WSA 160 Water Industry Standard for Calcium Aluminate Cement Mortars used for the renovation of wastewater structures and large diameter pipes

Issue: Draft for Public Comment

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The Water Services Association of Australia (WSAA) is the peak industry body representing the urban water industry. Our members provide water and sewerage services to over 24 million customers in Australia and New Zealand and many of Australia's largest industrial and commercial enterprises.

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PREFACE

This Standard was prepared by the Water Services Association of Australia (WSAA).

The objective of this Standard is to provide performance requirements for calcium aluminate cement mortars used for the renovation of non-pressure wastewater structures such as maintenance holes, wet-wells, tanks, pits, chambers, culverts, treatment plants and large diameter pipes (sized for personnel entry).

NOTE: Products complying with this Standard may also be suitable for the renovation of drainage pipes used for other applications such as stormwater. Design and installation requirements are covered by *WSA 201 Manual for Selection and Application of Protective Coatings and the Amendment covering CACs and Geopolymers.*

An online tool has been developed in order to assist the water industry in establishing in what sewer conditions a liner can be applied effectively and how long it can be expected to last. This tool, the Sewer Rehabilitation & Prioritisation Decision Platform, is available [location is TBC, fact sheet with details available here].

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FOREWORD

This Standard identifies the material and performance requirements of calcium aluminate cement (CAC) mortars, or concrete, to meet the corrosion resistance requirements of cement-based liners in the renovation of large diameter wastewater pipelines (sized for personnel entry), or structures, subjected to deterioration under various corrosion classification or service conditions. It is intended to provide manufacturers and specifiers with a means of demonstrating fitness for purpose.

This Standard differs from those applicable to conventionally installed piping systems in that it is required to verify certain characteristics of the components as manufactured as well as in the installed condition. In accordance with ISO terminology these have been identified as the “M” stage for the collective materials used to fabricate the liner and the “I” stage for the liner as installed.

The service life of products conforming to this Standard will be dependent upon the condition of the host pipe, or structure, the quality of the liner material and its application and the service conditions. The material and process selection shall therefore be in accordance with the requirements of the asset owner with respect to extending the service life of the host pipeline, or structure. Liners shall meet the compositional and material property requirements including elemental and mineralogical analysis of both the binder and aggregates. Use of supplementary and admixture materials needs to be declared. All materials are required to meet the performance requirements of this Standard.

As part of its product appraisal process, WSAA may request details of previous successful installations or require contractors to undertake trial installations. Such trial details may include:

- the type and size of structure renovated;
- service conditions, e.g. temperature, relative humidity, CO_2 and H_2S;
- the lining material and applied thickness;
- application method(s) and equipment used, e.g. trowel applied, spray;
- the cure time between the application of the liner and the restoration of the service;
- methods and equipment used to verify the quality of application;
- contractor details and date of installation; and
- where relevant, details of any subsequent rectification work applied to the renovation.

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the material and performance requirements, and test methods for in-situ calcium aluminate cement mortar spray linings for use in the renovation of non-pressure wastewater structures such as maintenance holes, wet-wells, tanks, pits, chambers, culverts, treatment plants and large diameter pipes (sized for personnel entry).

The standard is applicable to the calcium aluminate cement mortar applied as a spray lining or hand-trowelled to concrete and masonry structures in accordance with the code of practice *WSA 201 Manual for Selection and Application of Protective Coatings and the Amendment covering CACs and Geopolymers.* The principal intent of applying such a liner is to extend the service life of the structure by providing corrosion protection in sewer conditions.

An online tool has been developed in order to assist the water industry in establishing in what sewer conditions a liner can be applied effectively and how long it can be expected to last. A combination of the results from tests required in this product standard and sewer conditions are used in the model. This tool, the Sewer Rehabilitation & Prioritisation Decision Platform, is available [location is TBC, fact sheet with details available here].

1.2 CONFORMITY REQUIREMENTS

Methods for demonstrating conformity with this Standard shall be in accordance with Appendix A.

Product certification, when required, shall be undertaken in accordance with WSA TN-08.

Note: The word ‘shall’ is used in this Standard to designate a mandatory requirement. ‘Should’ indicates a recommendation.

