Steel Mains
SOLUTIONS FOR LIFE

# CEMENT MORTAR LINING

# An Introduction to
# Cement Mortar Lining

## General

Cement mortars are worldwide the most commonly used corrosion protection linings for steel pipes transporting potable water and wastewater. The Australian water industry requires pipelines to have a service life in excess of 100 years. This can be attained by selecting cement mortar lining as the pipeline corrosion protection system - an option that completely provides quality assurance while complying with the manufacturing and industry standards in today's market.

The mechanical properties of cement mortar lining (CML) protects the steel substrate by providing a physical separation barrier with very low water permeability. The lining delivers a secure corrosion protection for the internal pipe through the chemical process of passivation of the steel surface by the formation of a stable iron hydroxide film. The mortar provides internal pipe protection due to the highly alkaline environment produced by the hydration of Portland cement.

CML enjoys a proven track record of providing durability and has exceptional tolerance to varying water conditions, making it the most reliable corrosion protection material. The lining offers a service life in excess of 150 years and provides economical advantages in pipe installation and pipe lifespan. The long service life of CML is attributed to its proven record of strength, excellent hydraulic flow efficiency and the ability to create a barrier to aggressive ions, providing corrosion protection. As a result, CML is regarded as the acceptable standard lining for potable water pipes in the water industry.

## History

Cement mortar has been used to internally protect pipe since the 1840's when it was introduced in France and the USA. The techniques for application took some time to develop and it was not until the 1920's that the process of centrifugal spinning came into being.

This process allowed the rapid application of linings to the entire pipe surface by placing a mixture of sand, cement and water into the pipe and rotating it at high speed.

Spun Cement mortar lining, originally named after its inventor, was known for many years as the "Humes process". Humes Limited was a forebearer parent company to the present Steel Mains Pty Ltd.

# Manufacturing Process

## Lining Process

Post 1920s, the process of cement-mortar lining was further developed with new advancements and the process of centrifugal spinning was perfected. By placing a mixture of sand, cement and water into the pipe and rotating it at extreme speeds, the rapid application of linings for the complete pipe surface is provisioned.

Cement mortars are typically mixed with a cement/sand ratio of 2 to 1. They are mixed with water to form a slurry that is delivered to the rotating pipe in closely controlled quantities. Once the slurry is delivered, the pipe's rotation is accelerated to rotational speeds of as much as 1200rpm and radial accelerations of as much as 200 G.

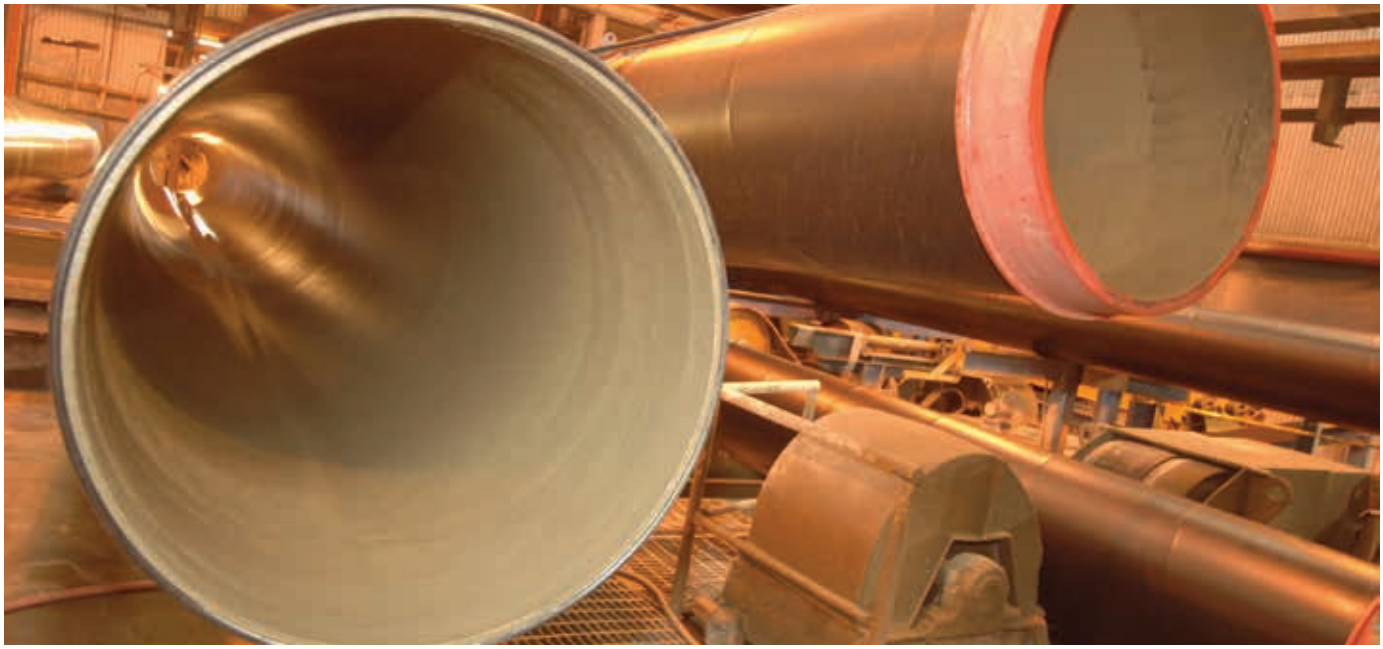
The centrifugal forces distribute the lining around the pipe circumference and compact it against the pipe wall. This rapidly consolidates the mortar driving off excess water and leaving a uniformly dense smooth compacted lining, with a very low water to cement ratio. Together with the low void content, this results in a strong and low permeability cement mortar lining. Note, these linings perform much better than cast concrete, due to the high cement content, low void content, and low water content of cement mortar.

