



THE USE OF CALCIUM SULFOALUMINATE RAPID SETTING CEMENT FOR UNDERGROUND CONSTRUCTION

Underground construction conditions vary from project to project. Things typically considered for underground construction and design are: variations in temperature, complex variety of ground conditions and geometry, occasional presence of large amounts of standing or running water, possible poor lighting conditions, possible high humidity, and sometimes, a very limited window of opportunity to complete work during a given cycle timeline.

Conditions such as these can make work very challenging. There are also times when work in roadway tunnels have constraints placed to complete work in a short period of time – often just a few hours. During these conditions traditional portland cement concrete is not suitable as it does not have time to cure and reach a sufficient structural strength to allow traffic to drive on it again quickly enough. There is an alternative type of cement that is suitable, which sets up quickly, is tough and durable, and will be discussed.

Concrete in general is a popular material for underground construction and repairs. It is relatively inexpensive, stable, strong, and for the skilled craftsman, easy to use. Portland cement concrete, from the 19th century, has been the standard for generations but it has its limitations. It requires quite a lot of water to hydrate, which sometimes causes bleeding. Most importantly, it does not set very quickly, and it also has a tendency to shrink. This shrinkage leads to cracking, which in turn affects the durability of the final concrete structure. Portland cement concrete can be accelerated with organic additives that can be expensive, have a short shelf life and require additional handling equipment to keep the material in suspension on a jobsite.

Calcium sulfoaluminate (CSA) cement has recently emerged as an innovative alternative to portland cement for tunneling and underground construction projects. It has been used for construction on above-ground projects for years and exhibits properties uniquely suited to the harsh environment of underground construction.



Chemically speaking, calcium sulfoaluminate cement is very different from portland cement. The active compound in the cement is calcium sulfoaluminate and is also called Klein's compound, from Alexander Klein who invented it in the 1950s. The hydration process for CSA cement involves the very rapid development of ettringite needles within the structure of the cement paste causing rapid strength gain. This cement was modified in the 1970s primarily as a concrete repair material. To date, the California Department of Transportation (Caltrans) has used CSA cement concrete

in California to successfully replace more than 350 lane-miles of freeway pavement. It has also been used to rehabilitate concrete runways at airports across the United States and throughout the world. Large sections of the SeaTac airport in Washington State were replaced with CSA concrete in 1995 and the pavement is in almost perfect condition today. During construction at SeaTac, rapid-setting CSA cement concrete was placed by closing the runway at midnight and re-opening it at 6 a.m. for a working cycle of six hours. During that six-hour interval the CSA cement concrete reached sufficient strength



so that equipment could pass over it and not damage it. In a recent study conducted at the University of Oklahoma, this CSA concrete was shown to have a 100-year plus lifecycle. The CSA cement concrete is durable and sets in 20 minutes; therefore, it does not need accelerating admixtures. It can be retarded for more working time, if required, by the use of retarding admixtures, giving up to 30-45 minutes working time. It has high early strengths (3,000 psi at 1.5 hours, 5,000 psi at 3 hours and 8,000 psi at 24 hours), low shrinkage, and does not bleed. This is because the water needed for hydration is absorbed in the structure of



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the cement. It is also very resistant to sulfate attack and to bacterial attack — a common problem in sewer system pipes. It also has a very low carbon footprint. Due to its chemical composition and high lifecycle, its carbon footprint is 32 percent less than the carbon footprint of portland cement.

CSA cement grout can be used for grouting, shotcrete and repair applications. Each is addressed in more detail below.

Grouting. CSA cement grout can be used whenever non-shrink grouts are required. CSA grouts have been successfully used for cable bolting, rock bolts and various anchoring applications. They have been used effectively in post tensioning grouts. They are also ideal for equipment setting grouts. CSA cement grouts formulated to flow easily have low shrinkage and high strengths.

Shotcrete. CSA concrete is an excellent choice for shotcrete and pipe liners for storm drain pipes, culverts, and manholes. Because it sets up quickly, shotcrete formulations using CSA cement does not require accelerating admixtures. Rapid-setting shotcrete formulations using CSA cement work especially well in underground mining when it is necessary to move in and out of an area quickly. Often, the CSA cement shotcrete can be sprayed as a relatively thin layer because of its high strength and bonding characteristics. Crews are able to return to work hours earlier than when an accelerated portland cement mix is used.

Repair. CSA cements have been used for decades in repair applications where high strength and fast set times are required. They have been used to repair spalls in roads and to patch tunnel walls and crowns. A unique feature of CSA cement is the ability to use up most of its hydration water. CSA concrete mix can also, as an alternative to premixing, be placed into standing water and mixed in place. The result is a hard, permanent wearing surface for trucks and equipment within an hour. This method works well both on surface and in underground applications. Such applications are not within the scope of portland cement concrete as the set time is often too long. With CSA cement it is also possible to match the elastic modulus of the repair material to that of the existing concrete ensuring a permanent and stable bond. The fast setting time and strength gain (3,000 psi compressive strength in one hour) allow reopening to traffic within hours.

Conclusion

CSA Cements are available worldwide through a few manufacturers. The largest manufacturer in North America is CTS Cement Manufacturing Corp. The CSA cement that CTS Cement manufactures is sold through distributors. The trade name for the CTS Cement Manufacturing Corp.'s CSA cement is "Rapid Set Cement." Rapid Set Cement is also sold in Australia, Europe and Asia. Other cement manufacturers in China and

throughout Europe also produce CSA cements as both standalone hydraulic cements and as a cementitious additive to enhance portland cement. Standalone cements are generally preferred for their consistency.

CSA cement is a proven growing technology for the underground construction industry. The fast set time, high strength, low porosity, high chemical stability and sulfate resistance make it a material uniquely suited for underground repairs, shotcrete and other applications as needed. It can be used to replace portland cement concrete when durability and quick turn-around time is required.

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CTS Cement Manufacturing Corp. is the leading manufacturer of advanced calcium sulfoaluminate (CSA) cement technology in the United States. Our Komponent® and Rapid Set® product lines are renowned for proven performance, high quality, and exceptional service life. Contact CTS Cement for support on your next project. Call 1-800-929-3030.

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