

SS 208 Rehabilitation and Corrosion Protection of Sewers using Calcium Aluminate Cement Mortar

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1. General

1.1 Intent

To set the requirements for the application of Calcium Aluminate Cement (CAC) mortar coating for corrosion protection of concrete and masonry sewers.

1.2 Scope

The work covered by this document entail supply, application, curing and testing of approved CAC product on sewer assets, to form a coating of specified quality. The work shall be carried out in the following steps:

- Pre-construction inspection and trial
- Surface cleaning and preparation
- Surface restoration and application of protective coating
- Assessment of in-situ performance

1.3 Roles and Responsibilities

Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Applicator (Contractor). Where a submission, request or proposal is required and it is not stated who the recipient shall be, it is to be provided by the Applicator to Sydney Water (Principal) for approval.

The use of this document does not relieve Supplier (of material) and Applicator of any responsibility for delivering the quality level of design, materials, workmanship, and performance, that they have been engaged to provide.

1.4 Definitions

Terms	Definitions
Admixtures	Those ingredients in concrete 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 mix that affect the way the plastic or hardened concrete performs.
Cement	Hydraulic powder that reacts with water to form a solid mass.
Calcium Aluminate Cement (CAC)	Calcium aluminate cement (CAC) is a hydraulic binder. It is a finely grounded 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.Al ₂ O ₃). It contains small grains of calcium aluminate clinker.
Coating	A layer of any substance spread over any surface.
Mortar	Mortar is a binding agent used in construction; prepared by mixing cement, fine aggregate and water. Admixtures may be added to it

1.5 References

Document Number	Title
AS 1012.5	Determination of mass per unit volume of freshly mixed concrete
AS 1012.9	Determination of the compressive strength of concrete specimens

Document Number	Title
AS 1012.10	Determination of indirect tensile strength of concrete cylinder
AS 1012.13	Method for determination of drying shrinkage of concrete
AS 1379	Specification and supply of concrete
AS 1580.408.5	Paints and related materials - Methods of test - Adhesion - Pull-off test
AS 1627.2	Metal finishing - Preparation and pre-treatment of surfaces – Part 2: Power tool cleaning
AS 2350.11	Methods of testing Portland, blended and masonry cements - Compressive strength
AS 3799	Admixtures
AS 3735	Concrete structures retaining liquids
EN 14647	Calcium aluminate cement – Composition, specification and conformity criteria
EN 196 – 2	Method of testing cement – Part 2: Chemical analysis of cement

2. Product

Materials and equipment used for this work shall be in accordance with the requirements specified herein along with the Supplier’s recommendations. If there is a disagreement between those, a direction from Sydney Water shall be sought.

Various products used for this application shall be fully compatible with each other to form a composite protective coating system.

The following subsections provide the requirements of the products referred to in this specification and the products that have been approved by Sydney Water. The CAC mortar used for protective coating shall be a proprietary pre-mixed product specially designed to withstand corrosive sewer environment. It shall use aluminate clinkers as the aggregates.

Other products of equivalent properties may be used subject to prior approval from Sydney Water.

2.1 Material requirements

2.1.1 Composition of Calcium Aluminate Cement (CAC)

The chemical composition of the CAC in the mortar shall comply with the following table.

Substances	% (weight)
Al ₂ O ₃	39-47
CaO	35-40
SiO ₂	2-7
Fe ₂ O ₃	9-17
Polymer additives	≤ 0.5
Others	≤ 5

2.1.2 Performance

The material shall have the following physical properties.

Parameters	Value
Compressive strength (MPa)	@6 hour >18
	@24 hour > 40
	@28 day ≥ 50
Flexural strength (MPa)	@24 hour > 6
	@28 day ≥ 8
Tensile strength (MPa)	@28 day ≥ 2.5
Drying shrinkage (microstrain)	@56 day ≤ 600

2.1.3 Handling and Storage

All materials shall be brought to the site in their original, unopened containers with the Supplier's label, batch number, application instruction and expiry date. The materials shall be stored under conditions that will not lead to deterioration.

The material batch numbers used for the works shall be recorded and provided to Sydney Water upon request.

2.1.4 Aggregate and Water

Calcium aluminate cement clinker shall be used as aggregate. This should be pre-mixed in the bags during CAC manufacturing process.

The maximum aggregates size shall be 4 mm. For repointing and coating of masonry structures, the maximum aggregates size shall be 2.5mm.

Water used in mixing shall be potable quality water conforming to AS 1379.