1.3 LIMITATIONS

This standard considers CAC mortar products in relation to their corrosion resistance properties. Structural repair of wastewater assets using CAC mortar is beyond the scope of this standard.

1.4 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

AS

1012.3.1 Methods of testing concrete Determination of properties related to the consistency of concrete - Slump test.

1012.9 Determination of the compressive strength of concrete specimens.

1012.10 Determination of indirect tensile strength of concrete cylinder.

1012.13 Method for determination of drying shrinkage of concrete.

1379 Specification and supply of concrete.

1478.1 Chemical admixtures for concrete, mortar and grout – Admixtures for concrete.

1478.2 Chemical admixtures for concrete, mortar and grout – Methods for sampling and testing admixtures for concrete, mortar and grout.

2563-1996 (R2016) Wavelength dispersive X-ray fluorescence spectrometers - Determination of precision.

2758.1 Aggregates and rock for engineering purposes Concrete aggregates.

ASTM

C143 Standard Test Method for Slump of Hydraulic-Cement Concrete

E168 Standard Practices for General Techniques of Infrared Quantitative Analysis

E1131 Standard Test Method for Compositional Analysis by Thermogravimetry

E1252 Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis

ISO

20720 Microbeam analysis — Methods of specimen preparation for analysis of general powders using WDS and EDS

24418 Microbeam analysis — A Guideline for Long Period Analysis Using SEM-EDS

EN

196-1 Methods of testing cement Part 1: Determination of strength.
196-2 Method of testing cement - Part 2: Chemical analysis of cement.
14647 Calcium aluminate cement – Composition, specification and conformity criteria.

WSAA

WSA 201 Manual for Selection and Application of Protective Coatings and the

Amendment covering CACs and Geopolymers.

1.5 TERMS AND DEFINITIONS

For the purpose of this Standard, the following terms and definitions apply:

1.5.1 Admixtures

Those ingredients in concrete, or mortar, other than cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures are chemical formulations added to the concrete, or mortar, mix that affect the way the plastic or hardened mortar performs.

1.5.2 Calcium Aluminate Cement

Calcium aluminate cement (CAC) is a hydraulic binder with a high alumina content. It is a finely ground inorganic material which when mixed with water forms a paste that sets and hardens by means of hydration reactions and processes. The main component of CAC is mono-calcium aluminate (CaO.Al2O3).

1.5.3 Calcium Aluminate Cement (CAC) mortar

A mortar that uses calcium aluminate cement as the hydraulic binder. The CAC may contain aggregate calcium aluminate cement clinker or siliceous aggregates. Aggregates shall be fine (< 5 mm).
The CAC may also contain supplementary cementitious materials, e.g. pozzolans, flyash, slag, and chemical admixtures to achieve required mortar properties.

1.5.4 Cement

Hydraulic powder that reacts with water to form a solid mass.

1.5.5 Coating

A layer of any substance spread over any surface.

1.5.6 Conversion

The transformation of meta-stable to stable calcium aluminate cement hydrates accompanied by rise in the porosity and reduction in strength of the CAC.

1.5.7 Corrosion Classification

A classification system that provides a grade to an asset from 1 to 5 based on the conditions in the sewer and its impact on the expected life of the asset. See fact sheet.

1.5.8 Declared value

Limiting value of a characteristic declared in advance by the lining system supplier, which becomes a requirement for the purposes of assessment of conformity.

1.5.9 Liner

a protective layer of material formed over the substrate after installation and curing is completed.

1.5.10 Minimum thickness

The minimum thickness of the liner as nominated by the asset owner. Note: the applied thickness of CAC liners is typically greater than or equal to 25 mm.

1.5.11 Mortar

A binding agent used in construction**;** prepared by mixing cement, fine aggregate and water. Admixtures and supplementary materials may be added to improve application and performance.

1.5.12 Pipeline system

Interconnecting pipe network for the conveyance of fluids.

1.5.13 Product stages

The liner material as installed and the component materials from which it is made can be considered at two distinct stages as follows:

1.5.13.1 "M" Stage

The stage as manufactured before any site processing or mixing of the components.

1.5.13.2 "I" stage

The stage as installed. That is, the final configuration of the material after site processing and installation.

