New and Unusual Products & Services

A New Admixture to Minimize Corrosion: Hycrete DSS

By Scott A. Civjan, Christine Bonczar, Benjamin Crellin

Significant deterioration of concrete structures can be attributed to corrosion of reinforcement. Large portions of Highway Department budgets are directly or indirectly spent on the evaluation, repair, or replacement of concrete elements. This is especially true in marine environments or regions where de-icing salts are used on roadways. Several methods are currently employed to reduce corrosion activity and/or increase the time to corrosion. Methods tend to focus on either reducing the transport mechanisms through the concrete (usually through decreased concrete permeability or membrane application), or directly interfering with the corrosion process (corrosion inhibitors). Specifically, concrete cover can be increased, lower water to cementitious material ratios (w/c) can be used (including the use of pozzolonic materials), overlays can be used, reinforcement can be coated or made of materials less susceptible to corrosion (stainless steel, microcomposite steel, or fiber reinforced polymers), corrosion inhibiting admixtures can be included, or structures can include cathodic protection systems. Typically a combination of several of these methods is employed in severe corrosive environments. And yet corrosion problems are still common (Figure 1). Engineers now have a new tool for reducing corrosion in structures, with some unique advantages over other methods.

Figure 1a: Typical Corrosion problems: Bent Cap

Figure 1b: Typical Corrosion problems: Guardrail

Figure 1c: Typical Corrosion problems: Abutment Wall

DSS (Hycrete)

A new concrete admixture (DSS, sold as Hycrete) has recently been developed. It is an extremely promising new tool in preventing corrosion in concrete structures. Testing at the University of Massachusetts, Amherst (UMass) and the University of Connecticut (UConn) have found significant improvement in concretes including DSS over those with other single admixtures. DSS comes as a liquid admixture and has an optimum dosage of ½ percent DSS by weight of cement. DSS provides stable air entrainment, though it can also include a defoaming agent to negate this effect. The latter may be advantageous to allow for standard methods of air entrainment, providing fewer changes to standard mix designs.

Corrosion Testing

Testing at UMass compared 14 different mix designs using macrocell, half-cell potentials, and visual evaluations. Mix designs included combinations of up to 3 admixtures (pozzolonic materials, corrosion inhibitor, DSS). Concrete containing DSS as the only admixture showed minimal corrosion activity through 186 weeks of testing. Only a triple combination of Calcium Nitrite, Silica Fume and Fly Ash equaled this performance. The Calcium Nitrite specimen showed corrosion activity at 170 weeks. Linear polarization techniques and visual examinations were used in testing at UConn. DSS was included in specimens at 1 or 2 percent by weight of cement. After 48

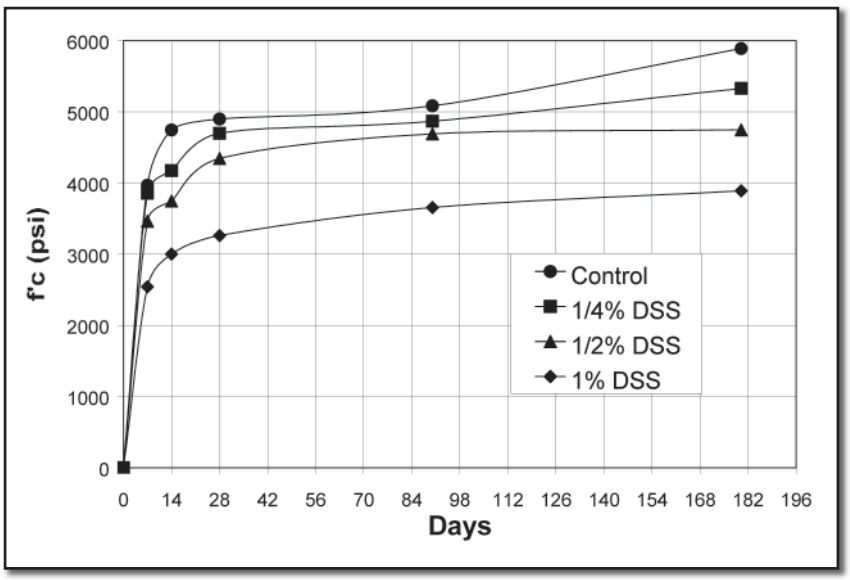

Figure 2: Compression Strength of DSS and DSS/CN Concretes (Averaged Results – w/c=0.40)

weeks of aggressive corrosion testing the investigators noted "Complete lack of corrosion in specimens containing the new chemicals" compared to the control and other single admixture specimens that indicated corrosion activity.

