASTM C142**

Standard test method for clay lumps and friable particles in aggregates

**ASTM D4867M**

Durability - Modified Lottman test

**Sabita Manual 35**

Design and Use of Asphalt in Road Pavements: Determining the binder film thickness in asphalt mixes

**Sabita Manual 35**

Design and Use of Asphalt in Road Pavements: Determining the Richness Modulus of EME asphalt mixes

**A20.1.4.9 Testing of surface treatments****SANS 3001-BT10**

Civil Engineering test methods Part BT10: Ball penetration test for the design of surfacing seals

**SANS 3001-BT11**

Civil Engineering test methods Part BT11: Texture depth measurement for the design of surfacing seals

**SANS 3001-BT20**

Civil Engineering test methods Part BT20: Certification of a binder distributor

**SANS 3001-BT21**

Civil Engineering test methods Part BT21: Validation of a binder distributor dipstick

**SANS 3001-BT22**

Civil Engineering test methods Part BT22: Power and road speed indicator tests for a binder distributor

**SANS 3001-BT23**

Civil Engineering test methods Part BT23: Pump system performance of a binder distributor

**SANS 3001-BT24**

Civil Engineering test methods Part BT24: Measurement of transverse distribution ('Bucket test') for a binder distributor

**A20.1.4.10 Testing related to chemical stabilisation****SANS 3001-GR50**

Civil Engineering test methods Part GR50: Preparation, compaction and curing of specimens of laboratory mixed cementitiously stabilized materials

**SANS 3001-GR51**

Civil Engineering test methods Part GR51: Sampling, preparation, compaction and curing of field mixed freshly cementitiously stabilized materials including the determination of the maximum dry density and optimum moisture content

**SANS 3001-GR52**

Civil Engineering test methods Part GR52: Sampling and preparation of cored specimens of field compacted, matured, cementitiously stabilized material

**SANS 3001-GR53**

Civil Engineering test methods Part GR53: Determination of the unconfined compressive strength of compacted and cured specimens of cementitiously stabilized materials

**SANS 3001-GR54**

Civil Engineering test methods Part GR54: Determination of the indirect tensile strength of compacted and cured specimens of cementitiously stabilized materials

**SANS 3001-GR55**

Civil Engineering test methods Part GR55: Determination of the wet-dry durability of compacted and cured specimens of cementitiously stabilized materials by hand brushing

**SANS 3001-GR56**

Civil Engineering test methods Part GR56: Determination of the wet-dry durability of compacted and cured specimens of cementitiously stabilized materials by mechanical brushing

**SANS 3001 GR57**

Civil Engineering test methods Part GR57: Determining the initial stabilizer consumption of soils and gravels

**SANS 3001 GR58**

Civil Engineering test methods Part GR58: Determination of the cement or lime content of stabilized materials by means of back-titration (acid base) method

**A20.1.4.11 Testing of pavements****SANS 3001-BT12**

Civil Engineering test methods Part BT12: Determination of the in-situ permeability of a bituminous surfacing (Marvil test)

**ASTM E 1705-95 (2005)**

Test method for measuring rut depth of pavement surfaces using a straightedge

**TMH 6**

Draft TMH6 1984: ST 3: Rolling straight edge for measuring surface irregularities

**TMH 6**

Draft TMH6 1984: ST 6: Measurement of the in-situ strength of soils by the Dynamic Cone Penetrometer (DCP)

**TMH 9**

Visual assessment of pavements

**TMH 13**

TMH13: Automated road condition assessments: Macro-texture, roughness, rutting and deflection testing subject to the provisions of Clause A20.1.5.5

## **A20.1.4.12 Testing of structural elements**

### **BS 5400 Part 9.2**

Tests on elastomeric bearings

## **A20.1.4.13 Testing geo-synthetics and geo-textiles**

### **SANS 1525**

Geosynthetics – Wide- width Tensile test

### **SANS 9862**

Geosynthetics – Sampling and preparation of test specimens

### **SANS 9863-1**

Geosynthetics –Determination of thickness at specified pressures Part 1: Single layers

### **SANS 9864**

Geosynthetics –Test method for the determination of mass per unit area of geotextile-related products

### **SANS 10318**

**Testing** geo-synthetics and geo-textiles

### **SANS 12224**

Geotextiles and geotextile-related products – Determination of the resistance to weathering

### **SANS 12236**

Geosynthetics – Static Puncture test (CBR test)

### **SANS 13431**

Geotextiles and geotextile-related products – Determination of tensile creep and creep rupture behaviour

### **SANS 13433**

Geotextiles and Geotextile-related products – Dynamic Perforation Test (Drop Cone test)

### **ASTM D 4533**

Standard Test Method for Trapezoid Tearing Strength of Geotextiles (commonly referred to as Trapezoidal Tear Strength)

### **ASTM D 4632 S**

Standard Test Method for Grab Breaking Load and Elongation of Geotextiles (commonly referred to as Grab Strength)

### **ASTM D 4355**

Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus

#### **a) Hydraulic Properties**

### **SANS 11058**

Geotextiles and geotextile-related products – Determination of water permeability characteristics normal to plane, without load

### **SANS 12956**

Geotextiles and geotextile-related products – Determination of the characteristic opening size

### **SANS 12958**

Geotextiles and geotextile-related products – Determination of water flow capacity in their plane

#### **b) Testing of soil compatibility**

### **ASTM D 5101**

Standard Test Method for Measuring the Filtration Compatibility of Soil-geotextile Systems (Gradient Ratio Test)

#### **c) Testing of paving fabrics in road maintenance applications**

### **ASTM D 6140**

Standard Test Method for Determining the Asphalt Retention of Paving Fabrics used in Asphalt Paving for Full-width Applications

#### **d) Testing for site adjudication and acceptance**

### **ASTM D 4759**

Standard Practice for Determining the Specification Conformance of Geo-synthetics -

### **ASTM D 4873**

Standard Guide for Identification, Storage, and Handling of Geo-synthetic Rolls and Samples

## A20.1.5 UNPUBLISHED TEST METHODS

The test methods in Clause A20.1.5 include those that are not contained in the standard test methods in Clause A20.1.3.2 and include tests in use or variations of published tests.

### A20.1.5.1 Testing hardened sprayed concrete

#### a) Determining the compressive strength

Sprayed concrete shall be tested for compressive strength, specimens shall be cored from test panels at age 3 to 7 days after spraying and cured in water in accordance with SANS 5865 (SANS 3001-CO3-5) until age of 28 days.

Specimens of hardened concrete shall be tested for compressive strength in accordance with SANS 5863 (SANS 3001-CO2-3, with the provision that the compressive testing machine shall be of sufficient capacity, be electronically controlled, be capable of maintaining a uniform rate of loading of approximately 15 MPa per minute, be calibrated by a recognised independent and accredited testing authority and shall comply with the requirements of SANS 3001-CO2-4 (EN 12390-4).

#### b) Drilling and testing cores for compressive strength

Testing shall be performed according to SANS 5865 (SANS 3001-CO3-5). The correction for transversely embedded reinforcement in the specimen shall be performed. The correction for excessive voids shall not be permitted:

- (i) When compressive strength is evaluated relative to the specified characteristic cylinder strength, the desirable core specimen length to diameter ratio shall be 2:1. The correction for length to diameter shall not be permitted; or
- (ii) When compressive strength is evaluated relative to the specified characteristic cube strength, the desirable core specimen length to diameter ratio shall be 1:1, and the correction for length to diameter ratio shall be permitted.

#### c) Concrete durability index testing

Test specimens shall be prepared in accordance with SANS 3001-CO3-1 from test panels, or if specified from the structure. Test panels shall have dimensions of 600 mm high by 400 mm wide by 150 mm thick and be placed, constructed and cured in the same manner as the Contractor utilised for the representative structural element. Test specimens shall be obtained perpendicular to the casting direction between 26 and 32 days after casting. A maximum of six test specimens shall be cored from the formed face of each test panel, excluding the outer 100 mm along the perimeter of the test panel. Test specimens shall represent the near surface properties of concrete and shall be typically obtained from the depth range of 5 mm to 35 mm from the formed face. Interior concrete obtained from a depth greater than 40 mm from the formed surface, shall not be utilised for concrete durability indexing purposes.

- (i) The oxygen permeability (OPI) test shall be conducted in accordance with SANS 3001-CO3-2, subject to amendments in Clause A20.1.5.1d) using at least four test specimens;
- (ii) The chloride conductivity (CC) test shall be conducted in accordance with SANS 3001-CO3-3, subject to amendments in Clause A20.1.5.1e), using at least four test specimens; and
- (iii) The water sorptivity (WS) test shall be conducted in accordance with Clause A20.1.5.1f), using at least four test specimens. The test specimens previously used for the oxygen permeability test may be reused and prepared in the prescribed manner.

#### d) Oxygen Permeability (OP)

Determine the best fit line using linear regression of  $\ln(P_0/P_t)$ , against  $t$  and forcing the regression line through the (0,0) point. Where the coefficient of correlation ( $R^2$ ) is less than 0,990, a retest should be done on the same specimen. If the subsequent test of the specimen also has a correlation coefficient of less than 0,990, this specimen should be discarded, and another test specimen prepared.

#### e) Chloride Conductivity (CC)

For conventional (normal-density) concrete, the porosity of the sample shall be greater than 6 %, in order for the test to be considered as valid. If porosity is less than 6 %, the vacuum saturation procedure should be followed.

#### f) Water Sorptivity (WS)

(Durability Index Testing Procedure Manual, 2009, [www.comsiru.uct.ac.za](http://www.comsiru.uct.ac.za) with project specific amendments)

##### (i) Specimens

From each trial panel, prepare four specimens in accordance with SANS 3001-CO3-1. It is acceptable practice to reutilise test specimens used in the Oxygen Permeability test, provided they are reconditioned according to the procedure set out below:

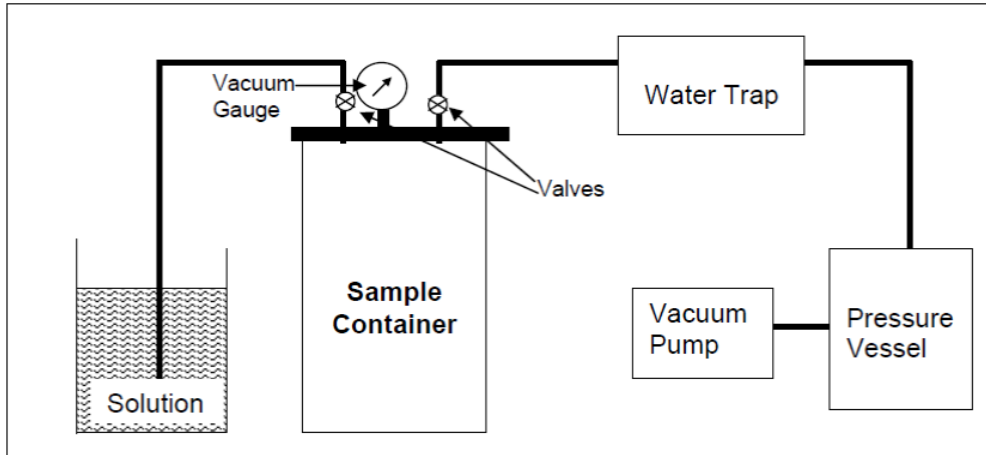
##### (ii) Apparatus

1. Oven, capable of maintaining a temperature of  $(50 \pm 2)$  °C. If the oven being used is of the closed (unventilated) type, the relative humidity inside the oven should be maintained by the inclusion of trays of saturated calcium chloride solution. The trays should provide a total exposed area of at least  $1,0 \text{ m}^2$  per  $1,0 \text{ m}^3$  of volume of the oven and should contain sufficient solid calcium chloride to show above the surface of the solution throughout the duration and method of curing, and the concrete age at time of testing shall be recorded and shall be representative of the Contractor's construction methodology.
2. Vacuum saturation facility (see Figure A20.1.5-1).
3. Plastic or stainless steel tray 20 mm deep and large enough to hold as many specimens as will be tested simultaneously, typically six.
4. Ten layers of absorbent paper towel. Alternatively, 2 rollers or 4 pins can be used to support the specimens tested.
5. Measuring scale, of accuracy at least 0,01 g.
6. Vernier calliper, capable of reading to 0,02 mm.
7. A solution of potable water saturated with calcium hydroxide (5g of  $\text{Ca}(\text{OH})_2$  per litre of water), maintained at  $(23 \pm 2)$  °C.
8. One or more stop watches as required.
9. Sealant to provide a watertight seal around the vertical curved edges of the specimens without blocking any part of the test face whatsoever: Either epoxy paint (ABE Epidermix 365 or Sikguard Wetseal) or packing tape can be used.
10. Desiccator, containing anhydrous silica gel as the desiccant, with the relative humidity controlled at a maximum of 60 %.

(iii) **Conditioning**

1. Directly after cutting, the specimens shall be placed in the oven at  $(50 \pm 2) ^\circ\text{C}$ , for  $7 \text{ d} \pm 4 \text{ h}$ .
2. Seal the vertical curved sides of the specimen using any of the recommended sealant techniques. If epoxy paint is used, care shall be taken not to get the epoxy on the flat test surfaces and there shall be no pinholes. After coating with epoxy paint, return the specimens to the desiccator or room where the ambient conditions are controlled to of  $(23 \pm 2) ^\circ\text{C}$  and less than 60 % relative humidity and allow the epoxy to dry for 18 to 24 hours. If packing tape is used, apply to the curved vertical edges at this time. No additional drying period is needed in this case. In either case, the extent of the protection must extend to the extreme edge of the sides towards the test face.
3. If the specimens have been previously tested in the oxygen permeability cells, specimens shall be placed back in the oven overnight prior to cooling in the desiccator.

**Figure A20.1.5-1 Vacuum saturation equipment setup for sorptivity test**



(iv) **Procedure**

1. Testing shall be carried out in a room maintained at a temperature of  $(23 \pm 2) ^\circ\text{C}$ .
2. If the specimens are taped, cool the specimens to a temperature of  $(23 \pm 2) ^\circ\text{C}$  in the desiccator. This cooling period should last for no less than 2 hours and no longer than 4 hours.
3. Measure and record, to an accuracy of 0,02 mm, the thickness and diameter of each specimen with the Vernier calliper at 4 points equally spaced around the perimeter of the specimen.
4. Calculate and record, to the nearest 0,02 mm the average of each set of four readings see A20.1.5.1f)(v)
5. Place 10 layers of paper towel on the tray. Alternatively, place the rollers or pins in position to support the specimen in the solution.
6. Pour calcium hydroxide solution into the tray. If used, paper towel should be saturated and water visible on the top surface. All air bubbles shall be removed by smoothing the paper pad towards the edges. If rollers or pins are used, they should be arranged as to support the specimen and the calcium hydroxide solution should be above the top of the support. The final water level should be such that it will be slightly above the bottom edge of the specimen and a maximum of 2,0 mm up the side of the specimen. Dampen an additional piece of paper towel for use in removing the excess water from the specimens and keep next to the tray to be used during the test.
7. Within 30 minutes after removing the specimen from the desiccator, determine the mass of the specimen to an accuracy of 0,01g and record as the dry mass at time 0. This mass shall be determined after the method used to seal the sides of the specimens has been applied.
8. Immediately place the specimen with the test face on the saturated wet paper, rollers, or pins and start the stopwatch.
9. Weigh the specimen at 3, 5, 7, 9, 12, 16, 20 and 25 minutes, after patting it once on the damp piece of absorbent paper. The specimen should appear saturated surface dry (SSD) on the test face at the time the mass is determined, i.e. it should look damp, but not have free water on the test face. During removal of a specimen from the tray for weighing, care must be taken to prevent dripping from one specimen onto the top of another.
10. Record the mass of the specimen to the nearest 0,01 g within 10 s of removal of the specimen from the tray and wiping excess water. Replace the specimens each time with the test face on the wet paper, rollers or pins. The stopwatch shall not be stopped during the weighing procedure. After a maximum period of 1 day after weighing of the specimen is completed, place the specimen in the vacuum saturation tank. The epoxy or tape must be left in place. The specimens should be arranged so as to maximise their exposed surface area. This may be achieved by standing the individual specimens upon their curved edges, rather than their flat sides.
11. Seal and close the vacuum saturation tank lid.
12. Evacuate the tank to between  $-75 \text{ kPa}$  and  $-80 \text{ kPa}$ , and maintain this vacuum for  $3 \text{ h} \pm 15 \text{ min}$ .
13. Isolate the tank and allow calcium hydroxide saturated water to flow into the chamber until the water level is approximately 40 mm above the top of the specimens. Ensure that no air enters the chamber during this procedure.
14. Re-establish the vacuum in the tank to between  $-75 \text{ kPa}$  and  $-80 \text{ kPa}$ , and maintain this vacuum for  $1 \text{ h} \pm 15 \text{ min}$ .
15. Release the vacuum and allow air to enter the chamber. Allow the specimens to soak in the calcium saturated water for  $18 \text{ h} \pm 1 \text{ h}$ .
16. Remove the specimens from the solution, dry them to saturated surface dry (SSD) condition, and immediately weigh to an accuracy of 0,01 g. Record this as the vacuum saturated mass ( $M_{sv}$ ) of the specimen.

(v) *Calculations*

1. Determine the porosity ( $n$ ) of each specimen, as a percentage, by applying the formula:

$$n = \frac{M_{sv} - M_{s0}}{Ad\rho_w} \times 100$$

Where:

- $M_{sv}$  is the vacuum saturated mass of the specimen to the nearest 0,01 g, in grams
- $M_{s0}$  is the mass of the specimen at time  $t_0$  (start of the test) to the nearest 0,01 g, in grams
- $A$  is the cross-sectional area of the specimen to the nearest 0,02 mm<sup>2</sup>, in millimetre squared
- $d$  is the average specimen thickness to the nearest 0,02 mm, in millimetres
- $\rho_w$  is the density of water, 1000 kg/m<sup>3</sup>, in kilograms per cubic metre

For conventional (normal-density) concrete, the porosity of the sample shall be greater than 6 %, in order for the test to be considered as valid. If porosity is less than 6 %, the vacuum saturation procedure should be followed.

2. Determine and plot the mass gain (Mwt) versus the square root of time by applying the formula:

$$M_{wt} = F \sqrt{t}$$

Where:

- $F$  is the slope of the best fit line from plotting Mwt against  $\sqrt{t}$ , in gram per square root of hour.
- $t$  is the time in hours after a specimen was first exposed to water on its test face, to the nearest 0,001 h, in hours

Do not include the zero-time reading in the data.

Use the following equation to determine the mass gain (Mwt):

$$M_{wt} = M_{st} - M_{s0}$$

Where:

- $M_{st}$  is the mass to the nearest 0,01 g of the specimen at particular time  $t$ , in grams.
- $M_{s0}$  is the mass to the nearest 0,01 g of the specimen at the initial time ( $t_0$ ), in grams.