1.5.14 Reapplication

Application of CAC to a structure previously renovated with a CAC liner.

1.5.15 Renovation

Work incorporating all or part of the original fabric of the pipeline, or structure, by means of which its current performance is improved.

1.5.16 Maximum service temperature

The maximum sustained temperature at which the calcium aluminate liner system is intended to operate.

1.5.17 Simulated installation

Installation of a lining system into a simulated host structure using representative equipment and processes to provide samples for testing which are representative of the actual installation.

1.5.18 Type Testing

Testing performed to prove that a material is capable of conforming to the requirements given in the applicable standard.

1.6 SYMBOLS AND ABBREVIATED TERMS

The following abbreviations apply to this Standard:

CAC Calcium aluminate cement

SECTION 2 MATERIAL REQUIRMENTS “M” STAGE

This section specifies the requirements for the components that together make a CAC mortar.

The actual values of the properties for the materials at the “M” stage are to be stated by the supplier and used for ongoing monitoring of quality.

2.1. COLOUR

Colouration may be used to monitor the quality of the mixing of individual ingredients in the calcium aluminate cement.

2.2. PARTICLE SIZE

The supplier shall specify the maximum particle size of the product in order to ensure compatibility with the intended spray nozzle diameter.

The maximum size of aggregate shall be 5 mm.

If CAC mortar contains fibres, the fibre size shall never be greater than 70% of the nozzle diameter.

2.3. MATERIALS SPECIFICATION

The manufacturer shall:

2.3.1. Provide a qualitative description of the calcium aluminate cement mortar.

2.3.2. Provide a specification listing relevant properties including specified values and tolerances. The properties shall include those listed in Table 1. Any other properties relevant to the particular lining system shall also be specified.

2.3.3. Nominate the minimum and maximum lining thickness appropriate for the product, corrosion classification or service conditions, service life required and any relationship between pipe/structure diameter and liner thickness.

2.3.4. Specify that water for mixing conforms to AS 1379 and shall be used for preparing the product for application.

2.3.5. Provide details of any admixtures to be used. For example, glass fibres for strength or shrinkage control and accelerators to reduce the curing time.

2.3.6. Portland cement shall not be added to CAC mortar.

2.3.7. Required quality assurance to ensure successful installation.

2.4. STORAGE AND TRANSPORT

The manufacturer of the calcium aluminate cement mortar shall provide instructions regarding the storage and transport of the material and/ or components including shelf life and any storage temperature limitations or other factors, e.g. humidity.

2.5. MARKING

Marking shall be applied to the outside of the calcium aluminate cement lining containers as delivered to the installation site. Marking shall include:

- Manufacturer's name and/or trademark;
- Lining system, e.g. Calcium Aluminate Cement Mortar Spray Lining;
- Application, e.g. Wastewater;
- Date of manufacture; and
- Batch number.

2.6. PERFORMANCE REQUIREMENTS

2.6.1 REBOUND

Rebound represents material wastage during application and is important in order to determine the correct amount of material to supply for the works.

Rebound is generally given as a percentage or as a mass per area measurement:

$$Rebound\ (\%) = \frac{Mass\ rebounded\ (kg)}{Total\ mass\ applied\ (kg)}\ \%$$

or

$$Rebound\ \left(\frac{kg}{m^2}\right) = \frac{Mass\ rebounded\ (kg)}{Area\ (m^2)}$$

The procedure outlined in JGC No.8 Recommendations for Shotcreting JSCE-F 563-2005 Test Method for Rebound Percentage of Sprayed Concrete (Mortar) shall be followed.

