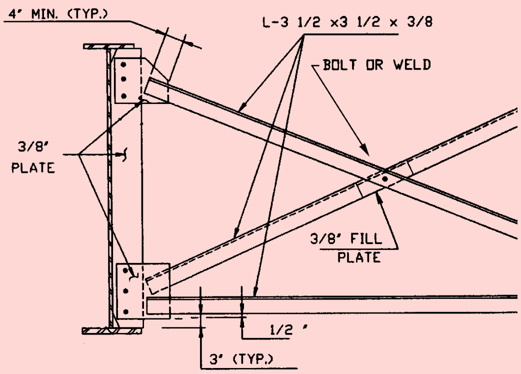

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Bridge Crossings

Practical Information For The Bridge Industry

Wider Girder Spacing:

Cost Savings with examples from the I-15 Reconstruction Design/Build Project

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Steel's greatest asset as a building material is its strength per unit weight. Historically, the available sizes of rolled beams and a lack of sophisticated design tools dictated the use of tightly spaced beams that were designed to span simply from pier to pier with expansion joints over each pier. As designers began to use calculators and later computers, longer and more complex continuous spans dictated greater use of built-up girders. These girders were typically designed with the use of least weight as a prominent design theme given the relative cost of raw material versus labor in the 1960s and 1970s.

But times have changed. Labor is $^{2}/_{3}$ to $^{3}/_{4}$ of the cost of a steel superstructure in today's marketplace. Reductions in the cost of fabrication significantly change the economics of material selection. For I-15 Reconstruction Project, the I-15 Steel Structures Team consisted of lead fabricator, Utah Pacific Bridge & Steel, and three other fabricators, Universal Structural Inc., Fought & Company, and Roscoe Steel & Culvert. The steel detailer, Tensor Engineering, and steel erector completed the I-15 Steel Structures Team that worked in concert with Wasatch Constructors to determine a way to cut 15% out of the steel superstructure cost.

The proposal…. to use fewer girder lines on the 70 steel bridges on this fast track, high profile, urban alignment. This decision achieved the following:

- Fewer girders to be fabricated
- Fewer crossframes to be fabricated
- Reduced fabrication time
- Fewer pieces to paint
- Fewer pieces to be erected
- Fewer bolts to tighten
- Reduced time of erection
- Fewer bearings to purchase and set
- Fewer pieces to inspect
- Reduced paperwork
- Streamlined, cleaner bridge appearance

Design Considerations

The steel bridges on the project used girder spacings ranging from 12 to 22′. Bridges with girder spacing of greater than 16′ on center utilized deck systems with transverse post-tensioning to limit the deck thickness.

The girder design, with a wider spacing, is not appreciably different than a design for a narrow spacing. Each girder carries a larger percentage of the structure's dead and live load, therefore making each individual girder heavier but achieving savings of 15 to 25% in the overall weight of the steel girders for the entire structure.

When laying out a girder system, consideration should be given to the need for phased redecking in the future. Try to determine how traffic could be maintained. On a typical two-way bridge, try to use an odd number of girders to allow $^{1}/_{2}$ at a time deck reconstruction. On the I-15 project, most of the main line structures required phased construction. The engineers had to lay out the girders for the structures for the initial as well as final cross section and determine the maintenance of traffic during construction.

Because each girder is heavier, for a girder of equivalent depth, the moment of inertia, I, is larger minimizing the possibility that live load deflection will control the design. Although high performance steel was not used on the I-15 project, wide girder spacings work well in concert with HPS for economical structures.

Often the change in the distribution of the dead and live loads to fewer girders and increasing the section

continued

modulus, *S*, results in a reduction in the girder's fatigue stress range. This makes it easier to avoid changing details in areas of high stress. For example, crossframes can be moved out of the highest stress range areas to avoid the need for any tab plates (bolted stiffener connections.)

On the I-15 project, the wide spacing did affect the geometry of the crossframes. The lengths of the members in the crossframes were often controlled to prevent buckling in the crossframe components. This resulted in the use of WT members for many of the crossframes.

Fabrication Issues

A fabrication plant is an assembly plant process. After preparing and receiving approval for the shop drawings, steel plate needs to be cut, joined, details added, heat cambered or curved, cleaned and painted, if required. Any reduction in the number of pieces that need to be built reduces the man-hours required to build the structure and the structure's cost.

A bridge that is 200′ long and 60′ wide would, in a traditional design, have 7 or 8 girders (7 to 8′ girder spacings.) On I-15, this same bridge would have 4 or 5 girders (13.5 to 18′ girder spacings). The structure would have 3 less girders, 27 fewer crossframes and 6 fewer bearings. Even saving just two girders eliminates 18 crossframes and 4 bearings.

Each girder is heavier than a traditional design, making it more stable during fabrication and erection. A possible drawback with the heavier pieces, however, is that some small fabrication shops might not have the crane capacity to handle the girder segments.

The need for the use of WT members increases the cost over the use of more traditional shapes such as angles and channels. A WT is a member that is not directly rolled. A W beam needs to be split into two pieces and each T straightened to create the WT shapes.

The reduction in the number of pieces that need to detailed, fabricated, handled, painted, documented and inspected clearly reduces the cost of the labor involved in the construction of each bridge on the project

Construction Techniques

The decks for these structures require more concrete or reinforcing steel than for a design with narrower girder spacings. A conventional cast-in-place deck will work for spacings up to 16′. Stay–in-place metal deck forms can span up to 14′ clear, therefore can be used for a 15 to 16′ girder spacing. Precast concrete deck panels can be used as well and designed as required to span wider girder spacings. As with a more traditional design, the use of steel or precast stay-in-place forms greatly reduces the cost of deck forming.

On the I-15 project, the Utah Department of Transportation mandated the use of conventional forming for all the steel bridges on the project. Conventional forming for wide girder spacings required the use of 4x4 members rather than traditional 2x4 construction.

Since overhangs are typically larger than normal, the overhang brackets should be reviewed and may need to be spaced more closely to carry the additional load. During the design of the girder, the exterior girder web should be evaluated for the additional forces induced by the bracket.

Fewer bearing pedestals need to be formed and fewer pieces lifted into place. However, larger cranes might be required since each girder is typically heavier than a traditional design. If the girders have bolted field splices, fewer overhead splices are required. On I-15, crane capacity was not an issue. Olsen Beal, the erector of all the project's bridges, had a number of cranes including three new high capacity machines. Erection time is reduced since the number of pieces to handle and bolt is significantly reduced. The disruption of traffic is reduced since fewer girders need to be lifted over traffic and bolted into place.

Maintenance consideration

Since the I-15 project is for a multi-lane high-speed highway, most of the bridges with girder spacings under 16′ on center have enough girders to do a phased deck replacement under traffic. The project incorporated the use of special admixtures and mix designs to improve the life span of the concrete decks.

When girder spacings require the use of a post-tensioned deck system, redecking becomes more difficult. Zero-tension deck systems with longitudinal and transverse post tensioning are anticipated to be long life systems, in the best case eliminating the need for future replacement before the end of the bridges useful life. With girder spacing over 16′ on center, these precast concrete deck systems are the best technology to allow for future replacement under traffic.

Summary

The use of wider girder spacings on the I-15 project was a major innovation that deserves a look by other transportation agencies. Though the more extreme spacings (16′ and greater) used on the project likely will not be readily accepted, there is a strong case for the use of wider girder spacings (up to 14′ o/c) on standard highway bridges to eliminate girder lines. This innovation saved time and money for the owner, fabricator, contractor and taxpayer.