3. Determine the correlation coefficient, R2 of the data using the RSQ {data range Mwt; data range of  $\sqrt{t}$ } function in Microsoft Excel. Do not include the zero-time reading in the data.
4. If the coefficient of correlation (R2) is less than 0,98, discard the last (25 min) value from the analysis, and re-determine the correlation coefficient.
5. If the correlation coefficient is still less than 0,98, discard the next value (20 min) from the analysis, and re-determine the correlation coefficient.
6. Repeat the procedure until a correlation coefficient of above 0,98 is achieved, or there are less than 5 data points remaining.
7. If a correlation coefficient of 0,98 cannot be obtained with a set of five or more values, regard the specimen as unsuitable for the determination of the sorptivity. However, record the range of data able to give a correlation coefficient of above 0,98.
8. Using the values obtained from procedures contained in Clause A20.1.5.1f)(iv) and (v) determine the slope of the best fit ( $F$ ) by linear regression analysis using the SLOPE {data range of Mwt; data range  $\sqrt{t}$ } function in Microsoft Excel. Do not include the zero-time reading in the data.
9. The sorptivity of the specimen ( $S$ ) is given by:

$$S = (Fd) / (M_{sv} - M_{s0})$$

Where:

- $F$  is the slope of the best fit line (5.8), in grams per square root of the hour
- $d$  is the average specimen thickness to the nearest 0,02 mm, in millimetres
- $M_{sv}$  is the vacuum saturated mass to the nearest 0,01g of the specimen, in grams

$M_{s0}$  is the mass to the nearest 0,01 g of the specimen at the initial time ( $t_0$ ), in grams

The procedure as stipulated in Clause A20.1.5.1f) (iii) to(v) is carried out separately for each specimen. The sorptivity index is given as the average of the water sorptivity of at least three valid individual test determinations.

(vi) *Test Report*

The following information shall be reported:

1. Identification mark of the specimen.
2. Detailed description of the specimen.
3. The effective porosity expressed as a percentage of each individual specimen to two decimal places.
4. The water sorptivity of each individual specimen.
5. The water sorptivity index to the nearest 1 decimal place
6. The range of data used in the calculations

(vii) *The following information shall be reported:*

1. Source of the specimen.
2. Location of specimen (i.e. within core or member).
3. Type of concrete, including binder type, water/cement ratio and other relevant data supplied with the specimen.
4. Curing history.
5. Usual specimen preparation, for example, removal of surface treatment.
6. Unusual features such as cracks, voids, excessively chipped edges, etc
7. Name of the test officer.
8. Age of concrete at time of testing.

**g) Energy absorption capacity**

The energy absorption capacity of fibre-reinforced concrete shall be determined from a slab specimen in accordance with EN 14488-5, except that the fibre reinforced concrete shall be cast into prepared formwork using conventional concreting techniques and cured in a consistent manner that is consistent with the curing method as planned by the Contractor on site, or if not specified by covering with approved absorbent material kept continuously wet and polythene sheeting.

**h) Testing the cover over reinforcement**

This procedure covers all measurements to be performed on reinforced and pre-stressed concrete structures to establish conformance to specified cover requirements.

(i) *Definitions aligned with RILEM TC230-PSC*

1. Minimum Cover: Minimum cover depth achieved in a lot. Defined as the characteristic value (percentile) below which a given percentage (typically 5 %) of all possible values of the cover depth population will fall.
2. Cover depth population: Collection of all theoretically possible measured concrete cover depths of a specific reinforcement layer (usually an outermost layer) of the concrete elements. This layer should have the same cover depth requirements and detailing of bars, spacers and ties throughout the element or within all concrete elements considered.
3. Lot: Number of concrete elements or surface zones where the cover depth of a specific reinforcement layer, assumed to be from the same population, is subject to inspection. Whenever possible, all the concrete elements, surface zones or units should have the same dimensions and the same method of execution.
4. Measurement point: Location at the surface of a reinforced concrete element where a single cover depth measurement is taken over a reinforcement bar.
5. Percentile: Value below which a given proportion of a collection of values (such as a data sample or a whole population) falls. For example, the 5<sup>th</sup> percentile of a population corresponds to the value below which 5 % of all theoretically possible values of the population will fall.
6. Sample: Collection of all cover depth measurements that have been performed or collection of all units that have been tested, which will be used as the basis for the evaluation of the conformity of the lot with respect to the specifications.

(ii) *Apparatus and cover meter devices*

Concrete cover testing shall be conducted using an approved cover meter device complying with the relevant modern standards BS 1881 Part 204 and ACI 228 and shall be capable of identifying the location and depth of reinforcement and to a lesser extent identify the diameter of embedded reinforcement. The Engineer shall at his sole discretion select specific areas and elements for cover testing. All cover meter devices proposed for use shall possess documentary proof of calibration by the original equipment supplier, or equivalent calibration authority, certifying the electronic calibration of the cover meter device not exceeding 5 years since the latest calibration. A standard control block, preferably with 40 mm cover, shall be used and maintained on site as a permanent control reference for cover depth. The Contractor shall be responsible to provide the cover meter device and calibration block. Unless specific payment for such provision has been allowed in the Contract Documentation, the provisions shall be deemed as being covered in the respective rates for steel reinforcement. The cover meter shall be routinely checked on site using the control block under the control of the Engineer and recorded daily in writing in the laboratory equipment calibration or control register.

The cover meter device shall be checked against the standard control block immediately prior to each day of measurement. Any deviation of reading on the standard control block shall be immediately reported to the Engineer, who may instruct the immediate replacement of the cover meter device at the Contractor's expense. The Contractor shall clean the measurement point area to ensure that no adhering debris, dust or localised surface deviations affect the cover test. All measurements shall be performed in accordance with the cover meter equipment manufacturer's guidelines.

(iii) Cover test procedure and method

1. Sampling ratio and bridge elements requiring specific cover measurement.

The cover meter tests shall be conducted for a minimum of 2 % of the surface area of concrete placed, for example 1,0 m<sup>2</sup> for every 50 m<sup>2</sup> surface area. For bridges, or elements thereof, constructed utilising a half-width construction strategy, the sampling ratio shall be increased to 3,3 % of surface area, for example 1,0 m<sup>2</sup> for every 30 m<sup>2</sup> surface area. The Engineer shall at his sole discretion select specific areas and elements for cover testing.

Critical elements for cover surveys are parapets, deck edges including underside of cantilevers, deck soffits, lower portions of columns and abutments and walls. All parapets including the parapet beam and aesthetic detail recesses shall be fully tested for cover compliance. In addition, the entire area up to 1,5 m high above ground level on piers, walls and abutments, including the rear of abutments and wingwalls, shall be fully tested before being backfilled. The Engineer will identify other critical areas required to be surveyed. Should any of these areas shows deficiencies, the Engineer may order additional cover tests on other areas at the Contractor's cost.

2. Preparation

The Engineer order to carry out a cover survey shall be recorded in writing in the established site test request system. The selected area for cover measurement is to be indicated on a sketch, appropriately referenced to clearly defined structural features to ensure that the area can be further investigated should a cover non-conformity be reported. The responsible person must identify the area to be scanned, take measurements on the required date, analyse the data and assess the results for conformance.

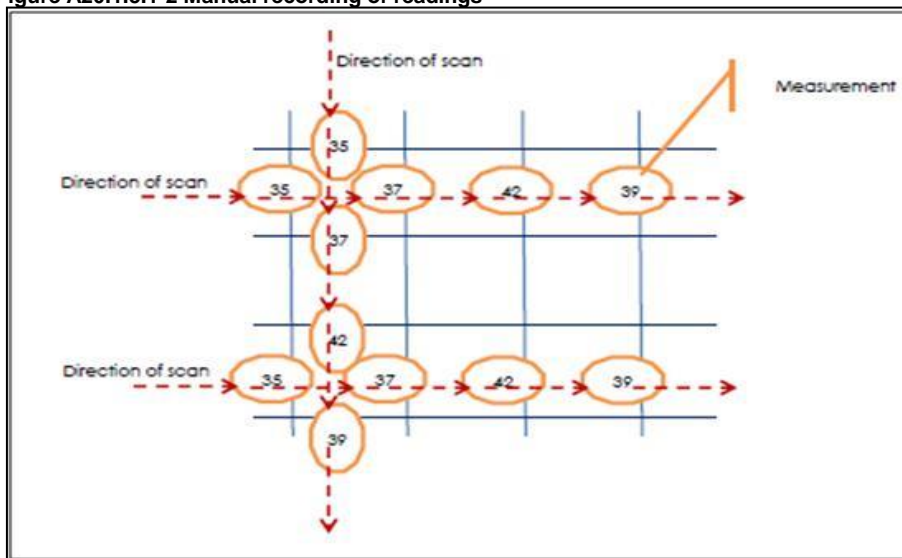
3. Generally accepted cover method or grid, block or image scan method

Individual cover depth measurements are to be recorded in the primary, outer reinforcement directions of a marked grid as per the cover meter equipment manufacturer's guidelines. A minimum of 12 individual cover depth measurements shall be recorded from a grid area of at least 600 mm by 600 mm, typically 0,36 m<sup>2</sup>, and the individual arithmetic mean cover calculated for this specific grid area. An example of Image Scan information and presentation is illustrated in Figure A20.1.5.1-2.

If the equipment used is not able to provide the above presentation it shall be done manually by determining the position of rebar first and to then manually record readings in order to establish the depth of rebar as shown in Figure A20.1.5.1-2.

For splices (and only when using the generally accepted cover method or grid, block or image scan method), the size of rebar shall be corrected manually on the device by applying a factor of 1,41 times the diameter of spliced reinforcement as shown on the drawings. Prior to correcting for splices, scan images must be evaluated to verify the presence of splice bars and only the affected individual cover depth measurements shall be corrected for splicing in order to yield a revised individual mean cover for the survey area.

Figure A20.1.5.1-2 Manual recording of readings



For the purposes of calculating the individual mean cover, individual cover depth measurements that have covers exceeding the specified nominal cover by the greater of twice the reinforcement diameter or 25 mm, whichever is greater, shall be capped at specified cover plus the greater of twice the reinforcement diameter or 25 mm in the calculations.

NOTE

Where it is established that there is insufficient cover before placing of subsequent concrete, for example starter bars from base not correctly positioned, remedial actions shall be performed before continuing with next concrete operation – these actions to be clearly recorded and area identified.

4. Normalisation procedure for the intended use of alternative cover method

Where the Contractor elects to utilise alternative methods such as the quick or linear scan method, he is hereby duly alerted to the fact that the second, or orthogonal rebar layer and the presence of lapped bars may significantly affect the cover readings reported using this method, resulting in the reporting of relatively smaller cover. The Contractor shall ensure stricter control over the achievement of cover takes place on site to ensure full compliance where alternative cover

methods are proposed and employed.

The normalisation procedure shall be satisfactorily executed in full and submitted in writing to the Engineer prior to the acceptance of the alternative cover method on site. The Engineer shall duly consider the technical submission and elect to approve the test method provided that the straight-line regression coefficient exceeds the minimum requirement specified below.

The Contractor shall perform a comparative parameter study comprising of a minimum range of 50 discrete individual cover surveys as recorded in the cover survey request system, where the alternative cover method is specifically limited to the same grid area used for the generally accepted method. The comparative results shall be tabled for each grid area and specific structural element type, and the individual mean cover in mm, and standard deviation in mm, shall be reported for each cover method per grid area. A graphical XY plot of individual mean cover from the two cover methods, with the generally accepted grid/block method plotted on the horizontal, independent variable, axis and the alternative cover method plotted on the vertical, dependent variable, axis. In order to accept the normalisation procedure, a correlation coefficient ( $R^2$ ) shall be equal to, or greater than, 0,90. The comparative analyses shall also determine the net reported shift in cover between the two methods, but the shift shall not under any circumstances be used to adjust any cover readings determined using the alternative cover method.

5. Quick or linear scan method as an alternative cover method.

After completion of the normalisation procedure, and acceptance of the comparative analysis by the Engineer, the alternative cover method may be utilised. Individual cover depth measurements are to be taken perpendicular to the layer of rebar closest to the concrete surface for each scan area, so that an individual mean cover to reinforcement can be determined for the tested area. A minimum of 40 individual cover depth readings shall be taken per m<sup>2</sup> per test area.

Readings are to be taken to identify individual bars within each 1,0 m<sup>2</sup> test area. At least three cover readings, at 100 mm spacing, per each individual bar, shall be shown in the test results but only the global mean cover measurement for the test area shall be used for payment purposes. Reports generated by the equipment shall be used for determining payment in accordance with Table A20.1.7-13 for conditional acceptance if applicable.

Where more than 2 % of individual cover measurement readings are below specified lower acceptance limit, the area shall be re-scanned, exclusively by the generally accepted image, block or grid scan method, to verify the individual mean cover.

An example of Quick Scan information and presentation is illustrated in Figure A20.1.5.1-2.

6. Processing, analysis and reporting of cover data

- Statistical analysis

Where the collection of cover data satisfies the requirements for full statistical control, cover data shall be analysed and reported in accordance with Chapter 9 of RILEM TC230-PSC. The analysis shall be based on the proportion of the cover depth population that is permitted to fall below the minimum cover is 5 % and the permitted owner's risk is 25 %. Exclusively quantitative analysis procedures shall be followed.

- Deemed to satisfy analysis

Where the cover data collected does not wholly comply with the criteria for executing full statistical control and the analysis in accordance with judgement Plan A specified in Clause A20.1.7.5c) shall be followed.

## A20.1.5.2 Tests on road elements

### a) Testing the soils, gravels, and crushed stone materials for earthworks and pavement layers

(i) General

Samples of soils, gravels and crushed-stone materials in earthworks and pavement layers shall be taken in accordance with the methods described in SANS 3001 suite of standards, all subject to the following additional provisions:

1. In the case of chemically stabilised material, determining the optimum moisture content and the maximum dry density shall be completed within the period given in SANS 3001-GR31 and field density shall be determined within 24 hours of compaction having been completed.

### b) Moisture content at the specified saturation degree ( $S_r$ )

Determine the apparent density ( $G_s$ ) of the material using SANS 3001 – AG 22 and calculate the moisture content.

$$W_v = S_r \{X_w/X_d - 1000/G_s\}$$

Where

$W_v$	=	moisture content of the specified degree of saturation (%)
$X_w$	=	density of water (kg/m <sup>3</sup> )
$X_d$	=	in-place dry field density of the material (kg/m <sup>3</sup> )
$G_s$	=	apparent density of the material (kg/m <sup>3</sup> )
$S_r$	=	specified degree of saturation (%)

## A20.1.5.3 Testing Bitumen and Asphalt

### a) Tests described in the standard specifications for bitumen and bituminous emulsions

The Engineer shall be entitled to order the Contractor to have materials tested by an approved laboratory for compliance with all or any of the requirements specified. The Contractor shall arrange with the testing laboratory for the original results of such tests to be submitted directly to the

Engineer with copies to himself as required.

The payment of such tests, on condition that the products comply with the requirements, shall be as specified in Section C20.1.

**b) Cantabro abrasion test**

If required, the resistance of porous asphalt briquettes to abrasion loss shall be determined by means of the Cantabro test described below. This test method entails a combination of published test methods. The abrasion loss value for freshly compacted specimens shall not exceed the values specified in Chapter 9.

(i) *Apparatus*

The apparatus shall be a Los Angeles Testing Machine as described in ASTM Method C131 or SANS 5846.

The machine shall consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 710 mm ± 5,0 mm and an inside length of 510 mm ± 5,0 mm.

The cylinder shall be mounted with stub shafts, attached to the end of the cylinder but not ending it and shall be mounted in such a manner that it may be rotated with the axis in a horizontal position with a tolerance in slope of 1 in 100.

An opening in the cylinder shall be provided for introduction of the test sample.

A suitable, dust-tight cover shall be provided for the opening with means for bolting the cover in place.

The cover shall be designed to maintain the cylindrical contour of the interior surface unless the shelf is so located that the charge and/or test sample will not fall on the cover or come in contact with it during the test.

A removable steel shelf extending the full length of the cylinder and projecting 92 mm ± 2,0 mm inward shall be mounted on the interior cylindrical surface of the cylinder, in such a way that a plane centred between the large faces coincides with an axial plane.

The shelf shall be 25 mm ± 1,0 mm thick and mounted by bolts or other suitable means so that it is firm and rigid.

The position of the shelf shall be such that the distance from the shelf to the opening measured along the outside circumference of the cylinder in the direction of rotation, shall not be less than 1 270 mm.

The machine shall be driven and counterbalanced to maintain uniform peripheral speed of 30 – 33 rpm for 300 revolutions.

If an angle is used as the shelf, the direction of rotation shall be such that the charge is caught on the outside surface of the angle.

(ii) *Test Procedure*

Marshall specimens shall be prepared as described in SANS 3001-BT1, but for this test each Marshall specimen shall be compacted with 50 blows only on each side.

For each binder content, three specimens shall be made for the abrasion test.

The compaction temperature depends on the type of binder to be used. For 50/70 penetration-grade bitumen) it shall be 115°C to 120°C and for bitumen-rubber (wet method) it shall be 135°C to 140°C, measured in the mould just prior to compaction.

The thickness of the test specimen shall be 63,5 mm ± 1,25 mm.

The mass of the specimen in air (P1) to the nearest 0,1 g and the average thickness to the nearest 0,1 mm, shall be determined.

The test specimen shall be placed in the Los Angeles apparatus without the abrasive charge of steel balls and the cover shall be fitted.

The machine shall be switched on and allowed to operate for 300 revolutions at a speed between 30 – 33 rpm.

After the required number of revolutions, the machine shall be stopped, and the specimen removed, and the mass determined (P2) to the nearest 0,1 g.

The test shall be carried out for each binder content in triplicate.

(iii) *Calculations*

The percentage abrasion loss for each specimen shall be calculated as follows:

$$P = 100 \cdot (P1 - P2) / P1$$

Where:

P1 = mass of specimen before testing.

P2 = mass of specimen after testing.

Note: The means of the three specimens shall be determined at each binder content.

(iv) *Notes:*

The determination of the optimum binder content is based on the following factors:

1. A minimum binder content limit to ensure resistance against aggregate loss due to traffic and to enhance durability.
2. A maximum binder content limit to avoid binder run-off and to ensure good drainage in the mix as a layer on the road.

### c) Air Permeability Test

Determination of the air permeability of compacted Marshall specimens or cores.

#### (i) Scope

The measurement of air permeability is non-destructive and may be performed on laboratory-compacted Marshall specimens or cores removed from a pavement.

#### (ii) Apparatus

Model AP-400 A, Asphalt Paving Meter, is a self-contained device capable of measuring air flow rates of up to 5,0 l per minute at low pressure differentials. The device has a maximum volume capacity of 1,0 l. It is equipped with two calibrated sight tubes; one measures in 25 ml increments for dense specimens, and the other is graduated in 500 ml increments for open, permeable specimens.

Incorporated in the unit are the valves required to perform the test: a pressure squeeze bulb for filling the test system with water; a sensitive manometer for pressure setting; a metal cylindrical jacket slightly larger than the 101,6 mm diameter Marshall specimen and containing a 101,6 mm diameter rubber triaxial sleeve as an inner liner; a domed test cap; and a specimen support.

