

TRANSPORT FOR NSW (TfNSW)
SPECIFICATION D&C TS 03323.2 (3211)
CEMENTITIOUS MATERIALS, BINDERS AND FILLERS

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CEMENTITIOUS MATERIALS, BINDERS AND FILLERS

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FOREWORD

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BASE SPECIFICATION

This document is based on Specification TS 03323.1:1.01 (TfNSW 3211 Edition 5 Revision 2).

TfNSW SPECIFICATION D&C TS 03323.2 (3211)

CEMENTITIOUS MATERIALS, BINDERS AND FILLERS

1 SCOPE

This Specification sets out the requirements for the supply of:

- (a) cementitious materials for use in concrete;
- (b) binders for earthworks and granular pavement materials; and
- (c) added fillers for asphalt.

2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

2.1 REFERENCED DOCUMENTS

Standards, specifications, and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure 3211/M.

3 DEFINITIONS AND ACRONYMS

3.1 DEFINITIONS

The term “Supplier” means the supplier of the product covered by the scope of this Specification.

The following definitions apply to this Specification:

Added filler	A material which is introduced from an external source, the majority of which passes a 0.075 mm AS sieve.
Amorphous silica	A very fine pozzolanic material composed mostly of non-crystalline silica.
Available lime	Alkaline constituents which are readily soluble in a sucrose solution as determined by AS 4489.6.1, using the calculation for calcium hydroxide.
Binder	A powdered manufactured material used in small amounts in stabilisation to change the properties of existing material.
Cement	A hydraulic cement that exhibits chemical reaction (also called hydration) when mixed with water.
Cementitious Materials	Materials incorporating hydraulic cements (e.g. general purpose cement, blended cement, and special purpose cement) with or without supplementary cementitious materials. Also known as cementitious binder.

Flue dust	An inorganic mineral material derived from the cement manufacturing process. Also known as “cement kiln dust”.
Fly ash	The solid material extracted from the flue gases of a boiler fired with pulverized coal.
Ground limestone	A calcium carbonate (CaCO ₃)-rich rock dust derived from the grinding of sound unfired limestone and complying with this specification.
Hydrated lime	Essentially calcium hydroxide (Ca(OH) ₂) in the form of a white powder produced by the addition of sufficient water to slake quicklime.
Powdered glass	A powdered form of glass that is usually a by-product of the domestic glass recycling industry.
Slow setting binder	A binder which, when mixed with the material to be bound, creates a mix with a nominated working time of at least 6 hours.
Supplementary cementitious materials	An inorganic material such as fly ash, slag or silica fume that reacts pozzolanically or hydraulically.
Quicklime	Calcium oxide (CaO) which can be readily slaked by reaction with water.
Water-to-cement ratio (w/c)	See preferred term “water-to-cementitious materials ratio (w/cm)”.
Water-to-cementitious materials ratio (w/cm)	The ratio of the water (by weight) to the cementitious materials (by weight). Also known as water-to-binder ratio (w/b).

3.2 ACRONYMS

ATIC	Australian Technical Infrastructure Committee
CMRS	Cementitious Materials Registration Scheme
GGBFS	Ground Granulated Iron Blast-furnace Slag
IAF	International Accreditation Forum
ID	Identification number
JAS-ANZ	Joint Accreditation System for Australia and New Zealand
LoI	Loss on ignition
NATA	National Association of Testing Authorities, Australia
SCM	Supplementary cementitious materials

4 SUPPLIER’S QUALITY MANAGEMENT SYSTEM

The Supplier must have in place a Quality Management System conforming to AS/NZS ISO 9001 as a means of ensuring that the product conforms to this Specification. The Quality Management System

must be certified by a third party organisation accredited by JAS-ANZ or recognised by JAS-ANZ through the International Accreditation Forum (IAF) multilateral recognition arrangement.

Provide evidence verifying conformity to this Clause.

5 GENERAL REQUIREMENTS

5.1 STORAGE

Store the cementitious materials, binder or filler materials inside silos, bins or sheds to maintain the contents in a dry state, and free from contamination.

Use the cementitious materials in the date order by which they are delivered, with the earliest delivered batches to be used first. Reject materials containing lumps or signs of moisture absorption. Re-test before use any bagged and bulk cement that are older than 3 months.

5.2 RECYCLED MATERIALS

For recycled materials that are the subject of “resource recovery exemptions” granted by the NSW Environment Protection Authority, both you and your suppliers must comply with the conditions attached to any exemption as a “consumer” or a “producer”, as appropriate, and provide evidence demonstrating such compliance including all record keeping requirements.

6 CEMENTITIOUS MATERIALS FOR CONCRETE

6.1 CEMENTS

6.1.1 Cement Types

Cement types are as follows:

- General purpose cement (Type GP)
- Blended cement (Type GB)
- Shrinkage limited cement (Type SL)
- Low heat cement (Type LH)
- High early strength cement (Type HE)

6.1.2 Properties and Characteristics

All cement types, whether general purpose (Type GP), special purpose (Types HE, LH, or SL), or blended cement (Type GB), must conform to AS 3972.

Blended cements may comprise a mix of general or special purpose cement, and one or more of the following: fly ash, ground granulated iron blast-furnace slag, and amorphous silica.

Blending of cements may be carried out at the cement supplier’s facilities or at the concrete batching plant. Regardless of the location of blending of cements, the individual components of the cements must conform to their respective requirements in this Specification.

6.1.3 Mineral Additions and Minor Additional Constituents

Mineral additions and minor additional constituents (as defined in AS 3972) contained in cements must conform to AS 3972.

Provide to the Principal details of any mineral addition and/or minor mineral contained in the cement.

6.2 SUPPLEMENTARY CEMENTITIOUS MATERIALS

6.2.1 Fly Ash

Fly ash must be Grade 1 to AS 3582.1.

