The Use of Xypex Admixture to Concrete as an Inhibitor to Reinforcement Steel Corrosion

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Abstract

There are many ways that reinforcement steel is protected from corroding in concrete. Most protection is applied directly to the concrete, such as epoxy coating, galvanising, and DCI type additives. Another relatively new method is to formulate concrete so that the concrete itself will prevent the reinforcement steel from corroding. By formulating the concrete to protect the reinforcement steel, it is anticipated that the concrete could protect itself also from premature failure. A practice-oriented research was completed on concrete with the "Xypex" admixture introduced.

This research indicated the effects of this admixture on preventing corrosion of reinforcement steel. It also indicated other virtues of this type of admixture such as healing and preventing shrinkage cracks, increasing life cycle of concrete, and the admixture's use as a sealer.

Introduction

Concrete is one of the most widely used construction materials due to its good durability and relatively low cost. When reinforced with steel it has very good structural properties allowing for its use in numerous structures such as bridge decks, abutments, structural walls, and prestress concrete structures. [1]. Even through concrete is highly resistive to permeability to the ingress of water and chloride, the steel within the concrete can corrode. The objective of this paper and research problem is to find an additive to the concrete that will further slow the ingress of water and chloride if not stop it completely.

Several concrete admixtures were reviewed. The Xypex admixture was chosen because of the following reasons:

1. There are several types of Xypex; the ones selected for this research were the Xypex Concentrate used as a slurry or broadcast method, and the Xypex Admixture which is introduced directly into the concrete either at the dispersing location or at the concrete plant.
2. Xypex did not require dry weather or surfaces for placement.
3. Xypex also performed as a water sealer.
4. Xypex reduced and/or eliminated surface cracks.
5. Xypex compatibility with concrete.

Xypex is a compound composed of Portland cement, silica sand, and many active chemicals which when introduced to concrete cause a catalytic reaction in the pores and capillary tracts of the concrete substrate. This reaction generates a non-soluble fibrous crystalline growth substantially throughout the concrete, thus rendering the concrete totally sealed against penetration of liquids from any direction. [2]

In order to determine if the use of "Xypex" would help to prevent a premature failure of concrete, it was decided that it would be tested in the laboratory and in the field for sodium chloride intrusion. During the laboratory testing the moulded cylinders would also be tested for strength comparison to a control concrete mix. Further it was decided to field test the "Xypex" material as both an admixture and in a slurry state. For the field tests, 8 test sites were located with the help of the New Jersey Department of Transportation, Bureau of Maintenance and Bureau of Materials Engineering and Testing. The field tests would consist of field evaluation of the pre-existing site and evaluation of the site with cores taken after the material had been in place for one or more winters. The following sites were chosen.

1. Spring Meadow Golf Course: Footing & Abutment Wall - Class A Transit Mix Concrete with Xypex Admixture; Wingwalls - Rapid Set 1-2-2 without Xypex.

2. Rt. 52 Rainbow Channel - Xypex Concentrate applied as an exterior coating.

3. Rt. 130 Brainard Lake: Deck Patch - Rapid Set 1-2-2 and Xypex Admixture.

4. Rt. 130 Crafts Creek: Under Side of Concrete Span - Applied Xypex Concentrate as an overhead procedure.

5. Rt. 495 Pedestrian Bridge: Abutment - Initial repairs using Xypex Concentrate, Overlay with Rapid Set 1-2-2 and Xypex Admixture.

6. Rt. 23 Peckmana Brook: Backwall - Repairs made with Rapid Set 1-2-2 and Xypex Admixture; Prestressed Box Beam - Applied same mixture to underside of box beam as an overhead repair.

7. Rt. 29 Storm Drain; Precast Deck- Class A Concrete with Xypex Admixture.

8. Rt. 9 Lake Pohatcong: Retaining/Dike Wall - Repaired with Xypex Concentrate Slurry.

Laboratory Results

The Xypex admixture in concrete was tested against a control mix of concrete. The test was performed twice, once for an air entrainment agent and once with no air added, the same quantity of air entrainment added to the control and Xypex mixes. The Portland cement used was Hercules. Both samples were subjected to a sodium chloride bath during the entire 28 days of the test. It is significant to note that the samples were placed into the bath immediately after the concrete had set in the moulds.