#### (iii) Test Procedure

1. Remove either stem valve by screwing counter-clockwise and lifting out of the case. Set the main control valve at 'exhaust' or 'test'. Fill the unit with 2 000 ml of water through the recess left by the stem valve.
2. Replace the stem valve in its mounting.
3. Fill one of the two calibrated volumetric cylinders in the following manner: NOTE: 1 000 ml cylinder is used for open specimens. 300 ml cylinder is used for dense specimens. (a) Push the main control valve to the 'off' position. (b) Open the stem valve above the selected cylinder by turning counter-clockwise. One revolution is adequate. Check to make certain that the volumetric cylinder stem valve not being used is closed tightly. The air flow valve on top of the rubber bulb assembly should be open (unscrewed about two turns). (c) Squeeze the rubber bulb, pumping air into the reservoir. The pressure will force water from the reservoir into the measuring cylinder, as can be seen by the rising water-level in the sight tube. Continue pumping until the sight tube is filled to within approximately 25 mm of the top. Close the stem valve connected to this tube. (d) Turn the main valve to the 'exhaust' position to allow excess air pressure to escape from the reservoir.

Connect the rubber tube of the specimen test cap to the pressure port located in the lower left corner of the instrument. Connect the second tube of the specimen test cap to the manometer port located at the top left of the manometer. (The rubber tubes of the test cap are interchangeable and may be connected to either the pressure port or the manometer port.)

4. Level the instrument by observing the level bubble and adjust the instrument on the swivel tripod.
5. Set the manometer at the 'zero' reading by loosening the screw at the bottom of the manometer and sliding the scale until the 'zero' reading coincides with the level of the manometer fluid in the nearly horizontal tube of the manometer. Be sure that the manometer valves are in an open position while zeroing the manometer and during a test.
6. The Marshall specimen is placed on the support and the metal cylinder, with the rubber triaxial sleeve in place, is slipped over both. The domed test cap with rubber tubes attached is then placed over the top of the specimen and the rubber -sleeve inflated with the hand bulb to seal the cap, specimen and support. If the vertical face of the specimen is rough, it may be sealed with paraffin wax prior to placing in cylinder.
7. The instrument is now ready to perform the test: the main valve is set at 'exhaust', the measuring cylinder is full, both manometer valves are open, the manometer is reading 'zero' and the test cap is sealed to the specimen.
8. Proceed as follows:
  - Push the main control valve to the 'test' position. Close the airflow valve at the top of rubber assembly.
  - Open the stem valve of the filled volumetric cylinder slowly, allowing water to flow from the cylinder back to the reservoir. Adjust the stem valve so that a constant pressure is developed and recorded by the manometer. Normally, tests are run at 6,4 mm of water pressure. The pressure is held constant throughout the test by minor adjustments to the stem valve.
  - Once constant pressure has been attained, the time required for water to flow between two of the calibration marks on the sight tube is measured accurately. A volume of flow sufficiently large to require a time interval of at least 20 seconds should be selected to obtain accurately repeatable results. Time intervals exceeding 2 minutes do not add to the accuracy of the test and only prolong the testing time.
9. A minimum of three Marshall specimens should be tested at each binder content and the mean rate of air flow through the specimens taken.
10. Calculation

The air permeability is then calculated using the following formula:

$$K = 2,331 \times 10^{-9} \frac{QL}{h}$$

Where:

K = fundamental permeability (cm<sup>2</sup>)

Q = rate of air flow through specimen (cm<sup>3</sup>/s) L = average height of specimen (cm) h = air pressure difference expressed in height of water column (cm)

It should be noted that the above formula applies only to a 101,6 mm diameter cylindrical specimen.

## **A20.1.5.4 Testing relating to chemical stabilisation**

### **a) Test for cementitious-binder content**

Where the Contract Documentation requires the determination of the cementitious-binder content due allowance shall be made for the presence in the unstabilised material of naturally occurring MgO or CaO (e.g. basalts, calccrete, etc., as well as previously stabilised layers, which affects the result of such tests. If the standard deviation of the natural  $C_aO$  plus  $M_gO$  content of the untreated material exceeds 0,35 %, any determination of the cementitious-binder content shall be ignored.

Sample holes shall be randomly spaced transversely as well as longitudinally over the area to be tested or as directed by the Engineer and if the material is road-mixed, separate samples shall be taken from the top and bottom of each hole.

### **b) Test to determine bulk spread rate of powdered chemical stabilising agents using the canvas patch test**

The following method shall be used for determining the bulk spread rate of a chemical stabilising agent where bulk distributors are used.

Clean canvas patches, each measuring 1,0 m x 1,0 m, shall be placed flat on the road in selected positions in relation to the bulk distributor's track. The number of patches shall be proportional to the length of powdered stabilising agent spread, varying from 10 patches for sections of at least 400 m, 6 patches for sections from 100 m to 400 m and 3 patches for sections under 100 m.

After the stabilising agent has been spread by the bulk distributor, the canvas patches shall be carefully lifted and all the material on the patches transferred to a container and weighed. The total mass of stabilising agent on each patch is then recorded and the average rate of application determined. Instead of canvas patches, flat metal trays may be used for collecting the stabilising agent.

### **c) Test for mix uniformity in chemically stabilised layers**

Where required by the Engineer, the Contractor shall determine the mix uniformity of chemically stabilised layers by means of indirect tensile strength tests, using SANS 3001-GR54

The Contractor shall timeously make the necessary arrangement to take samples in accordance with the requirements of the method used.

## **A20.1.5.5 Tests on pavements**

### **a) General**

The testing of macro-texture, roughness, rutting and deflection by specialised equipment in terms of TMH13: Automated Road Condition Assessments (various parts), shall be subject to the provisions herein.

### **b) Surface macro texture: Instrument assessment**

The surface macro-texture shall be measured following draft TMH 13 – Part E using non-contact laser spot sensors with a minimum resolution of 64KHz capable of meeting the output requirements for Mean Profile Depth (MPD) specified in ISO 13473-1 calculated and recorded at 10 m intervals. The position of the measurements shall be as specified and demarcated by the Engineer which normally includes one or both wheel paths and in-between wheel paths for segment lengths of 1,0 km or as otherwise specified in the Contract Documentation.

The operation and quality checks of the equipment shall be undertaken by an Independent ISO 9001-2015 certified service providers in accordance with the manufacturer's and draft TMH 13 requirements.

A validation of the equipment components shall be conducted and analysed for conformance by the Employer or his experienced and approved agent following the draft TMH 13 validation protocols. Such validation shall not be older than six months or as otherwise specified in the Contract Documentation. The Engineer, however may also conduct validation checks on site following the validation protocols on surfaces with texturing similar to that to be measured.

### **c) Road Roughness Measurements**

#### **(i) Direct Contact Roughness Measuring Devices**

Direct contact Roughness devices, also known as static devices, which are class 1 for vertical sampling intervals and class 3 longitudinal sampling interval profiling devices taking direct roughness measurements using precision inclinometers on the road surface, with built-in data capturing systems and outputs in International Roughness Index (IRI) reported in m/km or which can be processed into IRI outputs using public domain "Road Ruf" or "Proval" software. Longitudinal sampling intervals of 250 mm, or less, are typically used. These devices must be operated by experience staff and are used for benchmarking of IRI-values on selected road sections for Validation and Calibration purposes of other high-speed roughness measuring devices. These devices shall meet the standards and data output criteria, in IRI (m/km), specified in draft TMH 13 - Part C. These devices can also be used for the measuring of IRI (m/km) of shorter lengths of roadway, averaged for 100 m lengths, in both wheel paths separately of all traffic lanes and shoulders in excess of 2,0 m widths following the manufacture's operation manual and the requirements of TMH 13 – Part C. Using these devices, unless otherwise specified in the Contract Documentation, only one single pass of measurement is normally sufficient. For judgement purposes, the Average IRI per 100 m for a traffic lane or shoulder is calculated as follows:

Average IRI 100 m = (100 m IRI left wheel path + 100 IRI right wheel path)/2 for single passes with the equipment.

#### **(ii) High Speed Inertial Non-Contact Laser Profilometers**

All the equipment elements are attached to a motor vehicle which measures roughness at high speeds (between 30 and 100 kms/h). The accuracy and data output of profilometers shall comply with draft TMH 13 – Part C with a class 1 vertical resolution of equal to or less than 0,1 mm and a class 1 longitudinal sampling interval of less than or equal to 25 mm as defined in ASTM E950-09.

The roughness output, in International Roughness Index (IRI) in m/km is characterised by a fixed and specific computer algorithm for both wheel paths separately recorded and stored at 10 m intervals and averaged for each 100 m. The processing of the data in each wheel path shall be in accordance with ASTM E1170-97 and the World Bank Technical Paper 46.

These profilometers are calibrated by the manufacturer and shall be validated regularly on road sections specifically selected for this purpose against known IRI reference values established by class 1 direct contact profiling devices conforming to the requirements of TMH 13 – Part C. The validation shall be conducted and analysed for conformance by the Employer or his experienced and approved agent following the draft TMH 13 – Part C procedures and protocols. Such validation certificate shall

not be older than six months or as otherwise specified in the Contract Documentation.

The operation of the device shall be conducted by trained and experienced staff of an Independent ISO 9001 - 2015 certified service provider following ASTM E950-09(or latest version) test procedures together with strict daily quality measures and check lists. The roughness measurements for each wheel path shall be taken simultaneously, with the lasers, at a spacing of 1,75 m apart for all traffic lanes and shoulders in excess of 2,0 m in width, as determined according to the final line markings, following the Manufacturer's operational manual and the procedures of draft TMH13 - Part C. The lengths for testing with high speed inertial non-contract profilometers shall be 1,0 km or multiples thereof, unless otherwise specified in the Contract Documentation.

Three repeat runs for each measured traffic lane or shoulder, unless otherwise specified in the Contract Documentation, shall be conducted and the measurements of the left and right wheel paths per 100 m IRI-values of the runs shall be averaged to produce an Average IRI for each 100 m. The Average IRI for the 100 m traffic lane or shoulder is calculated as follows:

Run 1 IRI 100 m average = (100 m IRI left wheel path + 100 m IRI right wheel path)/2

Run 2 IRI 100 m average = (100 m IRI left wheel path + 100 m IRI right wheel path)/2

Run 3 IRI 100 m average = (100 m IRI left wheel path + 100 m IRI right wheel path)/2

Average IRI 100 m = (Run 1 IRI 100 m average + Run 2 IRI 100 m average + Run 3 IRI 100 m average)/3

#### d) Rutting Measurements

##### (i) High speed profilers

These profilers are high speed (80 km/h) instrumented vehicles using non-contact laser sensors to measure the transverse profile of the road surface meeting the requirements of ASTM E950-09 referred to in draft TMH13 Part D. To meet the accuracy requirements, the number of lasers shall be between 15 and 25 with the spacing configuration and focus of the sensors optimised to locate the low and high profiles in both wheel paths separately covering a measuring width of at least 3,2 m. At least one inertial motion sensor (IMS) shall also be fitted rendering the data collected suitable for the calculation of other rutting parameters such as rut area, ponding area cross fall and gradient.

The average rut depth in mm is characterised by a fixed mathematical algorithm and shall be recorded and stored at 10 m intervals, averaged and reported for each wheel path at 100 m intervals. In addition, the maximum rut measured within the reported 100 m average for each wheel path shall also be reported. The operation and quality checks of the equipment shall be undertaken by experienced staff of an independent ISO 9001-2015 certified service provider in accordance with the manufacturer's and draft TMH 13 – Part D requirements. A validation of the equipment components and systems shall be conducted following the TMH13 protocols and analysed for conformance by the Employer or his experienced and approved agent following draft TMH13 – Part D validation protocols. Such validation certificate shall not be older than six months or as otherwise specified in the Contract Documentation.

#### e) Deflection measurements using the Falling Weight Deflectometer (FWD)

(i) The FWD system for the measurements of deflections is based on a dynamic impulse load on a rubber buffer that transmits the force to a standard sized load plate with geophones (velocity transducers) attached to a bar to capture the deflection bowl of the pavement structure. A target load of 40 KN, as well as a 50KN, or as otherwise specified in the Contract Documentation, is normally applied for 20 – 30 milliseconds.

(ii) The primary equipment elements consist of the following:

- An appropriate vehicle or a vehicle and trailer combination
- A FWD device with a 300 mm diameter split or segmented base plate with a 5 mm patterned rubber pad
- A sensor bar with geophone sensors pointing in the direction of travel
- Appropriate weights to apply loads of 10 – 120 KN fitted on to adjustable height stops
- Appropriate thermometers for the measurements of air and road surface temperature – and / or pavement temperatures, when specified in the Contract Documentation.
- A calibrated distance measuring instrument fitted to the vehicle
- A real time differentially corrected Global Positioning System (GPS) linked to the data fitted directly above the load plate
- A computer and operating system
- Software with real time displays for quality checks during the testing operations
- Drill and bits for at depth pavement temperatures measurements, if required
- An auxiliary power source for the operation of hydraulic / electrical equipment
- Aerosol paint for spot markings of test points
- Safety signs and flashing amber lights

The minimum requirements of the measuring components and data acquisition system are specified in draft TMH 13 – Part F.

(iii) The minimum number of geophone sensors shall be nine or eleven spaced at offsets as outlined in Table A20.1.5-1 for basic deflection bowl parameters i.e.:

- |                              |   |             |
|------------------------------|---|-------------|
| - Maximum deflections (Ymax) | : | D0          |
| - Base layer index (BLI)     | : | D0 – D300   |
| - Middle layer Index (MLI)   | : | D300 – D600 |
| - Lower layer Index (LLI)    | : | D600 – D900 |

Note: D denotes the offset from the centre of the load plate.

**Table A20.1.5-1: Sensor offsets from the centre of the base plate, for nine or eleven configurations shall be as follows**

SENSOR NO	OFFSETS IN MILLIMETRES	
	NINE SENSOR CONFIGURATION	ELEVEN SENSOR CONFIGURATION
1	0	0
2	200	200
3	300	300
4	450	400
5	600	500
6	900	600
7	1 200	750
8	1 500	900
9	1 800	1 200
10	-	1 500
11	-	1 800

- (iv) Deflection measurements, in microns, are taken at test positions specified in the Contract Documentation, or the Engineer, following the manufacturer's procedures, regular quality control checks and operator validations/ operating procedures.

The weight shall be dropped four times at each test point as follows:

- Drop 1: At 40KN load, for seating purposes and not reported  
 Drop 2 & 3: At 40KN load and the deflections are reported individually for each drop  
 Drop 4: At 50KN load and the deflections reported separately

The deflections for each sensor are normalised for allowable small variation from the target loads, recorded for each drop separately and reported for each test position. The air and road temperatures together with the date and time shall also be recorded and reported together with the location details of each test point. All the deflection measurements shall be undertaken by trained and experienced staff of an Independent and ISO 9001 – 2015 certified service provider.

- (v) In the absence of formalised calibration trials for FWD equipment, as compiled by CROW and referred to in Draft TMH13, and for uniformity of calibrations, the protocols by SHRP and accepted by AASHTO designation: R32-11, shall be followed, the "reference" calibration of the load cell and sensors as well as the "relative" calibration of sensors (inter-sensor correlation) shall be conducted annually by an independent AASHTO-certified calibrating person. The operator shall in addition to the above independent calibrations also conduct at least monthly "operators" verification / reference Calibrations for temperature probes, distance measuring instruments, position of sensors and inter-sensors correlation (relative calibration). All the calibration and verification certificates and documentation shall be made available to the Engineer and /or Employer.
- (vi) For testing on trafficked roads, appropriate traffic accommodation shall be provided by the service provider or the Employer as specified in the Contract Documentation.

## **A20.1.5.6 Tests on structural elements**

### **a) Tests on elastomeric bearings**

(i) *General*

Tests on elastomeric bearings shall be conducted in accordance with BS 5400 part 9.2 and the bearings shall comply with the test requirements specified in the said specification.

(ii) *Compression and shear-stiffness tests*

When compression and shear-stiffness tests are conducted on sample bearers or on only a limited number of bearers in a consignment, the stiffness values as determined by the tests shall be within 20 % of the theoretical values.

### **b) Pre-stressed concrete: Testing pre-stressing steel, anchorage assemblies, couplings and grout**

(i) *General*

The Contractor shall arrange for samples of the materials he intends to use in the works to be tested by an approved laboratory/testing authority. The cost of testing pre-stressing steel, anchorage assemblies and couplings will be paid for as specified in Section C20.1. Control tests on the viscosity and bleeding of grout will be regarded as part of the Contractor's obligations under Clause A1.2.8.1 of Chapter 1 for process control and will not be paid for separately.

Material represented by samples that do not comply with the specified requirements shall be removed and replaced with suitable material.

(ii) *Anchorage and couplers*

Anchorage and couplers shall be tested in accordance with the requirements of BS EN13391. The anchorages and couplers shall be assembled with their practical application on the site where all the components necessary for anchoring shall be used but excluding the ducts.

(iii) *Pre-stressing steel*

Pre-stressing steel shall be tested in accordance with the requirements of Clause A13.5.5.2 of Chapter 13. Should any test piece fail to comply with the requirements specified for the pre-stressing steel, the material represented by that sample shall not be used without further testing and shall be replaced with materials conforming to the specifications if further testing confirms that they do not comply with the specifications.

(iv) Grout

The fluidity of grout shall be measured with a flow cone, immersion apparatus or viscometer. The instrument shall be accurately calibrated in a laboratory so that the specified viscosity of the grout can be controlled satisfactorily.

The procedure for conducting the flow-cone test for measuring the fluidity of grout shall be as follows:

Unless otherwise approved, the flow cone shall be as shown in Figure A20.1.5-3.

Immediately after the grout has been mixed, the pre-wetted flow cone, which is held firmly with its top rim in a level position, shall be filled with grout to the level indicated by the pre-set pointer, whilst the bottom orifice is held closed with a finger.

As soon as the required volume of grout, ( $\pm 1750 \text{ ml}$ ), is reached, the finger shall be released to allow the grout to flow out freely through the bottom orifice. A stop watch shall be used to determine the flow time for emptying the cone, to the nearest second.

The readings obtained during grouting shall be compared with the times determined in the laboratory for grouts of the specified viscosities.

The bleeding of grout shall be measured in a metal or glass container with an internal diameter of approximately 100 mm and a height of approximately 120 mm. The grout and water levels in the container shall be controlled with a metal bridge into which two adjustable studs A and B are secured. See Figure A20.1.5-4 for details of the apparatus.

The procedure for determining the bleedings of grout shall be as follows:

Studs A and B in the metal bridge shall be adjusted and locked so that the distance from the lower tips of the studs to the bottom of the container will be approximately 100 mm and 107 mm respectively. The volumes  $V_A$  and  $V_B$  for the container at the respective levels of the stud settings shall then be determined to the nearest  $\text{ml}$ .

The container shall be filled with freshly mixed grout to a level where the grout will just touch the tip of stud A, which points downwards. The bridge shall be then be removed and the container tightly sealed to prevent evaporation. The container shall then be stored at  $20^\circ\text{C}$  and kept free from vibrations for the entire duration of the test.

Three hours after the grout has been mixed, the container shall be opened and the free (bleed) water poured off. The bridge shall be placed over the container with the tip of stud B pointing downwards and water poured onto the grout with a measuring apparatus until the water level touches the tip of stud B. The volume of water added shall be determined to the nearest millilitre and designated as  $\Delta V$ .