To ensure uniformity of fly ash supplied, loss on ignition (*LoI*) and fineness as calculated using the 30 most recent successive test results must conform to that shown in Table 3211.1.

Table 3211.1 – Fly Ash Uniformity Requirements

Property	Formula	Limit
Carbon content (by loss on ignition)	$LoI_{avg} + 3SD$	$\leq 4.0\%$
Fineness	$Fineness_{avg} + 3SD$	$\leq 100\%$
	$Fineness_{avg} - 3SD$	$\geq 75\%$
	CoV	$\leq 3.0\%$

where:

LoI_{avg} = Mean of the test results

$Fineness_{avg}$ = Mean of the test results

SD = Standard deviation of the test results

CoV = Coefficient of variation of the test results = $\frac{SD}{Fineness_{avg}} \times 100\%$

6.2.2 Ground Granulated Iron Blast-furnace Slag

Ground granulated iron blast-furnace slag (GGBFS) must conform to AS 3582.2.

To ensure uniformity of GGBFS supplied, fineness as calculated using the 30 most recent successive test results must conform to the following:

$$(Fineness_{avg} - 3SD) \leq Fineness_{sample} \leq (Fineness_{avg} + 3SD)$$

where:

$Fineness_{sample}$ = Individual test result

$Fineness_{avg}$ = Mean of the test results

SD = Standard deviation of the test results

6.2.3 Amorphous Silica

Amorphous silica must conform to AS/NZS 3582.3. Respirable crystalline silica content must not exceed 1.5% as determined using quantitative X-ray diffraction (XRD) methodology.

For slurried or densified amorphous silica, sample and test from the raw materials used to make these products.

6.2.4 Powdered Glass

Powdered glass must conform to Table 3211.2.

Sample and test powdered glass in conformity with this clause and Table 3211/L.2 in Annexure 3211/L.

Table 3211.2 – Powdered Glass Requirements

Property	Test Method	Limit
% passing 45 µm sieve	AS 2350.9	≥ 90%
Loss on ignition	AS 3583.3	< 1.5%
Major oxides (Na ₂ O, CaO, Al ₂ O ₃ , K ₂ O, Fe ₂ O ₃ , MgO)	AS/NZ 2350.2	Report ⁽¹⁾
Silicon oxide (SiO ₂)		≥ 68%
Sulphur trioxide (SO ₃)		< 3%
Sugar	AS 1141.35	None present
Chloride content	AS 3583.13	< 0.1%
Strength Index	AS 3583.6	Report ⁽¹⁾
Lead	BS 6748	< 0.1%

Note:

⁽¹⁾ Report: no conformity criteria exist, but test results must be reported.

6.3 CEMENTITIOUS MATERIALS FOR LOW HEAT AND SULPHATE RESISTING CONCRETE - SPECIAL REQUIREMENTS

Use Type LH cement for low heat concrete only.

Use the following cements for either low heat or sulphate resisting concrete:

- (a) Type GP or Type SL cement with a minimum of 25% fly ash (by mass as cement replacement) mixed at the concrete batching plant;

or

- (b) Type GP or Type SL cement with a minimum of 65% GGBFS (by mass as cement replacement).

6.4 PRODUCT REGISTRATION

6.4.1 General

Cementitious materials (including SCM) for concrete must be registered under the Australian Technical Infrastructure Committee (ATIC) Scheme in accordance with ATIC SP43.

A list of registered cementitious materials may be accessed through ATIC website at: <http://atic.net.au/>.

Provide a monthly summary of test reports for all properties listed in Annexure 3211/L for cementitious materials to the ATIC Cementitious Materials Registration Scheme (CMRS) Administrator (cmrs@transport.nsw.gov.au).

6.4.2 Clinker Source Changes

When a source of clinker, or raw feed for clinker production, is relocated outside of an existing production facility, whether situated within or outside Australia, of less than five square kilometres in area contiguously, the ATIC registration of the cement affected will be considered to be void, and a new ATIC number will be required.

Every time when this occurs:

- (a) collect new samples and re-test in accordance with Annexure 3211/L;
- (b) carry out new trial mixes to the relevant specifications using the modified cement.

Submit the test results from the above to the Principal and ATIC CMRS administered by TfNSW Materials Technology (cmrs@transport.nsw.gov.au) for approval prior to using the modified cement.

6.5 VERIFICATION OF CONFORMITY

6.5.1 General

Sample the cementitious materials supplied, test and record the results in conformity with Annexure 3211/L. Provide analytical test data issued as a NATA endorsed test report to verify conformity of the product supplied with this Specification and ATIC SP43, to the Principal as soon as practicable.

For each delivery of each material to be incorporated into the Works, provide to the Project Verifier a delivery docket with the following information, as applicable:

- (a) product name and/or identification code;
- (b) ATIC registration number;
- (c) date, time, and place of loading of the material into the delivery vehicle;
- (d) NATA sample ID (or laboratory ID) identifying the test results which are representative of the despatched load.

6.5.2 Initial Sampling

Within one week after the start of the Works, deliver to the Principal a 5 kg representative grab sample of cement to be used in the Works, taken at the source of supply, together with the details stated in Clause 6.5.1, and packaged and labelled as detailed in AS/NZS 2350.1.

7 BINDERS FOR EARTHWORKS AND GRANULAR PAVEMENT MATERIALS

7.1 GENERAL

Where a blended binder is specified, or approved by the Principal, blend all components uniformly prior to delivery. The proportions of the individual components within the nominated blended binders must not vary by more than $\pm 3\%$ from that nominated.

7.2 HYDRATED LIME

Hydrated lime must conform to Table 3211.3. Sample and test hydrated lime in conformity with this Clause and Table 3211/L.3 in Annexure 3211/L.

