Weathering Steel for Bridges

Corrosion Protection without Coating

By Brian Kozy, Ph.D., P.E. & Lou Triandafilou, P.E.

Weathering steels are high strength, low alloy steels that can provide corrosion protection without additional coating. Increase in alloying elements, primarily copper, provides an arresting mechanism to atmospheric corrosion in the material itself. This resistance is due to the fact that this steel will develop a durable, tightly adherent protective surface patina comprised of corrosion by-products that act as a skin to protect the steel substrate. Section loss on the order of 100 mils (0.01 inches) may be expected before the patina sets up, but this is negligible to the structural performance.

The material was developed in the 1930s for use in coal hopper train cars to resist the corrosive effects of the sulfur in coal and exposure to long periods of rain. Experience at the time found that conventional steel was corroding in relatively short periods of time. What sets the material apart from conventional steel is in the chemistry. Weathering steel will have a minimum copper content of at least 0.20 percent, whereas conventional carbon steels have a copper content of less than .02 percent. The new generation of high performance steel (HPS) also provides weathering performance, with a slightly greater resistance to atmospheric corrosion than its predecessors.

When properly applied, the use of weathering steel has provided cost effective, low maintenance bridges. The material was first utilized on a bridge project in Morristown, NJ for the NJ Turnpike in 1964. It has been shown that several costs can be avoided by NOT painting. The time involved to shop apply some of the multi-coat systems can be considerable. In today's market place, where speed of construction is becoming so important, the curing time between coats is 'lost' time. Material sitting on the shop floor curing takes space that could otherwise be utilized to fabricate the next girder, which instead has to wait.

Although weathering grade steel material costs approximately 3-4 cents more per pound than comparable carbon steel, these costs are more than offset by lower fabrication costs, elimination of a shop coat of paint, and at least one cycle of field repainting in most cases. This translates into lower maintenance and life cycle costs, which reduces impact to the traveling public. The owner also gains a bridge with a natural appearance that blends with the environment and is highly sustainable. With these advantages in mind, approximately 40-45% of all steel bridges are being built with some form of weathering steel.

Along with the benefits, there are cautions which bridge owners need to consider when deciding to use uncoated weathering steel. Guidance with regard to proper environment, location, design details and maintenance is summarized in the Federal Highway Administration's (FHWA) Technical Advisory 5140.22, dated October 3, 1989.

Bridge owners have learned through experience that there are some site conditions not appropriate for weathering steel. These include areas subject to salt water spray or salt laden fog, areas of prolonged wetness where the steel is not allowed to dry, and industrial areas (particularly where sulfur exists). These areas can be evaluated in more depth by ASTM Test G92 *Characterization of Atmospheric Test Sites*, *Wet Candle Method,* and ASTM Test G84 *Time of Wetness Determination*, or by consulting a corrosion specialist.

Grade separations with low clearances and tunnel- like conditions may permit road spray, which is highly salt-contaminated, to accumulate on the superstructure. Low-level crossings over water (8 feet over moving and 10 feet over stagnant) may also create a corrosive atmosphere.

Proper drainage control details are designed to protect the steel girders from deck runoff. These include minimizing the use of deck expansion joints but use of drainage troughs where large movement joints are required; minimizing the use of scuppers; painting girder ends (5 to 10 feet); use of drip bars; eliminating debris traps; and, covering openings in boxes.

Guidance is also provided by FHWA to implement maintenance procedures to detect and minimize advanced corrosion. Owners have implemented such practices as controlling roadway drainage; regularly removing debris that traps moisture; and, regularly removing vegetation which prevents natural drying of the steel.

FHWA is making an effort to develop a deeper understanding of weathering steel bridge performance and to provide more detailed guidance on proper application. Research is underway involving 3D numerical simulations of truck passage events at bridges using Computational Fluid Dynamics (CFD) to quantify the amount of salt spray that is deposited on the girders and how this might be influenced by various geometric parameters. Also, FHWA has plans to perform a national study of weathering steel bridge performance in various micro and macro environments. These efforts will provide data for improving the guidance by better definition of "tunnel like conditions" and/or "coastal environments" to name a few.

In conclusion, uncoated weathering steel bridges have generally performed well when they have been designed and maintained in accordance with the guidance outlined above. Weathering steel can offer improved economy and life-cycle cost and aesthetics, and should be considered whenever possible.▪

Brian Kozy, Ph.D., P.E. is a Senior Bridge Engineer (Steel Specialist) for FHWA in Washington, D.C. Dr. Kozy leads the national Steel Bridge Program. He can be reached at ***brian.kozy@dot.gov****.*

Louis N. Triandafilou, P.E. is the Team Leader for the Bridge and Foundation Engineering Team, Office of Infrastructure Research & Development, FHWA Turner Fairbank Highway Research Center in McLean, VA. This Team is responsible for carrying out research on innovative applications of structural concrete, structural steel and geotechnologies.