Cracking in concrete is a very real and serious problem in corrosion control, allowing direct access of salts to the embedded steel. It was under these conditions that DSS excelled in laboratory testing. One specimen of each mix design at UMass was "pre-cracked" to the level of reinforcement. For this condition, DSS alone or in combination with Calcium Nitrite showed the least corrosion, far surpassing the performance of all other admixtures and admixture combinations studied. At UConn, one specimen was accidentally dropped and cracked during testing. The measured corrosion potential and corrosion rates indicated significantly improved performance for this specimen over the non-cracked control specimens, even with direct chloride access to the reinforcement. Subsequent "saw cut" specimens also saw significant improvements over the control.

Material Testing

UConn tested DSS at ¼, ½, 1 and 2 percent by weight of cement, though ½ percent is recommended. Absorption, which directly relates to the ability of salts to reach embedded steel, is reduced by more than 50 percent in concretes containing DSS. Freeze-thaw resistance of Hycrete concretes is excellent, though attention to air-entrainment (affected by whether a defoaming agent is included) is essential. Compression strengths for DSS mixes may be lower than for equivalent control mixes, with strength reductions in the range of 10 to 20 percent. Figure 2 shows recent strength results from UMass. Much of the strength reduction is likely due to the air entrainment properties of DSS, as strength loss was minimal when a defoaming agent was included in UConn stidoes. For higher dosages (1 to 2 percent DSS) strengths were reduced by approximately 40 percent, similar to results at UConn. Adequate strength concretes were attainable even with these strength reductions.

Field Implementation

A new study at UMass has been awarded for funding, and initiated in Fall 2004. It will specifically address mixing, construction, placement, and in-situ corrosion issues. The project will initially work with ready-mix companies to develop acceptable mix designs using DSS admixtures. The project goal is to verify mixing procedures and performance of DSS in large batch concretes, and implement DSS concretes in field studies. The project will include DSS concrete in several major construction demonstration projects throughout New England, and will include a program for long term monitoring of corrosion

activity. A few high-profile construction projects utilizing DSS as a demonstration material include a 100 cubic-yard bridge deck by the New Jersey Turnpike Authority and a 560 cubic-yard deck by the Kansas Department of Transportation (DOT). The latter of these has been instrumented for long term corrosion monitoring. In addition, Hycrete concrete demonstration projects by the Connecticut DOT (Jersey barriers), New York/New Jersey Port Authority (sidewalks), and Ohio DOT (noise barriers) have recently occurred.

Conclusions

DSS is a new admixture with outstanding potential for reducing life-cycle costs of concrete elements in corrosive environments. DSS concretes exhibit greatly reduced concrete permeability and appear to reduce corrosion once chlorides reach the level of the reinforcing steel. Corrosion activity was either greatly reduced or nonexistent at the conclusion of testing in studies at both UMass and UConn. Significant protection against corrosion activity was realized even in cracked concretes. An optimal dosage of ½ percent DSS by weight of cement is generally recommended.

Material characteristics of concrete containing DSS are similar to typical mix designs, and would be acceptable for high-performance concretes. DSS concretes using ½ percent DSS by weight of cement have a strength reduction of up to 20 percent, though strength loss can be minimized through the use of a defoaming agent. It is very important to be aware of whether a DSS admixture includes a defoaming agent, and to understand the interaction between DSS and air entraining admixtures to ensure proper strength and freeze-thaw resistance.

DSS is a very exciting new ad-mixture for concrete. Through lab-oratory studies and field demon-stration projects, the admixture is proving to be a viable and economical method to combat corrosion in concrete structures. The admixture will be available commercially from several admixture companies in the near future.▪

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