Table 3211.3 – Hydrated Lime Requirements

Property	Test Method	Requirement
Available lime content, calculated as calcium hydroxide	AS 4489.6.1	≥ 85.0% ⁽¹⁾
Sieve residue: % retained 300 µm sieve	AS 4489.2.1	≤ 2.0%
Moisture content before use	AS 4489.8.1	≤ 1.0%

Notes:

- ⁽¹⁾ Where the available lime content is less than 85.0% but greater than or equal to 80.0%, the hydrated lime may be accepted provided that:
- the Supplier can demonstrate with laboratory testing on at least three representative samples that the proposed hydrated lime (used at a higher application rate) produces an equal, or higher, unconfined compressive strength (UCS) as a commercially available fully conforming hydrated lime (used at the specified application rate); and
 - no additional payment will be made for any resulting increase in application rate required.

7.3 QUICKLIME

Quicklime must conform to Table 3211.4. Sample and test quicklime in conformity with this Clause and Table 3211/L.3 in Annexure 3211/L.

Table 3211.4 – Quicklime Requirements

Property	Test Method	Requirement
Available lime content, calculated as calcium oxide (CaO)	AS 4489.6.1	≥ 85.0% ⁽¹⁾
Particle size (% passing):	AS 4489.2.1	
4.75 mm AS sieve		98 – 100%
2.36 mm AS sieve		90 – 100%
Active slaking time (average of 3 determinations)	AS 4489.3.1	≤ 10 minutes
Temperature rise on slaking	AS 4489.3.1	≥ 40°C in six minutes

Notes:

- ⁽¹⁾ Where the available lime content is less than 85.0% but greater than or equal to 80.0%, the quicklime may be accepted provided that:
- the Supplier can demonstrate with laboratory testing on at least three representative samples that the proposed quicklime (used at a higher application rate) produces an equal or higher unconfined compressive strength (UCS) than a commercially available fully conforming quicklime (used at the specified application rate); and
 - no additional payment will be made for any resulting increase in application rate required.

Quicklime must not be used where slow setting binders are specified.

7.4 GROUND GRANULATED IRON BLAST-FURNACE SLAG

Ground granulated iron blast-furnace slag (GGBFS) must conform to AS 3582.2 and the following additional requirements:

- (a) The source material prior to milling must be of cementitious grade, and must have glass content greater than 85% when determined by the point count method specified in ASTM C295.
- (b) Mineral gypsum must be added during the milling process to provide appropriate setting times.
- (c) The sulphuric anhydride content of the final product, determined by testing in conformity with AS 3583.8, must not exceed 3.0%.
- (d) The fineness index of the final product, determined by testing in conformity with AS/NZS 2350.8, must be not less than 350 m²/kg.

7.5 OTHER MATERIALS

7.5.1 Fly Ash

Fly ash must be Grade 1 conforming to AS 3582.1, unless specified otherwise in the Annexures. Test results must indicate the grade of fly ash in the nominated mix design.

You may propose for the Principal's approval the use of Grade 2 fly ash conforming to AS 3582.1 for particular applications, but the Principal is not bound to accept your proposal.

7.5.2 Cements

Refer to Clause 6.1.

7.5.3 Powdered Glass

Refer to Clause 6.2.4.

7.5.4 Other Binders

Other binders which are approved under the TfNSW Technology Program or otherwise accepted by the Principal may be used.

7.6 VERIFICATION OF CONFORMITY

Unless specified otherwise in this Specification, sample the binders supplied, test, and record results in conformity with Annexure 3211/L.

For each delivery of binders for earthworks and granular pavement materials, provide accompanying test reports which are NATA endorsed verifying product conformity with Clause 7.

Each delivery must be clearly marked with:

- (i) name of the supplier;
- (ii) product name and/or number;
- (iii) product type;
- (iv) batch number and date of manufacture;

(v) source of supply.

Test reports must relate only to the source samples on which the tests were made and must not be older than three months. Provide new test reports whenever changes in source of raw material or production process occur.

8 ADDED FILLERS FOR ASPHALT

8.1 GENERAL

Each type of filler from each source must be of mineral material with a consistent composition, dry, free from lumps, organic material or other deleterious matter, and conform to AS 2150.

Store the added fillers inside silos, bins or sheds to maintain the contents in a dry state and free from contamination; and use them in the order they were delivered with the earliest delivered batches to be used first.

8.2 CEMENT WORKS FLUE DUST

Cement works flue dust (also known as “cement kiln dust”) must be obtained from a cement manufacturing plant, which is collected as residue from the cement manufacturing process.

Loss on ignition of the flue dust determined in accordance with AS 3583.3 must not exceed 6%.

Water soluble fraction of the flue dust determined in accordance with AS 1141.8 must not exceed 20%.

Determine and report the methylene blue value (MBV) in accordance with TS 02806.36 (TfNSW T659) of the portion of material passing the 0.075 mm AS sieve in accordance with AS 1141.11.

The particle size distribution for the flue dust determined in accordance with AS 1141.11.1 must conform to Table 3211.5.

Table 3211.5 - Grading Limits for Cement Works Flue Dust and Ground Limestone

AS sieve size (mm)	Percentage passing (by mass)
0.600	100
0.300	95 – 100
0.075	75 – 100

The moisture content of the flue dust determined in accordance with AS 4489.8.1 must not exceed 3%.

8.3 GROUND LIMESTONE

Ground limestone must contain more than 75% by mass of CaCO₃ (determined from an analysis of the source rock by X-ray fluorescence) and be free from clay or other materials deleterious to asphalt.

If the CaCO₃ content is less than 80%, the total organic carbon (TOC) content determined in accordance with EN 13639 must be less than 0.50% by mass.

Particle size distribution of the ground limestone determined in accordance with AS 1141.11 must conform to Table 3211.5.

The moisture content of the ground limestone determined in accordance with AS 4489.8.1 must not exceed 3%.

8.4 FLY ASH

Fly ash must be Grade 1 conforming to AS 3582.1.

