

ENHANCING STEEL BRIDGES

A series of NSBA focus groups brings to light methods to improve the cost, speed and quality of steel bridges



By Andy Johnson and
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Of critical importance to designers and owners alike is the question of how to enhance steel bridge design. Recently, the National Steel Bridge Alliance (NSBA) formed "brain storming" groups in New Jersey, California and Florida to help answer this question.

Each focus group consisted of design, construction and maintenance representatives from each DOT, steel fabricators, designers, contractors, erectors and steel producers. What follows is a compilation of the results from all three half-day sessions.

Interestingly, many of the individual points affect more than one of the key factors (cost,

speed and quality). In fact, it turns out that when a characteristic of a bridge is changed to improve one of the factors, it is likely that one of the other factors will be affected in a positive way. For example, anything that improves the speed of any phase of steel bridge construction should lower the cost: Time is money. Likewise, simplifying fabrication and/or construction details will lower cost and may also improve quality—both initial quality as the bridge will be easier to build and also long-term quality as the bridge will be easier to maintain.

GENERAL SUGGESTIONS

One of the easiest ways to improve details on a project is to involve the fabricator and/or NSBA early in the design phase. Making changes after the project is already designed is generally difficult and costly.

Along similar lines, there should be a series of "partnering" meetings during the course of a project to resolve issues regarding Requests for Information (RFI's), communication, shop drawings and other details, both technical and contractual. Finally, on significant projects, there should be a post-construction meeting to critique the process, performance and results. These meetings should involve owner, contractor, designer, fabricator and erector alike.

In the words of one participant: "When a plane crashes we don't say, O.K., Let's move on to the next flight." If we are interested in continual improvement of the construction process in order to satisfy the owner and improve construction profitability it makes sense to assemble the team one more time before racing on to the next project. This suggestion seems self-evident but such post-construction meetings are rarely held so we continue to repeat the same actions that threaten the successful outcome of future projects.

DESIGN/DETAILING CONSIDERATIONS

Some of the consultants believed that steel bridge design/contract drawings

The optimal pier spacing for concrete and steel designs is different. To truly compare alternate designs, both systems must be optimized for both the specific design and the different material.

include too much detail (such as dimensional information) that must be repeated on the shop drawings. Very often much of the information ends up having to be modified by the detailer; in effect, there is double work that ends up costing the owner unnecessary expense.

One designer compared steel contract drawings to those for pre-stressed concrete.

In the latter case, the contract drawings are detailed completely and no shop drawings are required. In steel's case, the contract drawings show too much detail and then shop drawings are required on top of that. Too much unnecessary information leads to an excessive number of RFIs—many of which are not answered on a timely basis, which in turn leads to otherwise avoidable delays and expense.

Cross-frames are a common example. Often, longitudinal spacing between cross-frames is dimensioned exactly. During shop drawing preparation, cross-frames are found to interfere with girder splice plates. This necessitates a request for clarification and/or permission to make adjustments to cross-frame spacing. This leads to delays in the schedule that are almost always expensive. A better option is to allow the fabricator/detailer to move cross-frame locations some range of distance in order to miss splice locations.

Another example has to do with connections and field splices. Connections and field splices should show only the number of bolts and thickness of material. Edge distances and bolt spacing are governed by AASHTO and should be calculated by the fabricator/detailer and checked by the shop drawing reviewer.

The cost in time and money for this double work is so significant that the AASHTO/NSBA Steel Bridge Collaboration has a special task force that is developing a set of specific guidelines showing the kind of information that needs to be shown on design/contract drawings and shop drawings. The guidelines should be published early in 1999.

Designers should optimize the design of the entire bridge including the deck, superstructure and substructure. While this point seems self-evident, many times—because of the pressures of time or budgets—optimization studies are not performed.

This is especially true when designs are being prepared for both steel and concrete alternates. Oftentimes the sub-

structure is the same for both options. This occurs because an optimal pier spacing for the concrete superstructure design is chosen and the same spacing is imposed on the steel superstructure. Various girder spacings should be reviewed, considering both first cost and future redecking possibilities. Consider performing budget studies on alternate design schemes for any bridge three spans or more.