The percentage of bleeding (B) shall be calculated from the formula.

$$B = \left\{ 1 - \left( \frac{V_B - \Delta V}{V_A} \right) \right\} \times 100$$

Figure A20.1.5-3 Flow Cone

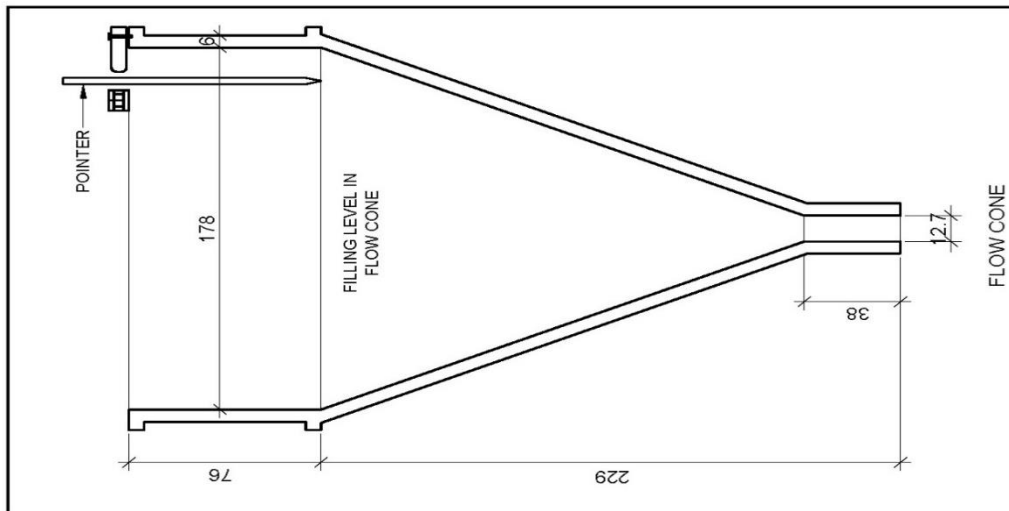
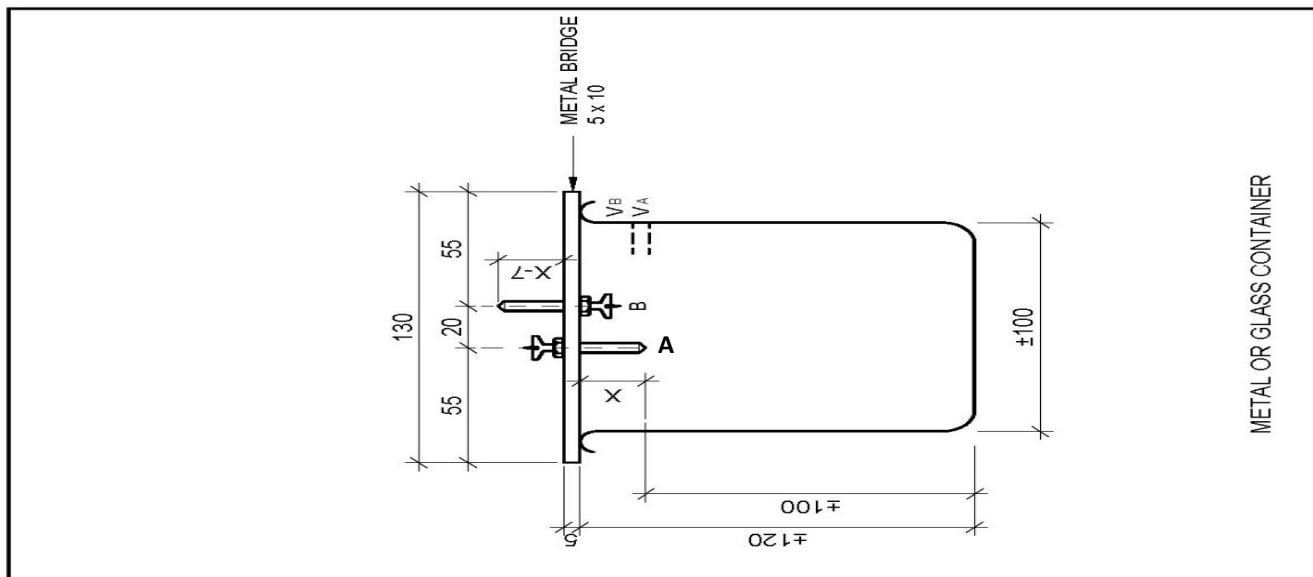


Figure A20.1.5-4: Metal or Glass Container



c) Tests on piles

(i) General

Testing to ensure concrete durability, specifications for the necessary cover to reinforcement and a quality assurance system including sonic tapping and cross hole sonic logging geophysical methods, to verify pile integrity is covered in this section.

1. Static Load Tests

The head of the test pile shall be exposed for checking position and slope. Where necessary, the head shall be cut further back to expose a full bond length of main reinforcing steel, and a suitable pile head slab for applying an axial load to the pile shall be cast. As an alternative, the head may be cut at right angles and the load applied direct to the pile.

The test load shall be applied to the top of the pile with a hydraulic jack. Where more than one jack is used for applying the load, all the jacks in the circuit shall be activated by the same pumping unit. The jack(s) shall be placed to ensure that the load is applied axially.

The applied load shall be calculated in accordance with the hydraulic pressure that is being monitored by two pressure meters in the circuit. The pressure meter shall be calibrated in divisions not exceeding 2 % of the maximum pressure applied, and the range of the meters shall not exceed 150 % of the maximum pressure. The jack(s) and meters shall be calibrated by an approved testing laboratory not more than 4 weeks before the tests will commence.

The deflection of the pile head shall be measured with two scale rulers and two dial extensometers. The scale rulers shall be fixed to the pile and placed on both sides of the pile on a diameter line, and the dial extensometers shall be similarly placed but on a diameter line at right angles to that in which the scale rulers have been mounted.

Level measurements shall be taken on the scale rulers and reduced as a level mark to a similar scale ruler placed at a distance from the test pile. All three scale rulers shall be calibrated in mm and the level-indicating instrument shall be capable of taking readings to 0,5 mm and approximate readings of up to 0,1 mm.

The dial extensometers shall have a range of 50 mm and shall be marked in 0,1 mm divisions to enable measurements to 0,05 mm to be taken. The plungers of the extensometer shall rest on a machined metal or glass surface.

The extensometers shall be supported by one or more beams kept in the shade. The supports for the beams shall be so placed as to limit the effect of earth movements around the test pile on the deflection readings.

The test load shall be applied in increments of 20 % of the specified working load to a maximum test load equal to twice the specified working load or the ultimate test load, whichever is the smaller.

A load increment may not be applied before the subsidence or heave rate has stabilised at a rate of not more than 0,10 mm in 20 minutes under the load applied.

After the loading has been completed, the maximum test load shall be maintained until the movement is less than 0,2 mm within a period of 24 hours. The load shall be removed in decrements of 20 % of the specified working load at intervals of not less than 20 minutes.

After the load has been removed, the readings on both meters registering the movement of the pile shall be recorded accurately to 0,1 mm, at intervals of 5, 10 and 20 minutes, and then every 30 minutes until the load is changed. The final recovery shall be recorded 24 hours after the maximum test load has been removed.

During the test, the pile shall be loaded with up to 100 per cent of the specified working load, and the load shall then be removed. It shall then be loaded to the maximum test load after which the test load shall be removed.

Compression load tests shall be performed as detailed in the Contract Documentation. If  $P_w$  is the working load on a pile all static testing shall be conducted to 1,5  $P_w$  or as directed in the Contract Documentation. Testing shall be done in increments of 0,1  $P_w$  with deflections of pile head being monitored using dial gauges accurate to 0,01 mm or similar methods. The test shall be thermally

protected such that sunshine or other extraneous forces have no effect. Tension restraint may be provided via working piles but only if they are designed as such. An unload/ reload cycle shall be performed at 0,5 Pw and loads in each cycle shall be maintained until deflections are less than 0,05 mm/minute.

Jacks and load cells used in the testing shall be recently (less than 6 weeks) calibrated.

While performing the load test, the Contractor shall provide safety equipment and employ adequate safety procedures. Adequate support for the load test plates, jack, and ancillary devices shall be provided to prevent them from falling in the event of a release of load due to hydraulic failure, test pile failure, or other cause.

2. Dynamic Load Tests

Dynamic Load Testing shall only be carried out by competent independent practitioners. Dynamic measurements following procedures set forth in ASTM D-4945 shall be conducted.

Should the test reveal non-compliance, the Contractor shall wait as detailed in Table A20.1.5-2 below and re-strike the dynamic load test pile with the dynamic testing instruments attached. A cold hammer shall not be used for the re-strike. The hammer shall be warmed before re-strike, by applying more than 20 blows to another pile or to timber mats placed on the ground. The maximum amount of penetration required during re-strike shall be 150 mm, or the maximum total number of hammer blows required will be 50, whichever occurs first. After re-striking, the Engineer will either provide the cut-off elevation or specify additional pile penetration and testing.

The following re-strike durations shall apply:

**Table A20.1.5-2: Re-strike durations**

SOIL TYPES	TIME DELAY UNTIL RE-STRIKE
Clean Sands	1 day
Silty Sands	2 days
Sandy Silts	3-5 days
Silty Clays	7-14 days*
Shales	10-14 days*

\* - Longer times may be instructed by the Engineer.

On completion of the load testing, any test or anchor piling not a part of the finished structure shall be removed or cut off at least 300 mm below either the bottom of footing or the finished ground elevation, if not located within the footing area.

(ii) *CAPWAP - Case Analysis of Piles using the Wave Application Protocol.*

CAPWAP is an acronym for Case Analysis of Piles using the Wave Application Protocol that is used to determine load capacity and integrity. It is performed by initially attaching two sets of strain gauges and two sets of accelerometers to the 4 sides of the precast or other type of pile. The response, via these gauges, is then measured as the pile is struck. From these two measurements, mathematical manipulation is used to ascertain the load deflection characteristics of the pile and any anomalies that may be present especially at the joints. It is also very useful during actual driving in ascertaining if the compressive capacity of any element or tensile capacity of the joints is being approached.

Wave equation analysis is a numerical method of analysis for the behaviour of driven foundation piles. It predicts the pile capacity versus blow count relationship (bearing graph) and pile driving stress. The model mathematically represents the pile driving hammer and all its accessories (ram, cap, and cap block), as well as the pile, as a series of lumped masses and springs in a one-dimensional analysis.

A drivability analysis produces a safe prescription for pile installation, including recommendations on cushion stiffness, hammer stroke and other driving system parameters that optimise blow counts and pile stresses during pile driving (for example if a soft or hard layer causes excessive tension or compression stresses or unacceptable blow counts)

The unit of measurement shall be the number of CAPWAP tests performed including for the frame the falling mass and the other necessary equipment to install strain gauges and accelerometers

This section covers the requirements to ensure the integrity of piled foundations. In broad terms the quality of concrete used in these elements is detailed with testing to ensure concrete durability, specifications for the necessary cover to reinforcement and a quality assurance system including sonic tapping and cross hole sonic logging geophysical methods, to verify pile integrity.

(iii) *Reinforcement cover tests*

For concrete within structures, an approved electromagnetic cover meter should be used to establish cover to reinforcement. In piles this is the distance from the edge of the pile to the outside of the spiral reinforcement.

This instrument shall be calibrated by direct measurement to exposed reinforcing bars.

The Contractor shall have an approved cover meter on site for use by the Engineer.

(iv) *Cross Hole Sonic Logger (CHSL)*

The following test method is used to verify integrity of piled foundations.

1. Description

By sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes), the

CHSL procedure inspects the drilled shaft structural integrity, and extent and location of defects, if any. At the receiver probe, pulse arrival-time and signal strength are affected by the concrete. For equidistant tubes, uniform concrete yields consistent arrival times with reasonable pulse wave speed and signal strengths. Non-uniformities such as contamination, soft concrete,

honey combing, voids, or inclusions exhibit delayed arrival times with reduced signal strength.

## 2. Apparatus

A Cross Hole Sonic Logger that meets the following minimum requirements:

- Computer based data acquisition system for display of signals during data acquisition, with a minimum 12-bit A/D converter with a sampling frequency of at least 500 000Hz and recording of all pulse signals for full analysis and individual inspection.

**Note:** Converting signals with low noise using high A/D resolution and sampling rates is important to obtain quality data and allow proper full data interpretation.

- Ultrasonic transmitter and receiver probes capable of producing records at a minimum frequency of 50 000 Hz with good signal amplitude and energy through good quality concrete. The probes shall be less than 28 mm in diameter and shall freely descend through the full depth of properly installed access tubes in the drilled shafts.
- Two depth sensors to independently determine transmitter and receiver probe depths.
- Triggering of the recording system time base with the transmitted ultrasonic pulse.

If no later drilling is envisaged, 50 mm nominal diameter 3,0 mm wall thickness tubes are specified for access for the probes in each drilled shaft or diaphragm wall. If later NX size drilling is required through the base of the tubes, the diameter shall be increased to 89 mm to enable access for the 76 mm outside diameter NX core. Round tubes with a regular internal diameter free of defects and obstructions, including any tube joints, to permit the free, unobstructed passage of the probes, shall be used. Tubes shall be watertight and free from corrosion with clean internal and external faces to ensure a good bond between the concrete and the tubes.

Tubes may be extended with mechanical couplings. Duct tape or other wrapping material to seal the joints and butt-welding of joints are prohibited. Tubes shall be installed by the Contractor such that the CHSL probes will pass through the entire length of the tube without binding. The Contractor shall ensure that access tubes are plumb and verify that unobstructed passage of the probes is achievable before the CHSL Consultant arrives.

**Note:** If an existing drilled shaft does not contain access tubes, access holes can be installed by coring a borehole in the concrete. Locate cored holes about 150 mm inside the reinforcement cage. Log core holes and include descriptions of any inclusions or voids. For drilled shafts with access tubes that do not allow the probe to pass through the entire length of the tube due to poor workmanship, replacement access holes may be provided by core drilling.

## 3. Tube installation and preparatory work

Fit the tubes with a watertight shoe on the bottom and a removable cap on the top. Secure the tubes at regular intervals not to exceed 1,0 m to the interior of the reinforcement cage. Install the tubes uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube. If no base integrity coring is required extend tubes to within 75 mm, of drilled shaft bottoms, and to more than 1,0 m above the drilled shaft tops. If base core integrity is required, then the tube base shall be 300 mm above pile base. Do not damage tubes during installation of reinforcement cage.

The Contractor shall ensure that tubes in no circumstances rest on the bottom of the drilled shaft excavation.

After placement of the reinforcement cage, and within 30 minutes of concrete placement fill tubes with clean fresh water. Cap tube tops to prevent debris from entering access tubes. Do not apply excessive torque, hammering or other stresses that could break the bond between tube and concrete when removing caps from the tubes.

Test the drilled shaft more than 3 but less than 10 calendar days after placement of all concrete in any drilled shaft, prior to loading.

After all CHSL testing is completed, and has received the Engineer acceptance, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube and fill all access tubes in the drilled shafts with grout.

## 4. Procedure

Prior to CHSL testing, the Contractor shall provide the Engineer and CHSL Consultant with a record of all drilled shaft lengths with elevations of the top and bottom, and installation dates of all drilled shafts. The access tubes shall be clearly labelled for identification by the CHSL Consultant.

CHSL testing shall be performed with the transmitter and receiver probes in the same horizontal plane in parallel tubes unless test results indicate potential defects, in which case the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes). Using the labelling established for the tubes perform CHSL testing between all tubes.

Lower the probes from the top, effectively measuring the access tube lengths. On reaching the base, pull the probes simultaneously, taking CHSL measurements at intervals of 50 mm or less, from the bottom, to the top of the shaft. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signals shall be immediately reported to the Engineer. Additional tests such as the offset elevation CHSL testing may be required by the Engineer to further evaluate the extent of such defects. If de-bonding between the access tube and the concrete is indicated by the CHSL results, an alternative test method will be required to determine the integrity of the concrete in the de-bonded region.

**Note:** In case defects are detected, additional tests or analysis options may include CHSL tomography,

Gamma-gamma nuclear density logging, sonic echo or impact response tests, high strain dynamic pile testing, static load testing, or concrete coring. If the drilled shaft is cored, an accurate log of the cores that include depth and core recovery shall be kept, and core and coring logs shall be properly identified and given to the Engineer.

The arrival times and the spacing of the tubes enable the velocity of the sonic pulses to be determined. For good quality concrete this value is usually around 4 000 m/sec.

In order for the best results to be obtained, other vibration sources on the site should be minimised. It is thus good practice to conduct testing on Saturday/Sunday when site activity is usually low.

## 5. Remarks

The test requires two persons to conduct efficiently. One to man the output recorded on the computer screen attached to the CHSL unit and the other to raise, at a continuous pace, the two probes from the base of the shaft being tested. Whilst this is a trivial task for shallow piled shafts (say less than 12 m deep), the task becomes more onerous for very deep (say 50 m) holes when the weight of the cables may become excessive for some. A fit, healthy individual is thus required for the task.

The aim of the test is to evaluate the quality of concrete in shafts. If testing indicates this to be satisfactory, the shaft may be approved. However, in the event of anomalies being present, remedial actions are necessary

These usually involve coring within the pile or alternatively tools are available to split the casing of the CHSL tube. Grouting via the use of packers is then conducted through the tube to eradicate the anomaly.

The test enables the performance of pile concrete to be evaluated.

### (v) *Sonic echo or Impact response test*

This test method is used to assess the integrity of the piled foundation. A pulse is injected into the pile by tapping the head of the pile and measuring the form of the wave as it proceeds down and up the pile again.

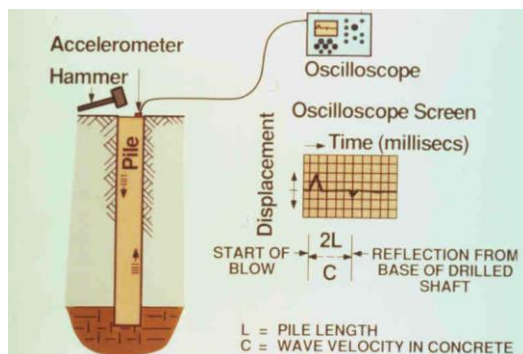
The most commonly available, economical, and easily applied type of integrity test is the sonic echo test. The advantage of the method is that a test can be performed rapidly, inexpensively, and without any internal instrumentation or tubes in the pile. The test may be performed on all pile types and sizes with influence depths being limited to 20-30 times pile diameter.

This test is performed by striking the top of the pile with a small, instrumented hammer. A sonic, compressive wave travels down the length of the pile and is reflected by an anomaly in the pile, or the pile tip if the pile is free of defects, and travels back to the top where it is picked up by a receiver on top of the pile. The reflections are used to indicate major changes in cross sectional dimensions or material properties. Wave propagation through the pile is affected by the pile impedance, which is defined mathematically as  $EA/C$ , where  $E$  is the elastic modulus of the pile,  $A$  is the area of the cross section, and  $C$  is the wave propagation velocity, which is related to the elastic modulus and mass density of the pile.

Impedance changes occur where there is a change in cross-sectional area of the pile. A bulge (increase in cross-sectional area) or a neck (reduction in cross-sectional area) can be detected by an increase or decrease, respectively, in impedance of the signal. Changes in impedance also indicate where a change in grout/concrete density occurs, indicating a possible defect in the grout/concrete. Other types of processing are sometimes used to interpret the measurements of reflections including impulse response and impedance logging.

