Technical Transfer Manual

TR-788: Mitigation of Chloride-induced Corrosion through Chemisorption

The goal of this project is to mitigate the chloride-induced corrosion in rebars caused by the use of deicing salts in the winter. Both migratory corrosion inhibitors and secondary coatings for rebars were investigated. In the previous project (TR-754), corn-derived polyols, such as, sorbitol, mannitol and maltitol were found to cut down the corrosion damage significantly. However, their effect on cementitious materials is not understood. In this project, we noticed that the cement mortar cubes exposed to more than 60 wet-dry cycles of deicing salt brine exhibited a strength loss of 12-17%. On the other hand, the mortar cubes exposed to the salt brine with 1% by wt. polyol had relatively lower strength loss of 2-8% which can be attributed to their pore clogging activity. Furthermore, the addition of 1% by wt. polyol to salt brine did not result in no additional scaling, mass loss and the XRD results did not show the formation of any new deleterious compounds.

The coatings prepared from Soy-protein as the base material and corn-derived sorbitol as the plasticizer is demonstrated to be a good alternative for in-situ secondary coating. While increasing the soy protein content improved the strength, increasing the sorbitol content solved the brittleness issue and improved the abrasive resistance. The heat-treatment followed by the alkaline denaturing by sodium hydroxide is a relatively inexpensive procedure to produce this coating material and can be done in the field without loss of quality control. With a viscosity ranging between 2.5-27 m.Pa.s based on the soy protein content, coating methods such as dip coating and spray coating can be adopted. The coating with 10-15% soy protein and 30% sorbitol was found to decrease the short- and long-term corrosion rates by 90% and 50%, respectively.

The secondary soy-protein coatings could reduce the bond with concrete necessitating more development length. We incorporated inert oxide particles into the soy-protein coating to improve the bond and other mechanical properties of the coating. In particular, we chose nano silica fume (SiO_2) with 96.6% silica and an average particle size of 150 nm, zinc oxide (ZnO) with an average particle size of 1.5 μm, and aluminum oxide (Al_2O_3) with an average particle size of 5 μm for their chemical inertness and small particle size. Increase in the abrasives weight resulted in thicker and stable coatings. The coatings exhibited superior abrasion resistance (no signs of abrasion even after 1600 liters of abrasive exposure), and lap shear strength. The instantaneous and long-term corrosion rate mitigation was 94% and 78%, respectively, for the coating with all the three abrasives added at 10% by wt. of the plasticizer. Furthermore, the pullout tests conducted on this coating revealed a 90% gain in bond strength. With this, incorporating the inert oxides into the coating can substantially improve their strength and performance both in the short- and long-term.

Based on this study, 1% by wt. of polyol can be added to the salt brine as migratory corrosion inhibitor without damaging the concrete. It is not necessary to add polyol in every batch of deicing solution. Exposing the roads to the polyol blended salt brine 2-3 times a season should be sufficient. The use of polyol blends should be avoided in recently constructed sections as there will be no initiation of corrosion in epoxy coated rebars unless there is damage. The soy-protein coating with 10-15% soy protein by wt. of water and 30% sorbitol by weight of soy protein is ideal for spot fixing damaged epoxy coatings or can serve as secondary coats to epoxy coatings to prevent damage during operation and transportation. However, if superior strength and bond performance is desired, adding 10% of SiO_2, Al_2O_3, and ZnO by the weight of plasticizer can substantially improve the corrosion resistance and mechanical properties including bond strength. However, it should be remembered that dispersing these oxide species into the coating in the field is challenging without special equipment. Future research should investigate improving the shelf life of these coatings or other alternatives that can be used as secondary coats without increasing the construction costs.