Designers should consider the interplay between steel and concrete, taking advantage of the inherent advantages of both materials. For example, steel girders are generally more readily integrated with concrete pier caps, rather than steel pier caps. For those projects where there is easy access to the pier location for forming and shoring, consider concrete pier caps. In addition the concrete pier cap may provide continuity all the way to the foundation. Concrete end diaphragms may be easier to design, detail and construct than steel diaphragms. This is especially true with skewed bridges where fitting of end diaphragms in steel is difficult.

Designers should consider a method for integrating bridge superstructure and substructure. This is especially true in seismic areas or in poor soil conditions where steel bridges, on tall piers for example, can be compared to an inverted pendulum. Integrating the two parts allows the structure to develop frame action to increase stiffness resulting in lower costs for both substructure and superstructure.



The use of weathering steel can reduce both initial costs and life cycle costs; however, it is critical to follow industry recommendations to avoid staining problems

Many steel bridge details can be rationalized and standardized such as limiting flange transitions, attachment of stiffeners, elimination of web stiffeners, minimizing the number of bolts in connections/splices, and specifying reasonable and rational paint and paint application standards, to name a few. Much has been written in this regard but there is still confusion and little consistency between states.

The AASHTO/NSBA Steel Bridge Collaboration is developing acceptable and uniform standards that can be adopted by all states. In the interim, the National Steel Bridge Alliance is conducting some joint (DOT-NSBA) reviews of individual state specifications and standard details; if you'd like a joint review for your state, please contact the NSBA.

Fabricators should have the option to increase web plate thickness to eliminate stiffeners. The additional web material cost may be more than offset by savings in fabrication. Also, elimination of the stiffener removes potential future fatigue areas (stiffener welds) and simplifies future maintenance cleaning and painting.

Maximizing the use of uncoated weathering steel (ASTM A709; Grades 50W, 70W, HPS-70W) can reduce initial and life cycle costs. Industry recommended details should be used to avoid local corrosion and/or staining problems. In addition, weathering steel can have an aesthetic advantage in rural settings

where the brownish patina blends with the natural landscape.

Guidelines can be found in the FHWA Technical

Advisory T5140.22, dated 10/3/89). Additional information can be found in the chapter, "Uncoated Weathering Steel Bridges", of the *Highway Structures Design Handbook* published by the National Steel Bridge Alliance.

Fabricators should have input on the number and location of field splices. All field splices should be considered optional unless dictated by site-specific requirements. Fewer splices means less fabrication time and expense and less erector time to connect all the splices. This needs to be balanced against shipping restrictions and erection crane capacity.

These balancing factors are different for each bidder and they should be free to determine what is most cost-effective for them.

Designers should maximize the use of neoprene pads for bridge bearings. Many bridge designers assume that steel reinforced elastomeric bearings are not suitable for steel bridges because of the relatively large translations and rotations of the bridge. In fact, if properly designed and manufactured, they can support large loads and tolerate large rotations.

Under certain conditions, elastomeric bearings can even accommodate over-rotations more satisfactorily than pot and spherical bearings. Complete bearing selection and design information can be found in the chapter on "Steel Bridge Bearings" in the *Highway Structures Design Handbook*.

Designers and owners should use jointless decks and integral or semi-rigid abutments whenever possible. This concept offers significant initial and life cycle cost advantages.

The feasibility of jointless decks has been well proven and the design procedures well documented over a number of years. Jointless decks mean less hardware installation and maintenance costs (for joints) and the elimination of most substructure maintenance costs. Elimination or at least minimizing the number of deck joints is also a recommendation for the successful use of weathering steel.

Guidelines can be found in the chapter on "Integral Abutments" in the *Highway Structures Design Handbook*.

Designers should consider the use of the newest grade of plate material for bridge construction, ASTM A709, Grade HPS-70W. This new, high strength, weathering steel is the result of a five-year development program co-sponsored by the Federal government and the steel industry.

This new low-carbon, low-sulfur steel has a minimum yield strength of 70 ksi, has a minimum toughness that exceeds the most stringent AASHTO requirement and is readily weldable. When incorporated in a bridge structure in a manner that takes full advantage of the increased strength of this material, HPS-70W is cost effective on a first cost basis and should provide trouble free service life as a result of the increased toughness.

SHOP DRAWING APPROVAL

By far the most discussed issue at the brain storming sessions was shop drawings and the shop drawing

Integral abutments and jointless decks can reduce both construction and maintenance costs

approval process. *The biggest concern was the amount of time required for approval.*

Approvals and responses to RFIs need to be streamlined. While it seems obvious that this affects the speed of a project, it became clear that a long and difficult approval process also has a significant impact on cost. Delays end up costing both fabricators and contractors money.