Figure A20.1.5-5 provides a simplified illustration of the sonic echo test. The displacement record shown in the Figure indicates the reflection off the base of a pile of the length,  $L$ , embedded in sound rock. The reflection occurring at a time shorter than  $2L/C$  (i.e. the first upward spike of record) suggests an impedance change in the pile above the pile toe.

**Figure A20.1.5-5 Sonic echo testing concept**



Although sonic echo testing is an economical and rather simple test, there are some important limitations to consider. As the sound wave travels along the pile, it loses energy and the strength of the reflected signal can become very weak. This means that for very long piles (i.e. with a depth-to-diameter ratio of greater than 30), the tip of the pile and anomalies or defects occurring at great depths will likely go undetected. The upper 6,0 m of a pile is most critical for structural capacity, particularly for shear and bending moment. As sonic echo testing is more reliable at shallower depths, this limitation is not as significant as for long drilled shafts. This makes testing using sonic echo quite useful for rapidly evaluating a large number of piles.

The wave energy is unlikely to detect anomalies or defects unless these are large compared to the wave length generated by the impact. Research indicates that defects that are shorter than 0,25 of the wave lengths are generally not detected. A typical hammer for sonic echo tests generates a wave length of approximately 1,6 m which means that defects or anomalies less than 0,4 m thick, will go undetected.

### 1. Testing of concrete in piles for durability

Refer to Clause A20.1.5.1c) and related sub clauses referred to regarding the tests on concrete used in piles, in particular to testing of:

- Durability Index
- Oxygen permeability
- Water Sorptivity
- Chloride Conductivity
- Cover over reinforcement

### 2. Quality of concrete for piles

Cement used for durability concrete shall contain between 25-30 % by mass of fly ash. Cement base grades may vary between 32,5 and 52,5 MPa and 'N' as opposed to 'R' grade is preferred for all except precast piles where rapid curing is required for production considerations. Cover shall be a minimum of 75 mm for concrete elements in contact with soil.

### 3. Acceptance limits

Table A20.1.5-3 details the criteria that will be used in the adjudication of concrete quality.

**Table A20.1.5-3: Concrete quality criteria**

Category	Oxygen permeability index (OPI)	Water Sorptivity	Chloride conductivity
Laboratory	>10,0	< 6	< 0,75
Full acceptance	> 9,4	< 9	<1.0
Conditional acceptance	9,0 – 9,4	9 – 12	1,0 – 1,5
Remedial acceptance	8,75 – 9,0	12 – 15	1,5 – 2,5
Rejection	< 8,75	> 15	> 2,5

Testing shall be carried out during the design phase such that 4 complete tests are conducted. During construction, testing will comprise one complete set of tests for every 100 m<sup>3</sup> for the first 1 000 m<sup>3</sup> and thereafter one set for every 500 m<sup>3</sup> of concrete cast.

#### d) Tests on silicone sealants

The following tests on silicone sealants will apply:

##### (i) Bond to cement mortar

Three briquettes, shaped in accordance with AASHTO T-132 and moisture-cured for at least 28 days, are sawn in half, cleaned and dried to a constant mass in an oven at a temperature of 110°C ± 5°C. After having cooled off, they are bonded with approximately 0,25 mm of silicone sealant and tested with clamps that comply with AASHTO T-132. They are tested under stress at a loading rate of 7,62 mm/min.

##### (ii) Non-adhesive period

Prepare the specimens in a mould with an area exceeding that of the brass weight described below and which is 6,35 mm thick. Place a 30 g brass weight with dimensions of 41,28 mm x 25,4 mm x 3,18 mm on a polyethylene strip applied to the sample after the specified curing period. After the weight has been removed, the polyethylene strip is removed by pulling it off at an angle of 90 degrees to the mix and at a rate of 25,4 mm in 5 seconds. No material may adhere to the polyethylene while it is non-adhesive.

##### (iii) Deformability and adhesion

Prepare concrete blocks of 25,4 mm x 25,4 mm x 76,2 mm in accordance with ASTM C-719. A sawn surface is used as the bonding surface. Seal 50,8 mm of the block and leave 12,7 mm at each end of the specimen unsealed. The sealant shall be 9,5 mm thick and 12,7 mm wide. Cure the specimen for 7 days in air at 25°C ± 1,7°C and for 7 days in water at 25°C ± 1,7°C. Subject the sealant to deformation in accordance with ASTM C-719. The ductility or compressive rate shall be 3,18 mm per hour. One cycle is defined as extension to a width of 25,4 mm and returning to the initial width of 12,7 mm.

## A20.1.5.7 Determining the effect of sand on the water demand of a concrete mix

### a) Definition

Water demand is defined as the quantity of water per cubic metre of concrete required to achieve a slump of 75 mm in a concrete with an optimum quantity of stone with a nominal size of 20 mm.

### b) Materials

The following materials are required:

- Ordinary Portland cement
- Crushed stone with a nominal size of 20 mm
- Sand or a sand mix to be tested.

### c) Method

- (i) Determine the relative density (*Rsa*) in accordance with SABS method 844 and the fineness modules (FM) of the sand or sand mix.
- (ii) Determine the compacted bulk density (CBD) of the 20 mm aggregate in accordance with SABS method 845. Also determine the relative density of the stone (*Rst*)
- (iii) Determine the required quantity of stone (*S*) per cubic metre of mix in kg/m<sup>3</sup> in accordance with formula:

$$S = CBD (0.975 - 0.1FM)$$

- (iv) Estimate the water demand (*W*) of the mix in l/m<sup>3</sup>. As a starting point 220 l/m<sup>3</sup> may be used.
- (v) Determine the required cement content (*C*) for the mix in kg/m<sup>3</sup> by using the water content (*W*) as obtained from (iv) and a water: cement ratio of 0.59.
- (vi) Determine the required sand content (*SC*) of the mix in kg/m<sup>3</sup> in accordance with the formula:

$$SC = 1 - (C/3140 + W/1000 + S/Rst)$$

- (vii) Decide on the mix size which will apply to the available equipment and calculate the mix quantities in relation to the calculated quantities per cubic metre. Do not produce a mix of less than 10 ℓ.
- (viii) Prepare the mix and determine the slump in accordance with SABS method 862. Where the slump does not amount to 75 mm, repeat the test with adjusted quantities of cement, water and sand. A good rule to remember is that a change of 10 ℓ/m<sup>3</sup> in the water content either halves or doubles the slump.
- (ix) The water content giving a slump of 75 mm will then be the water demand for the mix.
- (x) In view of obtaining repeatable results, the following parameters shall be kept constant in so far as is possible:
  - Material temperature
  - Mixing time
  - Source of cement
  - Source of stone

## **A20.1.5.8 Accelerated test method for determining the potential alkali reactivity of aggregates**

### **a) The method**

Three mortar prisms shall be prepared in accordance with the requirements of ASTM C 227-90. The prisms are removed from the mould after 24 hours and immersed in water in a closed container, placed in an oven and kept at a constant temperature of 80°C. After 24 hours in the oven, the prisms are taken to a room with a temperature of 23°C, where their lengths are measured with a vertical comparator (an indicator type of deformation meter) accurately to 2 µm before any significant cooling-down takes place.

This reading will be taken as the nil reading. After the initial reading has been taken, the prisms are immersed in the prescribed NaOH solution kept at 80°C. This solution is kept in a plastic container that seals tightly and is large enough for the prisms to be completely immersed. Plastic is used, as the caustic solution corrodes glass and metal. The prisms are measured every working day for a period of 14 days at a room temperature of 23°C and their linear expansion is calculated. The average expansion of the three prisms for each day is then calculated. Where none of the values deviate by more than 15 % from the average, the repeatability is regarded as being satisfactory. The average expansion after 10 or 12 days is taken to be the reference value for determining the potential alkali reactivity.

### **b) Criteria**

The criteria proposed provisionally for the accelerated mortar-prism testing method shall be as follows:

- (i) *Percentage of linear expansion after 10 days:*
  - < 0,08                      The alkali reactivity of the aggregate is not harmful
  - ≥ 0,08 but < 0,20      The alkali reactivity of the aggregate is harmful, and the aggregate is expanding slowly
  - ≥ 0,20                      The alkali reactivity of the aggregate is harmful, and the aggregate is expanding rapidly
- (ii) *Percentage of linear expansion after 12 days:*
  - < 0,10                      The alkali reactivity of the aggregate is not harmful
  - ≥ 0,10 but < 0,25      The alkali reactivity of the aggregate is harmful, and the aggregate is expanding slowly
  - ≥ 0,25                      The alkali reactivity of the aggregate is harmful, and the aggregate is expanding rapidly.

### **c) Interpretation**

For aggregates falling in the slowly expanding group, the alkalinity per m<sup>3</sup> of concrete shall not exceed 2,80 kg of Na<sub>2</sub>O equivalent.

For aggregates falling in the rapidly expanding group, the alkalinity per m<sup>3</sup> of concrete shall not exceed a value of 2,10 kg of Na<sub>2</sub>O equivalent per m<sup>3</sup>, depending on the reactivity.

The dilution and palliative effect of extenders in the cementitious binders, such as slagment (where permitted in structural concrete) and fly ash, shall be taken into account in the interpretation of the results.

## **A20.1.5.9 Binder distributors: Field spray flair transverse distribution test**

### **a) Scope**

This method sets out the procedure for the simple field determination of the transverse distribution of nozzle flairs of a binder distributor. Certain statistical criteria are applied to the results to determine conformance with requirements.

### **b) Definition**

The purpose of the test is to determine conformance of the transverse distribution, within a spray flair, as measured by direct discharge from 3 individual nozzles, representing the centre and each side of the spray bar, using the project binder.

### **c) Apparatus**

#### *(i) Steel troughs*

Steel troughs fitted with handles and manufactured from 3,0 mm mild steel plate, conforming to the following or similar dimensions:

Width	-	100 mm (outer edge)
Length	-	450 mm
Height	-	120 mm

A total of 9 troughs are required. Each trough must be clearly numbered on its side.

(ii) *Balance*

A balance capable of weighing up to 50 kg to an accuracy of 20 g.

(iii) *Personal protective clothing*

The appropriate safety gear must be worn when performing this test and should include a pair of appropriate protective gloves, face shield and approved overalls.

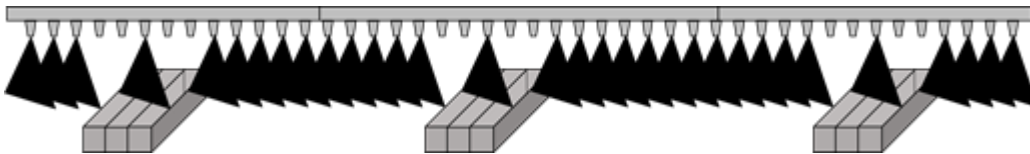
(iv) *Cleaning fluid*

Diesel or other suitable fluid.

**d) Preparation of the binder distributor**

- (i) Ensure that all the binder strainers on the sprayer have been cleaned.
- (ii) Preheat the binder in the distributor tank to within  $\pm 5^{\circ}\text{C}$  of the required spray temperature.
- (iii) Circulate the binder through the spray bar for at least 15 minutes.
- (iv) Position the spray bar over a full-length drip tray. A short preliminary spray is made to ensure that all the nozzles are functioning and that the machine is in normal working condition. Suck back the binder from the drip tray into the distributor tank on completion of test spray.
- (v) If necessary, correct any malfunctioning of the spray bar.
- (vi) Ensure that all nozzles are set at the same angle
- (vii) Select 3 nozzles representing the centre and each side of the spray bar, and close 2 nozzles each side of the selected test nozzles.

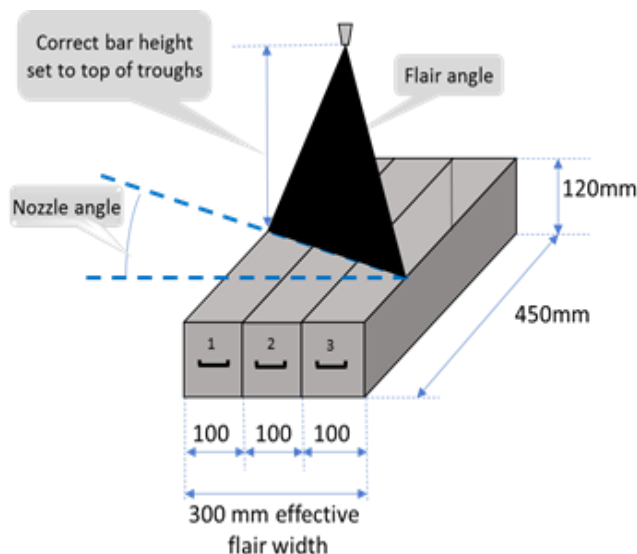
**Figure A20.1.5-6**



**e) Method**

- (i) Select a horizontal, flat area of at least 20 m by 7,0 m.
- (ii) Place and secure reinforced paper to cover a distance of 5,0 m.
- (iii) Set the spray bar height (Bottom of nozzles) to the calibrated height for the particular binder and nozzle angles.
- (iv) Increase the bitumen pump speed to yield the desired triple spray overlap in accordance to the type of nozzles and type of binder being used. Typically, this could vary between 12 and 20 litres per minute for conventional binders.
- (v) Spray a distance of 4,0 m to verify the effective spray flair width of 310 mm ( $\pm 15$  mm), perpendicular to the line of travel and adjust the spray bar height, if necessary.
- (vi) Ensure that all troughs are clean and free of any water or other materials.
- (vii) Place a set of three pre-weighed steel troughs described in Clause A20.1.5.9c(i) under each of the selected test nozzles, with the length of the troughs perpendicular to the spray bar, and in such a manner that the discharge of each test nozzle is collected in the three troughs. Ensure that the troughs are placed in numerical order.
- (viii) Adjust the spray bar height to ensure that the bottom of each test nozzle is at the correct height above the top of the troughs.
- (ix) Open the nozzles and spray sufficient binder to fill the troughs without risking spillage during handling.
- (x) Weigh the troughs to determine the mass of binder sprayed.
- (xi) On completion of the weighing and before the binder cools suck back the binder into the distributor tank.
- (xii) Only clean the troughs with a suitable cleaning fluid once they have cooled down to room temperature.
- (xiii) Store used cleaning fluid in a suitable container for re-use.

**Figure A20.1.5-7**



**f) Calculation and report**

- (i) Determine the net mass of binder in each trough to the nearest 20 grams.

$$\text{Net mass binder} = (M_1, M_2, M_3 \dots M_9).$$

- (ii) Calculate the average mass of the binder collected in all the troughs.

$$M_{\text{ave}} = \sum (M_1 - M_9) / 9$$

- (iii) Calculate the deviation from the average mass for every trough and express the value as a percentage.

$$\% \text{ Deviation} = (M_{\text{ave}} - M_i) / M_{\text{ave}} \times 100$$

- (iv) Check that the deviations are within the tolerances specified in SANS 3001-BT24 Paragraph 7: Acceptable tolerances of transverse distribution.  
(v) Report results on a suitable report sheet.  
(vi) Update the 'Nozzle flair' test and pump speed/pressure record with the relevant information for the distributor and binder type.  
(vii) Ensure that after the pump speed / pressure has been finalised and a final height of the spray bar has been determined that the road speed is also adjusted or interacts with the pump speed in order to achieve the correct rate of application.

**g) Non-compliance**

- (i) If the transverse distribution is out of specification, it is likely that the pump speed / pressure is incorrect  
(ii) Consult the depot calibration sheet and make the necessary adjustments to pump speed/ pressure and adjust bar height if necessary.  
(iii) Repeat the test procedure as described in Clauses A20.1.5.9e) and A20.1.5.9f)  
(iv) It may be necessary to repeat Clauses A20.1.5.9g)(i) and A20.1.5.9g)(ii) until compliance is achieved.  
(v) Update the 'Nozzle flair' and pump speed/pressure test record with the relevant information for the distributor.

**h) Accuracy**

Due to the varying nature of the different types of binders, cognisance must be taken of the respective binder's viscosity at spray temperature when establishing achievable tolerances, namely:

Conventional binders	40 – 100 CPs
Polymer modified binders	120 –200 CPs
Bitumen rubber	2,000 – 3,000 CPs

### A20.1.5.10 Testing Geosynthetics and Geotextiles

Geosynthetics and geotextiles are defined, and test methods given in SANS 10318 and include geotextiles, geogrids, geocomposites drainage systems, geonets, geocells and geomembranes.

### A20.1.5.11 Testing the binder drainage properties of Asphalt mixes using the Schellenberg Method

**a) Scope**

This test is used to determine the binder drainage properties of asphalt mixes during the mix design stage.

**b) Apparatus**

- (i) Glass beaker of 800 ml capacity with cover glass  
(ii) Electronic balance, fine measuring type that complies with SANS 1649, with a capacity of 5,0 kg and reading to 0,1 g.  
(iii) Oven, that is capable of maintaining a temperature range of 120 °C to 170 °C with continuous draft.

**c) Procedure**

- (i) Set the oven to a temperature of 170°C ± 1°C  
(ii) Weigh the beaker and record the mass (M1) to the nearest 0,1 g  
(iii) Immediately after completing the mixing of the asphalt sample at a temperature of 135°C transfer between 1000 g and 1100 g into the beaker, weigh and record its mass (M2) to the nearest ± 0,1 g  
(iv) Cover the beaker with the cover glass and place in the oven for 1 h ± 1 minute.  
(v) Remove the beaker from the oven and immediately empty the mixture from the beaker without shaking or vibration.  
(vi) Weigh the beaker with remaining binder and record the mass (M3) to the nearest 0,1 g.

**d) Calculation**

- (i) Calculate the mass of asphalt in the beaker using the following formula:

$$Ma = M2 - M1$$

where

**Ma** is the mass of asphalt in the beaker  
**M1** is the mass of the beaker  
**M2** is the mass of the beaker and the asphalt

- (ii) Calculate the percentage of binder remaining in the beaker using the following formula:

$$Pb = \frac{M3}{Ma} \times 100$$

where

**Pb** is the percentage of binder remaining in the beaker  
**M3** is the mass of the binder remaining in the beaker

**e) Test report**

Report the percentage of binder remaining in the beaker to the nearest 0,01 percent.

### A20.1.5.12 Operation of the rapid compaction control device (RCCD)

#### a) Scope

This method sets out the procedure for non-destructive testing for the evaluation of compaction and strength (CBR) of materials in thin layers for trench reinstatements and layer works for low volume roads

#### b) Apparatus

The apparatus (RCCD) consist of a frame incorporating handles, a foot plate, steel spring, hardened anvil, replaceable 30° cone and a trigger mechanism. The apparatus can be described as an impulse penetrometer with the steel spring providing energy. It can be operated by a semi-skilled operator.

#### c) Accuracy

The resolution of measurement readings is 1,0 mm with the accuracy of the penetration measurements of 0,5 mm.

#### d) Calibration

The RCCD apparatus measures the penetration resistance of layers of soil or gravel. Calibrating the depth of penetration against nuclear gauge dry density of specific material and California Bearing Ratio (CBR) of laboratory prepared samples, appropriate calibration equations are developed for application in practice. The steel spring, under normal usage conditions, needs calibration every 2 years.