Tight dimensional control is achieved through accurate batching, controlled delivery, rotation and high compaction. Required thicknesses can thus be achieved and fitness for purpose is assured.

The lining is cured for a minimum of four days before the pipe is transported for installation. The dense lining produced offers good chemical resistance to potable water, saline and wastewater applications.

| Pipe OD mm | CML mm | Tolerance ± mm |
|---|---|---|
| ≤ 273 (DN 250) | 9 | 3 |
| > 273 ≤ 762 (DN 750) | 12 | 4 |
| > 762 ≤1219 (DN 1200) | 16 | 4 |
| > 1219 | 19 | 4 |

Cement Mortar Lining (CML) Thickness to Australian Standard AS 1281



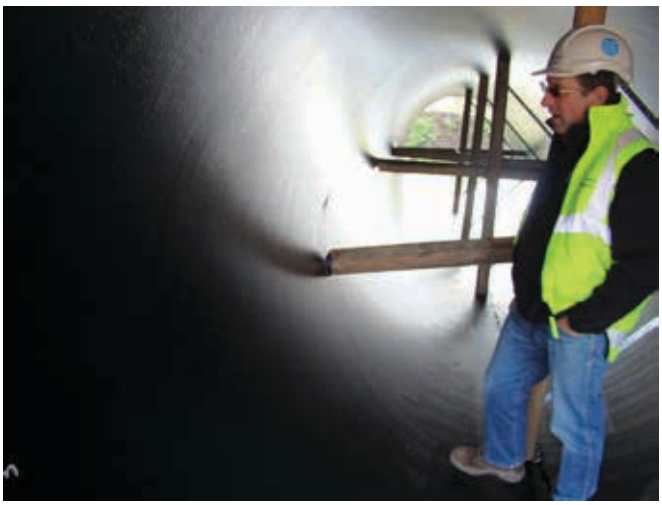
# Performance

## Service Performance

The long service history of cement mortar has allowed for continual assessment of performance.

Recent tests in Australia have been undertaken on cement mortar taken from pipes that had been in service for over 64 years in New South Wales, 40 years in Tasmania, and 34 years in Victoria.

Assessment of the samples verified that a service life of more than 150 years will be attained. These examinations, where extensive testing was undertaken, are in addition to the known experiences of Water Authorities over the past 95 years. These results are testament to the longevity and durability of cement mortar lined steel pipes.