2.1.5 Admixtures

Glass fibres may be used for strength and shrinkage control. Accelerators may be used for curing sections that are exposed to early sewer flows, subject to prior approval from Sydney Water. Portland based cement (calcium hydroxide) shall not be mixed with the CAC for rapid setting or for any other purpose.

If admixtures are to be used, the Applicator shall provide reason for its use and the manufacturer's approval. Preliminary tests will be necessary to demonstrate that the intended results are achieved with a specific admixture.

No admixture will be allowed unless recommended by the Supplier.

3. Execution

The Applicator shall develop methods to successfully execute the CAC mortar coating works in accordance with the requirements of this document.

Equipment used for application of the CAC coating shall have prior approval of the supplier as suitable for the purpose.

As the work is typically carried out in man-entry, confined, sewer environments, the Applicator shall make themselves fully familiar with the work environment and safety requirements before commencing work. The Applicator shall develop their work methods in accordance with the safety requirements.

Execution shall be carried out in a number of steps. Surface preparation prior to the application of CAC is essential. The preparation entails cleaning of the surface that is due to receive the CAC coating and then if and where necessary, restoration of the surfaces. Steps include:

- A pre-construction inspection and trial
- Surface cleaning
- Surface restoration
- Application of CAC mortar coating

3.1 Submissions

The Applicator, with assistance from the Supplier, shall submit the information regarding the CAC product proposed for use, prior to commencing any work or trial, to demonstrate its conformance to the clauses in this section and promote its safe use. The data shall include Technical Data Sheet (TDS), associated test certificates, and Safety Data Sheet (SDS).

Information pertaining to the application of the product shall include training needs and experience / accreditation required to carry out work at site.

The Applicator shall also provide specifications for the equipment required for the application.

3.2 Pre-Construction Inspection and Trial

The work site shall be inspected prior to any work commencing.

A minimum of one trial of CAC application shall be undertaken at the start of the work. The location and extent of the trial shall be selected in consultation with Sydney Water, to reflect the actual work condition. The trial shall include proposed methods of surface cleaning, surface restoration, and coating application. On completion of the trial, the tests specified herein shall be undertaken and the results shall be submitted.

If it becomes apparent during the trial that adjustments are required to the proposed materials, equipment or work methods, the adjustments shall be submitted for approval.

The trial area shall be a part of the overall work. Any unsatisfactory trial must be removed and/or repaired at no additional cost to Sydney Water.

The Applicator shall prepare and submit to Sydney Water a report detailing the findings and the results of the pre-construction inspection and trial application prior to commencing the full work.

3.3 Surface Cleaning

The surface condition of the structure shall be verified prior to commencing surface cleaning / preparation work. Variations in surface geometry due to corrosion or otherwise shall be factored into the tolerance of construction.

Surface cleaning comprises all works prior to surface restoration and application of protective coating. It may include concrete cleaning and breakout, abrasive blast cleaning, and exposed steel reinforcement cleaning. The main aim of surface cleaning is removing any corroded and foreign materials and subsequently creating sound clean substrates.

The selection of the cleaning method shall be the Applicators responsibility. The method should be so chosen that it:

- Does not have detrimental impact on the structural adequacy
- Maintains the bond between reinforcement and remaining sound concrete
- Avoids the removal of good substrate and/or good mortar joints

3.3.1 Cleaning and Breakout

Horizontal and vertical limits of the repair area shall be marked prior to cleaning using saw cut with a minimum depth of 25 mm and taper length of 75 mm.

Cleaning of the deteriorated concrete surface shall be carried out by high-pressure water cleaning with a minimum pressure of 30 MPa to remove surface contaminants and concrete softened by acid attack. The water pressure shall be carefully chosen so that it does not remove good concrete.

Deteriorated concrete surfaces and mortar joints in masonry shall be broken out and removed so that only sound substrate, with pH 8.5 or greater, remains.

All foreign materials such as oils, grease, existing coating, waxes, form release agents, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.

Where there is a potential of excessive removal of substrate material during the cleaning process, a direction from Sydney Water shall be sought.

The surface preparation method or combination of methods shall be selected taking into account the deteriorated condition of the structure. On completion of the cleaning, the testing specified herein shall be undertaken and the results shall be submitted.

The cleaned surface including exposed steel reinforcement shall be visually inspected for surface cleanliness, soundness, and profile.

