Steel Bridge Fabrication

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PDH: 3

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1.0 INTRODUCTION

The purpose of this course is to explain the basic concepts of fabricating steel bridge structures. It is intended to serve as a resource for the engineer while preparing the design of the structure and as a reference throughout the life cycle of the bridge. The user of this guide should be familiar with the AASHTO/NSBA Steel Bridge Collaboration documents, S2.1, Steel Bridge Fabrication Guide Specification (1), and G12.1, Guidelines for Constructability (2).

The methods employed in the fabrication of a bridge structure are as variable as the structure itself. The terms and procedures listed in the text are general and do not reflect any single firm's process. Each fabricator has its own way of solving the problems associated with each structure. This course is to serve as a reference document to facilitate fabricator/engineer communication.

2.0 GOVERNING SPECIFICATIONS

American Institute of Steel Construction is the governing body that certifies fabricators. There are multiple levels of certification, from simple bridges to complex bridges with fracture critical endorsements and sophisticated paint endorsements.

AASHTO (American Association of Highway Transportation Officials) adopts specifications that are generally the controlling documents for the design and construction, including tolerances, of steel bridges. These documents include the *AASHTO Standard Specifications for Highway Bridges,* (3), and the *AASHTO LRFD Bridge Design Specifications, 5th Edition* (4) *and the AASHTO LRFD Construction Specifications* (5).

ASTM (American Society of Testing and Materials) documents provide guidelines for acceptability of the material purchased. These guidelines include, among others, dimensional tolerances, chemical compositions and tensile and yield strengths.

The *AASHTO/AWS D1.5* document (6) controls the welding, testing and quality assurance portions of the superstructure including tolerances of fabricated members. This document also contains the Fracture Control Plan for Non-Redundant Members.

SSPC (Society for Protective Coatings) (7) produces documents which apply to the coating and surface preparation of steel superstructures.

Owner Specifications augment and/or supersede the above documents.

AASHTO/NSBA Steel Bridge Collaboration Documents provide beneficial information regarding the state of the art principles for steel bridges.

3.0 MATERIAL PROCUREMENT

3.1 Steel Attributes

3.1.1 ASTM vs. AASHTO

Steels for bridge structures manufactured domestically are generally specified to conform to either ASTM A709 or AASHTO M270. These specifications are generally equivalent and include the composition of the steel and the grades allowed by the specification. Although ASTM A709 is specified more frequently, the owner stipulates which specification to use.

3.1.2 Grades

The names of the grades covered by the ASTM and AASHTO requirements are equivalent to the yield strength of the steel, e.g. Grade 50 indicates that F_y = 50 ksi.

3.1.3 Weathering Steel

Weathering steel has a certain metallurgical composition that permits the steel to form a protective coating and not require additional coatings to prevent corrosion. Material with this composition is appended with a “W”, e.g. Grade 50W indicates that F_y = 50 ksi and it is a weathering steel.

3.1.4 High Performance Steels (HPS)

ASTM A709 HPS50W, HPS70W and HPS100W steels are products that have F_y of 50, 70 or 100 ksi. In addition, these classes of steels have superior toughness properties compared to non-HPS materials.

HPS steels have several detractors that limit the use to specialized situations. HPS steels generally are more expensive than non-HPS steels. HPS steels generally have a longer lead time than non-HPS steels. In addition to these two items, there is a minimum tonnage required for ordering HPS material per thickness. The fabricator may be able to combine tonnages from several projects to obtain the minimum tonnage required for ordering. Because of this requirement, it is generally better to limit the use of HPS material to webs and flanges, and not field splice material or stiffeners. Additionally, HPS material is available only in plates; structural shapes are not available.

3.1.5 Charpy V-Notch (CVN) Testing

Charpy testing is a process to determine a measure of the fracture toughness of the subject steel. Material requiring CVN testing should be noted on the contract documents. The fabricator incurs additional cost to obtain these tests. Material requiring CVN testing shall be so noted on the mill orders and test reports. Noting of CVN testing may be placed on the steel itself. Zone 3 CVN requirements on structural shapes are difficult to achieve with consistency.

3.1.6 Fracture Critical Material (FCM)

Fracture Critical Material is a requirement for certain portions of fracture critical members and must be called out on the contract documents. The steel that conforms to this requirement is of a higher toughness (and cost) than corresponding non-FCM steels.