### Corrosion Control

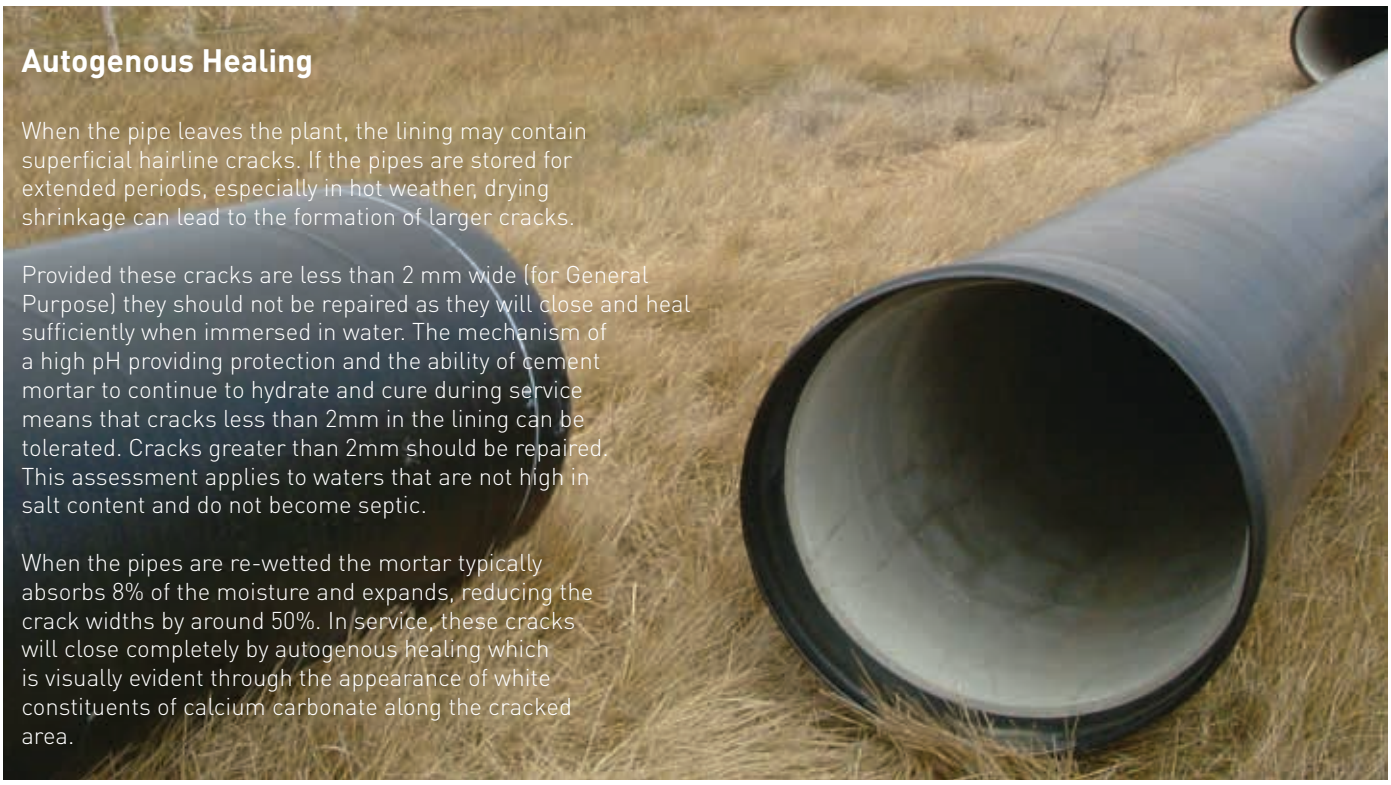
The primary function of cement mortar lining is to provide a protective barrier against corrosion. Steel pipes used in water transmission systems are vulnerable to corrosion due to the presence of dissolved oxygen, minerals, and other corrosive agents in water. Cement mortar lining acts as a physical and chemical barrier, preventing direct contact between the corrosive elements and the steel surface.

The cement mortar lining contains anti-corrosive properties due to the hydration of the cement mortar lining. At pH levels above approximately 9, a stable hydroxide film is formed on the inside surface of the steel. The alkaline properties of cement mortar create an environment that inhibits the corrosion process. The high pH level of the mortar reduces the solubility of minerals, thereby reducing the potential for scale formation and corrosion. Additionally, the impermeability of the lining prevents the penetration of water and oxygen, further minimizing the risk of corrosion.

Whilst this passive hydroxide film remains intact, no corrosion occurs. Whilst the passive film could be destroyed by a high-chloride environment, special measures can be taken for conveying saline waters to prevent this occuring (in particular the maximum allowable crack width is reduced). The corrosion protection is always active since it provides protection even where there are discontinuities in the lining.

Cement mortar lining holds a water absorption rate of 8% which hinders oxidation due to the slow oxygen diffusion rate through the lining. Due to the properties of cement mortar, water is absorbed when it travels through the pipe, which decelerates the diffusion of oxygen and swells the cement to close any gaps. This completely protects the steel and the swelling of the cement additionally increases the strength and cohesion.