The moisture content of the fly ash determined in accordance with AS 4489.8.1 must not exceed 3%.

The water soluble fraction of the fly ash determined in accordance with AS 1141.8 must not exceed 20%.

8.5 GROUND GRANULATED IRON BLAST-FURNACE SLAG (GGBFS)

Ground granulated iron blast-furnace slag (GGBFS) must conform to AS 3582.2.

The moisture content of the GGBFS determined in accordance with AS 4489.8.1 must not exceed 3%.

The Contractor must submit a certificate of compliance with AS 3582.2.

8.6 CEMENT

Cement must conform to AS 3972.

The moisture content of the cement determined in accordance with AS 4489.8.1 must not exceed 3%.

The Contractor must submit a certificate of compliance with AS 3972.

8.7 HYDRATED LIME

Hydrated lime must conform to AS 1672.1 and Table 3211.6.

Table 3211.6 – Hydrated Lime Requirements

Property	Test Method	Requirement
Available lime content, calculated as calcium hydroxide	AS 4489.6.1	≥ 80.0%
Sieve residue: % retained 300 µm sieve	AS 4489.2.1	≤ 2.0%
Moisture content before use	AS 4489.8.1	≤ 1.0%

8.8 VERIFICATION OF CONFORMITY

Sample and test fillers for asphalt materials in conformity with Clause 8 and Table 3211/L.4 of Annexure 3211/L.

9 MATERIALS REQUIREMENTS FOR SPECIFIC APPLICATIONS

In addition to the requirements stated in the preceding clauses, cementitious materials, binder, and filler materials for specific applications must comply with the requirements in the relevant Annexure, as follows:

Annexure	Associated TfNSW Specifications ⁽¹⁾	
Annexure 3211/A	TS 01733.2 (D&C B80)	Concrete Work for Bridges
Annexure 3211/B	TS 01734.2 (D&C B82)	Shotcrete Work
	TS 02170.2 (D&C R68)	Shotcrete Work Without Steel Fibres
Annexure 3211/C	TS 03270.2 (D&C R82)	Lean-mix Concrete Subbase
Annexure 3211/D	TS 03271.2 (D&C R83)	Concrete Pavement Base
Annexure 3211/E	TS 03264.2 (D&C R53)	Concrete for General Works
	TS 03269.2 (D&C R81)	No Fines Concrete Subbase
Annexure 3211/F	TS 02161.2 (D&C R50)	Stabilisation of Earthworks
	TS 03266.2 (D&C R71)	Construction of Unbound and Modified Pavement Course
	TS 03267.2 (D&C R73)	Plant Mixed Heavily Bound Pavement Course
	TS 03268.2 (D&C R75)	Insitu Pavement Stabilisation using Slow Setting Binders
	TS 03272.2 (D&C R90)	Roller Compacted Concrete Subbase
	TS 03324.2 (D&C 3221)	Roller Compacted Concrete
Annexure 3211/G	TS 03283.2 (D&C R116)	Heavy Duty Dense Graded Asphalt
	TS 03284.2 (D&C R117)	Light Duty Dense Graded Asphalt
	TS 03285.2 (D&C R118)	Crumb Rubber Asphalt
	TS 03286.2 (D&C R119)	Open Graded Asphalt
	TS 03287.2 (D&C R121)	Stone Mastic Asphalt
	TS 03288 (R123)	Thin Open Graded Asphalt Surfacing
	TS 03289.2 (D&C R126)	High Modulus Asphalt (EME2)

Note:

- ⁽¹⁾ There are no requirements additional to that stated in the preceding clauses for applications under Specifications TS 03321 (TfNSW 3201) “Concrete for Maintenance” and TS 03325.2 (TfNSW D&C 3222) “No-Fines Concrete (for Subsurface Drainage”); hence these two specifications are not listed in the table above.

ANNEXURE 3211/A – TS 01733.2 (D&C B80)**A1 CEMENTS**

Use only the following cements in the Works:

- (a) Type GP cement plus SCM(s) approved by the Principal;
- (b) Type GB cement;
- (c) Type SL cement with autoclave expansion less than 0.8% when determined in accordance with ASTM C151.

Do not use Type HE cement in the Works.

A2 SCMs

Use only the following SCMs in the Works:

- (a) Fly ash;
- (b) GGBFS;
- (c) Amorphous silica.

A3 BLENDED CEMENTS

Blended cements must contain either cement (Type GP or Type SL) and one SCM (termed “binary blended cement”) conforming to the ranges in Table 3211/A.1, or cement (Type GP or Type SL) and two SCMs (termed “ternary blended cement”) conforming to the ranges in Table 3211/A.2.

Blending of cement must be achieved either at the cement manufacturer's facilities and/or at the concrete batching plant. Blended cement containing amorphous silica may only be used under TS 01733.2 (TfNSW D&C B80) for precast concrete members.

A4 ALLOWABLE PROPORTION OF SCMs IN BATCHED CONCRETE**A4.1 Using Binary Blended Cements**

Table 3211/A.1 – Allowable Range of Single SCM in Binary Blended Cement

SCM	Minimum (% by mass)		Maximum (% by mass)
	General Applications	Special Applications ⁽¹⁾	
Fly Ash	20	25	40
GGBFS	30	50	70
Amorphous Silica	4	8	8

Notes:

- (1) Use of concrete under any of the following conditions is classified as “special application”:
 - Control of potential alkali aggregate reactions as required in TS 01733.2 (TfNSW D&C B80) Clause 2.5.
 - Exposure classifications B2, C1, and C2 in accordance with Table B80.6.
 - Additional cement requirements specified in Annexure B80/A.