AASHTO/AWS D1.5 (6) outlines fracture critical material requirements in the Fracture Control Plan (Section 12 in D1.5-2008). The fabricator incurs additional cost due to increased documentation required, more restrictive testing and heating for welding.

3.2 Ordering of Material

3.2.1 Steel Plates

Due to the lead times associated with structural steel, material required for the structure typically must be ordered well in advance of fabrication. These lead times range from a few days to a few months depending upon the grade, thickness and market conditions. Generally, plate material for main members (webs, flanges, etc.) is a custom order from the mill. Fabricators do not inventory raw material. Plate material for stiffeners, gusset plates, etc. will more likely come from a service center.

Plate mills generally roll material in preset widths and thicknesses. The fabricator nests the parts required to fabricate the project (webs, flanges, etc.) on these preset sheet sizes to maximize the use of the material. The fabricator may combine pieces from different projects to best use the material.

3.2.2 Steel Shapes

Structural shapes are rolled on a schedule. This may lead to longer lead times if the order is not placed when the mill is rolling that shape, and the next rolling will not be for a while. Additionally, due to the minimal tonnage of shapes required for secondary members, it is more likely the shapes will be bought from a steel service center.

Minimizing the number of different steel grades, thicknesses and structural shapes on a project is the most cost-effective.

3.3 Material Traceability

All material for steel bridges must be marked with the grade, specification, and heat number as a minimum. The material will arrive from the mill with the heat numbers stenciled on the plate. Chemical composition and testing results are recorded by heat number. These are two main criteria that are reviewed by the owner’s representatives. The fabricator needs to record this heat number and the piece it is consumed into so each component of the bridge can be traced back to the heat it was produced from. The heat numbers must remain traceable throughout the fabrication process.

4.0 QUALITY CONTROL/ASSURANCE

4.1 Role of QC/QA Staff of Fabricator

Generally, all work completed by the fabricator is inspected and signed off in process by the fabricator's Quality Control (QC) department. The QC department documents information needed during fabrication, assembly, painting and shipment. This includes material test reports (MTR). They also will serve as liaison between the owner's representative and the fabrication group.

4.1.1 Non-Destructive Weld Testing (NDT)

Certain welds on bridge superstructures are required to be tested for weld soundness and quality. There are several methods of testing with the following being the most prevalent. AWS D1.5 and owner specifications stipulate which welds need to be tested and the method that is to be used.

4.2 Radiographic Testing (RT)

RT is essentially an X-ray of the welded joint. RT is capable of detecting embedded flaws and is generally used for butt splices in webs and flanges. RT is not used for corner and T-joint complete joint penetration (CJP) welds due to the inability to get an accurate radiograph of the joint.

Due to the radiation used for this test, metal shielding and a clear space around the testing environment are necessary for safety. Figure 1 shows the shielding apparatus required for this testing method. Qualified personnel are mandatory to administer the inspection. Where other options are available, this method is not preferred due to these issues which increase cost and duration.

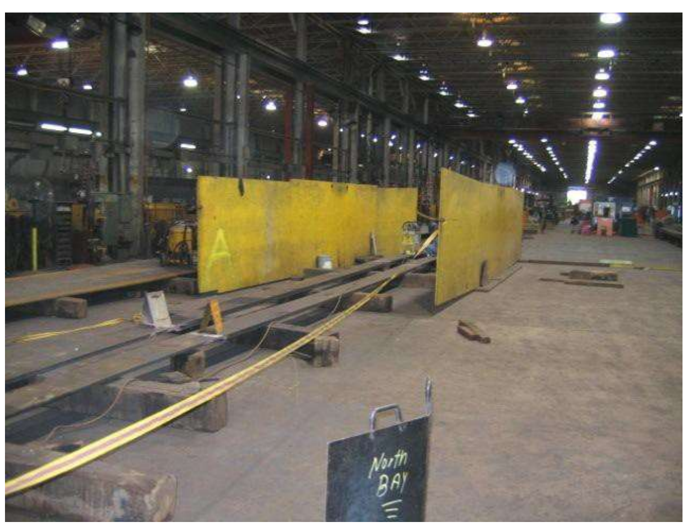

Figure 1 Photo showing the radiographic testing (RT) of a complete joint penetration weld (CJP) with clear area and shielding provided