CAC for Sewage Applications

Application of CALUCEM–Calcium Aluminate Cements

INTRODUCTION

The problem of corrosion due to internal attack from aggressive fluids such as sewage and industrial waste is pervasive in many countries. As liquid waste is becoming more and more concentrated, chemically resistant construction materials are required. This is achieved by using Calcium Aluminate Cement (CAC). The lack of free lime and other ingredients that are sensitive to sulphates, enables Calcium Aluminate Cement to be an extremely suitable material for long-term solutions. ISTRA CAC has proved its suitability in sewers and sewage treatment plants for decades. High resistance to sewage, extraordinary abrasion resistance and high resistance to biogenic corrosion by sulphuric acid makes ISTRA CAC the ideal construction material.

MECHANISM OF CORROSION

Why choose a Calcium Aluminate Cement instead of Ordinary Portland Cement (OPC) for sewage applications?
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 sulfide escapes into the sewer atmosphere and is then carried to the crown of the pipe by convection.

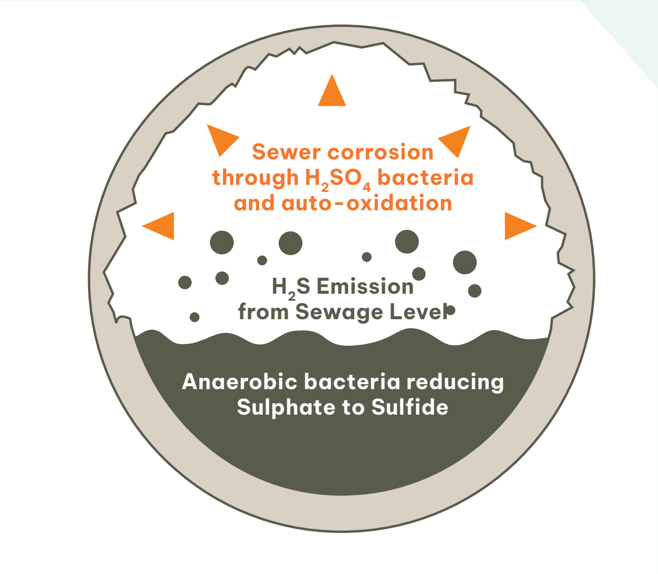

Figure 1: Mechanism of Biogenic Sulphuric Acid Corrosion

Figure 2: Sewer with BSAC

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, leaving a silica gel. The severe damage in a sewer caused by BSAC is shown in figure 2.

Calucem by Molins

TEST RESULTS WITH ISTRA CALCIUM ALUMINATE CEMENTS FOR SEWAGE APPLICATIONS

BIOGENIC SULPHURIC ACID CORROSION

A time saving test was developed which reproducibly demonstrates the impact of BSAC on concretes in waste water systems. As the first step Thiobacillus thiooxidans cells have been cultivated by fermentation. The produced bacteria have been subsequently pumped with a nutrient solution into a glass bio-reactor in which mortar prisms of the size 10 x 10 x 60 mm were stored. The bio-reactor was tempered to give optimum bacteria growth conditions. The entire surface of the mortar prisms was quickly covered by a bio film in which the biogenic sulphuric acid attack took place. The bacteria produced sulphuric acid with a pH of 1. The prisms have been removed monthly for weight loss determination after cleaning in an ultrasonic bath. Figure 4 gives the optical appearance of mortar prisms made by OPC and CAC.