TABLE 1 PROPERTIES OF THE INDIVIDUAL COMPONENTS OF THE CAC MORTAR (UNCURED)

Property	Test Method[a]	Conditions
Durability Requirements		
Composition of binder	Elemental/compositional analysis by XRF: • AS 2563-1996 (R2016); or • ASTM C114-18 Refer Test Method 2B.2 for Analysis of the Elemental Composition of Concrete by X-ray Fluorescence.	Refer Table 2 for acceptable compositional range. Refer to Sewer Rehabilitation & Prioritisation Decision Platform for suitability of binder composition to specific corrosivity classification.
Composition of aggregate [c]		Refer 2.2. Refer Table 3 Refer to Sewer Rehabilitation & Prioritisation Decision Platform for suitability of aggregate composition to specific corrosivity classification.
Composition of fibres	Declared value	Conform to alkali resistance as specified in ASTM D7705/D7705M Conform to chemical resistance as specified in ASTM C581 Steel fibres shall not be used.
Use of admixtures [d]	AS 1478.1 AS 1478.2	Declared value
Binder aggregate ratio (w/w)	Declared value	Refer tables 2 and 3
Acceptable moisture content in storage [b]	Declared value	<5%, or as specified by the supplier
Maximum Nominal Aggregate Size (mm)	AS 1141.11.1:2020	≤ 5 mm

Property	Test Method[a]	Conditions
Notes a. Alternate test methods, for example ISO, ASTM, EN, and DIN may be nominated by the supplier if their appropriateness can be demonstrated. b. May be used to determine if storage requirements met, or if shelf life expired. c. CAC is susceptible to the action of alkaline hydroxide. Aggregates that have components that can release free alkali shall not be used. In particular the use of granite, shale and micaceous and feldspathic aggregates in CAC shall be avoided. d. Inclusion of admixtures requires acceptance by the Water Authority and may vary on a case-by-case basis. There is currently no standard for the use of admixture in calcium aluminate cement unlike that for ordinary Portland cement (AS1478.) The effect of admixtures on calcium aluminate cement is significantly different to ordinary Portland cement. The utility shall be consulted prior to their use. If to be used, prior test to establish the compatibility and of dosage of each type of admixtures are compulsory and shall be reported to the utility prior to use.		

TABLE 2 CHEMICAL COMPOSITION OF CAC BINDER

Substance	Weight (%)
Al_2O_3	30-58
CaO	30-40
SiO_2	0-20
Fe_2O_3	0-18
MgO	0.5-3
TiO_2	<2.5
Other metal oxides	trace

TABLE 3 CHEMICAL COMPOSITION OF AGGREGATE

Substance	Requirements[a]
Al_2O_3	35% - 58%
CaO	30-40
SiO_2	1-99
Sulfide content (as S_2-)	≤ 0.10%
Chloride content	≤ 0.10%
Alkali content[b]	≤ 0.4 %
Sulfate content (as SO_3)	≤ 0.5 %
Notes: a - Requirements are given as percentage by mass of the final cement. b - Expressed as Na_2O equivalent (Na_2O + 0,658 K_2O)	

SECTION 3 MATERIAL REQUIREMENTS "I" STAGE

3.1. INSTRUCTIONS

Technical information relating to the CAC mortar and correct installation methods shall be readily available to aid the user and installer. The information may be in the form of a technical manual or equivalent document and be written in plain English and supplemented by figures and diagrams as applicable. The information provided shall satisfy the requirements of a warranty as referenced in the Plumbing Code of Australia (PCA) and those requirements of the AS/NZS 3500 series of Standards.

The information shall consider the requirements in WSA201, Manual for the Selection and Application of Protective Coatings. Where deviation from the requirements of this manual is necessary this shall be highlighted for the review and approval of the asset owner.

The information shall include details of:

3.1.1. the mixing ratio of the components by mass or volume as appropriate, including the acceptable ratio tolerance;
3.1.2. the bulk density of the combined water and concrete mix conforming to optimal and maximum water to concrete ratio including the acceptable tolerance;
3.1.3. the temperature band within which the components and blend shall be maintained;
3.1.4. curing times and whether these are thickness dependent;
3.1.5. any restrictions on the ambient conditions on site that might adversely affect the application of the lining;
3.1.6. surface preparation including whether the prepared surface need be wet or dry, including acceptable range of moisture vapour emission rate; and
3.1.7. finishing requirements, e.g. trowelling,
3.1.8. suitable substrate material,
3.1.9. repair of pipelines renovated using CAC mortar product,
3.1.10. safety data sheets,
3.1.11. work health and safety requirements.

3.2. PERFORMANCE REQUIREMENTS

The calcium aluminate cement cured in accordance with the manufacturer's written instructions, shall be tested as per Table 4.

