Corrosion Protection in High Performance Concrete

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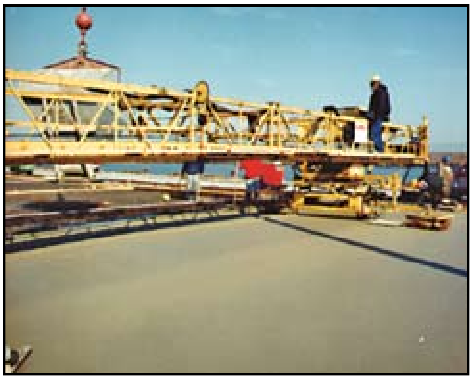
*Corrosion of reinforcing steel in concrete is a recurring problem in the industry. The addition of a concrete corrosion inhibitor is a chemical solution that is specific for concrete with its high alkalinity. Corrosion inhibitors can mitigate the rate of corrosion in concrete, although the mechanism by which this is accomplished is complex, and no general theory is applicable to all situations. Some corrosion inhibitors have been used commercially in concrete in the US for over a quarter of a century. Many references on the use of corrosion inhibitors in concrete can be found on the Concrete Corrosion Inhibitors Association web site (**www.corrosioninhibitors.org**).*

Concrete structures can be designed, specified, and constructed properly to give life spans of 100 years or more. However, corrosion of reinforcing steel dramatically reduces the performance and service life of concrete. The challenge is to construct high performance concrete structures that are immune to reinforcing steel corrosion and exhibit minimal cracking. Achieving this requires a thorough understanding of concrete mix design, chemical admixtures (air entraining agents, water-reducing agents, high-range water-reducing admixtures and corrosion inhibitors), supplementary cementitious materials, and construction techniques, as well as the environment in which the structure must perform.



The Construction of the Port of Willington (DE).

Table 1 provides two examples of high-performance mix designs currently used by the Port Authority of New York and New Jersey for parking structures and bridge decks. Mix 1 was used in parking structure "E" at Newark Airport. When properly mixed, placed, finished, and cured, this concrete is very durable and should perform well for many years.

Sample Mix Design

	Mix 1	Mix 2
Cement	420 lbs	470 lbs
SCM	240 lbs (Slag)	190 lbs (Fly Ash)
Fine Aggregate	1050 lbs	1000 lbs
Coarse Aggregate #57 well graded	2050 lbs	2050 lbs
AEA	as required	as required
HRWR	75 oz +/-	65 oz +/-
Corrosion Inhibitor (Calcium Nitrite)	384 oz	384 oz
Water	235 lbs +/-	235 lbs +/-
Air Content	5% – 8%	5% – 8%
Slump	4 – 6 inches	4 – 6 inches
W/cm	0.40	0.39

Table 1: Port Authority of New York and New Jersey – Mix Designs

The above mix design has redundancy built into its formula. Corrosion-inhibiting admixtures provide long-term protection for the reinforcing steel in the anticipation of some structural cracking that may occur in normal use. Corrosion-inhibiting admixtures are especially useful in long-term high performance concrete exposed to salt spray, brackish water, or deicers.

The world's largest public parking structure opened on February 24, 2002 at the Detroit Metropolitan Wayne County Airport. The 11,500-space deck was an addition to the Northwest Airlines McNamara Terminal. The intricate 10-level structure is a third of a mile long; it varies in width from 240 to 360 feet and covers a total of 89 acres. Throughout the entire structure, the design incorporated three gallons per cubic yard of an inhibitor. This inhibitor was used to extend the life of the structure by mitigating the corrosion of steel reinforcement, which could be caused by the ingress of water carrying chloride ions.

Table 2 provided the mix design for this parking structure.

Another project where a corrosion inhibitor was used successfully was the Port of Wilmington (Delaware). In 1998, an exten-

Detroit Metropolitan Wayne County Airport Parking Deck.

Sample Mix Design

600 lbs	St. Mary's Type I Cement
120 lbs	St. Mary's Slag Cement
1442 lbs	Sand
880 lbs	⅜ inch Slag Stone – Levy Detroit
560 lbs	¾ inch Slag Stone – Levy Detroit
200 lbs	Water
7 oz/cwt	High-Range Water Reducer
10 oz/cwt	Water Reducing Agent
1 oz/cwt	AEA
3 gal	Corrosion Inhibitor

Table 2: Detroit Metropolitan Wayne County Airport Parking Deck – Mix Design.

sion to the existing pier was being constructed to increase the port's capacity. A primary design objective of this project was to extend the structure's service life. Unfortunately, this type of structure comes in direct contact with seawater containing salt. This dramatically accelerates the corrosion of the reinforcement and significantly reduces the service life of the structure. Consequently, it was necessary to provide additional protection for the reinforcement in the concrete. The corrosion inhibiting admixture forms a protective layer around steel reinforcement to reduce the occurrence of corrosion. This protective layer will significantly extend the expected service life of the concrete structure. In most cases, it does not change the working properties of the fresh concrete, allowing placement and finishing to proceed using normal construction practices.

The use of a mathematical model has now become common in the industry for predicting the service life of reinforced concrete structures subjected to harsh weather conditions. This model, Life 365, is used by structural and civil engineers to compare concrete corrosion inhibition systems to determine how to obtain a long service life at the lowest life-cycle cost. (Life 365 is also available at **www.corrosioninhibitors.org**.) An upgraded version is now being developed and will be available in 2007.

Several corrosion inhibitors have now been tested and sold for use in severe conditions for many years. These effective inhibitors are available from member companies of the Concrete Corrosion Inhibitors Association (CCIA). The companies in CCIA are Axim Concrete Technologies, BASF (Master Builders), Euclid Chemical, Grace Construction Products, and Sika Corp.▪

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