MDOT Research Spotlight
Michigan Department of Transportation
Office of Research & Best Practices

Corrosion-Resistant Alloy Steel Extends Life of Bridges

Michigan DOT's Office of Research and Best Practices is continually looking for innovative approaches to tackle Michigan's toughest roadway problems, such as corrosion of steel reinforcement bars in highways and bridges. With this in mind, Michigan DOT researchers engaged in an evaluation of alternatives to traditional steel reinforcement, seeking to extend the service life of bridges and to minimize repair interruptions for Michigan's motorists.

Problem

Deicing materials keep Michigan's roadways drivable in the winter months, but the chloride ions will inevitably find their way to the steel reinforcing bars and contribute to the slow and certain deterioration of the steel. Corrosion converts steel into rust, a substance that occupies three to six times the volume of the original steel. It is this increase in volume that ultimately causes the cracking and separation in steel-reinforced concrete structures. Cost of repairs for bridge and highway damage caused by steel corrosion has soared upward of $4 billion a year in the United States.

Approach

To combat this costly trend, state DOTs continue to seek new alternatives to corrosion-prone reinforcing bars. Stainless steel is a highly corrosive-resistant material; unfortunately, its cost also can be prohibitively expensive. Another anti-corrosion technique, epoxy-coated reinforcement, has gained widespread acceptance as a less expensive means of extending the service lives of bridges and structures. Research suggests that by acting as a barrier between the steel and contaminants (moisture and chlorides), this type of treatment can extend the life of a structure to as high as 40 years.

The specialty steel studied in this research is highly resistant to corrosion, making it an excellent building material for bridges and other highway structures.

In order to design bridges with a 75-year service life, as targeted by the American Association of State Highway and Transportation Officials and others, engineers began to look beyond epoxy-coated reinforcement and consider different steel chemistries to combat corrosion. A Michigan DOT research project turned to MMFX steel, a promising carbide-free microcomposite steel produced by MMFX Technologies Corp. This steel claims up to three times the strength of typical carbon steel and five times the resistance to corrosion.

Research

To fully evaluate this specialty steel and make recommendations for Michigan's structures, investigators carried out research in four phases:

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Project Information

Report Name: *Corrosion Resistant Alloy Steel (MMFX) Reinforcing Bar in Bridge Decks*

Start Dates: 2001 - Technical investigation
2003 - FHWA Innovative Bridge Research and Construction project
Report Date: September 2007
Research Report Number: R-1499

Total Cost: $167,000
Cost Sharing: $137,000 from FHWA Innovative Bridge Research and Construction Program

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- The first phase consisted of an extensive literature review. To fully understand the factors involved in corrosion and corrosion mitigation, the investigators studied other states' experiences with using this microcomposite steel in highway structures. Researchers accomplished this by reviewing deployments in Iowa, Florida, Virginia, West Virginia and South Dakota.
- In the second phase, researchers conducted an in-house evaluation by putting the steel through a series of laboratory tests to determine its properties, including yield strength, tensile strength and ductility. Researchers also evaluated corrosion resistance over a simulated nine-year period by submerging concrete-encased steel in a corrosion tank.
- In the third phase, investigators reviewed the 2003 demonstration project Innovative Bridge Research and Construction, sponsored by the Federal Highway Administration (FHWA), featuring the use of this steel for reinforcement. This study highlighted differences in the frequency of repairs for bridges constructed using coated versus uncoated steel.
- The final phase consisted of a thorough economic analysis of this steel as compared to epoxy-coated steel.

Results

Researchers agreed that previous studies and implementations demonstrate that this specialty steel exhibits greater corrosion resistance, greater strength and a lower life-cycle cost than epoxy-coated steel. Additionally, through an in-depth analysis of the steel's performance and cost, investigators calculated that it provides an estimated 12 years of additional service life compared with epoxy-coated, with only a marginal difference in cost: approximately $12 per square yard of bridge deck surface.

Researchers also identified the types of structures that best suited this steel as a building material based on code-related issues. For example, its significantly higher yield and tensile strengths make it suitable for only certain designs. A detailed action plan in the final report spells out recommendations for further implementation, performance monitoring and the addition of this material into the Michigan DOT Special Provision for Microcomposite Steel Reinforcement.

> *"For highly congested urban areas where reducing the need for bridge reconstruction can be a major savings for the agency and motorists alike, microcomposite steel is worth the investment."*
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> *Steve Kahl, P.E.*
> *Project Manager*

Value

Michigan's economy depends on functioning roadways and bridges, and the direct costs of repair and maintenance are only part of the equation: FHWA finds that indirect costs to the user due to traffic delays and lost productivity can be an order of magnitude greater than direct repair and maintenance costs. Given the importance of building long-lasting bridges, the initial added cost of construction with MMFX steel, where appropriate, can be quickly offset by increased bridge service life. This will provide long-term savings to the state and its travelers. ■

Michigan Department of Transportation

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