3.2.1. Convertibility Testing

CAC shall be tested to for convertability in accordance with Test Method 2B.6 Analysis of Calcium Aluminate Cement Conversion by Thermal Gravimetric Analysis. Conversion can occur in CAC with varying degrees of severity. Conversion results in an increased porosity of the CAC, which makes it more susceptible to corrosive attack. Conversion can be affected by temperature and usually occurs over long time periods in sewer conditions.

3.2.2. Self-compaction

CAC mortar shall be self-compacting such that any voids are less than 4 mm.

Verification of self-compaction: a core sample of sample prepared in the field, i.e. not a laboratory prepared sample, shall be taken following initial curing. The sample shall be cut with a diamond saw to provide two cross sections. Cross sections shall be examined visually, and any voids measured.

Measurement equipment: micrometer, calliper, or other suitable gauge, capable of measuring to within 0.1 mm.

3.2.3. Segregation

The CAC mortar shall be tested for segregation of aggregate. Segregation is not acceptable.

Verification of segregation: 2 core samples of a field application, i.e. not a laboratory prepared sample, shall be taken following initial curing. Each sample shall be cut with a diamond saw to provide two cross sections (4 total tests surfaces). Cross sections shall be microscopically examined visually for segregation of aggregate.

TABLE 4 PROPERTIES OF THE CAC MORTAR (I STAGE)

Property	**Test Method** [a]	**Conditions**
Maximum Water to Concrete ratio (litres/20kg concrete)	Declared value	None (information required for application)
Bulk Densities of Mortar (conforming to optimal and maximum water to concrete ratio) (kg/m^3)	Declared values	None (information required for application)

Property	Test Method [a]	Conditions
Placement Tests		
Setting times (initial and final) [c, d]	ASTM C403/C 403M	The final setting shall not be less than 80 minutes and shall not be greater than 240 minutes for application in 'live sewer'.
Slump [e]	AS1012.3.5 2015 AS/NZS 2350.4:2006	0-10 mm
Rebound test	JSCE-F 563-2005 Test Method for Rebound Percentage of Sprayed Concrete (Mortar)	Refer 2.6.1 Report as per requirements of JSCE-F 563-2005
Properties of cured material		
Binder Mineral Hydrate Phases	• TGA: ASTM E1131 • FTIR: ASTM E168, ASTM E1252 • XRD	Refer Test Method 2B.5
Conversion[b]	TGA: ASTM E1131 See section 3.2.1	Refer 3.2.1 Refer Test Method 2B.6
Alkali aggregate reaction (AAR)	ASTMC 227 ASTMC 289	Pass
Acid Neutralisation capacity	European Committee's CEN/TS 14429 or CEN/TS 14997	Recorded value
Early compressive strength development (1, 7, 14, 28[b] days)	AS1012.9 2009 ASTM C39/C39-18	@1 day > 20 MPa @7 days > 45 MPa @14 days > 50 MPa @28 days > 60 MPa
Self-compaction	Refer 3.2.2	Voids < 4.0 mm
Segregation	Refer 3.2.3	Pass
Tensile strength	AS 1012.10	@28 days ≥ 2.5MPa
Flexural strength	EN 196-1	@ 1 day (24 hours) > 6 MPa

Property	Test Method [a]	Conditions
		@ 28 days > 8 MPa

Notes
a. Alternate test methods, for example ISO or ASTM, may be nominated by the supplier if their appropriateness can be demonstrated.
b. Refer to Sewer Rehabilitation & Prioritisation Decision Platform to interpret results. Available [location is TBC, fact sheet with details available here].
c. Longer final setting times could be used if the asset is off-line and in maintenance holes above the flow line.
d. If these setting times cannot be met, manufacturers shall recommend an appropriate curing accelerating curing reagent. The utility shall be consulted on the acceptability of the use of curing reagents. Test of compatibility of curing reagent to mortar and dosage shall be submitted to the utility.
e. For wet-spray application a positive displacement pump should be considered (e.g., continuous mixing rotor stator pump)
General: curing temperature shall be at typical ambient conditions: 15-30°C

4. SAMPLING

The supplier shall document the method used for acquiring samples for testing for installation quality control purposes. Unless otherwise noted, the samples may be obtained by means of one of the following methods:

(a) a simulated installation;
(b) an installation; or
(c) any other method that can be demonstrated to replicate the characteristics of an installation.