A4.2 Using Ternary Blended Cements**Table 3211/A.2 – Allowable Range of SCMs in Ternary Blended Cement**

SCM I	SCM II	Combination A (% by mass)		Combination B (% by mass)	
		Maximum % SCM I ⁽¹⁾	Minimum % SCM II ⁽¹⁾	Minimum % SCM I ⁽¹⁾	Maximum % SCM II ⁽¹⁾
Exposure Classifications B2, C1					
Fly Ash	Amorphous Silica	30	4	15	7
GGBFS	Amorphous Silica	40	4	25	7
GGBFS	Fly Ash	40	15	25	30
Exposure Classification C2					
Fly Ash	Amorphous Silica	30	6	20	7
GGBFS	Amorphous Silica	50	6	30	7
GGBFS	Fly Ash	50	20	40	30

Notes:

⁽¹⁾ Combinations A and B represent the two outer limits respectively when one SCM is used in combination with another SCM.

For combinations within these outer limits, determine the respective percentages of SCM I and SCM II by linearly interpolating between these outer limits, as shown in the example in Annexure 3211/H.

ANNEXURE 3211/B – TS 01734.2 (D&C B82) AND TS 02170.2 (D&C R68)

B1 CEMENTS

Use only the following cements in the Works:

- Type GP cement plus SCM(s) approved by the Principal;
- Type GB cement;
- Type SL cement with autoclave expansion less than 0.8% when determined in accordance with ASTM C151.

Do not use Type HE cement in the Works.

B2 SCMs

Use only the following SCMs in the Works:

- Fly ash;
- GGBFS;
- Amorphous silica.

You may use other SCMs where approved by the Principal.

B3 BLENDED CEMENTS

Blended cements must contain either cement (Type GP or Type SL) and one SCM (termed “binary blended cement”) conforming to the ranges in Table 3211/B.1, or cement (Type GP or Type SL) and two SCMs (termed “ternary blended cement”) conforming to the ranges in Table 3211/B.2.

B4 ALLOWABLE PROPORTION OF SCMs IN BATCHED CONCRETE

B4.1 Using Binary Blended Cements

Table 3211/B.1 – Allowable Range of Single SCM in Binary Blended Cement for Shotcrete

SCM	Minimum (% by mass)		Maximum (% by mass)
	General Applications	Special Applications ⁽¹⁾	
Fly Ash	20	25	40
GGBFS	30	50	70
Amorphous Silica	4	8	10

Notes:

⁽¹⁾ Use of concrete under any of the following conditions is classified as “special application”:

- Control of potential alkali aggregate reactions as required in TS 01734.2 (TfNSW D&C B82) or TS 02170.2 (TfNSW D&C R68).
- Exposure Classification C.
- Additional cement requirements specified in Annexures B82/A or R68/A.

B4.2 Using Ternary Blended Cements**Table 3211/B.2 – Allowable Range of SCMs in Ternary Blended Cement for Shotcrete**

SCM I	SCM II	Combination A (% by mass)		Combination B (% by mass)	
		Maximum % SCM I ⁽¹⁾	Minimum % SCM II ⁽¹⁾	Minimum % SCM I ⁽¹⁾	Maximum % SCM II ⁽¹⁾
Exposure Classifications B2, C1					
Fly Ash	Amorphous Silica	30	4	15	7
GGBFS	Amorphous Silica	40	4	25	7
GGBFS	Fly Ash	40	15	25	30
Exposure Classifications C2					
Fly Ash	Amorphous Silica	30	6	20	8
GGBFS	Amorphous Silica	50	6	30	8
GGBFS	Fly Ash	50	20	40	30

Notes:

⁽¹⁾ Combinations A and B represent the two outer limits respectively when one SCM is used in combination with another SCM.

For combinations within these outer limits, determine the respective percentages of SCM I and SCM II by linearly interpolating between these outer limits, as shown in the example in Annexure 3211/H.

ANNEXURE 3211/C – TS 03270.2 (D&C R82)**C1 CEMENTS**

Use only the following cements in the Works:

- (a) Type SL cement;
- (b) Type SL cement plus SCM(s) approved by the Principal.

Type GP cement that is compliant with the Type SL shrinkage requirements in AS 3972 and ATIC SP43 is considered to be Type SL cement.

C2 SCMs

Use only the following SCMs in the Works:

- (a) Fly ash;
- (b) GGBFS.

C3 MINIMUM CEMENTITIOUS MATERIALS CONTENT

- (a) Minimum Type SL cement content must be 90 kg/m³.
- (b) Minimum total cementitious material content must be 250 kg/m³.

C4 BLENDED CEMENTS

Blended cements must contain either Type SL cement and one SCM (termed “binary blended cement”) conforming to the ranges in Table 3211/C.1, or Type SL cement and two SCMs (termed “ternary blended cement”) conforming to the ranges in Table 3211/C.2.

C5 ALLOWABLE PROPORTION OF SCMs IN BATCHED CONCRETE**C5.1 Using Binary Blended Cements**

Table 3211/C.1 - Range of Single SCM in Binary Blended Cement

SCM	Minimum (% by mass)	Maximum (% by mass)
Fly Ash	40	75
GGBFS	10	70

C5.2 Using Ternary Blended Cements

Table 3211/C.2 - Range of SCMs in Ternary Blended Cement

SCM I	SCM II	Combination A (% by mass)		Combination B (% by mass)	
		Maximum % SCM I	Minimum % SCM II	Minimum % SCM I	Maximum % SCM II
GGBFS	Fly Ash	50	40	10	75

Notes:

- ⁽¹⁾ Combinations A and B represent the two outer limits respectively when one SCM is used in combination with another SCM.
For combinations within these outer limits, determine the respective percentages of SCM I and SCM II by linearly interpolating between these outer limits, as shown in the example in Annexure 3211/H.

ANNEXURE 3211/D – TS 03271.2 (D&C R83)**D1 CEMENTS**

Use only the following cements in the Works:

- (a) Type SL cement;
- (b) Type SL cement plus SCM(s) approved by the Principal.

Type GP cement that is compliant with the Type SL shrinkage requirements in AS 3972 and ATIC SP43 is considered to be Type SL cement.