SODIUM CHLORIDE TEST DATE - % OF CHLORIDES

	CONTROL W/DAREX 2 %	XYPEX W/DAREX 2 %	CONTROL NO AIR %	XYPEX NO AIR %
TOP 1/3 OF 8" SAMPLE	0.074	0.035	0.076	0.059
MIDDLE 1/3 OF 8" SAMPLE	0.014	0.013	0.045	0.049
BOTTOM 1/3 OF SAMPLE	0.028	0.015	0.032	0.025

These results represent one third of an 8" cylinder or 2.66" of a 4" x 8" specimen. The greatest percentage of chlorides is reflected in the first third of the specimen. Even though the Xypex percentages are below the control percentages, it should be noted that Xypex depends on moisture for the migration of its crystalline chemicals into the capillary voids of the concrete. Had the concrete been initially cured in a humidity room or in non-chloride water bath, it is very possible that the percentages of chloride retention in the Xypex specimens would have been less.

Further, these results did not indicate a significant decrease in chloride content over the bottom two thirds. There was a significant decrease in the first third, this suggests that the chloride content from the first third was forced to migrate with the crystalline growth through the bottom two thirds of the concrete specimen.

The specimens were also tested for strength. The Xypex concrete were found to have a compressive strength gain over the control specimen of 139% at 3 days, 130% at 7 days, and 120% at 28 days.

Field Results

The contractors and NJDOT personnel found that there was no added work in the application of the Xypex versus normal concrete placement or slurry placement. At the present time cores are being taken from the previously mentioned areas to determine chloride content. Because of needed emergency repairs no cores were taken to determine the chloride content prior to placement of the Xypex concrete. Where Xypex was used as a slurry, additional cores will be taken from adjoining or nearby similar structures without the Xypex material. This may give information as to the increase or lack of chloride content.

Other field observations were the Xypex healed numerous old cracks of ¼" in width and less.

Recommendations

1. Retest the Xypex in a laboratory control situation after first curing the specimens in a humidity room or non-chloride water bath.

2. Complete coring of field tests and determine chloride content.

3. Perform a core test of material used in the field after three or more winters.

Conclusions

Although the testing has not been completed, this writer has concluded that Xypex Admixture and slurry can be used to slow down the process of the ingress of chlorides in concrete. The material should be given major consideration when concrete projects are subjected to de-icing chemicals and other harsh environments. Both the admixture and the slurry performed well as a waterproofing material. Since these products become an integral part of the concrete they could also be used as a protective coating where environmental concerns are at stake. The crystalline structure of Xypex is still reactive in the field test sites and should help to prevent or seal minor defects that may occur over time, such as shrinkage cracks.

References

[1] Berke, N.S., "Concrete", MNL-20 (ASTM) *Corrosion Tests and Standards Manual,* Robert Baboian, June 1995, pp 331-337

[2] Xypex Chemical Corporation Specification Manual, Copyright 1980, pp 1-36

Collaborator

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CUSTOMER PRODUCT EVALUATION

1. Please briefly describe the type of application(s) that the product was used for during this period.

   The Pennsylvania Turnpike Commission has been using Xypex Concentrate Admix for over five (5) years in the pre-casting of concrete single and double faced median barrier.

2. Please estimate extent of usage in terms of approximate miles of pre-cast concrete highway components.

   Approximately 100 miles.

3. Please specify test results as performed by your organisation ie compressive strength, protection against chloride ion penetration, etc.

   Compressive strength results are enhanced with the addition of Xypex. PTM 414, Chloride Ion permeability - Xypex always performed the best by allowing the least amount of penetration.

4. As a general performance statement, would you acknowledge that you have found this product to perform satisfactorily and meet desired specification requirements to protect concrete?
   X Yes ___ No

We greatly appreciate your time and effort in providing this information. Thank you.