ArcelorMittal USA

Plate

HPS 70W: High Strength Steels for Bridges

New York Thruway Bridge

Background

New high performance steels (HPS) are being developed through a cooperative agreement between the Federal Highway Administration (FHWA), the American Iron and Steel Institute (AISI), and the Department of the Navy. The efforts are coordinated by the High Performance Steel Steering Committee. The first of these steels is ASTM A709 Grade HPS 70W (HPS 485W), known simply as HPS 70W.

HPS 70W is defined as steel plate that has:

- A minimum yield strength of 70 ksi (485 MPa)
- High levels of fracture toughness (zone 3 minimum)
- Reduced preheat requirements for welding
- Improved weathering properties per ASTM G101

This steel is an improved version of an older and discontinued grade – A709 Grade 70W.

Advantages

The combination of the higher yield strength, weathering properties and reduced preheat requirements can result in significant cost savings – both short and long term – for bridge owners. For bridge replacements, HPS 70W's higher strength level should result in lighter superstructures and the use of shallower girders that may permit bridge designers to reuse the existing substructure elements.

Availability

Lengths to 50 ft. (15 m), widths to 195 in. (4.95 m) and thicknesses to 4 in. (100 mm) – based on quenched and tempered (Q&T) material from ArcelorMittal USA plate facilities at Burns Harbor and Gary, In., Coatesville or Conshohocken, Pa. ArcelorMittal USA has developed the capability on the Burns Harbor 160" Plate Mill to produce "as-rolled", or thermomechanical controlled processed (TMCP) HPS 70W plates up to 1.375 in. (35 mm) thick, 120 in. (3 m) wide and 600-1500 in. (38.1 m) long. This ability to produce HPS 70W "on-line" removes the Q&T 50 ft. (15 m) length limitation, speeds up delivery and reduces costs. For more information on ArcelorMittal USA TMCP plate, see below. A709 A709/A709M-06 permits the production of HPS 70W plates by Q&T or TMCP. AASHTO M270-02 also allows the use of TMCP.

Tensile Requirements

Yield strength (minimum)	70 Ksi (485 MPa)
Tensile strength	85-110 Ksi (585-760 MPa)
Elongation in 2” (50 mm) minimum	19%

Charpy V-Notch Impact Toughness Requirements (FCM - Fracture Critical Member)

Non FCM	25 ft-lbs. Min. @ -10°F (34 J @ -23°C) (all Zones)
FCM	35 ft-lbs. Min. @ -10°F (48 J @ -23°C) (all Zones)

Chemical Composition Requirements

Element	Composition %
Carbon (C)	0.11 Max.
Manganese (Mn)	** 1.10 - 1.35
Phosphorus (P)	0.020 Max.
Sulfur (S)	* 0.006 Max.
Silicon (Si)	0.30 – 0.50
Copper (Cu)	0.25 – 0.40
Nickel (Ni)	0.25 – 0.40
Chromium (Cr)	0.45 – 0.70
Molybdenum (Mo)	0.02 – 0.08
Vanadium (V)	0.04 – 0.08
Aluminum (Al)	0.01 – 0.04
Nitrogen (N)	0.015 Max.

* *All HPS 70W is calcium treated for sulfide shape control*

** *For plates over 2.5 inches (65 mm) in thickness, the Mn maximum is 1.50%.*

Properties

Over a hundred thousand tons of HPS 70W steel has been used in bridge fabrication. The mechanical properties for 240 Q&T plates ranging in thicknesses from 0.5 to 3.1 in. (13-80 mm) are summarized in Figures 1-3. The excellent Charpy V-Notch impact properties are demonstrated in Figure 3. Furthermore, the calculated weathering index of HPS 70W for 64 production heats is shown in Figure 4. The goal of HPS 70W is to meet a minimum 6.5 weathering index according to G101. A minimum index of 6.0 is considered by G101 to provide an acceptable level of atmospheric corrosion resistance.