#### e) Method

An operating manual is supplied with the apparatus which must be followed by the operator. The test positions, randomly selected, must be indicated to the operator. At each test position three measurements, ± 300 mm apart, are made and the readings recorded on a log sheet. The average of the three readings will constitute the penetration for each location.

#### f) Operational limitations

- (i) The RCCD can only be used on material with an unconfined compressive strength of less than 3 000 KPa.
- (ii) Maximum depth of penetration is 150 mm
- (iii) The readings on coarse grained materials will vary and fluctuate
- (iv) The coned points need to be replaced when worn.

#### g) Calculation and reporting

The average of the three readings for each position is calculated and reported.

### A20.1.5.13 Testing the saturated volume of fine aggregate for slurry

#### a) Scope

This method sets out the procedure for the field determination of the saturated volume of fine aggregate used in bituminous slurry mixtures.

#### b) Definition

The purpose of this test is to determine the saturated volume of the fine aggregate that is delivered to the slurry mixer. The result of this test is used to determine the application rate of the slurry.

#### c) Apparatus

- (i) Transparent plastic measuring cylinder of capacity 1000 ml graduated at 1,0 mm intervals
- (ii) Measuring tape of length 10 m, graduated in 1,0 mm intervals
- (iii) Steel strike-off beam of length 3,0 m

#### d) Method

- (i) Strike off every load of fine aggregate delivered to the slurry mixing plant using the strike-off beam
- (ii) Measure the dimensions of the truck hopper using the measuring tape and calculate its volume (A)
- (iii) Sample the aggregate from the conveyor belt feeding the mixer
- (iv) Fill the measuring cylinder with the aggregate up to the 1000 mm mark, to the closest millimetre
- (v) Drop the cylinder 10 times from a height of 50 mm onto the top of a wooden table
- (vi) Read the volume of the aggregate in the measuring cylinder to the closest millimetre (B)
- (vii) Add water to the measuring cylinder until it covers the aggregate to a depth of 50 mm
- (viii) Shake the mixture well and place on a horizontal surface
- (ix) Allow to settle until the liquid above the surface of the aggregate is sufficiently clear to enable a reading to be taken
- (x) Read the volume of the saturated aggregate in the measuring cylinder to the closest millimetre (C)

#### e) Calculation

Calculate the saturated volume of the fine aggregate in the truck hopper.

$$V = A \left\{ 1 - 0.72 \frac{(B - C)}{C} \right\}$$

where

- V is the volume of the saturated aggregate in the truck hopper, expressed in m<sup>3</sup>  
A is the volume of the aggregate in the truck hopper, expressed in m<sup>3</sup>  
B is the measuring cylinder reading after it has been dropped 10 times onto the table, expressed in mm  
C is the measuring cylinder reading after saturation, expressed in mm

#### f) Record

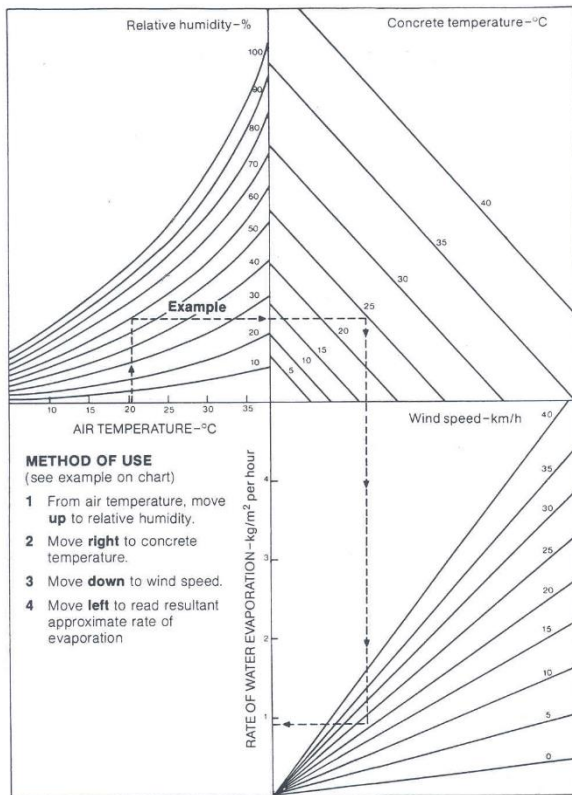
Record the volume of saturated aggregate in the truck hopper to the nearest kg / m<sup>3</sup>.

### A20.1.5.14 X-RD (X-ray diffraction) test

Refer to the Handbook of X-Ray spectrometry: methods and techniques (Renier E van Grieken – Author)

### A20.1.5.15 Nomogram for determining the rate of water evaporation

The rate of water evaporation in kg/m<sup>2</sup>/hour for concrete slabs is determined from the Nomogram hereunder using the inputs of relative humidity, air temperature, concrete temperature and wind speed as an extract from ACI 205.



Effect of ambient conditions on rate of evaporation

### A20.1.5.16 Curing concrete to attain accelerated strength development (55°/20 hours)

#### a) Scope

A method is described for curing concrete cubes at 55°C for 20 hours with a view to pre-estimating the 28-day compressive strength for purposes of quality control. The accelerated tests are additional tests and do not replace the 28-day tests.

#### b) Apparatus

The following apparatus is required:

- Apparatus for preparing the concrete cubes in accordance with method SANS 5861-3 (SANS 3001-CO2-2) and SANS 5863 (SANS 3001-CO2-3)
- Plastic sheets of 180mm X 180 mm
- Hessian sheets for covering samples
- A suitable water bath with a thermostat to maintain the temperature constantly at 55°C ± 1°C, with a circulation system and adequate capacity

#### c) Method

Prepare the required number of concrete cubes in accordance with method SANS 5861-3 (SANS 3001-CO2-2) and SANS 5863 (SANS 3001-CO2-3) and completely cover the exposed surface within the cube mould with small plastic sheets and then with wet hessian. Keep it covered for 3 hours ±15 minutes.

Place the concrete cubes in their moulds in the hot-water bath at a rate which will not allow the water temperature to drop below 54°C. Record the exact time when each is placed into the water and leave it in the water at a temperature of 55°C ± 1°C for 20 hours ±15 minutes.

Remove the cubes, in their moulds, from the water and then carefully from their moulds. Cool the cubes for 2 hours ±15 minutes in water at 20°C ± 5°C.

Test the compressive strength of the cubes in accordance with method SANS 5863 (SANS 3001-CO2-3).

#### **d) Calculating the compressive strength**

The cube compressive strength is calculated in accordance with the prescribed method. For calculating the expected 28-day compressive strength, the ratio between the 28-day compressive strength and the strength of rapid-hardening cubes shall be determined for each type of concrete mix by correlation techniques. For purposes of the initial work, it is mentioned that research has shown that the strength of the cubes treated and tested as described above will be approximately 0,58 times the 28-day compressive strength for concrete cubes prepared from ordinary cement (for strengths between 30 and 65 MPa). For rapid-hardening cement, the corresponding factor is 0,59 and for PBFC it is 0,66.

### **A20.1.6 SPECIAL TEST METHODS**

#### **A20.1.6.1 General**

Special tests, which, in terms of the definition under Clause A20.1.2, require specialised equipment and expertise not normally available in an independent site laboratory, are listed in this Section.

#### **A20.1.6.2 Special tests on cement, concrete and structural elements**

##### **SANS 50197**

Testing of cement

##### **SANS 50450**

Testing of fly ash

##### **SANS 50934 4-6**

Testing of admixtures

##### **SANS 53263**

Testing of silica fume

##### **SANS 55167**

Testing of GGBS

##### **SANS 51008**

Mixing water for concrete – Specification for sampling, testing and assessment for suitability of water, including water recovered from processes in the concrete industry, as mixing water in concrete.

##### **SANS 5865 (SANS 3001-CO3-5)**

Drilling, preparation and testing for compressive strength of cores taken from hardened concrete

1. Determination of the tensile strength of hydraulic cement mortars
2. Concrete durability index testing: refer to Clause A20.1.5.1c)
3. Oxygen Permeability: refer Clause A20.1.5.1d)
4. Chloride Conductivity: refer Clause A20.1.5.1e)
5. Water Sorptivity: refer Clause A20.1.5.1f)
6. Energy absorption capacity: refer Clause A20.1.5.1g)
7. Tests on elastomeric bearings: refer Clause A20.1.5.6a)
8. Pre-stressed concrete: Testing pre-stressing steel, anchorage assemblies, couplings and grout: refer Clause A20.1.5.6b)
9. Tests on silicone sealants: refer Clause A20.1.5.6d)
10. Tests on piles: refer Clause A20.1.5.6c)(i)
11. CAPWAP - Case Analysis of Piles using the Wave Application Protocol: refer Clause A20.1.5.6c)(ii)
12. Testing the cover over reinforcement: refer Clauses A20.1.5.1h) and A20.1.5.6c)(iii)
13. Sonic echo or Impact response test: refer Clause A20.1.5.6c)(iv) and (v)
14. Accelerated test method for determining the potential alkali reactivity of aggregates: refer Clause A20.1.5.8

#### **A20.1.6.3 Special tests on aggregates**

SANS 3001-AG16

Civil Engineering test methods Part AG16: Determination of the durability mill index for aggregates

SANS 3001-AG11

Determination of the Polished Stone Value of Aggregates

#### **A20.1.6.4 Special tests on bituminous stabilised materials (BSM)**

SANS 3001 BSM1

Civil Engineering test methods Part BSM1: Determination of foamed bitumen characteristics

SANS 3001 BSM2

Civil Engineering test methods Part BSM2: Making test specimens from bitumen stabilized material using vibratory hammer compaction

SANS 3001 BSM3

Civil Engineering test methods Part BSM3: Determination of indirect tensile strength of bitumen stabilized material

SANS 3001 BSM4

Civil Engineering test methods Part BSM4: Determination of the shear properties of bitumen stabilized material (triaxial test)

### **A20.1.6.5 Special tests on nuclear gauges**

SANS 3001 NG1

Civil Engineering test methods Part NG1: Administration, handling and maintenance of a nuclear density gauge

SANS 3001 NG2

Civil Engineering test methods Part NG2: The validation of standard calibration blocks

SANS 3001 NG3

Civil Engineering test methods Part NG3: Calibration of a nuclear density gauge

SANS 3001 NG4

Civil Engineering test methods Part NG4: Verification of a nuclear density gauge

### **A20.1.6.6 Special tests on binders**

SANS 4001-BT10

Civil Engineering test methods Part BT-10: Performance grade bitumen

SANS 4001-BT2

Civil Engineering test methods Part BT2: Cutback bitumen

SANS 4001 BT3

Civil Engineering test methods Part BT3: Anionic road emulsion

SANS 4001 BT4

Civil Engineering test methods Part BT4: Cationic road emulsion

SANS 4001 BT5

Civil Engineering test methods Part BT5: Inverted road emulsion

SABITA TG1 Series tests for modified binders

### **A20.1.6.7 Special tests on asphalt**

SANS 3001 PD1

Civil Engineering test methods Part PD1: MMLS3 testing of asphalt mixtures

AASHTO T324

Hamburg wheel tracking test for permanent deformation

AASHTO T321

Four-point beam fatigue test

AASHTO TP79

Dynamic modulus/stiffness of asphalt

EN 12697:2004

Test methods for hot mix asphalt: Permeability of specimen

### **A20.1.6.8 Special tests on cementitiously stabilised materials**

SANS 3001-GR56

Civil Engineering test methods Part GR56: Determination of the wet-dry durability of compacted and cured specimens of cementitiously stabilised materials by mechanical brushing

### **A20.1.6.9 Special tests on pavements**

TMH 13

COTO Draft TMH13: Automated Road Condition Assessments: Part C Roughness, Part D Rutting, Part E Skid resistance and Texture, Part F Deflection, subject to the provisions of Clause A20.1.5.5

### **A20.1.6.10 Special tests on geosynthetics**

SANS 1525

Geosynthetics – Wide- width Tensile test

SANS 9862

Geosynthetics – Sampling and preparation of test specimens

SANS 9863-1

Geosynthetics –Determination of thickness at specified pressures Part 1: Single layers

SANS 9864

Geosynthetics –Test method for the determination of mass per unit area of geotextile-related products

SANS 11058

Geotextiles and geotextile-related products – Determination of water permeability characteristics normal to plane, without load

SANS 12224

Geotextiles and geotextile-related products – Determination of the resistance to weathering

SANS 12236

Geosynthetics – Static Puncture test (CBR test)

SANS 12956

Geotextiles and geotextile-related products – Determination of the characteristic opening size

SANS 12958

Geotextiles and geotextile-related products – Determination of water flow capacity in their plane

SANS 13431

Geotextiles and geotextile-related products – Determination of tensile creep and creep rupture behaviour

SANS 13433

Geotextiles and Geotextile-related products – Dynamic Perforation Test (Drop Cone test)

ASTM D 4533

Standard Test Method for Trapezoid Tearing Strength of Geotextiles (commonly referred to as Trapezoidal Tear Strength)

ASTM D 4632 S

Standard Test Method for Grab Breaking Load and Elongation of Geotextiles (commonly referred to as Grab Strength)

ASTM D 4355

Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus

ASTM D 5101

Standard Test Method for Measuring the Filtration Compatibility of Soil-geotextile Systems (Gradient Ratio Test)

ASTM D 6140

Standard Test Method for Determining the Asphalt Retention of Paving Fabrics used in Asphalt Paving for Full-width Applications

## **A20.1.7 ACCEPTANCE CONTROL BY STATISTICAL JUDGEMENT PRINCIPLES**

### **A20.1.7.1 General requirements**

#### **a) Determining lot size**

##### *(i) Road construction layers*

The lot size shall normally be a section compacted in one process where essentially the same materials and construction equipment have been used. Where production is on a continuous basis, a lot shall normally mean the product of one day's work and shall not exceed the product of two full day's work. However, a lot of any smaller size may be ordered by the Engineer where

- the properties under investigation exhibit abnormal local variation within the normal lot size;
- an area is obviously of a different quality than the rest,
- the rate of production is very high.

##### *(ii) Concrete strength*

The lot size shall be determined by the Engineer, with due regard to the size and the type of structure in which the concrete is placed, the specific portion of the structure and the total quantity of concrete placed in a day. The lot sizes in concrete structures could therefore vary considerably and particularly in the case of small structures, it could be necessary to combine samples of the same grade of concrete from different structures, provided that the concrete is obtained from the same concrete plant and is cast in the same period using the same techniques.

##### *(iii) Concrete durability*

The lot size and sampling must be in accordance with Clauses A20.1.5.1c), d), e) and f) or as directed by the Engineer.

##### *(iv) Concrete cover over reinforcement*

The lot size and sampling must be in accordance with Clause A20.1.5.1h) or as directed by the Engineer.

##### *(v) Other*

In the other cases, as for example in material stockpiles where a lot in accordance with the definition under Clause A20.1.2 does

not apply directly, the Engineer will determine lot sizes in accordance with circumstances pertaining to each case.

### A20.1.7.2 Taking samples

#### a) Stratified random sampling

When any lot is tested, whether a normal sized lot or an isolated section that clearly exhibits an abnormal variation of the property under consideration, all samples shall be taken in a stratified random pattern. For this purpose, use shall be made of fractional tables generated by recognised random number systems. Refer to examples in TMH5.

#### b) Minimum samples per lot

For purposes of acceptance control and in the absence of it being specified in the Contract Documentation the Engineer shall, in advance, determine sample size "n". The larger the sample, the more reliable the analysis will be, and no sample sizes shall be smaller than those given in Tables A20.1.7-9 and A20.1.7-10.

### A20.1.7.3 Outliers

#### a) Methods

Where a test result deviates from the other values in a sample of the lot such test results should be further investigated to confirm whether the difference is significant by following Method 1 or Method 2. Method 1 shall be followed for identifying possible outliers for all work, except for granular base and asphalt work, for which Method 2 shall be used.

When there is a positive indication from Method 1 or Method 2 that the test result is a possible outlier, further investigations must be carried out and if required retesting in the same location or sub-stratum of the lot must be carried out.

In the event of confirmation that the test result is incorrect it shall be discarded and replaced by the new test when assessing the lot. Should the test result be found to be correct, the integrity of the product shall then be further investigated, and the extent of the sub-lot represented by the outlier determined, tested and assessed for acceptance or rejection separately.

##### (i) Method 1

Calculate the value of  $T_o$  and round off to two decimal places from

$$T_o = (x_o - \bar{x}_n)/S$$

Where  $\bar{x}_n$  and S are the arithmetic mean and the sample consisting of "n" observations standard deviation respectively, and

$x_o$  is the value of the test result differing most from the mean.

Compare the value of  $T_o$  with the value of T for the applicable value of n, from Table A20.1.7-1

If the absolute value of  $T_o$  is equal or greater than T, then  $x_o$  is a possible outlier by difference.

**Table A20.1.7-1: Number of observations versus critical values of T**

Number of observations (n)	Critical value (T)
4	1,46
5	1,67
6	1,82
7	1,94
8	2,03
9	2,11
10	2,18
11	2,23
12	2,29
13	2,33
14	2,37
15	2,41
16	2,44
17	2,47
18	2,50
19	2,53
20	2,56

##### (ii) Method 2

In the case of granular base layer and asphalt work the following procedure shall be used:

Calculate the absolute value  $C_o$  from

$$C_o = |x_o - \bar{x}_n|$$

Where  $x_o$  represents the possible outlier, and  $|x_o - \bar{x}_n|$  is the absolute value of the difference between  $x_o$  and  $\bar{x}_n$  and is always positive.

Compare  $C_o$  with the critical value C.

If the absolute value  $C_o$  is equal to or greater than C, the test result  $x_o$  is a possible outlier by difference.

(iii) *Critical values for C*

The critical values for different values of n are given in Tables A20.1.7-2 and A20.1.7-3 for the different product properties.

**Table A20.1.7-2: Critical values for possible outliers for granular base**

N	CRITICAL VALUE C
	For relative compaction as a percentage
4	3,1
5	3,4
6	3,6
7	3,7
8	3,8
9	3,9
10	3,9

**Table A20.1.7-3: Critical values for possible outlier for Asphalt**

N	CRITICAL VALUES C		
	For relative compaction as a percentage	For bitumen content as a percentage	For voids in mix as a percentage
4	2,2	0,3	1,3
5	2,3	0,4	1,4
6	2,5	0,4	1,5
7	2,6	0,4	1,6

#### A20.1.7.4 Resubmission

Where a lot has been accepted conditionally or has been rejected, the Engineer may agree to its resubmission for approval if

- it has been reworked and the Engineer is satisfied that a proper attempt was made to improve the properties which were unacceptable;

or

- where, in his opinion, there are valid technical reasons.

In both cases a fresh sample shall be taken and a fresh (second) set of test values determined. The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly.

Where in the opinion of the Engineer a significant difference does occur, the submission of the lot shall be regarded as a first submission and be assessed as such and only the second set of test values shall then be used for this purpose.

Where in the opinion of the Engineer no significant difference occurs, the submission of the lot shall be regarded and assessed as a resubmission, which will mean, inter alia, that the first and second sets of test values shall be combined for purposes of assessment.