Surface pH readings of the 'freshly broken' cleaned concrete surface shall be undertaken, one in every 100 m² of area, using phenolphthalein solution spray (pH 8.5 or more will turn purple in colour). Where the broken cleaned surface has been exposed to air for a few hours or longer, the surface should be scored prior to spraying the solution. Non-conforming areas shall be further cleaned and broken out.

3.3.2 Exposed Steel Reinforcement Cleaning

Any exposed steel reinforcement shall be cleaned using power tool to AS 1627.2, Class St3 or PSt3.

Upon cleaning reinforcements shall be coated with a corrosion resistant, zinc rich, coating within 4 hours of cleaning to avoid flash rusting.

3.4 Surface Restoration

Surface restoration comprises all work following surface cleaning and prior to the application of protective coating. It may include patch repair, crack repair, joint repair, and infiltration repair. The restoration can be carried out using lime or Portland based cement. No CAC coating shall be applied over those restorations until the cement has cured.

Any reinforcement repairs shall be undertaken prior to surface restoration.

3.4.1 Patch Repair

Patch repair using a compatible repair mortar shall be undertaken for areas with deep voids, partially or fully exposed steel reinforcement following surface cleaning. The reinforcement shall be fully re-embedded without any air pocket being entrapped.

Where steel reinforcement is only partially exposed and there are no voids behind the reinforcement, protective coating may be applied directly following appropriate cleaning and priming with an appropriate zinc rich primer.

A minimum cover of 20 mm over the reinforcement shall be achieved. The surface shall be struck flush with the cleaned concrete adjacent to the void and the surface profile shall be made to achieve optimum bond with the protective coating.

3.4.2 Crack Repair

Non-active cracks within the host concrete surface greater than 0.3 mm in width shall be repaired. The path along the crack shall be chased forming a wedge shape slot of 20 mm wide x 20 mm deep. The slot shall then be hand filled with mortar. The surface shall be struck flush with the cleaned concrete adjacent to the crack.

Any infiltration at the crack shall be stopped prior to undertaking crack repair. Any active crack shall be repaired using a joint repair method below.

3.4.3 Internal Joint Repair

The purpose of joint repair is to maintain the continuity of protective coating, to stop infiltration and/or exfiltration, and to stop odour escaping.

All existing internal joints shall be rehabilitated. They do not include construction joints where surfaces of abutting concrete pour have been poured directly against each other to form a continuous coating.

Existing joint materials shall be removed to an adequate depth so that there is a minimum of 5 mm air gap between the existing and new joint systems. The sealing strip across the joint shall be joined to provide a continuous watertight strip along its entire length. The repair shall extend to the full width of roof and walls.

Protective cover plates shall be provided. They shall be made from non-corrosive materials that are proven to have adequate strength to sustain impact and abrasion from floating debris and vigorous washing. Any fixing left in the wall following removal of previous cover plates shall be cut back 25 mm below the cleaned concrete surface and zinc primed the cut end prior to resurfacing.

Sydney Water shall be allowed to inspect the new joint system following installation of the sealing strip but prior to installation of the cover plates.

3.4.4 Infiltration Repair

An approved hydraulic cement product shall be used to stop active minor leaks.

For major leaks, a chemical grout sealant as approved may be used. It shall be injected into the joints, cracks, or drilled holes. Any drilled hole shall be patched upon completion of the sealing operation.

Some leaks may require weep holes to localise infiltration.

3.4.5 Masonry Structure

Loose and protruding brick shall be removed using hammer and chisel. Voids caused by the removal of brick shall be reconstructed using sound clean bricks and suitable mortar. Care must be taken to ensure the integrity of the structure during this process. Lost mortar joints may be re-pointed with the protective coating specified herein, provided it can fill a minimum depth of 20 mm (from the brick surface) of the lost mortar joint or ensure bonding with the existing sound mortar.

Any infiltration shall be stopped prior to undertaking the repair using the method specified herein.

3.5 Application of CAC Coating

3.5.1 Mixing and Application

Only CAC mortar product(s) approved by Sydney Water shall be used. The material shall be applied strictly in accordance with the Supplier's written recommendations.

The mortar shall be prepared using potable quality water. The water-cement ratio shall be restricted to less than or equal to 0.4 (corresponding to an effective w/c of 0.33 to 0.36).

For hand application, due consideration shall be given to the ambient temperature, heat of hydration, setting time, distance of placement from the point of mortar mixing so that the mortar remains workable during application.

Contact or contamination with any other type of cement shall be avoided. Residue of any such material in the equipment or on tools shall be cleaned before use. Lime or Portland cement shall never be mixed with CAC.

