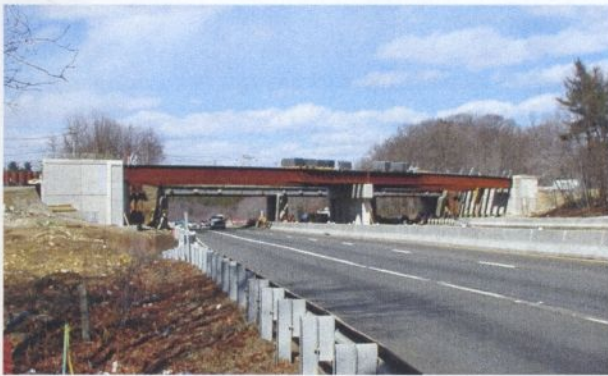




## HIGH PERFORMANCE STEEL SCORES BIG

### With Massachusetts Highway Department's Route 3 North - Design/Build Project

The Route 3 North Transportation Improvements Project is the Massachusetts Highway Department's first design/build project and its first use of Grade 485W (70 ksi) High Performance Steel (HPS). The project consists of widening 39 kilometers (21 miles) of limited access highway from two to three lanes, adding a shoulder, and replacing 45 bridges. There are 13 interchanges along the corridor and each one will be reconstructed. Located in Middlesex County, Massachusetts, the roadway serves as a link between New Hampshire and Interstate 95 in Massachusetts and is lined with many technology-related companies. Traffic studies conducted in the 1990's analyzed current and future traffic trends that led to the recommendation to widen the roadway from two to three lanes.



Because of the need to immediately address the severe traffic problems that have existed for years, MassHighway opted for a design/build project to expedite design and construction. Additionally, MassHighway added a 30-year own and maintain component to the project. The project was advertised in 1999 and called for a 42-month design/build schedule. The winning bid, \$385 million for construction and approximately \$150 million for operating and maintaining the highway for thirty years, was submitted by The Modern Continental Team which consists of Modern Continental Construction Company and URS Corporation as the design engineer. The development agreement was signed on August 17, 2000 and construction is scheduled for substantial completion on February 17<sup>th</sup> 2004.

The development agreement required that the bridges be designed to support MS 22.5 (HS25) loading modified for military loading and a 75-year design life. The bridge

clearance for both mainline and local streets was set at 5.0 meters (16.4 feet). The superstructure was designed based on the Allowable Stress method. The substructure was designed per Load Factor Design. The 75-year design life required that the project team look at high performance materials such as Grade 485 High Performance Steel to provide an edge in durability and reduced maintenance costs. For the bridge decks, High Performance Concrete (35 kPa (5,000 psi) silica fume modified concrete) with a 20 mm (13/16') integral wearing surface was used. A 50-mm (2") future wearing surface was incorporated into the design to allow for a future bituminous concrete overlay.

The design is also based on MassHighway's new Bridge Manual, which calls for all bridges to be constructed with either integral or semi-integral abutments. The bearings consisted of elastomeric pads and no anchor bolts. Where expansion joints were used, they were either asphaltic plug joints or silicone joints. All of these features are part of the new Bridge Manual which was designed, in part, to address previous maintenance issues common in most bridges.

There are a total of 45 bridges in the project. Of those, 41 are steel girder bridges. The remaining bridges are smaller structures (5 to 10 meters) and are being replaced with pre-cast concrete arch structures, concrete box culverts or corrugated metal pipe arches. The bridges carrying Route 3 are single spans and vary in length from 12 to 60 meters (39 to 197 feet). Of the thirteen bridges that cross Route 3, eleven are two-span and two are four-span structures and vary in total length from 48 to 110 meters (158 to 360 feet). Four of the bridges over Route 3 have curved girders.



In determining the superstructure type, the design team looked at pre-cast concrete sections versus steel plate girders. Comparison studies were done during the

proposal phase comparing a pre-cast concrete alternate consisting of New England Bulb-Tees with Grade 385W (50 ksi) steel girders. At the time of the proposal, High Performance Steel was relatively new to the market and not considered. After the project was awarded to the Modern Continental Team however, the designers went back and looked at the use of high performance steel and its potential cost savings. Comparison designs were developed based on all Grade 345W steel and compared to a mixed/hybrid girder designs that utilized Grade 485W on the bottom flange in the positive regions for both simple and continuous span and Grade 485W on the top and bottom flange over the piers. High Performance Steel provided the biggest savings over the bridge piers, as deflection is not a controlling issue. The steel weight produced by using HPS versus conventional Grade 345W is approximately 12% for simple spans and 11% for continuous spans. This reduction in steel was enough to offset the premium paid for HPS.



The premium paid for HPS steel over conventional Grade 345W is approximately 7 cents per kilogram (15 cents per pound). Incorporating High Performance Steel into the girder designs provided cost savings of approximately 3.5% over conventional steel. Other benefits that steel provided versus the concrete alternative included:

**Weight:** The steel girder designs weighed approximately one-third less than a bulb tee section. The reduced superstructure weight reduced the loads on substructure elements allowing for spread footings at some locations where a heavier superstructure would have required a pile foundation. Other factors were transportation costs and "pick" weights. Heavier bulb-tee sections would require the use of larger cranes and more extensive rigging.

**Superstructure Depths:** The vertical clearance for the existing bridges is approximately 4.5 meters. With the proposed 5.0-meter clearance and span lengths of the new bridges longer than the existing ones, the roadway profiles were increased approximately 1.0 meter (3.3 feet). Because bulb tees have a deep section, the profile increase would have been greater. The profiles were raised for all the structures spanning over Route 3, placing

the bridge at the crest of a vertical curve. The steel plate girders more easily incorporate the vertical curve effects into the girder and camber than could pre-cast beams.

**Cost:** After reviewing the design schedule and factoring in materials, transportation, erection and roadway alignment issues it was determined that steel was the most economical in overall cost. The table below compares the total weight in metric tons for both the 485W HPS/345W and the 345W alternatives studied.

Bridge Type	Total wt. 485W/345W	Total wt. 345 W	Cost Savings
Multi-span	4,694 tons	5,308 tons	3.9%
Single-span	3,595 tons	4,041 tons	3.3%

Deflection criteria controlled the design of the single-span bridges as well as the positive moment regions of continuous span structures. As noted previously, the bridge superstructure was designed based on Allowable Stress Design that requires bridges be designed to a deflection criteria of 1/800. Deflection criteria coupled with premium in costs limit the benefits that Grade 485W HPS can provide.

One way to increase the cost savings is by designing per AASHTO's LRFD Bridge Design Specifications. The LRFD specification views deflection criteria as optional and takes a more relaxed stance. Deflection criterion could be reduced from AASHTO's Standard Specifications and varied based on the roadway's functional classification, design speed and ADT.

When completed in February 2004, MassHighway will have its first bridges constructed with High Performance Steel. It is expected that these bridges will provide the mandated life expectancy of 75-years based on the materials used and the elimination of steel joints and bearings.

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**Developer: Modern Continental Construction**



**Design Engineer: URS Corporation**