In order to be able to determine theoretically whether there is a significant difference between the two sets of test values (suffixes a and b), the Fisher F-test shall be conducted and if necessary, also the t-test, all as described below.

- (a) The Fisher F-test is conducted as follows:

Calculate the value of  $F = S_g^2/S_k^2$ ,

where

$S_g$  = the greater standard deviation value of  $S_a$  and  $S_b$

$S_k$  = the smaller standard deviation value of  $S_a$  and  $S_b$ .

The value of  $F_{0,05}$ ,  $\bar{U}_g$ ,  $\bar{U}_k$ , is obtained from Table A20.1.7-4 where

$\bar{U}_g$  = sample size minus one, from the sample with the larger standard deviation.

$\bar{U}_k$  = sample size minus one, from the sample with the smaller standard deviation.

Where  $F > F_{0,05}$ ,  $\bar{U}_g$ ,  $\bar{U}_k$ , a significant difference occurs theoretically between the two sets of test values but where  $F < F_{0,05}$ ,  $\bar{U}_g$ ,  $\bar{U}_k$ , the difference is not necessarily significant, and the t-test shall also be conducted with a view to obtaining a decision.

**Table A20.1.7-4 Values of F-Distribution ( $\alpha = 0.05$ )**

Uk	Ug																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30					
1	161,44	200	216	225	230	234	237	239	241	242	243	244	245	245	246	246	247	247	248	248	249	249	249	249	250	250				
2	18,51	19,0	19,2	19,2	19,3	19,3	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,4	19,5	19,5	19,5	19,5	19,5	19,5				
3	10,13	9,55	9,28	9,12	9,01	8,94	8,89	8,85	8,81	8,79	8,76	8,74	8,73	8,71	8,70	8,69	8,68	8,67	8,67	8,66	8,65	8,64	8,63	8,62	8,62	8,62				
4	7,71	6,94	6,59	6,39	6,26	6,16	6,09	6,04	6,00	5,96	5,94	5,91	5,98	5,87	5,86	5,84	5,83	5,82	5,81	5,80	5,79	5,77	5,76	5,75	5,75	5,75				
5	6,61	5,79	5,41	5,19	5,05	4,95	4,88	4,82	4,77	4,74	4,70	4,68	4,66	4,64	4,62	4,60	4,59	4,58	4,57	4,56	4,54	4,53	4,52	4,50	4,50	4,50				
6	5,99	5,14	4,76	4,53	4,39	4,28	4,21	4,15	4,10	4,06	4,03	4,00	3,98	3,96	3,94	3,92	3,91	3,90	3,88	3,87	3,86	3,84	3,83	3,82	3,81	3,81				
7	5,59	4,74	4,35	4,12	3,97	3,87	3,79	3,73	3,68	3,64	3,60	3,57	3,55	3,53	3,51	3,49	3,48	3,47	3,46	3,44	3,43	3,41	3,40	3,39	3,38	3,38				
8	5,32	4,46	4,07	3,84	3,69	3,58	2,50	3,44	3,39	3,35	3,31	3,28	3,26	3,24	3,22	3,20	3,19	3,17	3,16	3,15	3,13	3,12	3,10	3,09	3,08	3,08				
9	5,12	4,26	3,86	3,63	3,48	3,37	3,29	3,23	3,18	3,14	3,10	3,07	3,05	3,03	3,01	2,99	2,97	2,96	2,95	2,94	2,92	2,90	2,89	2,87	2,86	2,86				
10	4,96	4,10	3,71	3,33	3,33	3,22	3,14	3,07	3,02	2,98	2,94	2,91	2,89	2,86	2,85	2,83	2,81	2,80	2,78	2,77	2,75	2,74	2,72	2,71	2,70	2,70				
11	4,84	3,98	3,59	3,20	3,20	3,09	3,01	2,95	2,90	2,85	2,82	2,79	2,76	2,74	2,72	2,70	2,69	2,67	2,66	2,65	2,63	2,61	2,59	2,58	2,57	2,57				
12	4,75	3,89	3,49	3,11	3,11	3,00	2,91	2,85	2,80	2,75	2,72	2,69	2,66	2,64	2,62	2,60	2,58	2,57	2,56	2,54	2,52	2,51	2,49	2,48	2,47	2,47				
13	4,67	3,81	3,41	3,03	3,03	2,92	2,83	2,77	2,71	2,67	2,63	2,60	2,58	2,55	2,53	2,51	2,50	2,48	2,47	2,46	2,44	2,42	2,41	2,39	2,38	2,38				
14	4,60	3,74	3,34	2,96	2,96	2,85	2,76	2,70	2,65	2,60	2,57	2,53	2,51	2,48	2,46	2,44	2,43	2,41	2,40	2,39	2,37	2,35	2,33	2,32	2,31	2,31				
15	4,54	3,68	3,29	2,90	2,90	2,79	2,71	2,64	2,59	2,54	2,51	2,48	2,45	2,42	2,40	2,38	2,37	2,35	2,34	2,33	2,31	2,29	2,27	2,26	2,25	2,25				
16	4,49	3,63	3,24	2,85	2,85	2,74	2,66	2,59	2,54	2,49	2,46	2,42	2,40	2,37	2,35	2,33	2,32	2,30	2,29	2,28	2,25	2,24	2,22	2,21	2,19	2,19				
17	4,45	3,59	3,20	2,81	2,81	2,70	2,61	2,55	2,49	2,45	2,41	2,38	2,35	2,33	2,31	2,29	2,27	2,26	2,24	2,23	2,21	2,19	2,17	2,16	2,15	2,15				
18	4,41	3,55	3,16	2,77	2,77	2,66	2,58	2,51	2,46	2,41	2,37	2,34	2,31	2,29	2,27	2,25	2,23	2,22	2,20	2,19	2,17	2,15	2,13	2,12	2,11	2,11				
19	4,38	3,52	3,13	2,74	2,74	2,63	2,54	2,48	2,42	2,38	2,34	2,31	2,28	2,26	2,23	2,21	2,20	2,18	2,17	2,16	2,13	2,11	2,10	2,08	2,07	2,07				
20	4,35	3,49	3,10	2,71	2,71	2,60	2,51	2,45	2,39	2,35	2,31	2,28	2,25	2,22	2,20	2,18	2,17	2,15	2,14	2,12	2,10	2,08	2,07	2,05	2,04	2,04				
21	4,32	3,47	3,07	2,68	2,68	2,57	2,49	2,42	2,37	2,32	2,28	2,25	2,22	2,20	2,18	2,16	2,14	2,12	2,11	2,10	2,07	2,05	2,04	2,02	2,01	2,01				
22	4,30	3,44	3,05	2,66	2,66	2,55	2,46	2,40	2,34	2,30	2,26	2,23	2,20	2,17	2,15	2,13	2,11	2,10	2,08	2,07	2,05	2,03	2,01	2,00	1,98	1,98				
23	4,28	3,42	3,03	2,64	2,64	2,53	2,44	2,37	2,32	2,27	2,23	2,20	2,18	2,15	2,13	2,11	2,09	2,07	2,06	2,05	2,02	2,00	1,99	1,97	1,96	1,96				
24	4,26	3,40	3,01	2,62	2,62	2,51	2,42	2,36	2,30	2,25	2,21	2,18	2,15	2,13	2,11	2,09	2,07	2,05	2,04	2,03	2,00	1,98	1,97	1,97	1,94	1,94				
25	4,24	3,39	2,99	2,60	2,60	2,49	2,40	2,34	2,28	2,24	2,20	2,16	2,14	2,11	2,09	2,07	2,05	2,04	2,02	2,01	1,98	1,96	1,95	1,93	1,92	1,92				
26	4,23	3,37	2,97	2,59	2,59	2,47	2,39	2,32	2,27	2,22	2,18	2,15	2,12	2,09	2,07	2,05	2,03	2,02	2,00	1,99	1,97	1,95	1,93	1,91	1,90	1,90				
27	4,21	3,35	2,93	2,57	2,57	2,46	2,37	2,31	2,25	2,20	2,17	2,13	2,10	2,08	2,06	2,04	2,02	2,00	1,99	1,97	1,95	1,93	1,91	1,90	1,88	1,88				
28	4,20	3,34	2,91	2,56	2,56	2,45	2,36	2,29	2,24	2,19	2,15	2,12	2,09	2,06	2,04	2,02	2,00	1,99	1,97	1,96	1,93	1,91	1,90	1,88	1,87	1,87				
29	4,18	3,33	2,90	2,55	2,55	2,43	2,35	2,28	2,22	2,18	2,14	2,10	2,08	2,05	2,03	2,01	1,99	1,97	1,96	1,94	1,92	1,90	1,88	1,87	1,85	1,85				
30	4,17	3,32	2,89	2,53	2,53	2,42	2,33	2,27	2,21	2,16	2,13	2,09	2,06	2,04	2,01	1,99	1,98	1,96	1,95	1,93	1,91	1,89	1,87	1,85	1,84	1,84				

b) The t-test is conducted as follow:

$$S = \sqrt{\{(n_a - 1)S_a^2 + (n_b - 1)S_b^2\} / (n_a + n_b - 2)}$$

Then calculate

$$t = |\bar{x}_a - \bar{x}_b| / S \cdot \sqrt{1/n_a + 1/n_b}$$

where

$|\bar{x}_a - \bar{x}_b|$  is the absolute value of the difference between  $\bar{x}_a$  and  $\bar{x}_b$  and is always positive.

Determine the degrees of liberty

$$\bar{U} = n_a + n_b - 2.$$

The value of  $t_{0,05, \bar{U}}$ , is obtained from Table A20.1.7-5

Where  $t > t_{0,05, \bar{U}}$ , a significant difference occurs between the two sets of results and if  $t < t_{0,05, \bar{U}}$ , there is no significant difference.

**Table A20.1.7-5: Values of t-Distribution ( $\alpha = 0,05$ )**

$\bar{U}$	T	$\bar{U}$	t	$\bar{U}$	T
1	6,3138	11	1,7959	21	1,7207
2	2,9200	12	1,7823	22	1,7171
3	2,3534	13	1,7709	23	1,7139
4	2,1318	14	1,7613	24	1,7109
5	2,0150	15	1,7530	25	1,7081
6	1,9432	16	1,7459	26	1,7056
7	1,8946	17	1,7396	27	1,7033
8	1,8595	18	1,7341	28	1,7011
9	1,8331	19	1,7291	29	1,6991
10	1,8125	20	1,7247	30	1,6973

## A20.1.7.5 Assessment Methods

### a) General

Certain requirements and limit values are laid down in the specifications with regard to the properties of materials and quality of workmanship. Tests shall be conducted, and measurements taken for controlling the relevant quality of the workmanship and the properties of materials supplied. The results of such tests and measurements shall be assessed for acceptance on the basis of the prescribed criteria for compliance with the specified statistical requirements described herein, as well as the non-statistical requirements in the various Chapters of the Contract Documentation or the Contract Documentation.

Compliance, in terms of this Chapter, may be judged by the application of two plans.

For certain properties statistical judgment plans are prescribed for assessing the test results; where no such statistical judgment plan has been prescribed, the specified requirements and limit values specified in the various Chapters shall be fully complied with.

### b) Judgement plans

#### (i) Judgement Plan A

This Plan is for judging measurement of concrete cover and concrete durability. In accordance with this plan, the compliance of the individual results only with the specified requirements is determined and the variability of test results is not computed. In some quality assessment that falls into this category, the mean of the results may be specified as the method of assessment.

#### (ii) Judgement Plan B

For judging measurements of relative compaction, concrete strength, as well as certain properties of asphalt. In this judgement plan the variability of the values of tests is calculated and applied where acceptance limits for sample means are determined.

Despite acceptance of those properties judged by these statistical methods, the materials or work submitted shall be rejected when other properties, which are not controlled by statistical methods, fail to comply with the requirements of the specifications or where there are other causes for rejection such as obviously defective workmanship or excessively variable properties, visible signs of poor workmanship and similar considerations which constitute sufficient grounds for rejecting the work without any further testing.

#### (iii) The Engineer shall be entitled to access separately any specified portion or a lot if, in his opinion, it exhibits significant deviations as compared with the remainder of the lot. However, once the Engineer is satisfied that a specific lot is to be evaluated for acceptance purposes, then, in order not to change the Contractor's or the Employer's risks, the statistical judgment plans shall be strictly adhered to in all cases where they are used and decisions based on these plans shall not be altered.

It shall be a condition of the Contract that the theoretical validity of the various statistical judgment plans is accepted and that the validity of the decisions made on the basis of these judgment plans cannot be disputed on the grounds of statistical theory or a specified or implied producer's risk or on the grounds of unjust enrichment.

#### (iv) Construction tolerances for rehabilitation work

These judgement plans shall be applicable to rehabilitation work except for situations as described in the definition under Clause A20.1.2.

**c) Application of Judgement Plan A**

Judgement Plan A shall apply to concrete cover and concrete durability. Where properties are determined as non-compliant with the specified requirements, conditional acceptance in accordance with Clause A20.1.7.6 may apply.

(i) *Concrete Cover*

Concrete cover, tested after casting concrete, shall be judged in accordance with the following procedure:

1. Taking the cover readings

The number of cover measurements per cover survey shall be at least 12 over a nominal survey area of 600 mm x 600 mm. A minimum of three cover surveys are required per lot and the minimum total area represented by cover survey in a lot shall exceed 1,0 m<sup>2</sup>. Larger sample sizes will give more reliable results.

2. Calculating the deviations

Compute the arithmetic mean cover for each cover survey, reported to the nearest whole number. Compute the “grand” sample mean cover per lot from the previously computed mean cover for each cover survey that comprised the lot.

3. Identifying outliers

Outliers shall be identified, discarded, and if possible, replaced with fresh tests values or as prescribed in Clause A20.1.7.3.

4. Assessing the results

The mean cover determined per cover survey shall exceed the specified cover minus  $C_{max}$ , as specified in Table A20.1.7-6. The lot shall comply with the requirements specified for concrete cover if the mean cover for the lot is not less than the specified cover minus the  $C_{ave}$  tolerance specified.

**Table A20.1.7-6: Values for assessment of Cover**

Specified cover (mm)	$C_{max}$ (mm)	$C_{ave}$ (mm)
75	15	5
60	12	5
50	10	5
40	8	5
35	7	5
30	6	5

(ii) *Concrete Durability*

Concrete durability, comprising oxygen permeability index, chloride conductivity and water sorptivity properties, shall be judged in accordance with the following procedure:

1. Taking the readings

For each durability parameter specified, the number of concrete durability measurements shall be at least 4. Larger sample sizes will give more reliable results.

2. Calculating the deviations

Compute the sample mean value per lot for each durability parameter.

3. Identifying outliers

Check this work by re-measuring any results that may possibly be defective. If applicable, this may occur by replacement of a specimen. Outliers are identified using the method in Clause A20.1.7.3 a)(i).

4. Assessing the results

The following criteria will apply when results are assessed:

- Oxygen Permeability Index (OPI)

The lot shall comply with the requirements specified for oxygen permeability if the mean OPI for the lot is not less than the specified OPI minus the  $B_{ave}$  tolerance specified in Table A20.1.7-7.

- Chloride Conductivity

The lot shall comply with the requirements specified for chloride conductivity if the mean chloride conductivity for the lot is not greater than the specified chloride conductivity plus the  $B_{ave}$  tolerance specified in Table A20.1.7-7.

- Water sorptivity and curing efficiency

The lot shall comply with the requirements specified for water sorptivity if the mean water sorptivity for the lot is not greater than the specified water sorptivity plus the  $B_{ave}$  tolerance specified in Table A20.1.7-7.

**Table A20.1.7-7: Values for assessment of Concrete durability**

Specified concrete durability property	Unit	$B_{ave}$ (mm)
Oxygen permeability index	log scale	0,25
Chloride conductivity	milli Siemens/cm	0,20
Water Sorptivity	mm/(hour <sup>0.5</sup> )	1,50

The relevant test methods for concrete durability are included in Clause A20.1.5.1c) and the other relevant sub clauses referred to.

**d) Application of Judgement Plan B**

(i) *General*

In this judgement plan the variability of the values of tests is calculated and applied where acceptance limits for sample means are determined. It is typically used for judging relative compaction, concrete strength, as well as certain properties of asphalt. Where properties are determined as non-compliant with the specified requirements, conditional acceptance in accordance with Clause A20.1.7.6 may apply.

The characteristic properties to be controlled in accordance with this judgment scheme are as shown in Table A20.1.7-8.

**Table A20.1.7-8**

Structure	Characteristic
Gravel pavement layers	Relative compaction
Crushed-stone base or subbase and Bound Macadam (BM)	Relative compaction
Asphalt base and surfacing	Relative compaction Binder content of mix Void content of mix
BSM layers	Relative compaction
Structural Concrete	Compressive strength
Concrete for pavements	Compressive strength

The procedure to be followed when assessing the above properties shall be as follows:

(ii) *Taking samples and test the properties*

The sampling shall be in accordance with the relevant Chapter and other relevant Clauses of this Chapter, including tables for the minimum number of samples following a stratified random sampling procedure as defined under Clause A20.1.2 with reference to random sampling and stratified sampling as defined under Clause A20.1.2. The sampling method shall be in accordance with Clauses A20.1.3.5 and the test methods in accordance with the relevant Chapters or as prescribed by the Engineer.

(iii) *Identifying outliers*

Outliers shall be identified, discarded, and if possible replaced with fresh test values, all as prescribed in Clause A20.1.7.3.

(iv) *Calculating standard deviation and the mean of sample values*

Use the sample results for calculating the standard deviation  $S$  and the mean  $\bar{x}_n$  of the sample values in accordance with the definitions under Clause A20.1.2.

Where it is a resubmission (as defined under Clause A20.1.2), the first and second sets of sample results shall be used for determining a combined sample means  $\bar{x}_{ab}$ , standard deviation  $S_{ab}$  and sample size  $n_{ab}$  as determined below:

$$n_{ab} = n_a + n_b$$

$$\bar{x}_{ab} = (n_a \bar{x}_a + n_b \bar{x}_b) / (n_a + n_b)$$

$$s_{ab} = \sqrt{\{(n_a - 1)s_a^2 + (n_b - 1)s_b^2 + n_a(\bar{x}_{ab} - \bar{x}_a)^2 + n_b(\bar{x}_{ab} - \bar{x}_b)^2\} / (n_a + n_b - 1)}$$

where subscript (a) refers to the first set of test values,  
 (b) refers to the second set of test values,  
 (ab) refers to the combined properties.

(v) *Determining the judgment limits*

All judgment limits shall be computed to three decimal figures.

1. First submission

The acceptance limits  $L_a$  and  $L'_a$  are calculated in accordance with the formulas given below in the case of a first submission (as defined under Clause A20.1.2)

**For lower-limit specifications**

$$L_a = L_s + S.k_a$$

Accept the lot if the sample mean  $\bar{x}_n$  is equal to or greater than the acceptance limit  $L_a$ , otherwise reject the lot.

**For upper-limit specifications**

$$L'_a = L'_s - S.k_a$$

The values of  $k_a$  are given in Table A20.1.7-11/1 for the  $\emptyset$  values displayed in Table A20.1.7-9

Accept the lot if the sample mean  $\bar{x}_n$  is equal to or less than the acceptance limit  $L'_a$ , otherwise reject the lot.