The surface prior to coating application shall be clean and sound. Any crack, leak, defective joint, deteriorated inlet or outlet, or exposed reinforcement shall be repaired. The surface preparation method shall be in accordance with requirements detailed in the previous sections.

The prepared concrete substrate shall be saturated with clean water just prior to the application. However, the water shall not be so excessive as to affect the water/cement ratio at the interface.

Heat of hydration shall be controlled to avoid adverse effects on the mortar setting. Use of cool water in the preparation of the mortar or multiple layer application will be permitted.

During application, accumulation of excess material in the surrounding area shall be prevented if necessary, by covering such areas and removing material after work.

The product shall be cured properly according to the manufacturer/supplier's recommendation before returning to active flow. If a subsequent layer of coating is required, after the previous coating has been exposed to the flow, then it shall be cleaned using high-pressure water and roughened to create optimum surface for bonding.

The applied product shall be defect free.

3.5.2 Coating Thickness

The minimum thickness of the CAC coating application for a service life of 50 years, over and above any surface restoration or filling surface irregularities, shall be calculated using the following formula.

$$T = 0.3835[H_2S] + 32$$

where T = CAC coating thickness (mm) [rounded to the nearest 5 mm]

$[H_2S]$ = average concentration of gaseous H_2S in the sewer atmosphere (ppm)

Sydney Water shall advise the methodology to determine the average concentration of gaseous H_2S in the sewer atmosphere where the works are to be undertaken.

3.5.3 Finish

The product shall be applied filling any surface irregularities to form a smooth, uniform, and monolithic protective coating. The bench, invert, and transitions to the pipes shall be smooth and sloped in the direction of the flow. Any horizontal flat surface area, which may be used for stepping, shall be made slip resistance.

Spray or trowel application of the CAC coating walls and ceiling are acceptable. Compaction of the mortar shall be ensured. Light trowel finish is required when spraying the product to achieve a surface profile of 2 mm or less. Gradual deviations from vertical or horizontal alignment of the finished coated surface shall not exceed 10mm when measured against a 1m straight edge.

The surface of any areas found to have exceeded the limit shall be mechanically rubbed or ground, or additional coating shall be placed to achieve the required finish.

3.6 Quality Control

3.6.1 Supplier Supervision

A representative from the Supplier shall witness the application of the product during the trial period and other times deemed required/critical. The representative shall provide technical support relating to the product when required. The representative shall ensure and be satisfied that the product has been applied in accordance with the Supplier's specification.

3.6.2 Approved Applicators

The application of CAC product shall only be carried out by an Applicator who is approved by the Supplier. Upon request, Sydney Water shall be provided with an up-to-date work record detailing the time, location, names of product, equipment, method, and applicator(s) of the product application. This record shall be cross-checked for compliance with the Applicator data information submitted prior to commencement of the work.

3.7 Defects

The finished coating shall be free of all defects, which affect the hydraulic performance, structural adequacy or ongoing requirements for operation and maintenance of the sewer.

This shall include defects arising from substandard materials, inadequate surface preparation, poor placement, workmanship, or inadequate curing of the mortar. Any defective work will be unacceptable. The only exception is inherent defect(s), as defined by the Applicator and agreed by Sydney Water.

Defects, which are considered unacceptable in all coatings, include, but are not limited to the following:

- Inadequate compressive and bond strength
- Inadequate coating thickness
- Excessive variation in surface profile (max 5mm height variation in 100mm long section)
- Cracks, pinholes
- Leakage through the coating
- Uneven surface, poor joints and coating terminations, poor general finish
- Inadequate cover to reinforcement
- Surface bulges, delamination
- Surface softening

Any area found to be defective shall be assessed further. More tests may be required to determine the extent of the defect(s). The Applicator may be instructed to remove and repair defective work at no cost to Sydney Water.

3.8 Inspection and Testing

The various tests and acceptance criteria are as stated below. The work will be deemed to have failed if the test(s) does not meet the acceptance criterion. An example of inspection and testing plan is provided in Appendix 1.

3.8.1 Chemical composition and physical performance

The chemical composition and physical characteristics of each manufactured CAC batch shall be tested by the Supplier and comply with the requirements in Clauses 2.1.1 and 2.1.2. Non-complying batch shall be not be used for the works.

3.8.2 Compressive Strength

For each batch or each day of work, the Applicator shall prepare and send a cast sample of the applied material for compressive strength testing. The testing shall be in accordance with AS1012.9 or equivalent and undertaken by a NATA accredited material testing facility.