APPENDIX A - MEANS FOR DEMONSTRATING CONFORMITY WITH THIS STANDARD

(Normative)

A1 SCOPE

This Appendix sets out a means for consistent demonstration of conformity with this Standard through the use of a minimum sampling and testing frequency plan. Where variations to this plan are made, demonstration of conformance with the minimum requirements may be necessary.

A2 RELEVANCE

The long-term performance of pipeline systems is critical to the operating efficiency of water agencies in terms of operating licences and customer contracts. The long-term performance of plumbing systems is similarly critical to the durability of building infrastructure, protection of public health and safety and protection of the environment.

A3 DEFINITIONS

A3.1 Acceptable quality level (AQL)

When a continuous series of lots or batches is considered, the quality level which, for the purpose of sampling inspection, is the limit of a satisfactory process average (see AS 1199.1).

NOTE: The designation of an AQL does not imply that a manufacturer has the right knowingly to supply any non-conforming unit of product.

A3.2 Material or compound batch

A clearly identifiable quantity of a particular material or compound.

A3.3 Production batch

A clearly identifiable collection of units, manufactured consecutively or continuously under the same conditions, using material or compound to the same specification.

A3.4 Lot

A clearly identifiable subdivision of a batch for inspection purposes.

A3.5 Sample

One or more units of product drawn from a batch or lot, selected at random without regard to quality.
NOTE: The number of units of product in the sample is the sample size.

A3.6 Sampling plan

A specific plan, indicating the number of units of components or assemblies to be inspected or tested.

A3.7 Process verification test (PVT)

A test performed by the manufacturer on materials, components, joints or assemblies at specific intervals to confirm that the process continues to be capable of producing components conforming to the requirements of the relevant Standard.
NOTE: Such tests are not required to release batches of components and are carried out as a measure of process control.

A3.8 Batch release test (BRT)

A test performed by the manufacturer on a batch of components, which has to be satisfactorily completed before the batch can be released.

A3.9 Type testing (TT)

Testing performed to prove that the material, component, joint or assembly is capable of conforming to the requirements of the relevant Standard.

A4 MINIMUM SAMPLING AND TESTING FREQUENCY PLAN

A4.1 General

Table A1 sets out the minimum sampling and testing frequency plan for a manufacturer to demonstrate compliance to this Standard. Where variations to this plan are made, demonstration of conformance with the minimum requirements may be necessary.

A4.2 Testing

Testing shall be conducted by a testing laboratory or facility that fulfils the requirements of AS ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories.

NOTE: AS ISO/IEC 17025 can apply to first-party, i.e. manufacturer or supplier, second-party or third-party testing laboratories and facilities.

A4.3 Retesting

In the event of a test failure, the products manufactured since the previous test(s) conforming to the requirements outlined in Table ZA1 shall be quarantined as a batch. A further set of samples shall be selected randomly from the quarantined batch using a sampling plan to AS 1199.1. If the retest requirements are met, the batch may be released and compliance with this

Standard for the quarantined batch may be claimed.

Should a failure on retesting occur, then the quarantined batch shall be rejected and claims and/or marking indicating conformity to this Standard shall be suspended until the cause of the failure has been identified and corrected.

A4.4 Rejection after retest

In the event of a quarantined batch being rejected after retesting, it may be subjected to 100% testing for the failed requirement(s), and only those items found to comply may be claimed and/or marked as conforming with this standard.