Figure 1: Production Results A709 HPS 70W Tensile Property Data

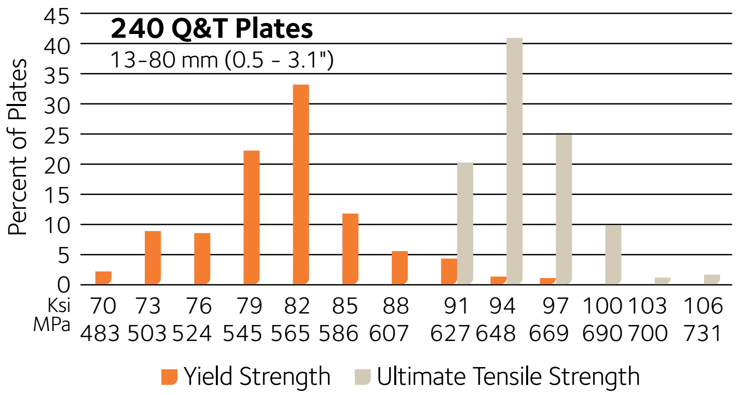


Figure 2: Production Results A709 HPS 70W Yield/Tensile Ratio

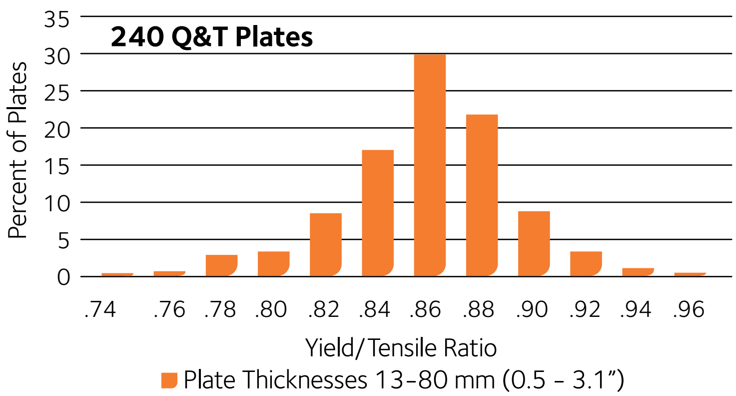


Figure 3: Production Results A709 HPS 70W CVN Impact Data @ -23C (-10F)

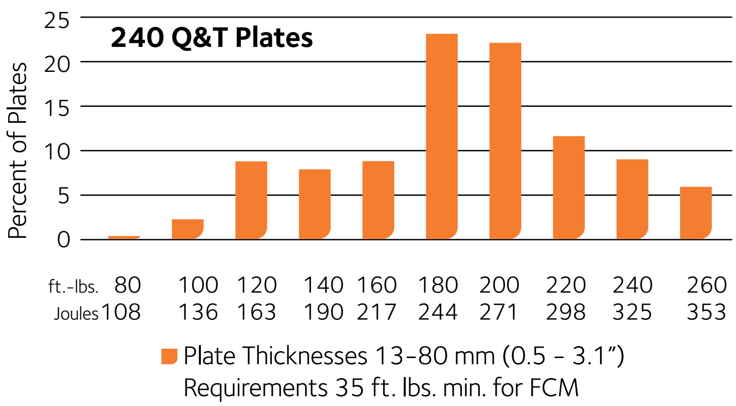
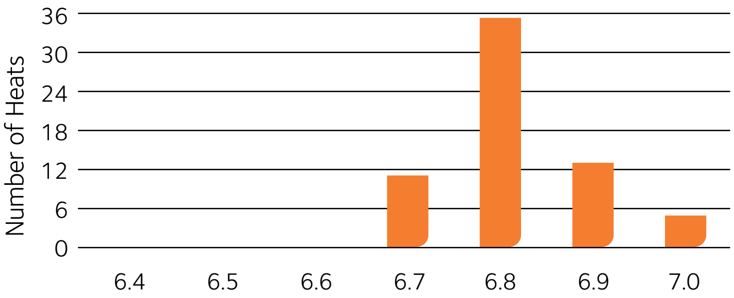


Figure 4: ASTM G101 Weathering Index 64 Heats of HPS 485W (70W)



6.0 min. for normal weathering steel
6.5 min. for HPS

A comparison of TMCP and Q&T properties over the same thickness range from the Burns Harbor Mill is given below. Very similar average and standard deviations are demonstrated.

Comparing Q&T and TMCP HPS 70W – 0.5 – 2" thick*

	No.	YS ksi	s.d.	UTS ksi	s.d.	LCVN @-25F, ft-lb.	s.d.
TMCP	1365	78.6	4.8	96.0	5.3	129	45
Q&T	424	83.9	6.2	95.9	3.9	141	43

** Burns Harbor 160" Plate Mill*

Fabrication Guidelines

A Guide for Highway Bridge Fabrication with HPS 70W Steel was adopted by AASHTO in May, 1999 and an updated second edition approved in June, 2003. The first edition (HBF-1) should be used with ANSI/AASHTO/AWS D1.5-95 and is available from the AASHTO Bookstore at www.aashto.org The second edition is available at www.steel.org.

The suggested welding practices should be taken from this guide. The improved weldability of this grade is demonstrated by the comparison below to the original grade 70W. There has been found to be no significant difference in weldability between Q&T and TMCP processed HPS 70W, principally because they have the identical chemistry.