D2 SCMs

Use only the following SCMs in the Works:

- (a) Fly ash;
- (b) GGBFS.

D3 ALLOWABLE PROPORTION OF CEMENTITIOUS MATERIALS IN BATCHED CONCRETE

Comply with the following requirements:

(a) For workability

The minimum mass of cementitious material must be as detailed in Table 3211/D.1.

Table 3211/D.1 – Minimum Cementitious Material Content by Mix Type

Mix Type	Minimum Mass (kg/m ³)
PCP, JRCP, CRCP	300
SFCP	350

(b) For carbonation resistance

The minimum proportion of cement, SL_{min} , is determined as follows:

$$SL_{min} \geq 100 - 0.55 [FA + 0.5 \times GGBFS]$$

where:

$$SL_{min} = \text{Minimum Type SL cement (\% by mass)}$$

$$FA = \text{Mass of fly ash (kg/m}^3\text{)}$$

$$GGBFS = \text{Mass of GGBFS (kg/m}^3\text{)}$$

(c) For control of potential alkali-aggregate reactivity (AAR)

Where SCMs are used in blended cements to comply with the actions required under Table R83.4 of TS 03271.2 (TfNSW D&C R83), the limits must be as specified in Table 3211/D.2.

Table 3211/D.2 – Range of SCMs in Binary and Ternary Blended Cement

SCM	AAR Class	Limits ^(1, 2)	
		Minimum (%)	Maximum (%)
Fly Ash	Non-reactive	15 – (0.5 x <i>GGBFS</i> %)	40 – (0.5 x <i>GGBFS</i> %)
	Slowly Reactive / Reactive	20 – (0.5 x <i>GGBFS</i> %)	
GGBFS	Non-reactive	10 – (2.0 x <i>FA</i> %)	65 – (2.0 x <i>FA</i> %)
	Slowly Reactive / Reactive	40 – (2.0 x <i>FA</i> %)	

where:

FA% = Percentage of fly ash by mass of total cementitious material

GGBFS% = Percentage of GGBFS by mass of total cementitious material

Notes:

- (1) It is acceptable to use mixes without SCMs. However, where they are used, these limits apply. For example, if fly ash is used with non-reactive aggregates, proportions between 1% and 14% are not acceptable.
- (2) By mass, relative to total cementitious material.

ANNEXURE 3211/E – TS 03264.2 (D&C R53) AND TS 03269.2 (D&C R81)

E1 CEMENTS

Use only the following cements in the Works:

- (a) Type GP cement;
- (b) Type GP cement plus SCM(s) approved by the Principal;
- (c) Type GB cement.

E2 SCMs

Use only the following SCMs in the Works:

- (a) Fly ash;
- (b) GGBFS;
- (c) Amorphous silica.
- (d) Powdered glass.

E3 ALLOWABLE PROPORTION OF SCMs IN BATCHED CONCRETE

The requirements under following Clauses E3.1 and E3.2 applies only where so stated in TS 03264.2 (TfNSW D&C R53) and TS 03269.2 (TfNSW D&C R81) for particular circumstances.

E3.1 Using Binary Blended Cements

Table 3211/E.1 - Allowable Range of Single SCM in Binary Blended Cement

SCM	Minimum (% by mass)	Maximum (% by mass)
Fly Ash	25	40
GGBFS	30	70
Amorphous Silica	4	8
Powdered Glass	5	20

E3.2 Using Ternary Blended Cements

Table 3211/E.2 - Allowable Range of SCMs in Ternary Blended Cement

SCM I	SCM II	Combination A (% by mass)		Combination B (% by mass)	
		Maximum % SCM I ⁽¹⁾	Minimum % SCM II ⁽¹⁾	Minimum % SCM I ⁽¹⁾	Maximum % SCM II ⁽¹⁾
Fly Ash	Amorphous Silica	30	4	20	8
GGBFS	Amorphous Silica	50	4	10	8
GGBFS	Fly Ash	50	20	30	30
Powdered Glass	Fly Ash	20	25	5	40

Notes:

- ⁽¹⁾ Combinations A and B represent the two outer limits respectively when one SCM is used in combination with another SCM.
For combinations within these outer limits, determine the respective percentages of SCM I and SCM II by linearly interpolating between these outer limits, as shown in the example in Annexure 3211/H.

**ANNEXURE 3211/F – TS 02161.2 (D&C R50), TS 03266.2
(D&C R71), TS 03267.2 (D&C R73), TS 03268.2 (D&C R75),
TS 03272.2 (D&C R90) AND TS 03324.2 (D&C 3221)**

F1 BINDERS

Use only the following binders in the Works:

- (a) Hydrated lime;
- (b) Quicklime;
- (c) GGBFS;
- (d) Fly ash (Grade 1);
- (e) Type GP cement;
- (f) Type GB cement;
- (g) Special purpose cements: Types HE, LH, or SL;
- (h) Other blends of cements as approved by the Principal;
- (i) Powdered glass;
- (j) Other binders where approved by TfNSW Technology Program.

ANNEXURE 3211/G – TS 03283.2 (D&C R116), TS 03284.2 (D&C R117), TS 03285.2 (D&C R118), TS 03286.2 (D&C R119), TS 03287.2 (D&C R121), TS 03288 (R123) AND TS 03289.2(D&C R126)

G1 ADDED FILLERS

Use only the following added fillers in the Works:

- (a) Flue dust;
- (b) Ground limestone;
- (c) Fly ash;
- (d) Hydrated lime;
- (e) Other mineral fillers.

Where the above materials are added as fillers in asphalt, they must comply with the requirements for dry compacted voids and methylene blue value (MBV) in the applicable asphalt specification.

ANNEXURE 3211/H – INTERMEDIATE PERCENTAGES FOR TERNARY BLENDS

Refer Clauses A4.2, B4.2, C5.2, D3 (c), and E3.2.

