Stainless rebar keeps traffic flowing

Whether on local streets or major highways, bridges are crucial transportation links – crossing roads, canyons or vast expanses of water. Closing them for repairs causes lengthy delays, time- and fuel-consuming detours and loss of productivity. It is therefore imperative for traffic flow to keep bridges in good condition. Durable molybdenum-containing stainless steel reinforcing bar is increasingly used to extend the service life of new and refurbished bridges, reducing the need for repairs and improving infrastructure investments.

Bridges naturally deteriorate as a consequence of age and heavy use, but climate is also a significant factor. This is particularly true in coastal regions where seawater is present in the atmosphere and in regions with long, snowy winters that require regular use of deicing salts. Both can spell trouble for bridges because both environments contain chlorides which greatly accelerate corrosion of the carbon steel commonly used for bridge components.

In reinforced-concrete bridges, chlorides can migrate over time through pores and cracks in the concrete covering to attack the embedded carbon steel reinforcing bars (rebars). The resulting corrosion product (iron oxide, or rust) needs more space than the original steel and consequently exerts pressure on the surrounding concrete. The pressure causes more cracks in the concrete to form, facilitating more chloride migration to the rebar. This vicious cycle accelerates the rate of deterioration and can threaten structural integrity if left unchecked. Needless to say, a bridge with corroded structural components is extremely dangerous!

North America

In 2002, the U.S. Federal Highway Administration (FHWA) found that of the 583,000 bridges in the U.S., approximately 15% were "structurally deficient" due to corrosion[1]. The report estimated the annual direct cost of corrosion to replace, repair and maintain these bridges at 8.3 billion dollars. Worse yet, it estimated the "indirect cost to the user, such as traffic delays and lost productivity…to be as high as 10 times that of the direct corrosion costs."

The FHWA report led to a large number of bridge replacement and rehabilitation projects across the U.S. In order to overcome the carbon steel rebar corrosion problem, the FHWA and several states approved the use of solid, corrosion-resistant stainless steel rebar, particularly for decks, barrier walls and support piers. As a result, over 100 U.S. bridges have now been built or rehabilitated with stainless steel rebar.

Because Canada experiences winters similar to the U.S. "snow belt" with extensive use of deicing salts and because it has bridges near the Pacific and Atlantic oceans, its infrastructure faces similar challenges. In 2004, the Ministry of Transportation in Canada's most populous province, Ontario (MTO), tested various rebar materials including galvanized and epoxy-coated carbon steel rebar and collected in-service data on their performance. Based on this data and on life cycle cost considerations, the MTO issued a memorandum requiring designers and engineers to use stainless steel rebar for bridges with very high traffic volumes. The reason was that replacement or major rehabilitation of bridges with average daily traffic of 100,000 vehicles or more would cause unacceptable traffic disruption[2]. The memorandum recommended Type 316LN austenitic stainless steel with 2–3% molybdenum and 2205 duplex stainless steel with 2.5–3.5% molybdenum as rebar materials.

Since then, scores of bridges on strategic roads and major highways have been replaced or rehabilitated in Ontario using these superior rebar materials. One example is the widening and re-decking of the Hurdman Bridge, which carries traffic on the busy Highway 417 over the Rideau River in the Canadian capital of Ottawa. Since the spring of 2014, new deck and barrier walls have been assembled in stages using 320 tonnes of 2205 duplex stainless steel rebar. Additionally, a large quantity of Type 316 stainless steel tie-wire was used to hold the rebar together prior to pouring the concrete. Because the deck was built in stages, hundreds of stainless steel couplers were needed to connect the rebar in the adjoining deck sections. Amazingly, all this work required only a restriction of traffic flow, rather than a full bridge closure.

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1 "Corrosion costs and preventive strategies in the United States," FHWA-RD-01-156 (2002) National Technical Information Service. Springfield, VA. USA.

2 Bridge Office Design Bulletin, "Corrosion protection guidelines for concrete bridge components." Memorandum, January 16, 2004. MTO Bridge Office. St. Catharines, Ontario. Canada.

Stainless steel rebar installation on the Hurdman Bridge in Ottawa. The work is done in stages so that some traffic can continue to flow across the bridge as seen in the background of the picture. © Frank Smith

A global trend

Stainless steel rebar use for bridges and other concrete structures is not limited to North America, but is growing around the world. In Asia, Hong Kong's Shenzhen Western Corridor Bridge used some 1300 tonnes of 2205 duplex stainless steel in the supports of its 3.8 km roadway. In Morocco, North Africa, the Casablanca Hassan II Mosque was in danger of crumbling into the ocean after only ten years of exposure to the waves. Originally built with carbon steel rebar, it underwent major restorations to replace structural slabs and pillars using high-performance concrete reinforced with 2205 duplex stainless steel (see the July, 2009 issue of MolyReview).

Stainless steel rebar remains strong and ductile in both frigid winter and sweltering summer, and it requires no special coating, cathodic protection or concrete sealer. Although the total construction cost may increase 1–10% when substituting stainless steel for carbon steel, this initial investment buys greatly reduced maintenance costs and greatly increased service life (projected at 75–100 or even 120 years for bridges). Several bridges have been built with a cost increase of only 1–3%. The cost savings achievable over the lifespan of the bridge make stainless steel rebar the obvious choice.

Stainless steel rebar is versatile and useful in many other applications. The added corrosion resistance and excellent durability of molybdenum-containing grades make them strong competitors for any application that demands reliable performance with minimum upkeep. Parking garages, retaining walls, tunnels, airport taxiways, and sea walls are just a few examples of structures that rely on stainless steel rebar. No matter where you go, stainless steel rebar will help to get you there safely, and maybe even on time! (Frank Smith)