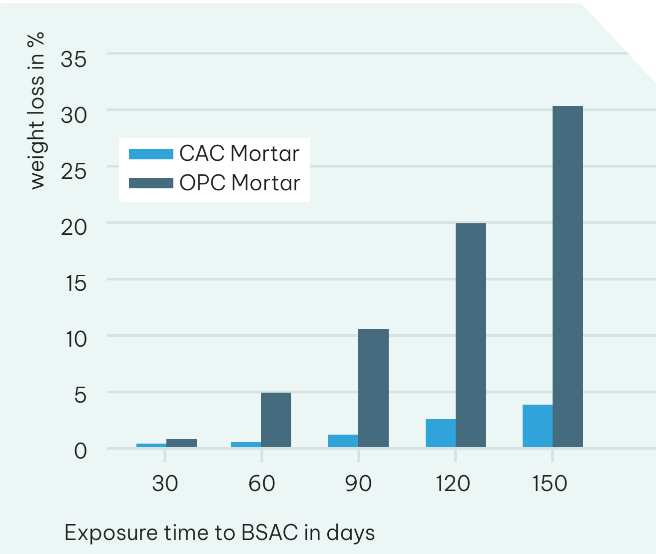

Figure 3: weight loss of mortar prisms made of OPC- and CAC

The CAC based mortar showed an 8 times smaller loss of weight than a comparable OPC cement mortar. Aluminum from the calcium aluminates has been identified as the growth-retarding factor. Therefore, ISTRA Calcium Aluminate cement contributes to minimizing the corrosion of concrete for sewage applications.

The results above confirm the experiences with CAC in sewage applications, which have persisted since the 1940s. CA cements clearly possess superior resistance to biogenic sulphur acid corrosion (BSAC).

ACID CORROSION TEST OF ISTRA CALCIUM ALUMINATE CEMENT MORTAR

Istra 40 mortar was tested for acid corrosion and compared with ordinary Portland Cements a CEM I 42.5 R mortar. Two sets of mortar cuboids have been produced with 100 x 100 mm and different heights of 65 mm, 70 mm and 75 mm. Set one was made with Istra 40 and siliceous aggregates (2/8 mm and 8/16 mm to enhance corrosion of the cement matrix). OPC cuboids with 65 mm height were made for comparison with the same kind of aggregates as for CAC.
The weight change of the Istra 40 and OPC-mortars was measured after subsequent immersion in 10 % sulphuric acid for 24h and additional 48 h . Figure 4 compares the cuboids with 65 mm height made of Istra 40 and OPC. The sulphuric acid has already corroded the corners and fringes of the OPC cuboids. Coarse aggregate grains are visible on the surface. The Istra 40 cuboids show nearly no sign of corrosion after 72 h in 10 % sulphuric acid.

Figure 4: Istra 40 mortar (left side) and OPC mortar(right side) after 72h of corrosion in 10 % sulfuric acid

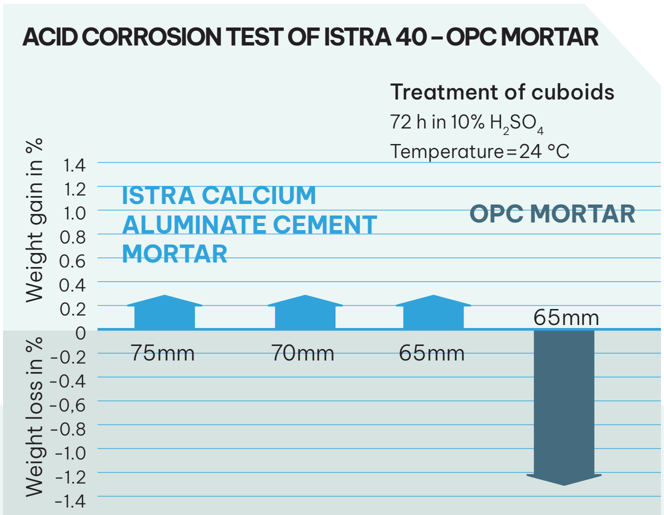

Figure 5: Weight loss Istra 40 and OPC mortar

The weight change of all Istra 40 cuboids is 4 times smaller than the weight change of cuboids made with OPC. OPC-mortar cuboids show a weight loss of about 1.3 %. All the cuboids made of Istra 40, manufactured with the same kind of aggregate like the OPC cuboids, have nearly no change in weight. The results display the excellent resistance of Istra 40 mortars against 10 % sulphuric acid under the test conditions.