Combinations A and B represent the two outer limits respectively when one SCM is used in combination with another SCM (designated SCM I and SCM II respectively) in a ternary blend.

For combinations within these outer limits, determine the respective percentages of SCM I and SCM II by linearly interpolating between these outer limits, as shown in the example below.

Example

Ternary blended cement is to be used for bridgeworks concrete exposure classification C2 conforming to TS 01733.2 (TfNSW D&C B80).

SCM I is GGBFS, and SCM II is Fly Ash.

From Table 3211/A.2, the respective percentages for Combinations A and B are obtained as follows:

Combination A:
Max SCM I = 50%,
Min SCM II = 20%

Combination B:
Min SCM I = 40%,
Max SCM II = 30%

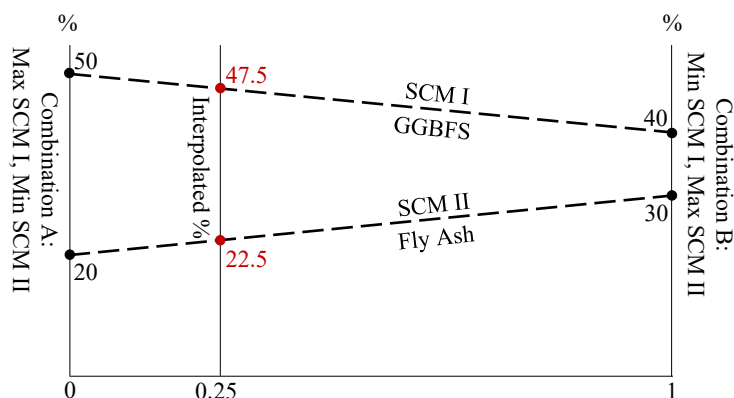


Figure 3211/H.1 - Example for Interpolation of SCMs Ranges between Combinations A and B

For a combination between Combination A and Combination B, at “quarter point” from Combination A, the respective percentages of SCM I and SCM II are determined by interpolation to be 47.5% and 22.5% as shown in Figure 3211/H.1.

ANNEXURE 3211/I – (NOT USED)

ANNEXURE 3211/L – SAMPLING AND TESTING

L1 GENERAL

Sample the material in conformity with the relevant Australian Standards.

Obtain samples of materials as individual randomly chosen samples, rather than composite samples.

The Principal may carry out surveillance of the sampling and testing, and may obtain samples at any stage and location for audit testing.

L2 FREQUENCY OF SAMPLING AND TESTING

L2.1 Cementitious Materials for Concrete

The minimum frequency of sampling and testing must be in accordance with ATIC SP43 Appendix A “Product Conformity & Conformity Assessment”, amended as shown in Table 3211/L.1, for the following materials.

- (a) General purpose and blended cements to AS 3972;
- (b) Fly ash to AS 3582.1;
- (c) GGBFS to AS 3582.2;
- (d) Amorphous silica to AS/NZS 3582.3.

Table 3211/L.1 – Modifications to ATIC SP43 Appendix A

SP43 Appendix A Clause	Modifications
A2 Conformity Assessment	Delete: Clause A2 in its entirety.
Table A1	Delete: Autoclave expansion limits given in ASTM C151; to AS/NZS 2350.17 or AS 3583.4 Add: Autoclave expansion less than 0.8%; to ASTM C151
A3.15 Blend Verification	Delete: Wording from “to \pm 3% proportions” to “... from a grab sample” Add: A blend tolerance of \pm 3% must be observed for each of the nominated cementitious materials. Each cementitious material must conform to the relevant Australian Standard. Verification of blend accuracy by chemical composition must be conducted on a weekly grab sample.
A3.16 Sampling Plan	Delete: Clause A3.16
A3.17 Type Testing (TT)	Delete: Clause A3.17

L2.2 Powdered Glass for Concrete

The minimum frequency of sampling and testing for powdered glass must be as shown in Table 3211/L.2.

Table 3211/L.2 – Minimum Frequency of Testing – Powdered Glass

Property	Test Method	Minimum Frequency
% passing 45 µm sieve	AS 2350.9	Each 500 tonnes or weekly
Loss on ignition	AS 3583.3	
Major oxides (Na ₂ O, CaO, Al ₂ O ₃ , K ₂ O, Fe ₂ O ₃ , MgO)	AS/NZ 2350.2	
Silicon oxide (SiO ₂)	AS/NZ 2350.2	
Sulphur trioxide (SO ₃)	AS/NZ 2350.2	
Sugar	AS 1141.35	
Chloride content	AS 3583.13	
Strength Index	AS 3583.6	
Lead	BS 6748	

L2.3 Binders for Granular Pavements

The minimum frequency of sampling and testing for binders for granular pavements must be as shown in Table 3211/L.3.

Table 3211/L.3 – Minimum Frequency of Testing – Binders for Granular Pavements

Property	Test Method	Minimum Frequency
Hydrated Lime		
Available lime	AS 4489.6.1	1 per 600 tonne per source of supply
Residue on sieving	AS 4489.2.1	
Moisture content	AS 4489.8.1	
Quicklime		
Available lime	AS 4489.6.1	1 per 600 tonne per source of supply
Particle size (% passing)	AS 4489.2.1	
Active slaking time	AS 4489.3.1	
Temperature rise on slaking	AS 4489.3.1	
Fly Ash		
Fineness	AS 3583.1	1 per Contract
Loss on Ignition	AS 3583.3	1 per Supplier's production day

Property	Test Method	Minimum Frequency
GGBFS		
Glass content of GGBFS	ASTM C295	1 per 600 tonne per source of supply
Sulphuric anhydride content	AS 3583.8	
Fineness index	AS 2350.9	

L2.4 Added Fillers for Asphalt

The minimum sampling and testing plan for added fillers for asphalt must be as set out in Table 3211/L.4.