# Performance



## Autogenous Healing

When the pipe leaves the plant, the lining may contain superficial hairline cracks. If the pipes are stored for extended periods, especially in hot weather, drying shrinkage can lead to the formation of larger cracks.

Provided these cracks are less than 2 mm wide (for General Purpose) they should not be repaired as they will close and heal sufficiently when immersed in water. The mechanism of a high pH providing protection and the ability of cement mortar to continue to hydrate and cure during service means that cracks less than 2mm in the lining can be tolerated. Cracks greater than 2mm should be repaired. This assessment applies to waters that are not high in salt content and do not become septic.

When the pipes are re-wetted the mortar typically absorbs 8% of the moisture and expands, reducing the crack widths by around 50%. In service, these cracks will close completely by autogenous healing which is visually evident through the appearance of white constituents of calcium carbonate along the cracked area.

## Calcium Aluminate Cement Mortar Lining for Aggressive Applications

In aggressive applications such as very low pH (<5.5), high $CO_2$ or very high sulphates, sulphate resistant cement (SR) or calcium aluminate (CA) cement can be used to resist attack and protect the steel substrate.

Aggressive free carbon dioxide ($CO_2$) in water can result in the formation of carbonic acid, which can deteriorate cement mortar lining. This is particularly common in groundwater sources with high levels of dissolved $CO_2$.

To combat the effects of aggressive free $CO_2$, measures such as carbonation-resistant cement mortar lining can be employed by using sulphate resistant (SR) rated cement.

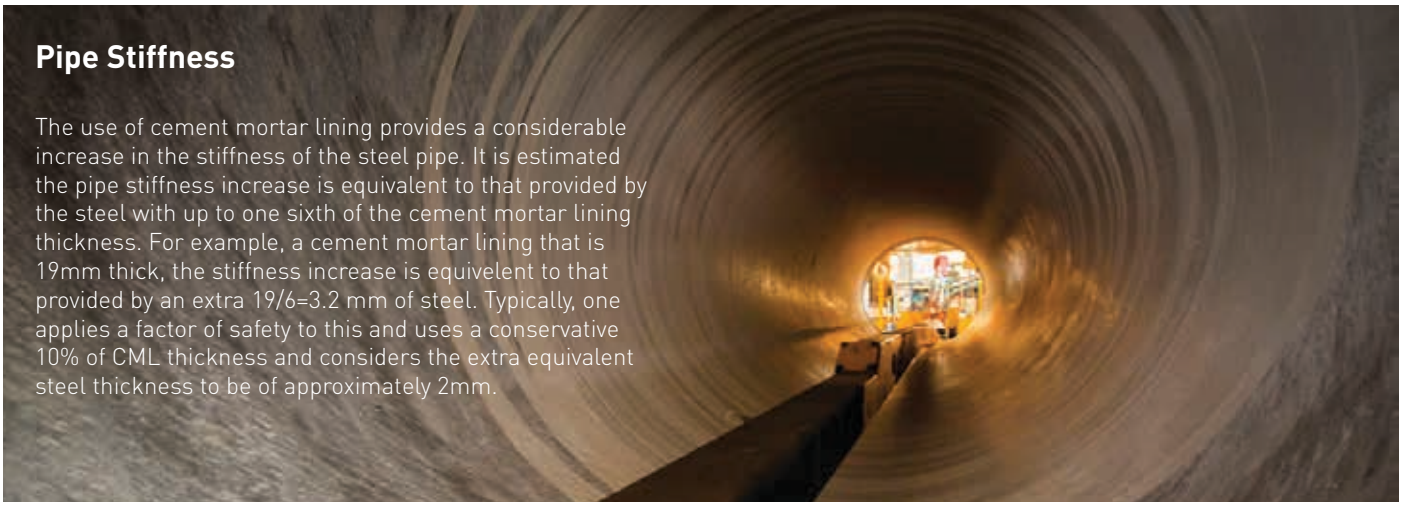
Sulphuric acid has a highly corrosive effect on cement mortar lining. To withstand such conditions, the use of sulphuric acid resistant cement mortar lining becomes necessary. This specialized lining incorporates high-alumina cement, which offers superior resistance to acid corrosion.

