CAC for Pipes Production

Application of CALUCEM – Calcium Aluminate Cements

INTRODUCTION

ISTRA Calcium Aluminate Cements (CAC) are frequently used in the production of cementitious pipe inlinings for sewage applications. The benefits of CAC concrete are: high resistance against sulphuric acid corrosion, high early strength and durability.

Typically, an internal CAC mortar coating is applied to ductile iron pipes by using a spraying or spinning technique. After the coating has been applied, the pipes are cured in defined conditions.
During these production steps several parameters can influence the workability and quality of the mortar inliner.

This application sheet illustrates how changes in the amount of water and the type of sand can influence the CAC mortar performance.

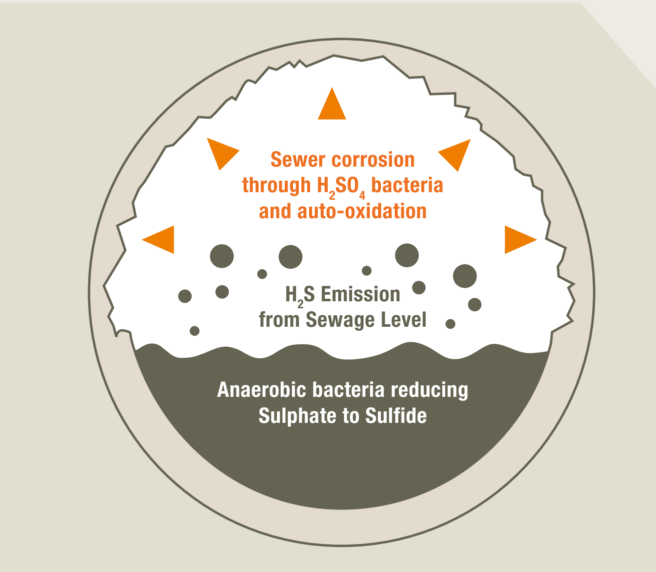

Figure 1: Mechanism of Biogenic Sulphuric Acid Corrosion

ISTRA CALCIUM ALUMINATE CEMENTS IN SEWAGE APPLICATIONS

MECHANISM OF CORROSION

Bacteriogenic acid attack is a problem in sewers which run partially full (figure 1). Anaerobic bacteria reduce sulphates in the effluent to sulphides and lead to the formation of hydrogen sulphide (H_2S).
The hydrogen sulphide escapes into the sewer atmosphere and is then carried to the crown of the pipe by convection.

Once there, it oxidizes to sulphur or dissolves in moisture to form sulphuric acid (H_2SO_4). Both species of sulphur are nutrients for a second set of aerobic bacteria. This bacterial action produces sulphuric acid – known as biogenic sulphuric acid corrosion (BSAC).
The sulphuric acid attacks the Portland cement mortar by dissolving the Portlandite ($Ca(OH)_2$) and calcium silicate hydrate phases, forming a silica gel and gypsum. Because of their high solubility both phases are washed out and a destroyed surface is left behind.

BENEFITS OF CAC

So why chose a CAC instead of an OPC for sewage applications? The simple answer is that CAC does not contain free lime (Portlandite) and less calcium silicate hydrate phases. When CAC mortar is attacked by H_2SO_4 an aluminium-gel is formed. This AH_3-gel closes the pores of the cement inliner. Thus you get a much denser microstructure that protects the ductile iron pipe against corrosion. Furthermore CAC posses a higher neutralization effect and therefore raises the pH-value in the surrounding area of the mortar, which, on the other hand, reduces the sulphuric acid attack.
Due to the high strength of the mortar, layers of only a few mm are sufficient for effective abrasion resistance lasting decades.

CALUCEM

TEST RESULTS WITH ISTRA CALCIUM ALUMINATE CEMENTS FOR PIPE PRODUCTION

In order to take advantage of the good properties of Istra CAC against bacteriogenic acid attack, abrasion and loss of durability, some things should be kept in mind.
The flowability of the CAC mortar slurry is of utmost importance when the spinning technique is used for the pipe coating process and responsible for the performance of the final product. If the mortar is too liquid, it will flow out at the end of the pipe and the protective CAC lining does not reach the required thickness. If the mortar is too stiff, it may lead to a varying mortar distribution in the inliner and negatively affect the sewage flow inside the pipe.
The CAC mortar flowability can be adjusted by varying the sand gradation, amount of water or by the addition of additives.

