EVALUATION OF MECHANICAL AND CORROSION PROPERTIES OF MMFX REINFORCING STEEL FOR CONCRETE

Report Number: FHWA-KS-02-8

By
Lien Gong, David Darwin, JoAnn P. Browning, and Carl E. Locke, all of University of Kansas

RESEARCH

Introduction

Deicing salts can cause the deterioration of bridges as the deicers diffuse through bridge decks and cause corrosion of the reinforcing steel. In 1992, it was estimated that in the United States the cost of bridge repairs in the federal-aid system due to corrosion damage was $51 billion (Fliz et al. 1992). Thus, cost-effective methods to prevent the corrosion of reinforcing steel are of great importance.

Methods that are used to reduce the corrosion of reinforcing steel include the use of corrosion-inhibiting concrete admixtures, low permeability concrete, greater concrete cover over the reinforcing steel, cathodic protection and epoxy-coated reinforcing bars. The research presented in this report addresses another solution: developing corrosion-resistant reinforcing steel. A new iron-alloy, containing nine percent chromium with the trade name MMFX II, was developed to be corrosion resistant.

Project Objective

The principle goal of this study was to evaluate concrete reinforcing steel that is supposed to have superior corrosion resistant properties in the presence of chloride ions. Rapid tests were used to determine the corrosion potential and macrocell corrosion rate of MMFX reinforcing steel when exposed to 1.6 and 6.04 molal ion concentrations of NaCl. These tests gave an early comparison of the relative corrosion resistance of the reinforcement. Southern Exposure and cracked beam tests were used to provide a measure of the long-term corrosion resistance of the steel. The nature of the corrosion products on the steels was also evaluated by using a scanning electron microscope.

Project Description

The corrosion performance of a new reinforcing steel (MMFX) was compared with that of epoxy-coated and uncoated conventional steel. The steels were evaluated using rapid macrocell tests developed at the University of Kansas, plus two bench-scale techniques, the Southern Exposure (SE) and cracked beam (CB) tests. Macrocell corrosion rate and corrosion potential were measured for both rapid and bench-scale tests. Macrocell mat-to-mat resistance was measured only for bench-scale tests. The test specimens of corrosion tests consisted of bare bars and bars cast in mortar for the rapid tests, and bars cast in concrete for the SE and CB tests. A water-cement ratio of 0.5 was used for rapid tests and 0.45 for SE and CB tests. Combinations of conventional steel and MMFX steel were tested in both rapid and bench-scale tests.

Project Results

The MMFX steel exhibits a macrocell corrosion rate between one-third and two-thirds that of conventional reinforcing bars in the rapid and bench-scale tests. However, epoxy-coated reinforcement with the coating penetrated, corrodes at a rate between 5 percent and 25 percent that of conventional steel and provides superior corrosion performance to MMFX reinforcing steel. It is not recommended that MMFX steel be combined with conventional steel in reinforced concrete structures. Although the corrosion rates were lower than conventional steel when MMFX was placed at either the anode or the cathode in rapid and SE tests, they were higher than that exhibited by MMFX steel alone. The MMFX steel is a high-strength material with properties similar to those specified under ASTM A 722. The chemistry of MMFX steel is consistent for bars within the same heat and very close for the two heats analyzed. Corrosion products with similar morphology are observed on both conventional and MMFX steel, suggesting that products have similar composition.

Report Information

For technical information on this report, please contact: David Darwin, Ph.D., P.E., Director of Structural Engineering and Materials Lab, University of Kanssas, 1530 West 15th Street, Room 2006, Lawrence Kansas 66045-7609; Phone: 785-864-3826; Fax: 785-864-5631; e-mail: daved@ukans.edu.

For a copy of the full report, please contact: For a copy of the full report, please contact: KDOT Library; 2300 SW Van Buren Street, Topeka, Kansas 66611-1195; Phone: 785-291-3854; Fax: 785-296-2526; e-mail: library@ksdot.org.