Applications include aggressive gravity sewage, bore water, pressurised sewage mains, and effluents. For these applications, there are additional requirements such as a higher thickness, additional curing, and tighter crack width tolerance i.e 0.5mm. A guide to the use of cement mortar lining for water chemistries is as follows:

| Chemical species | Tolerable concentration for SR cement | Tolerable concentration for CA cement |
|---|---|---|
| Sulphate $SO_4^{2-}$(mg/L) | 6000 max | no limit |
| Magnesium, $Mg^{2+}$(mg/L) | 300 max | no limit |
| Free aggressive carbon dioxide $CO_2$(mg/L) | 30 | no limit |
| pH(mg/L) | 6.0 min | 4.0 min |
| Hydrogen Sulphide $H_2S$ (ppm) | 0.5 max | 10 max |

Chemical Resistance of Cement Mortar Linings

# Additional Advantages



## Pipe Stiffness

The use of cement mortar lining provides a considerable increase in the stiffness of the steel pipe. It is estimated the pipe stiffness increase is equivalent to that provided by the steel with up to one sixth of the cement mortar lining thickness. For example, a cement mortar lining that is 19mm thick, the stiffness increase is equivelent to that provided by an extra 19/6=3.2 mm of steel. Typically, one applies a factor of safety to this and uses a conservative 10% of CML thickness and considers the extra equivalent steel thickness to be of approximately 2mm.

## Hydraulic Efficiency

CML facilitates long-lasting hydraulic efficiency due to its advantageous properties of a smooth and resistant lining which provides a long term low coefficient of friction, reducing frictional losses and promoting efficient fluid flow. These properties of cement mortar lining maximise flow capacity by reducing pressure loss which works in the interest of hydraulic efficiency.

By ensuring a smooth inner surface, the lining minimises turbulence and flow disruptions, enhancing the overall hydraulic performance of the system. This benefit is particularly important in large-diameter pipes or systems with high flow rates, where even small improvements in hydraulic efficiency can yield significant operational advantages.

## Internal Joint Reinstatement

SINTAJOINT® and SINTALOCK® are registered trademark pipeline joints offered by Steel Mains. These joints are coated with Sintakote and overlapped with cement mortar lining which does not require further lining reinstatement.

Sintajoint - Rubber Ring Joint

Sintalock I - Rubber Ring Joint

Sintalock II - Rubber Ring Joint

## Handling and Storage

All pipes including cement mortar lining should be handled with due care.Mistreatment, poor handling and poor unloading practice can result in lining damage. To minimise damage, adequate support and restraint should be provided during transportation to site.

Correct use of and suitable handling equipment must also be used. Storage should be on sand ramps or short-term site storage (no longer than a few months) on sawdust bags if on even ground.

If pipes are to be stored for long periods on site then sand mounds similar to factory storage ramps are the best solution. Sawdust bags will decompose with time and can be a fire hazard. Transport shall be on padded bolsters with a minimum 90° contact angle. Above all, it is important that Sintajoint pipe ends are protected from damage that may result if placed directly on rough ground.

## Seal Coating of Cement Mortar Lining

For many pipelines in Australia a seal coat is specified depending on the combination of water softness, aggressiveness, the pipe size and residence time. A seal coat is usually specified to control the pH level in the conveyed water. Occasionally, a seal coat is specified to extend the life of the CML.

The material used is a water contact approved bitumen coating. For more information about this coating, please contact your local Regional Sales Manager.

## Standards

Australian Standard AS1281 covers the requirements for cement mortar lining of steel pipes and fittings. This is done by either the centrifugal process, spray or hand application method for pipe manufacture prior to their installation in pipelines. Only centrifugal application of cement mortar lining is allowed by the AS standard for pipes. CML pipelines are used for the conveyance of water intended for human consumption or for the conveyance of wastewater.

Cement mortar linings are specified to comply with:

- AS 3972 - General Purpose Portland and blended Cement
- EN 14647 - Calcium Aluminate Cement

Cement mortars used for linings are available in various formulations and are specified to comply with AS 3972 -General purpose Portland and blended cements. Requirements include both the composition as well as the properties and performance of the cement; or EN 14647 for highly aggressive wastewater and sewerage pipelines.

EN 14647 covers formulations of calcium aluminate cement in terms of composition, specification and conformity. Potable water pipelines use cement supplied to AS 3972. Wastewater pipelines use cement supplied to either AS 3972 or EN 14647 depending on the aggressivity of the wastewater.

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