TABLE A1
MINIMUM SAMPLING AND TESTING FREQUENCY PLAN

Characteristics	Clause	Requirement	Test method	Frequency
GENERAL PROPERTIES OF CAC MORTAR				
Colour	2.1	Details needed if used for quality control.	Declared value	At any change in material formulation, design or process
Particle size - aggregates	2.2 Table 1	≤ 5mm	AS 1141.11.1	
Particle size – fibres	2.2	≤ 70% of nozzle diameter	Declared value	
Nozzle size	2.2	Specify nozzle diameter in mm compatible with product	Declared value	
Min./max. lining thickness	2.3.3	Declared values	Declared value	
Admixtures	2.3.5	Declared values	Declared values	
Storage conditions	2.4	Declared value	Declared value	
MATERIAL PROPERTIES OF CAC MORTAR COMPONENT MATERIALS AT "M" STAGE (UNCOMBINED, UNCURED)				
Composition of binder	Table 1	Refer Table 2	Elemental/compositional analysis by XRF: • AS 2563-1996 (R2016); or • ASTM C114-18 Refer Test Method 2B.2	At any change in material formulation, design or process
Composition of aggregate	Table 1	Refer Table 3		
Composition of fibres	Table 1	Conform to alkali resistance as specified in ASTM D7705/D7705M Conform to chemical resistance as specified in ASTM C581 Steel fibres shall not be used.	Declared value	
Use of admixtures	Table 1	Declared value	AS 1478.1 AS 1478.2	
Binder aggregate ratio (w/w)	Table 1	Refer Tables 2 and 3	Declared value	
Acceptable moisture content in storage	Table 1	<5%, or as specified by the	Declared value	

Characteristics	Clause	Requirement	Test method	Frequency
		supplier		
MATERIAL PROPERTIES OF CAC MORTAR (COMBINED, UNCURED)				
Maximum Water to Concrete ratio (litres/20kg concrete)	Table 1 3.1.1	Declared value	Declared value	At any change in material formulation, design or process
Bulk Densities of Mortar (kg/m^3)	Table 1 3.1.2	Declared value	Declared value	
Setting times (initial and final)	Table 1	For applications on assets with a tidal zone: 80-240 minutes.	ASTM C403/C 403M	
Slump test	Table 1	0-10mm	AS1012.3.5 2015 AS/NZS 2350.4:2006	
Rebound	2.6.1 Table 1	Declared value	JSCE-F 563-2005 Test Method for Rebound Percentage of Sprayed Concrete (Mortar)	
Temperature range of mixed components	3.1.3	Declared value	Declared value	
Curing time	3.1.4	Declared value. May be thickness dependent.	Declared value	
Ambient conditions	3.1.5	Declared value	NA	
Surface preparation requirements	3.1.6	Supplier specified, WSA 201	NA	
Acceptable range of moisture vapour emission rate	3.1.6	Supplier specified	WSA201	
Finishing requirements	3.1.7	Declared value	NA	
MATERIAL PROPERTIES OF CAC MORTAR AT "I" STAGE (COMBINED, INSTALLED, CURED)				
Binder Mineral Hydrate Phases	Table 4	Refer Test Method 2B.5	• TGA: ASTM E1131 • FTIR: ASTM E168, ASTM E1252 • XRD	At any change in material formulation, design or process
Conversion	3.2.1 Table 4	Refer 3.2.1 Refer Test Method 2B.6	TGA: ASTM E1131	
Alkali aggregate reaction (AAR)	Table 4	Pass	ASTMC 227 ASTMC 289	
Acid Neutralisation capacity	Table 4	Recorded value	European Committee's CEN/TS 14429 or CEN/TS 14997	
Early compressive strength development (1, 7, 14, 28^d days)	Table 4	@1 day > 20 MPa @7 days > 45 MPa @14 days > 50 MPa @28 days > 60 MPa	AS1012.9 2009 ASTM C39/C39-18	
Self-compaction	Refer 3.2.2 Table 4	Voids < 4.0 mm	Refer 3.2.2	
Segregation	Table 4	Pass	Refer 3.2.3	
Tensile strength	Table 4	@28 days ≥ 2.5MPa	AS 1012.10	
Flexural strength	Table 4	@ 1 day (24 hours) > 6 MPa @ 28 days > 8 MPa	EN 196-1	

APPENDIX B - TEST METHODS ASSOCIATED WITH THIS STANDARD

Test Method 2B.2 Analysis of the Elemental Composition of Concrete by X-ray Fluorescence

Test Method 2B.5 Analysis of Calcium Aluminate Cement Hydrates by Thermal Gravimetric Analysis

Test Method 2B.6 Analysis of Calcium Aluminate Cement Conversion by Thermal Gravimetric Analysis

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