EXPERIENCES WITH ISTRA CALCIUM ALUMINATE CEMENTS IN SEWAGE APPLICATIONS

High resistance to sewage, extraordinary abrasion resistance and high resistance to biogenic corrosion by sulphuric acid make ISTRA CA cements the ideal construction material in the sectors:

- Sewage pipe lines, ductile casting type (DIP, Ductile Iron Pipe)
- Sewage pipe lines, concrete type
- Sewers, sewage treatment plants

DUCTILE CAST IRON PIPES

Ductile cast iron pipes have been used in the sewage sector for decades. To guarantee their long-term service life, they are coated with an inner lining of CA cement mortar. The strength of these mortars and their high abrasion resistance to aggressive sewage will protect the cast pipe against corrosion and maintain the efficiency of these pipes for decades. The so-called "Inliner" made of ISTRA CA cement mortar, which is applied in a spinning procedure, obtains its extremely dense structure by means of the high compaction developed during this spinning process, which also enables extremely high strength. The strength level of ISTRA CA cements is clearly superior to the strengths of normal OPC and blast-furnace cement.

Figure 6: Ductile Iron Pipe with ISTRA 50 Inliner

The increased sulphate resistance, compared with Ordinary Portland Cement (OPC), is caused by a lack of the C3A phase as well as by a lack of free lime in Calcium Aluminate Cements. Calucem ISTRA CAC have greater sulphate resistance than either highly sulphate resistant Portland or blast-furnace slag cements (HS cements). The increased sulphate resistance and extreme density of our CA cement mortars protect the cast pipe against contact with aggressive liquids. The high alkalinity of our CAC-mortar guarantees good protection against rust. Owing to the high strength of the mortar, layers of only a few mm are sufficient for effective abrasion resistance lasting decades.

CONCRETE PIPES

Concrete pipes are wide-spread in the sewage sector and have stood the test of time. However, declining amounts of sewage and consequently a concentration of mud make the sewage more and more aggressive. Concrete pipes based on Portland cement are not always able to resist aggressive effluents.

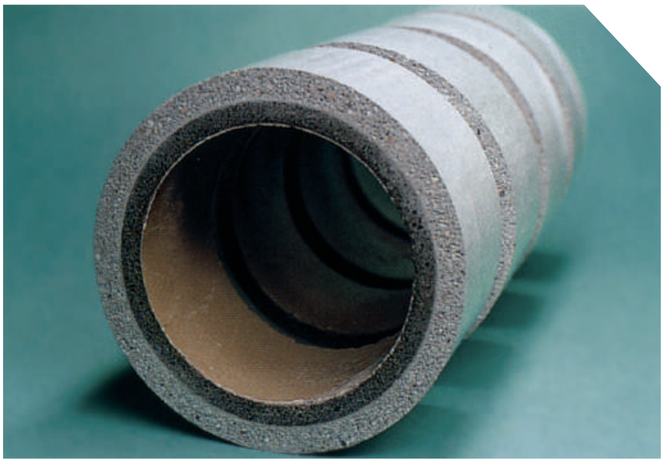

Figure 7: OPC concrete pipe with ISTRA 40 inliner

Biogenic corrosion by sulphuric acid as a consequence of the chemical action on sewage can damage concrete pipes based on Portland cement, and potentially destroy them. Bacteria which feed on sulphur compounds from the sewage, such as H2S, produce sulphuric acid as a metabolic by-product. This acid destroys the concrete above the water level.

For this reason, CA cements have been proven successful in the sewage industry for more than 50 years, as protection against biogenic corrosion by sulphuric acid. Combined with selected aggregate materials and additives, ISTRA CA cements are the reliable solution for the application of concrete pipes in the sewage sector for the coming decades. ISTRA Calcium Aluminate Cements can be applied as a coating, as a repair mortar, or as a complete concrete pipe.

SEWERS, SEWAGE TREATMENT PLANTS

CA cements have proved a success in sewer access shafts, in containers at the end of pressure pipe lines and in treatment basins, and they prove their efficiency compared to common concretes and mortars.

Figure 8: Sewer access shaft made of Istra 50

CA cements can be applied as shotcrete mortars, self-leveling compounds and pumpable concretes. ISTRA CA cements are applied as coatings to sewers and containers where biogenic corrosion by sulphuric acid tends to occur.

BENEFITS

ISTRA Calcium Aluminate Cement are more cost efficient compared to epoxy resins, zinc coating and other special cements.
ISTRA Calcium Aluminate cement has been used in sewage applications for up to 20 years now. Beside the good mechanical strength, wear resistance, ease for 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

STARTING FORMULATIONS

Starting formulations for sewage pipe in-lining with spray- and spinning technique 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.

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