Current Welding Guidelines for HPS 70W

- **Minimum Preheat and Interpass Temp., °F (°C)**
- **Submerged Arc Welding with H4 Hydrogen Control Level with pre-qualified consumables**

Thickness of Thickest Part at Point of Welding of A709

A709 Grade	To 3/4" (19mm) Incl.	Over 3/4" (19mm) to 1-1/2" (38mm) Incl.	Over 1-1/2" (38mm) to 2-1/2" (64mm) Incl.	Over 2-1/2" (64mm)
HPS 70W (485W)	50 (10)	70 (21)	70 (21	125 (52)
70W (485W)	50 (10)	125 (52)	175 (79)	225 (107)

- maximum interpass temperature 450°F (232°C)
- heat input 40 - 90 KJ/in. (1.6 - 3.5 KJ/mm)

Product Development

HPS 70W in both Q&T and TMCP conditions is now being widely used in bridge construction. ASTM A709-05, also offers a grade HPS 50W, which has the identical chemistry as HPS 70W. HPS 50W also meets Zone 3 toughness criteria for 50 ksi yield strength grades and can be welded using the guidelines for traditional 50W. The HPS Steering Committee has also developed a Q&T Cu-Ni alloy, HPS 100W grade with improved toughness and weldability, which appears in A709-05. Separate ArcelorMittal USA plate brochures for both HPS 50W and HPS 100W are available on the ArcelorMittal USA website at www.arcelormittal.com.

Specification Coverage

ASTM A709/A709M-07 and more recent versions: Standard specification for Structural Steel Plates for Bridges. AASHTO M270-07 has added all three HPS grades, but generally lags ASTM A709 by a year for most current changes.

High Performance Steel Projects

Over 43 state departments of transportation (DOT) and other owner agencies have used or are designing bridges with HPS 70W plates. There are over 250 bridges using HPS 70W opened to traffic with many others in various stages of production. Some of the first to use this grade include departments of transportation (DOT) and highway departments from the states of Tennessee, Nebraska, New York, Massachusetts, North Carolina, Pennsylvania, Virginia, Utah, Colorado, New Jersey, Missouri, Iowa, Illinois, West Virginia, Maine, the New York State Thruway Authority and the Pennsylvania Turnpike Commission.

The Tennessee DOT, using HPS 70W plates for a two-span bridge (236 ft. – 236 ft.) in Jackson County, reported weight savings (vs. Grade 50W) of roughly 25 percent. Final cost savings was about 10 percent. A second HPS bridge was built on Route 52 over the Clear Fork River in June, 1997. Due to crane reach limitations, HPS 70W was used to make girder sections as light as possible. This is a 995 ft., four-span structure with a maximum span of 350 ft. Grade HPS 70W was used in the non-composite negative moment field sections and a hybrid section consisting of a 50W compression top flange and web, together with an HPS 70W tension bottom flange in the composite positive moment field sections. A third bridge over the Clinch River was the first use of TMCP HPS 70W.

The University of Nebraska at Lincoln is the principal investigator for Nebraska's three-phase HPS bridge project. Their first HPS 70W bridge was built near Snyder. The second bridge was Dodge Street over I-480 in Omaha, and a third bridge will investigate more innovative uses of the steel.

The New York State Thruway Authority projects involved superstructure replacements for twelve bridges, six of which are overpasses. HPS 70W welded plate girders 29 to 30 in. deep were used over two equal spans of approximately 100 ft. Use of this new steel not only permitted removal of two hazardous shoulder piers, but also resulted in an improved under clearance, as the HPS girders replaced 36 in. deep rolled beams.

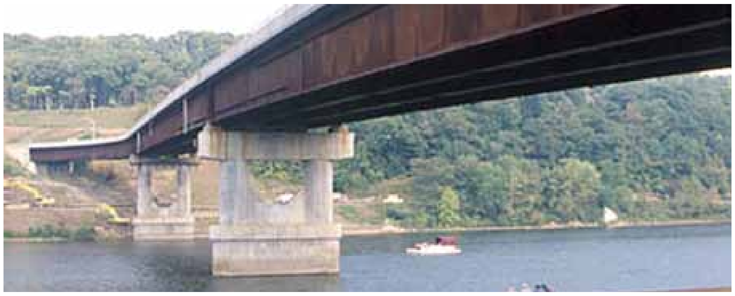
A listing of completed and future HPS projects may be obtained by referring to the HPS Scoreboard located on the AISI website http://www.steel.org/infrastructure/pdfs/HPSScoreboard.xls.

Summary

Valuable experience is being gained through the use of cost-effective HPS 70W steel plate girders on FHWA bridge demonstration projects, as well as owner projects. Availability of TMCP HPS 70W, plus broader mill production and fabrication experience, will lead to significant cost savings for steel bridges.

More information:

Alex Wilson, Coatesville, Pa
+1 610 383 3105 or alex.wilson@arcelormittal.com



Ford City Bridge in Pennsylvania

Clear Fork Creek Bridge in Tennessee

Martin's Creek Bridge in Tennessee

Reference

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ArcelorMittal USA
Corporate Office
1 South Dearborn Street
18th Floor
Chicago, IL 60603-9888
USA

T +1 800 422 9422
www.arcelormittal.com

ArcelorMittal USA
Plate
ARC Building
139 Modena Road
Coatesville, PA 19320-0911
USA

T +1 800 966 5352
www.arcelormittal.com

ArcelorMittal USA
Plate
250 West U.S. Highway 12
Burns Harbor, IN 46304-9745
USA

T +1 800 422 9422
www.arcelormittal.com

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