For the contractor, shop-drawing delays can affect all aspects of a project. Time spent waiting for shop drawing approval often means that the contractor has to delay other critical decisions.

Most construction projects follow a linear path, a delay at the beginning will necessarily delay everything that follows. If this condition is part of a pattern in a particular state, bids by fabricators and contractors alike tend to be higher in that state than in others.

Both contractors and fabricators in the focus groups made this point perfectly clear. They were able to site specific differences in bid prices for similar projects between neighboring states. The problem lies in a procedure that typically involves drawings and/or RFIs being processed in a linear fashion i.e., from fabricator to contractor to owner to designer and back. Each step along the way eats up time. In many cases, the documents are being handled by parties who are either not knowledgeable about the particular details or are unaffected by them.

The focus groups made several recommendations:

1. Limit copies of shop drawings and RFIs to those who need them.
2. "Shotgun" submittals to all parties rather than sending them in linear fashion. The contractor could even have the option to designate the detailer as his agent rather than stamping and approving every drawing.

3. A subset of the above recommendation is to have the fabricator make early submittals directly to the designer (with copies to the contractor) and final submittals to the contractor and owner.
4. Shop drawings should be transferred electronically in order to minimize time and handling.
5. Parties should avoid checking items that are the fabricator's responsibility.
6. Use the language, "Approved as noted. Revise and resubmit." This allows the fabricator to proceed while making the necessary changes for final submittal.
7. When reviewing shop drawings conduct a full review. Don't return corrections piecemeal.

The focus groups also suggested that a checklist be developed to show the critical items to be checked by each party. In fact, the AASHTO/NSBA Steel Bridge Collaboration is preparing such a checklist. It will clearly define the responsibilities of each party in checking specific areas of shop drawings. They expect to release the checklist early in 1999.

FABRICATION/ERECTION

Owners should require fabricators to have AISC "Major Steel Bridge" certification at the time of award to the General Contractor. This assures an appropriate level of quality and eliminates the need for a possibly time-consuming and contentious pre-qualification procedure.

The general contractor should select the field-bolting method. Any tensioning

method allowed by the Research Council on Structural Connections (RCSC) should be acceptable.

Each contractor has experience and equipment that may enable him to tension bolts more efficiently using one allowed method versus another.

Fabricators/erectors should have the option of either applying all paint coats in the shop or the field.

Allow fabricators to have standard welding procedures that are approved annually by the owner. This allows the fabricator to use pre-approved procedures rather than going through the time-consuming and costly process of getting them approved for each project.

For rolled beams and shallow plate girders, consider the use of standard channels for diaphragms. A single piece, while heavier than a cross frame, will be faster and less costly to fabricate and erect.

When possible, design should allow cross frames to be shop fabricated as a unit. Considerable erecting time can be saved in placing one fabricated unit in lieu of field fitting all the members of a cross frame assembly.

CONTRACTING

In order to expedite the mill order and delivery of material for bridge projects of significant size, the owner should consider contracting directly with the fabricator for the steel package and providing fabricated steel to the successful general contractor. This procedure can save considerable time in the schedule.

The owner should consider paying the steel fabricator for rolled shapes and plate material that has been purchased for a specific project. There can be a lengthy period between the fabricator's receipt of this material (which must be paid for) and delivery of the final fabricated steel. The carrying cost of this material is often considered in the fabricator's bid price. The FHWA will participate in payment for stockpiled shape and plate material on Federally funded projects..

Another way to save time is for the owner to require the general contractor to name the structural steel fabricator at the time of award to the general contractor. This eliminates the long negotiating period (sometimes referred to as an auction) after award to the general contractor and ensures that material ordering and steel fabrication can start in a timely manner.

The NSBA wishes to thank all the participants - DOT personnel, general contractors, consultants, fabricators and steel erectors - whose many constructive comments proved to be very valuable in the never-ending quest for quality in steel bridges. Making suggestions is one thing. Acting on those suggestions is another. We see a number of constructive changes that have taken place in the three states where the focus group discussions were held. The distribution of this report will hopefully allow other states to benefit from the insights brought to light in New Jersey, California and Florida.

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