Table 3211/L.4 – Added Fillers for Asphalt

Property	Test Method	Minimum Frequency
Particle size distribution (cement works flue dust and ground limestone)	AS 1141.11	One per 500 tonnes of production of each added filler type
Fineness (fly ash)	AS 3583.1	One per 500 tonnes of fly ash production
Water soluble fraction (fly ash and cement works flue dust)	AS 1141.8	One per 500 tonnes of production of each added filler type
Loss on ignition (fly ash and cement works flue dust)	AS 3583.3	
Available lime (hydrated lime)	AS 4489.6.1	One per 500 tonnes of hydrated lime production
Sieve residue (hydrated lime)	AS 4489.2.1	
Moisture content (hydrated lime, flue dust, ground limestone, cement and GGBFS)	AS 4489.8.1	

L3 RE-TESTING

In the event that a test result shows a nonconformity, establish the reason of non-conformance and re-test.

If the re-test again shows a nonconformity, suspend any further use of the material represented by the test result, until the cause(s) of the nonconformity has been identified and corrected.

Submit all test results (including any test results showing nonconformities) to the Principal.

ANNEXURE 3211/M – REFERENCED DOCUMENTS

TfNSW Specifications

TS 01572.2 (TfNSW D&C Q6)	Quality Management (Major Works)
TS 01733.2 (TfNSW D&C B80)	Concrete Work for Bridges
TS 01734.2 (TfNSW D&C B82)	Shotcrete Work
TS 02161.2 (TfNSW D&C R50)	Stabilisation of Earthworks
TS 03264.2 (TfNSW D&C R53)	Concrete for General Works
TS 02170.2 (TfNSW D&C R68)	Shotcrete Work Without Steel Fibres
TS 03266.2 (TfNSW D&C R71)	Construction of Unbound and Modified Pavement Course
TS 03267.2 (TfNSW D&C R73)	Plant Mixed Heavily Bound Pavement Course
TS 03268.2 (TfNSW D&C R75)	Insitu Pavement Stabilisation Using Slow Setting Binders
TS 03269.2 (TfNSW D&C R81)	No Fines Concrete Subbase
TS 03270.2 (TfNSW D&C R82)	Lean-Mix Concrete Subbase
TS 03271.2 (TfNSW D&C R83)	Concrete Pavement Base
TS 03272.2 (TfNSW D&C R90)	Roller Compacted Concrete Subbase
TS 03283.2 (TfNSW D&C R116)	Heavy Duty Dense Graded Asphalt
TS 03284.2 (TfNSW D&C R117)	Light Duty Dense Graded Asphalt
TS 03285.2 (TfNSW D&C R118)	Crumb Rubber Asphalt
TS 03286.2 (TfNSW D&C R119)	Open Graded Asphalt
TS 03287.2 (TfNSW D&C R121)	Stone Mastic Asphalt
TS 03288 (TfNSW R123)	Thin Open Graded Asphalt Surfacing
TS 03289.2 (TfNSW D&C R126)	High Modulus Asphalt (EME2)
TS 03324.2 (TfNSW D&C 3221)	Roller Compacted Concrete

TfNSW Test Methods

TS 02806.36 (TfNSW T659)	Methylene Blue Adsorption Value of Road Construction Material
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Australian Standards

AS 1141	Methods for sampling and testing aggregates
AS 1141.8	Method 8: Water-soluble fraction of filler
AS 1141.11	Method 11: Particle size distribution by sieving
AS 1141.17	Method 17: Voids in dry compacted filler
AS 1141.35	Method 35: Sugar
AS 2150	Hot mix asphalt - A guide to good practice
AS 2350	Methods of testing portland, blended and masonry cements
AS/NZS 2350.1	Method 1: Sampling

AS/NZS 2350.2	Method 2: Methods of testing portland blended and masonry cements – Chemical composition
AS/NZS 2350.8	Method 8: Fineness index by air permeability method
AS 2350.9	Method 9: Determination of residue on the 45 µm sieve
AS/NZS 2350.17	Method 17: Determination of soundness of masonry cement
AS 3582	Supplementary cementitious materials for use with portland and blended cement
AS 3582.1	Part 1: Fly ash
AS 3582.2	Part 2: Slag - Ground granulated iron blast-furnace
AS/NZS 3582.3	Part 3: Amorphous silica
AS 3583	Methods of test for supplementary cementitious materials for use with portland and blended cement
AS 3583.3	Method 3: Methods of test for supplementary cementitious materials for use with portland cement - Determination of loss on ignition
AS 3583.4	Method 4: Determination of autoclave expansion
AS 3583.6	Method 6: Determination of relative water requirement and strength index
AS 3583.8	Method 8: Determination of sulfuric anhydride content
AS 3583.12	Method 12: Determination of available alkali
AS 3583.13	Method 13: Determination of chloride content
AS 3972	General purpose and blended cements
AS 4489	Test methods for limes and limestones
AS 4489.2.1	Method 2.1: Fineness - Wet sieving
AS 4489.3.1	Method 3.1: Slaking - Dewar flask
AS 4489.6.1	Method 6.1: Lime index - Available lime
AS 4489.7.1	Method 7.1: Loss on ignition - Quicklime, hydrated lime and limestone
AS 4489.8.1	Method 8.1: Free moisture - Convection oven
AS/NZS ISO 9001	Quality management systems – Requirements

ASTM Standards

ASTM C151	Standard Test Method for Autoclave Expansion of Hydraulic Cement
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete

Euro Norm Standards

BS 6748	Specification for limits of metal release from ceramic ware, glassware, glass ceramic ware and vitreous enamel ware
EN 13639	Determination of Total Organic Carbon in Limestone

Australian Technical Infrastructure Committee (ATIC)

ATIC SP43	ATIC-SPEC Section SP43 Cementitious Materials for Concrete
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