VARIATION IN THE SAND GRADATION

In common formulations, sands are mostly considered to be equivalent. Sands can vary significantly in grain size distribution, between suppliers or even from a single source. This directly influences the flowability of the coating mortar.
To investigate the correlation between CAC mortar flowability and sand grain size distribution, different sand samples have been chosen.
The sand grain size distributions are displayed in figure 2.
Sand 1 has the highest amount of fine particles. Sand 2 has a lower amount of fine particles and a higher percentage of coarser particles compared to sand 1. Sand 3 has the lowest amount of fine particles and the highest amount of coarse particles of all three tested sands.
The sands were mixed with CAC in the ratio sand/cement = 2 and with a defined water cement ratio of 0.55.
A flow-ring (dimensions: 68 x 35 mm) was used for generating slump-flow values, simulating the coating mortar cast into the pipe before spinning process. The CAC mortar was continuously mixed over the whole time of the flow measurement. After 5 and 25 minutes of mixing the flow-ring was filled with the mortar up to the upper edge. After that, the ring was removed upwards and the spread was measured in two opposite directions. The test results can be seen in figure 3.

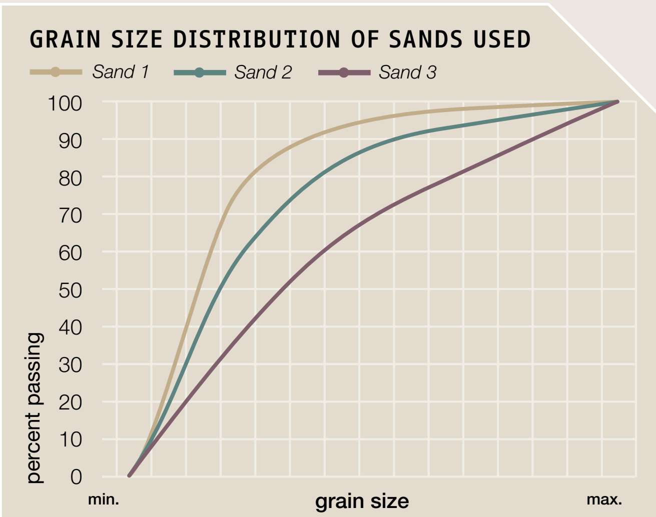

Figure 2

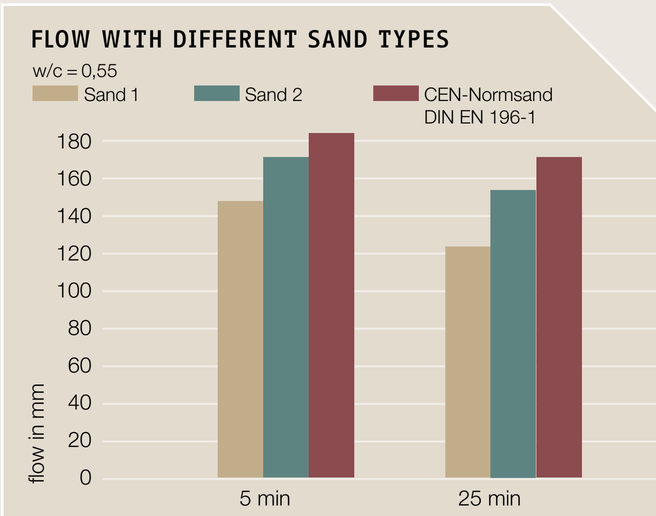

Figure 3

RESULTS

The flowability of all mortars decrease over time; independent of the sand used. The mortar with sand 1 shows the smallest slump flow after 5 and 25 minutes. At the given w/c-ratio 0.55, the amount of fine particles in sand 1 is too high to get completely dispersed by the available water. This leads to the lowest slump flow values within the test series. Sand 2 mortar in contrast has fewer fines relatively to sand 1. Therefore, the water for dispersing the fine amount increases relatively compared to sand 1. Therefore, the resulting slump flow is accordingly larger. The mortar with sand 3 is right from the beginning more liquid which can be contributed to the lowest amount of fines in the sand 3. Therefore the slump flow is clearly larger.

CONCLUSION

It was shown that a variation in the sand gradation can have a deep impact on the slump-flow of the mortar; although the amount of water has not been changed. For this reason it is recommended the sand granulometry to be tested prior to use. Beside the sand gradation the shape of the sand grains is important. A high percentage of angular particles hinder the material transport at the slump flow. Sand grains with a spherical shape, on the other hand, favour it.

The test results can be seen in figure 3.

VARIATION IN THE WATER AMOUNT

Water is the cheapest, but also the worst plasticizer. Too much water reduces the density of the microstructure and leads to a loss in compressive strength. Furthermore, incorrect water content is linked to bad slump flow or bleeding and segregation (see figure 4). Consequently, a careful adjustment to the amount of mixing water is essential prior to the beginning of the coating process.

In order to demonstrate the influence of water on the mortar slurry flowability, three mixtures have been tested. CAC was mixed with sand 1 (s/c=2) and different water amounts. The three mixtures were tested according to the test procedure previously described in the section "variation in the sand gradation". The slump-flow test results can be found in figure 5.

