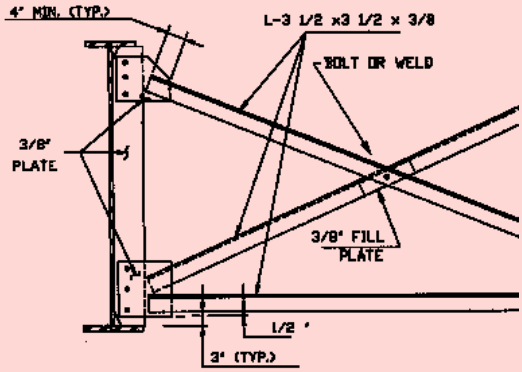

BRIDGE CROSSINGS

Practical Information For The Bridge Industry

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Twelve Commandments For Economic Steel Box Girders

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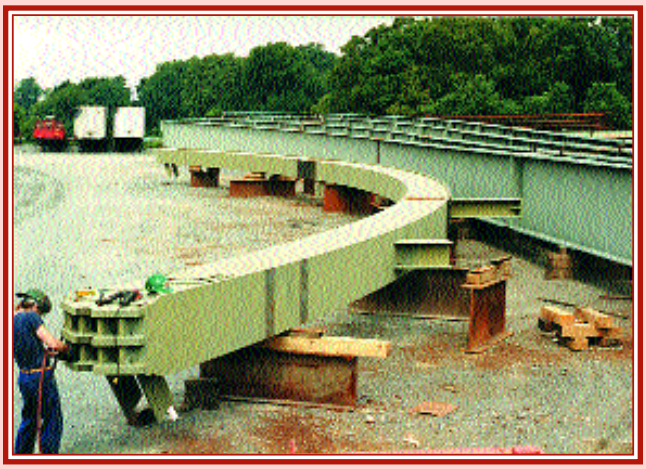

Putting the finishing touches on a weld at the base of a curved box girder.

What bridge designer hasn't marveled at the final outcome of countless hours, days, weeks or months of thought-provoking labor? When finally, after much work, hard copy printouts of computer data fill offices. The design is finally ready to release for bid.

Fabricators receive the design and estimators eagerly roll up their sleeves and begin working on the material and labor take-off required to cost a job. Sometimes, though, a profound silence can almost be heard as the same thoughts go through everyone's head: "Why did they do it that way? How are the shop people going to do this? Boy, is this expensive. Do you think they'll accept a change? Who should I call?" When there's this much doubt, it can only mean the member in question is a four-sided (enclosed) box girder.

While there are many box girder designs, they all share many common characteristics. And if designers would follow some common sense rules, there'd be a lot fewer questions asked about them. These "12 Commandments" should be chiseled in granite in every designer's office for future reference.

I. Thou Shall Have Good Width.

Most fitting and welding sequence procedures start with the bottom flange (splicing, if necessary). When this component is ready for fit-up, any internal detail possible to fit and weld in wide-open spaces is accomplished. This detail is fit and welded only after the bottom flange is set to a plane incorporating any weld shrinkage allowances necessary to produce the desired outcome. Mill-to-bear configurations are verified and details can be approached easily. Once the webs are fit and tacked in place, a U-shape exists that must be accessible to the workforce. In this configuration, details are more difficult to fit and weld. Most fabricators only dream of a minimum inside dimension (web face to web face) of 4'.

II. Thou Shall Have Good Height.

Let's assume the average worker is between 5' and 6' tall. Simple put, this means a person bent at the waist cannot occupy less than 4' in height. And workers actually would prefer not to have to strain their back. A target of minimum height should be in the range of 5'.

III. Thou Shall Have Two Access Doors.

The location of access doors is critical to airflow once the lid is put in place. A box with top and bottom flanges and two webs in place is a confined space by definition. Visually observing activities in the fabrication process is critical, along with supplying proper airflow to workers. Taking necessary equipment inside also creates restrictions that

The proper placement and proper size of access holes is very important in box girder design

must be dealt with in order to accomplish required tasks. The shortest distance between two points is a straight line. Therefore, access doors should be place on either end.

Incorporating fillet weld details, which can be accomplished from the exterior once closure plates are put in place, would be an added benefit. Adding details such as curved flanges on the top corners (similar to the "bull nosed" railroad girders) in profile adds unnecessary expense. If the argument is between aesthetics and inspection ease, add a third door elsewhere. Often, adding a third door in the top flange at the box center is a good option. In this way, a confined space tripod could be used to lift an individual out, if necessary. Regardless, the two access doors, one on each end, are a must.

IV. Thou Shall Abide By OSHA Rules And Regulations Addressing Confined Space.

Boxes are typically produced utilizing a Fit-Weld procedure. Fabricators create these procedures in order for those involved to clearly understand requirements. They also are used to define a step-by-step process to avoid distortions and potential weld problems.

Somewhere in the process, the box member takes on the shape, thereby introducing confined space rules and regulations. When this occurs, the fabricator must address all possible hazards. Entry-Permit Programs must be developed. They are created to protect employees from toxic, explosive or asphyxiating atmospheres. Workers are required to have permits from authorized company supervisors or entry. By definition, confined spaces requiring permits are those atmospheric, engulfment or configuration hazards. The Permit Program must establish procedures and practices for safe entry, testing and monitoring of conditions, rescue services, rescue training and equipment needs.

Designers need to understand these concepts because many times "Design For Manufacturing" technology can reduce costs.