Any area found to have less than the specified compressive strength shall be assessed further. More tests may be required to determine the extent of defects. The Applicator may be instructed to remove and repair these areas at no cost to Sydney Water.

Subject to consistent results and approval from Sydney Water, the above method may be substituted with non-destructive test methods using Schmidt hammer.

3.8.3 Thickness of Coating Material

The Applicator shall measure the thickness of applied repair and/or coating material at any location selected by Sydney Water using core samples or a non-destructive method approved by Sydney Water. Unless specified otherwise by Sydney Water, the sampling rate shall be one for every 100 m² repair area. Subject to the approval from Sydney Water, the sampling rate may be reduced following consistent pass results.

Any area found to be thinner than the specified minimum thickness shall have additional material applied, in accordance with this specification, to make up to the required thickness. The Applicator may be instructed to take more cores at no cost to Sydney Water to establish that the coating thickness conforms to the drawings and specification.

In addition to the above testing, it is a good practice to continually check the thickness of the coating during application. This can be done by using a small calibrated stick/rod.

3.8.4 Bond Strength

Bond strength of the applied resurfacing/coating material shall be tested using core samples or dollies (50 mm in diameter). Sydney Water will nominate sampling locations.

The testing shall be in accordance with AS 1580.408.5 or equivalent. It shall be undertaken by a NATA accredited material testing facility or an independent inspector approved by Sydney Water. All core locations shall be repatched with the coating system in accordance with this specification.

Any area found to have bond strength less than the followings shall be deemed defective.

- For concrete substrate 2.0 MPa
- For brick masonry substrate 1.0 MPa

More tests might be required to determine the extent of deficient bonded areas. The poorly bonded area shall be removed and repaired at no cost to Sydney Water.

The sampling rate shall be one for every 100m². Subject to the approval from Sydney Water, the sampling rate may be reduced following consistent pass results.

3.8.5 Drumminess

The applied coating including patch repair or resurfacing material used in surface preparation shall be inspected for delamination (drumminess) using light hammer. Area found to be drummy shall be tested for bond strength in accordance with Clause 3.8.4.

Document ownership and change history

Ownership

Role	Title
Group	Urban Design and Engineering
Owner	Steve Keevil-Jones, UD&E Manager
Author	Jerry Sunarho, Senior Engineer

Revision log

Version No.	Prepared by	Date	Approved by	Issue date
1	Jerry Sunarho Sudipta Basu	17/01/2011	Jansen Chan	16/01/2011
2	Jerry Sunarho Robert Loncar	31/01/2020	Steve Keevil-Jones	19/03/2020

Detailed changes

Version No.	Clause	Description of revision
1		First issue
2	General	New document template and minor editorial changes
	2.1.4	Maximum aggregate size for repointing and coating masonry structures
	3.1	A new clause. Previously part of Clause 2.1.
	3.3.1	Minimum pressure for cleaning deteriorated concrete
	3.3.2	Deletion of abrasive blast cleaning from the previous version.
	3.5.2	Addition of a formula to calculate CAC coating thickness
	3.5.3	Trowel finish is required for spray application
	3.7	Removal of inherent defects and simplified list of defects
	3.8.1, 2, 4	Removal of statistical acceptable testing results

Appendices

Attachment	Title
1	Inspection and Test Plan for CAC application

Appendix 1

Inspection and Test Plan

Construction phase		Inspection and test	Applicator	Supplier	Sydney Water
1	Prior to commencement of work	Submission of applicator and product data, including batch material testing	X	X	H
2	Approved materials on site and delivered	Visual inspection Record product details	X	W	S
3	Pre-construction inspection	Inspect and verify surface profile, joints, and dimensions Report findings including any discrepancy from drawings	X	W	H
4	Trial	Undertake all testing specified for each work activity Report findings including any modifications to the proposed methods	X	X	H
5	Surface cleaning	Visual inspection (soundness, cleanliness, surface profile) pH level measurement	X	W	S
6	Surface restoration	Visual inspection (surface profile, crack, delamination, infiltration, joint repair) Compressive strength testing Repair mortar thickness verification including cover to reinforcement Bond strength testing	X	W	S
7	Protective coating application	Visual inspection (surface profile, crack, delamination, pinholes) Thickness verification Bond strength testing	X	W	S
8	Completion of protective coating application	Submission of warranty certificate and all completed testing results	X	X	H

X = Responsible for

W = Option given to inspect

H = Mandatory hold point

S = Surveillance