**For double-limit specifications** calculate

$$L_a = L_s + S.k_{ad}$$

$$L'_a = L'_s - S.k_{ad}$$

The values of  $k_{ad}$  are given in Table A20.1.7-11/2 for the  $\emptyset$  values displayed in Table A20.1.7-9

Accept the lot if the sample mean  $\bar{x}_n$  falls between the lower acceptance limit  $L_a$  and the upper acceptance limit  $L'_a$  or is equal to either one, otherwise reject the lot.

Where a lot has been rejected, it may nevertheless be considered for conditional acceptance in terms of Clause A20.1.7.6 in accordance with the applicable provisions and conditions.

2. Resubmission

Where a lot is resubmitted for approval in terms of the definition under Clause A20.1.2 the acceptance limits are determined as follows:

**For a single-limit specification**

$$L_a = L_s + S_{ab}.k_a$$

$$L'_a = L'_s - S_{ab}.k_a$$

Accept the lot if  $\bar{x}_{ab} \geq L_a$  in the case of a lower-limit specification and if  $\bar{x}_{ab} \leq L'_a$  in the case of an upper limit specification, otherwise reject the lot.

**For a double-limit specification**

$$L_a = L_s + S_{ab}.k_{ad}$$

$$L'_a = L'_s - S_{ab}.k_{ad}$$

Accept the lot if  $L_a \leq \bar{x}_{ab} \leq L'_a$ . If not, reject the lot.

The values of  $k_a$  and  $k_{ad}$  used in the above cases shall agree with the sample size  $n_{ab}$ .

Where a resubmitted lot is rejected, it may nevertheless be considered for conditional acceptance in terms of Clause A20.1.7.6 and the provisions and conditions therein.

The evaluation of a resubmitted lot shall be final and binding on both Employer and Contractor. The provisions of this section shall be strictly complied with.

Where a resubmitted lot is rejected, the Contractor shall be obliged to bear the costs of the additional tests conducted on the resubmitted lot.

(vi) Values of constants

The values of the specification limits  $L_s$  and  $L'_s$  are summarised in Table A20.1.7-9. The minimum sample size “n” and the maximum percentage of defectives ( $\emptyset$ ) in an acceptable product are also given in the table.

The values of  $k_a$  and  $k_{ad}$  are given in Tables A20.1.7-9-11/1 and A20.1.7-11/2.

**Table A20.1.7-9: Values of Constants n,  $L_s$ ,  $L'_s$  AND  $\emptyset$**

Material	Properties	Minimum sample size (n) per lot				Lower specification limits $L_s$	Upper specification limit $L'_s$	$\emptyset$ (%)
		Road category						
		A	B	C	D			
Selected subgrade	Relative compaction $^*_1$	6	6	4	4	93 % or 95 %	-	15
Subbase	Relative compaction $^*_1$	8	6	4	4	95 % or 97 %	-	15
Granular Base	Relative compaction $^*_1$	8	6	4	4	98 % or 97 % if stabilised	-	15
Crushed stone base or subbase	Relative compaction $^*_2$	8	6	4	4	As specified in relevant Chapter	-	15
Asphalt base or surfacing, Bound macadam	Relative compaction	8	6	4	4	See note 1		10
	Binder content	8	6	4	4			10
	Voids in mix	8	6	4	4			10
Structural concrete	28-day Compressive strength	See Table A20.1.7-10				See note 2	-	5
Pavement concrete	Compressive strength (28 days)	10	8	6	4	As specified in Chapter 6		5
Chemically stabilised layers	Relative compaction $^*_1$	8	6	4	6	95 % or 97 %	-	10
BSM	Relative compaction $^*_1$	8	6	4	4	98 %	-	10

$^*_1$  Relative compaction based on maximum dry density SANS 3001-GR30 (MDD)

$^*_2$  Relative compaction based on apparent density SANS3001-AG22 (AD)

**Notes 1** (refer to Table A20.1.7-9)

(vii) Asphalt base or surfacing: Specification limits for –

- Relative compaction  $L_s = 93$  % of voidless density (Rice's Method)  
 $L'_s = 97$  % of voidless density (Rice's Method)

The above relative compaction specifications are applicable to all asphalt mixes, except for EME, SMA, UTFc, Porous mixes and mixes underlying concrete pavement slabs, for which the requirements shall be specified in the Contract Documentation or as outlined in the SABITA manuals for the relevant mix types.

- Binder content for all mix types using both conventional and homogeneous modified binders:

$L_s =$  specified binder content -0,30 % binder

$L'_s =$  specified binder content +0,30 % binder

- Binder Content for non-homogeneous modified binders (Bitumen – rubber mixes)

$L_s =$  specified binder content -0,40 % binder

$L'_s =$  specified binder content +0,40 % binder

- Void content

$L_s =$  specified values -1,0 %

$L'_s =$  specified values +1,0 %

**Table A20.1.7-10: Minimum sample size for structural concrete**

Size of lot in m <sup>3</sup>	Min sample size for structural concrete (n)
0 – 20	4
21 – 40	6
41 – 70	9
71 – 100	12
101 – 150	14
>150	16

**Note 2** (refer to Table A20.1.7-10)

For concrete, the sample size (n) refers to the number of valid test results. A valid test result is the arithmetic mean of at least 3 cube or cylinder specimens, where the difference between the highest and lowest result does not exceed 15 percent.

(viii) *Specification limits for compressive strength of concrete*

$L_s$  = the specified 28-day characteristic compressive strength as specified in the various Chapters with reference to cube or cylinder specimens for example class C32/40 concrete,  $L_s = 32$  MPa for cylinder specimens or  $L_s = 40$  MPa for cube specimens.

**Table A20.1.7-11/1: Values of  $k_a$  (single limits)**

Sample size (n)	$k_a$		
	$\emptyset = 5 \%$	$\emptyset = 10 \%$	$\emptyset = 15 \%$
4	0,747	0,445	0,220
5	0,821	0,520	0,300
6	0,878	0,576	0,358
7	0,923	0,620	0,403
8	0,961	0,656	0,440
9	0,993	0,687	0,470
10	1,020	0,713	0,496
12	1,065	0,755	0,538
14	1,101	0,789	0,571
16	1,131	0,817	0,598
18	1,155	0,840	0,620
20	1,177	0,860	0,640

**Table A20.1.7-11/2: Values of  $k_{ad}$  (double limits)**

Sample size (n)	$k_{ad}$			
	$\emptyset = 5 \%$	$\emptyset = 10 \%$	$\emptyset = 15 \%$	$\emptyset = 20 \%$
4	0,605	0,299	0,061	-0,161
5	0,691	0,390	0,163	-0,038
6	0,756	0,456	0,235	0,043
7	0,809	0,509	0,290	0,103
8	0,852	0,551	0,334	0,149
9	0,888	0,587	0,370	0,188
10	0,919	0,617	0,401	0,219
12	0,971	0,666	0,451	0,271
14	1,012	0,706	0,489	0,310
16	1,046	0,738	0,521	0,342
18	1,074	0,764	0,547	0,369
20	1,099	0,787	0,570	0,391

(ix) *Controlling more than one property*

Where more than one property of a lot is to be controlled statistically, or otherwise, the lot shall be accepted if all the properties comply with the specified requirements, but the lot shall be rejected if one or more of the properties do not comply with the specified requirements, or the lot may be conditionally accepted subject to the requirements of Clause A20.1.7.6.

## **A20.1.7.6 Conditional acceptance**

### **a) General provisions**

Where a lot is rejected under judgement plan A or Judgement Plan B but the test results are such that the lot complies with the requirements for conditional acceptance specified hereafter, the Engineer may accept the lot conditionally, that is, the lot may be accepted at reduced payment in lieu of complete rejection, provided that:

- (i) conditional acceptance shall be in the sole discretion of the Engineer and is not an option that may be exercised by the Contractor or a right the Contractor may claim;
- (ii) the lot is approved in respect of all other requirements including those not judged by a statistical judgment plan;
- (iii) the Contractor shall have the option to remove and reinstate at his own cost conditionally acceptance work with work which complies with the requirements for acceptance at full payment;
- (iv) conditional acceptance and the corresponding reduced payment shall apply only in respect of the work and properties listed in Clause A20.1.7.6b) below.
- (v) none of the obligations of the parties shall change as defined in the Contract Documentation.

**b) Properties to which conditional acceptance applies**

Conditional acceptance may be applied in respect of the properties listed below in Table A20.1.7-12

**Table A20.1.7-12: Properties in respect of which conditional acceptance may be applied**

Property	Structure
Relative compaction	i) Asphalt base or surfacing ii) Chemically stabilised layers iii) Plant mixed paver laid layers iv) BSM layers
Bituminous binder content	Asphalt base or surfacing
Voids in mix	Asphalt base or surfacing
28-day compressive Strength	All strength concrete. (concrete pavements not included. See note 1)
Concrete cover	All reinforced and pre-stressed concrete
Oxygen Permeability Chloride Conductivity Water Sorptivity	All durability properties (Class D) concrete

**Note 1:**

See Clause A6.1.8 of Chapter 6 for details regarding reduced payment in the case of inadequate concrete strength or layer thickness in concrete pavements.

(i) *Criteria for conditional acceptance for Judgement Plan A*

Any lot that does not comply with the requirements for acceptance, in accordance with judgement plan A may be conditionally accepted should the value of the sample mean  $\bar{x}_n$  lie within the rejection limits given in Table A20.1.7-14.

The payment reduction factors shall be calculated in accordance with Table A20.1.7-13.

**Table A20.1.7-13: Fixed payment reduction factors for concrete**

Property	Payment reduction
Concrete Cover	70 %
Oxygen Permeability	80 %
Chloride Conductivity	80 %
Water Sorptivity	80 %

The percentage reduced payment shall be applied to the complete specific concrete member represented by the lot and shall apply to all the relevant pay items of the applicable Chapters in terms of concrete durability and cover.

(ii) *Criteria for conditional acceptance for Judgement Plan B*

Any lot that does not comply with the requirements for acceptance, judgement plan B may be conditionally accepted should the value of the sample mean  $\bar{x}_n$  lie within the rejection limits given in Table A20.1.7-14.

The variable payment reduction factor ( $f_r$ ) shall be calculated in accordance with the following formula:

For conditional acceptance at a lower limit

$$f_r = 0,67 + 0,3 (\bar{x}_n - L_r) / (L_a - L_r)$$

For conditional acceptance at an upper limit

$$f_r = 0,67 + 0,3 (L'_r - \bar{x}_n) / (L'_r - L'_a)$$

See Clause A20.1.2 for the meaning of the symbols.

(iii) *Applying the payment-reduction factor*

The payment-reduction factor, either fixed or variable type, shall be applied to all payment items related to the assessed products.

**Table A20.1.7-14: Rejection limits ( $L_r$  en  $L'_r$ ) for sample mean ( $\bar{x}_n$ )**

Property	Structure	Rejection limits ( $L_r$ and $L'_r$ )
Relative compaction	Chemically stabilised layers	$L_r = (L_a - 1,500)$ % of relative compaction
	Asphalt base or surfacing	$L_r = (L_a - 1,000)$ % of relative compaction $L'_r = (L'_a + 0,500)$ % of relative compaction
	Bituminous stabilised materials	$L_r = (L_a - 1,500)$ % of relative compaction
Concrete compressive strength	All strength concrete (excluding that in pavement)* <sup>1</sup>	$L_r = 0,9 L_a$
Concrete Cover	All reinforced and pre-stressed concrete	$L_r = (\text{specified cover} - 7 \text{ mm})$
Concrete Durability	Oxygen Permeability (OPI)	$L_r = (\text{Specified OPI} - 0,40)$
	Chloride Conductivity (CC)	$L'_r = (\text{Specified chloride conductivity} + 0,40)$
	Water sorptivity (WS)	$L'_r = (\text{Specified water sorptivity} + 2,50)$
Bituminous binder content (%)	Asphalt	$L_r = (L_a - 0,200)$ % binder $L'_r = (L'_a + 0,200)$ % binder
Voids in mix (%)	Asphalt	$L_r = (L_a - 0,300)$ % voids $L'_r = (L'_a + 0,300)$ % voids

Where payment items are introduced into the Contract Documentation or are changed in the schedule of quantities, the payment reduction factor shall apply to the payment items corresponding to the relevant payment items.

Where a lot is conditionally accepted in regard to more than one property, the payment-reduction factor for each property shall be computed and the factor that gives the largest reduction shall be applied.

\*<sup>1</sup> In the case of concrete pavement, the provisions of Clause A6.1.8 of Chapter 6 shall apply.

# **B20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP**

## **PART B: LABOUR ENHANCED**

### **CONTENTS**

#### **B20.1.1 SCOPE**

#### **B20.1.2 DEFINITIONS**

#### **B20.1.3 TEST METHODS**

#### **B20.1.4 PUBLISHED TEST METHODS**

#### **B20.1.5 UNPUBLISHED TEST METHODS**

#### **B20.1.6 SPECIAL TEST METHODS**

#### **B20.1.7 ACCEPTANCE CONTROL BY STATISTICAL JUDGEMENT PRINCIPLES**

### **B20.1.1 SCOPE**

All specifications under this heading in the various sections of PART A, shall apply.

### **B20.1.2 DEFINITIONS**

All specifications under this heading in the various sections of PART A, shall apply.

### **B20.1.3 TEST METHODS**

#### **B20.1.3.1 Using DCP testing on community and other low volume traffic roads**

a) **Compaction testing of the base on community and other low volume roads may be carried out using the DCP.**

- (i) Construct a trial section, including the granular base, with a length of at least 100 m.
- (ii) Carry out relative compaction tests on the completed base layer at 5 positions using SANS 3001-NG5.
- (iii) Calculate the mean relative density of the section. The compaction of the base layer shall comply with the specified requirements for relative compaction.
- (iv) Carry out DCP probing at each of the same 5 positions, determining the number of blows required to reach a depth of 150 mm.
- (v) Calculate the mean penetration rate.
- (vi) Provided the quality of the material used in the base layer is not changed the compaction of further sections may be controlled using DCP probes.
- (vii) Compaction is acceptable when the mean penetration rate is at least 90 % of that obtained on the trial section.

#### **B20.1.4 PUBLISHED TEST METHODS**

All specifications under this heading in the various sections of PART A, shall apply.

#### **B20.1.5 UNPUBLISHED TEST METHODS**

All specifications under this heading in the various sections of PART A, shall apply.

#### **B20.1.6 SPECIAL TEST METHODS**

All specifications under this heading in the various sections of PART A, shall apply.

#### **B20.1.7 ACCEPTANCE CONTROL**

All specifications under this heading in the various sections of PART A, shall apply.

Note: Labour Enhanced project testing and judgement should be specified in the relevant Chapter and the Contract Documentation.

## C20.1 TESTING MATERIALS AND JUDGEMENT OF WORKMANSHIP

### PART C: MEASUREMENT AND PAYMENT

#### Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the equipment, labour, tools, incidentals and supervision to carry out the activity in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the Conditions of Contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

Item	Description	Unit
<b>C20.1.1</b>	<b>Special tests on elastomeric bearings</b> (150 % vertical load and 150 % shear distortion)	<b>Number (No)</b>

The unit of measurement shall be the number of elastomeric bearings tested as described.

The tendered rate shall include full compensation for having the test conducted by an approved laboratory, also for replacing the bearings that may possibly been damaged during testing.

Item	Description	Unit
<b>C20.1.2</b>	<b>Special tests requested by the Engineer</b>	
C20.1.2.1	Employer's contribution to concrete durability tests	
(a)	Tests for water sorptivity	Prime Cost
(i)	Handling costs and profit in respect of item C20.1.2.1(a)	percentage (%)
(b)	Tests for oxygen permeability	Prime Cost
(i)	Handling costs and profit in respect of item C20.1.2.1(b)	percentage (%)
(c)	Tests for chloride conductivity	Prime Cost
(i)	Handling costs and profit in respect of item C20.1.2.1(c)	percentage (%)
(d)	Tests for concrete cover	Prime Cost
(i)	Handling costs and profit in respect of item C20.1.2.1(d)	percentage (%)
C20.1.2.2	Employer's contribution to other special tests	
(a)	Specify test	Prime Cost
(i)	Handling costs and profit in respect of item C20.1.2.2(a)	percentage (%)

The Prime Cost provided to cover the cost of special tests as requested by the Engineer in terms of Clause A20.1.3.6b) shall be expended in accordance with the provisions of the Conditions of contract. Payment will not be made for any special test should the test indicate that the specifications have not been complied with.

Item	Description	Unit
<b>C20.1.3</b>	<b>Providing testing equipment:</b>	
C20.1.3.1	Core drill	number (No)

The unit of measurement shall be the number of each item provided. The core drill shall be an approved type capable of drilling cores with diameters of 100 mm and 150 mm in concrete, stabilised layers and asphalt. It shall be provided with a water supply and necessary drilling parts. The core drill shall be operated by the Contractor and for acceptance control in the presence of representatives of the Engineer.

Item	Description	Unit
<b>C20.1.4</b>	<b>Special tests using Automated Road condition assessment instruments operated by service providers as requested by the Engineer for acceptance control in terms of Clause A20.1.3.6b)(iii)</b>	
C20.1.4.1	Using Highspeed Inertial Non-Contact laser profilers (Clause A20.1.5.5c)(ii))	Prime Cost
(a)	Handling cost and profit in respect of item C20.1.4.1	percentage (%)
C20.1.4.2	Using Direct Contact Devices (Clause A20.1.5.5c)(i))	Prime Cost
(a)	Handling cost and profit in respect of item C20.1.4.2	percentage (%)
C20.1.4.3	Rutting measurements (Clause A20.1.5.5 d)(i))	Prime Cost
(a)	Handling cost and profit in respect of item C20.1.4.3	percentage (%)
C20.1.4.4	Surface macro texture (Clause A20.1.5.5 b))	Prime Cost
(a)	Handling cost and profit in respect of item C20.1.4.4	percentage (%)
C20.1.4.5	Deflection measurements (FWD) (Clause A20.1.5.5e))	Prime Cost
(a)	Handling cost and profit in respect of item C20.1.4.5	percentage (%)

The prime cost sum shall be paid in accordance with the provision of the Conditions of Contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost item. The percentage shall cover all the Contractors' sourcing, handling, supervision, profit, payment of the service provider and liability costs in providing the services. The Contractor shall arrange with the service provider to forward the test results directly to the Engineer and will forfeit his mark-up when the service provider is not paid in time.

Item	Description	Unit
<b>C20.1.5</b>	<b>Financial contribution for an independent laboratory</b>	<b>Month</b>

The unit of measurement shall be the month.

The monthly contribution by the Contractor shall be a negative amount for all process control testing, excluding acceptance control and other testing ordered by the Engineer, as provided in the Contract Documentation.

This shall cover the Contractor's contribution towards the establishment and operation of services provided by an independent laboratory over the contract period including any approved extension of time and shall be deducted from the Contractor's interim payment certificates. However, excluded from the tendered contribution shall be the cost of all other special tests requested by the Engineer.

**Note:**

Providing testing equipment for use by the Engineer.

Except for the equipment listed in Item C20.1.3.1, this specification does not envisage the provision of testing equipment by the Contractor for the use of the Engineer but where necessary provision shall be made therefore in the Contract Documentation and the relevant pay items shall be described.