V. Thou Shall Have Access Holes And Diaphragm Manholes No Smaller Than 2'-8" x 3'-0".

According to medical charts, a 6' man in perfect health will weigh in the range of 170-185 lbs. Most six-footers exceed this weight, or we wouldn't have near the number of health centers in existence. Suit up a painter or welder to do their work and you have added restrictions, to say nothing of all the hoses, cables and equipment they use.

VI. Thou Shall Have Manholes Concentric In Location.

Another critical detail to employ is keeping these manholes in alignment at an elevation equal to mid-depth. The proximity of internal diaphragms relative to each other at bearing areas needs close scrutiny. If workers must fit between them to fit and weld, give them space to work: A 3' dimension is a good target. There are box girders in existence designed with access holes alternating from top to bottom along the length of the member. Try crawling through one with these details! Fabrication and inspection personnel should not need obstacle course training to accomplish their work.

VII. Thou Shall Select Corner Seams Conducive To Ease of Accomplishment.

If the width figure of 4' is denied (see Commandment I), use full penetration welds on corner seams from the outside. Many fabricators prefer two full penetration seams under any circumstances. This allows the final two welds to be completed without adopting necessary confined space rules. Happy welders mean quality welds the first time.

VIII. Thou Shall Allow Clearances For Personnel To Perform Quality Welds And Inspection.

Too many times the distances between internal box components and/or restrictions due to box height and width are not dimensioned for ease to perform various tasks. Design concepts need verification before being stamped “final”. Fabricators, through the National Steel Bridge Alliance, are eager to help.

IX. Thou Shall Only Use Full Penetration Welds Where Necessary.

Typically, box girders and (I-cross girders) incorporate heavy plate material in bearing areas and seat connection details for connecting I-girders. The material is full-penetration welded and opposed by details on the far side requiring heavy welds. Other times certain cross-section configurations of longitudinal I-girders incorporate numerous heavy welds in the same vertical plane.

During the welding process, these welds create stress issues sometimes resulting in lamellar tearing or distortions falling outside workmanship specifications. Details usually require fit-up, which takes extra time, along with welding sequences incorporating unnecessary and costly handling and rolling of members.

Fabricators can supply cost-effective input in the early stages to help designers understand these issues and to avoid costly details.

X. Thou Shall Limit The Use Of Wide Flange Beams To Fabricate A Box.

Good box fit-up requires exact dimensioning and fabricating of sub-assembled details. Often, for example, many fabricators will mill all four sides of welded baffle plates to guarantee the needed exact dimensioning.

If two beams are used to produce a box, they must be identical as received. Mill rolling tolerances allow for variations in depth, flange width, flanges out of square, web off center, length, camber and sweep. The time needed to deal with these tolerances to make two pieces identical can result in excessive fabrication costs or delays in meeting customer schedules. Details inside this configuration also do not allow access to perform work. Temporary restraints are usually requested by the fabricator to control distortions while welding

flanges together to make the box.

On occasion, two girders are fabricated and joined with bolted baffle plates. Designers need to consider erection difficulties and desired outcome. For example, erection is very difficult when baffle units are to maintain full bearing on flanges and also to serve a common web connection for girders framing into the box. Soliciting fabrication and erection input early in design to avoid any conflict or uncertainties during the bid can reduce costs and is well worth the effort.

XI. Thou Shall Employ Limited And Similar Cross Frames And Diaphragms Easily Fabricated And Erected.

If detail material is made using CNC burners, punches, drills, anglemasters, etc., the use of jigs to fit these members will guarantee a good fit. However, changing jig set-ups adds to overall project costs. If these members are designed and detailed for duplication in fitting and welding, economy is realized for the owner. Full plate diaphragms cut out of a girder in lieu of fabricating many small units saves a tremendous amount of time in handling and straightening. Similarly, if a hundred cross frames are identical, rather than one of a kind, the jig change time saved is tremendous. It’s analogous to changing the configuration of every automobile in an assembly line. Very few could afford these “custom” cars.

Back-to-back angle cross frames incorporating spacer plates and knife connected in the field also should be avoided. The handling associated with painting these members drives their price off the charts. Erectors must connect these cross frames to stiffeners in the field. “Don’t scratch the paint” is the gentlest phrase heard from workers making these connections on job sites. Future blast and

paint maintenance costs alone should keep owners from using this detail. Finally, checking blast profile and paint millage between angle legs spaced by a ⅜" bar creates impossible workmanship issues.

XII. Thou Shall Not Incorporate Fracture Critical Members (FCM) Without Forethought.

Too many times designs are received with entire sheets noted: "All steel components on this drawing are FCM." Please, consider material and inspection costs prior to applying this statement. Engineering, detailing, procurement, and quality assurance/quality control functions need clear defining requirements to accomplish their work efficiently. Misinterpretation cannot exist. It's costly and delays progress. The result can be missed schedules and late shipping, which can lead to backcharges and litigation!

Communication

The fabrication industry can supply a wealth of information to those tasked with putting box girder concepts into reality. The outcome must make the job easier, worker friendly, cost competitive and more economical. Questioning if the 12 Commandments have been followed is a good start. Greater communication and understanding between designers, fabricators and erectors can create action plans leading to better concepts. Let's keep the doors open to communication.

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The mission of The National Steel Bridge Alliance (NSBA), which was formed in 1995, is to enhance the art and science of the design and construction of steel bridges. Its activities include organizing meetings, conferences and national symposia, conducting the Prize Bridge Awards competition, supporting research, developing design aids, and providing assistance to bridge owners and designers. The NSBA membership includes representatives from all aspects of the steel bridge industry.