LAKE VILLA, ILL. MIGHT NOT BE A PARTICULARLY WELL-KNOWN TOWN, BUT IT IS SIGNIFICANT IN TERMS OF STEEL INNOVATION. The Chicago suburb is home to only the second bridge using a new high-performance ASTM A710 Grade B steel, and the first to use it for main load-carrying members.

The North Milwaukee Avenue bridge carries auto and truck traffic on Illinois Route 83 over the Canadian National Railroad tracks in Lake Villa. The bridge it replaces was originally built in 1930 and was widened in 1964, and again in 1971, to accommodate more traffic; the former structure was removed in stages during construction to permit continued traffic flow.

Completed in October 2006, the new bridge has a continuous span length of 430.6 ft back-to-back of the abutments, where it rests on elastomeric bearings. The span is supported by only two new piers, replacing eight old ones, and there are two new abutments using 12-in.-diameter metal shell piles as foundations. The bridge’s overall width between its outer parapet edges is 58 ft. There are two auto lanes, each 15 ft wide, along with a 12-ft central median, and 7-ft-wide sidewalks on both sides of the bridge. The line perpendicular to the center line of the bridge is skewed 70° with respect to the railroad track lines.

Ten plate-girder lines support the 7.5-in.-thick reinforced concrete deck. The plate girders, made composite by use of welded steel studs with the deck, have a nominal depth of 4 ft, with girder center lines spaced 5.75 ft apart. Each girder consists of an ASTM A710 Grade B ½-in.-thick web plate, with 1.125-in. by 16-in. lower flanges, and 0.875-in. by 16-in. upper flanges in the composite areas. In sections over piers, where the girders are non-composite, the upper and lower flanges are 1.875-in. by 16-in. The bearing stiffeners are ¾-in. by 7-in. by 48-in. and milled to bear on the flanges at piers and abutments. The web-to-flange welds are ⅛-in. fillets, with ¼-in. fillets on the stiffeners. Since ASTM A710 Grade B high-performance steel is not yet available in rolled shapes, ASTM A588 weathering steel was used as a substitute for the W16x36 diaphragms.

Composing a New Breed of Steel

The girders, made from new weathering ASTM A710 Grade B copper alloy precipitation-strengthened steel, are in the hot-rolled and air-cooled condition. This new breed of steel was developed and thoroughly investigated at Northwestern University with assistance from S. Bhat, Ph.D., of Inland Steel Company (now Mittal USA). Since no heat treatment after hot-rolling or thermomechanical-controlled processing is required, it can be produced by any steel company in any plate length. The first use of this new steel, produced by Oregon Steel Mills, was used to seismically retrofit the approaches of the Poplar Street Bridge over the Mississippi River, near St. Louis, Mo., in 2000. The new North Milwaukee Ave. Bridge in Lake Villa is the first bridge to use this steel for main-load-carrying members and only the second use of the steel anywhere.

Breaking it down, the steel has a virtually ferritic microstructure, because the carbon content is very low. Alloying elements, such as chromium and molybdenum, frequently used in martensitic alloy steels, are not added and are limited to residual levels found in steel scrap. A limited amount of nickel (0.9 percent) is added to prevent hot-shortness during hot-rolling. Columbium (0.05 percent) and titanium (0.03 percent) are added to control grain size during hot-rolling and welding. Due to its low carbon content and limits on alloying elements that decrease the weldability of steels, A710 Grade B has the lowest carbon equivalent among high-performance steels. When used for bridge construction, it demonstrated outstanding weldability.

The strength of this high-performance steel is derived from nano-sized copper-alloy precipitates that are formed during air-cooling after hot-rolling (Figure 1). A710 Grade B has a yield strength of 70 ksi or...
The 1/8-in.- to 1/4-in.-thick steel plates for the bridge were produced by International Steel Group (now Mittal Steel USA) in Coatesville, Pa, by hot-rolling and aircooling. The chemical composition of this steel is provided in the table below. The yield strengths of the plates were in the 72 to 90 ksi range, and the ultimate tensile strengths ranged from 82 to 102 ksi, with elongation to fracture over 25 percent. The Charpy V-notch impact energies for most of the plates were over 100 ft-lb at -10 °F, significantly exceeding the 35 ft-lb required for ASTM A709 HPS 70W steel for Zone 2 for fracture-critical locations (Figure 3).

Welding the Girders

When it comes to welding A710 Grade B steel, submerged-arc welding (SAW) is recommended, since flux-core welding without cover gas might lead to lower toughness of weld deposits. Flux-core-arc welds (FCAW) joining A710 Grade B without argon/CO₂ cover gas and appreciable nickel contents (0.4 percent or more) typically have only about 25 percent of the toughness of A710 Grade B. The lower toughness of FCAW is attributed to the higher hydrogen contents associated with flux-core wire, particularly if selfshielded, as compared to the better shielding characteristics of dry flux with SAW, or the moisture-free cover gases used with gas-metal arc welding (GMAW). All specified SAW and GMAW electrodes should contain at least 0.5 to 0.8 percent nickel in their weld deposit chemistry in order to obtain excellent low-temperature toughness when welding A710 Grade B.

An Economical Paint Job

The girders for the bridge were not painted, resulting in a significant cost savings of about $300,000. Un painted steel
girders permit easier handling during assembly, while painted girders require special handling to prevent coating damage. And since repainting will not be required, future maintenance costs will also be reduced.

**All the Right Reasons**

The construction of the North Milwaukee Ave. bridge clearly demonstrates the advantages of A710 Grade B steel: outstanding mechanical properties, fracture toughness, good weldability, and superior weathering characteristics. It can be produced economically by any steel mill in any plate length, because it does not require heat treatment or controlled hot-rolling and cooling.

Whether they realize it or not, motorists driving over the bridge are relying on a new, yet stable and economical, material to support them on their journey.

_Vaynman is a research professor and Fine is a professor, both with Northwestern University. Habin is an engineer of structural materials with the Bureau of Materials & Physical Research. Biondolillo is a resident engineer, District One, Bureau of Construction, with the Illinois Department of Transportation. Crosby is chief engineer of Industrial Steel Construction._

**Owner**

Illinois Department of Transportation, District 1, Schaumburg, Ill.

**Designer**

Graef, Anhalt, Schloemer and Associates, Chicago

**Steel Producer**

Mittal Steel USA, Coatesville, Pa. (AISC member)

**Fabricator**

Industrial Steel Construction, Gary, Ind. (AISC member)

**General Contractor**

Dunnet Bay Co., Glendale Heights, Ill.

**Photos and Illustrations**

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