Figure 4: from left to right: bad flow, good flow, bleeding and segregation

RESULTS

The more water you add the higher the slump flow is. Starting with a w/c ratio of 0.5 the cement slurry flow has been gradually raised by adding 30 L/m^3 (w/c=0.05) water. In our experiments the right slump could be adjusted with a w/c ratio of 0.55. The flow spread is around 150 mm after 5 min and 125 mm after 25 min.

The mortar shows a smooth surface and a uniform spread. At the mixture with w/c = 0.5 the amount of water is not high enough to consolidate the material and the mortar is stiff. The mortar with w/c = 0.6 has the highest slump flow and cannot hold back the water. In this case there is no homogenous slump flow. Segregation and bleeding occur from the middle to the edge.

CONCLUSION:

In figure 4 the clear influence of water on the mortar properties is shown. When too little water is added to the mortar the result is a bad slump flow. By raising the amount of water, the slump flow can be increased but close attention must be given to the performance. An overdose of water can lead to bleeding and segregation and that in turn can be the reason for defects in the inliner of the ductile iron pipe. In the worst case the cement lining could be washed out.

Apart from adding water to the mortar, the desired flowability could also be reached by using plasticizers. However, it is essential to carefully adjust the amount of plasticizer used. Not every plasticizer shows the same effect and an over dosage should be prevented in any case.

The test results can be seen in figure 3.

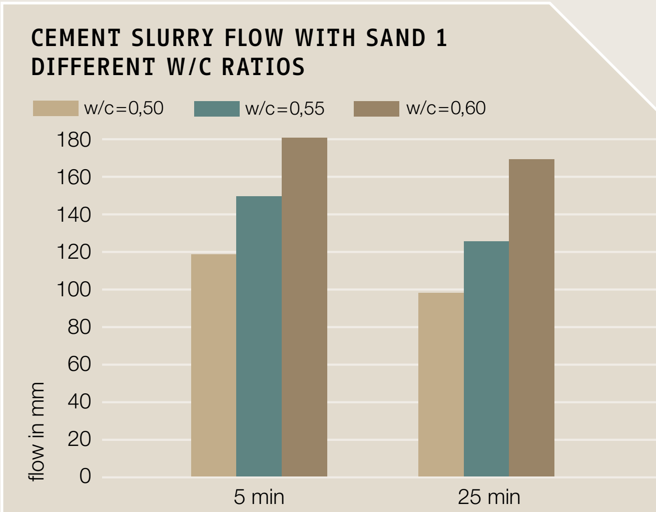

Figure 5

POST TREATMENT

After coating the ductile iron pipes, it is recommended to cure them under defined conditions. Thereby the humidity and temperatures must be kept high, until the final strength of the mortar inliner is reached. By doing so, the occurrence of harming influences can be minimized or prevented.

FINAL CONCLUSION

It is evident that cement mortar inliner for ductile iron pipe is a complex process, even though the system looks rather simple: Sand, Water and Istra CAC. A lot of factors have an influence on the performance of the final product. ISTRA CAC is the key to producing a long lasting product. Because of its properties it is resistant against aggressive media such as waste waters and linked effects like bacteriogenic acid attack and abrasion.

BENEFITS

ISTRA Calcium Aluminate Cement is a high quality cement that has been used in sewage applications for decades. Beside the good mechanical strength, wear resistance, ease of repair and less downtime, ISTRA Calcium Aluminate Cement offers unique outstanding properties for sewage applications:

- Excellent iron corrosion resistance
- Extraordinary abrasion resistance
- Resistance against biogenic corrosion
- Sulfate resistance
- High strength

START FORMULATIONS

Starting formulations for sewage pipe in-linings for both spraying and spinning techniques are available upon request.

MORE INFO

For additional information about ISTRA Calcium Aluminate Cements, please visit the CALUCEM web site at **www.calucem.com** or contact us worldwide.

www.calucem.com

SALES OFFICE EUROPE

Calucem GmbH

Besselstraße 8
D-68219 Mannheim
Germany

Tel. +49-621-10759-0
Fax +49-621-10759-200

E-Mail: info@calucem.com
Website: www.calucem.com

SALES OFFICE NORTH AMERICA

Calucem, Inc.

7540 Windsor Drive, Suite 304
Allentown, PA 18195
USA

Tel. +1-484-223-2950
Fax +1-484-223-2953

Contact: Mr. Doug Ostrander
E-Mail: nam.info@calucem.com

SALES OFFICE ASIA

Calucem Pte Ltd

10 Anson Road #26-03
International Plaza
Singapore 079903

Tel: +65-6536-3776
Fax: +65-6536-6073

Contact: Mrs. Catherine Tay
E-Mail: asia.info@calucem.com

CALUCEM