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STRUCTURE BULLETIN

NCDOT Construction Unit

Website email

Merry Christmas!

If you want to see why it's a big deal to cross structures with equipment and why we require submittals for such, check out this link from a bridge replacement project in Nova Scotia.

Current Issues: Structural Steel Connections

Proper structural steel connections are of paramount importance to the structure. Improperly fitting splices together or improperly connecting diaphragms together can have serious detrimental effects on the structure. We will address each of these cases in this bulletin and discuss how to correctly assemble connections.

First, splices are critical friction connections. A friction connection means that the strength of the splice is derived from the friction between plates as they are compressed together by the bolts. There should be no shear on any bolt in a proper splice. There is a certain amount of play in these connections to make these easier to assemble. This play comes in the form of oversized bolt holes. Normally the holes are 1/16" larger than the nominal diameter of the bolt shank. While this does not sound like much it is enough play to assemble connection out of alignment significantly, depending on the splice dimensions. The error created in this manner can be either vertical or horizontal.

If a splice is connected incorrectly vertically this will result in the splice being either low or high. A low splice results in increased buildups (which could go beyond the limits of the SIP angles), increased concrete on the girder (which could overload the girder), and shear studs not engaging the bottom mat (which could necessitate additional reinforcing steel). A high splice results in decreased buildups (possibly negative buildups, necessitating raising the grade and increasing concrete weight on other girders) and shear studs which are higher than the top mat (resulting in decreased concrete cover). In a continuous, multi-span structure this error can also translate into the next span. Much as a see-saw operates, the low splice in span A may result in a high splice in span B.

A splice connected incorrectly horizontally will result in excess sweep in one direction, or what you might call a kink in the girder. This can result in increased or decreased bay widths. (cont.)
Such deviations could mean the SIP panels might not fit into a bay which is too narrow, or the angle legs are too far apart to support the panel if the bay width is too large.

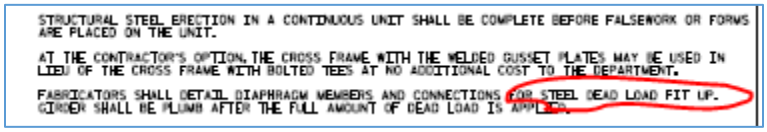
Second, diaphragms are necessary for the proper location and stability of the structural steel. There are far fewer holes in a diaphragm connection than a splice, so most times contractors neglect to use drift pins in these connections. Sometimes this works out, but on wide bridges this can be problematic. If girder erection starts at one side of a wide bridge and progresses to the other side, and if all the play in the bolted connection goes to one side, then the small amount of play grows with each connection. I have seen bridges where this was done, and the error being pushed to one side of the bridge resulted in the bottom flange of the last girder being in conflict with the anchor bolts. Using a few drift pins in each diaphragm would have avoided this problem.

Errors in both splices and diaphragm connections can be significantly reduced if the specifications are simply followed. Section 440-6 states:

fill 25% of the holes with bolts and 25% of the holes with cylindrical erection pins, before placing permanent fasteners. For continuous units, pin and bolt all beam and girder splices and bring the splices to the correct elevations before permanently fastening. For bolted connections use fit-up bolts and optional shipping bolts with the same nominal diameter as the permanent fasteners, and use cylindrical erection pins which are 1/32 inch larger. Use permanent bolts as fit-up bolts if desired.

Cylindrical erection pins, or drift pins, are the key to proper alignment. The specifications require a **minimum** of 25% of the holes in the connection to contain drift pins. If your splice contains 500 bolts (100 top flange, 100 bottom flange, and 300 web) then you should have a minimum of 125 drift pins (25 in the top flange, 25 in the bottom flange and 75 in the web). These pins should be evenly spaced around the connection, not concentrated in one spot. Ideally, they are placed more near the outside corners of the connection and the ends of the members being spliced.

The other 25% of holes should be filled with bolts. These can be either erection bolts or the permanent fasteners can be used (more on that in a minute). The purpose of these bolts is to pull the plies of the connection together before any tensioning of the permanent bolts begins. Snugging refers to bringing the bolts to a snug tight condition. Snug tight is defined by the AISC/RCSC as when all the plies in a connection have been pulled into firm contact by the bolts in the joint, and the bolts have been tightened sufficiently to prevent removal of the nuts without a wrench. They go onto say that this is typically achieved by a few impacts of an impact wrench, the application of an electric wrench until it begins to slow, or by the full effort of an ironworker with an ordinary spud wrench. It may be difficult to achieve the snug tight condition for large splices with multiple layers. During the snugging process the first bolts to be tensioned can loose their tension as the other bolts around them are tensioned, so the use of these erection bolts minimizes this. As mentioned before, permanent bolts may be used for this application, but this must be done with caution. Initially pulling the plies together can damage the bolt threads (especially if insufficient drift pins were used to properly align the plies), so if there is any doubt that damage has occurred the contractor should be directed to remove these bolts from the connection and check for damage before final tensioning. Testing for damage is as simple as running a nut up on the bolt the full length of the threads by hand. Also, if a permanent bolt is used as an erection bolt and already has a DTI installed you must check that the DTI has not been partially compressed when pulling the plies together. If this happens the DTI must be replaced. Bolts should never be hammered in. If this is necessary, you probably do not have the connection properly aligned or the hole is not drilled correctly.



STRUCTURAL STEEL ERECTION IN A CONTINUOUS UNIT SHALL BE COMPLETE BEFORE FALSEWORK OR FORMS ARE PLACED ON THE UNIT.

AT THE CONTRACTOR'S OPTION, THE CROSS FRAME WITH THE WELDED GUSSET PLATES MAY BE USED IN LIEU OF THE CROSS FRAME WITH BOLTED TEES AT NO ADDITIONAL COST TO THE DEPARTMENT.

FABRICATORS SHALL DETAIL DIAPHRAGM MEMBERS AND CONNECTIONS FOR STEEL DEAD LOAD FIT UP. GIRDER SHALL BE PLUMB AFTER THE FULL AMOUNT OF DEAD LOAD IS APPLIED.

Erection Detailing

Another factor in erection of structural steel is the way in which the steel was detailed. There are three common methods for detailing structural steel: No-Load Fit (NLF), Steel Dead Load Fit (SDLF), and Total Dead Load Fit (TDLF). The inspector should know which method the plans call for because it affects how the contractor will have to manipulate the girders during erection.

Probably the most common condition for straight, lightly skewed bridges is **Steel Dead Load Fit.** This means the diaphragms and cross frames are detailed to fit up when the girders are erected and are deflecting due to their own weight. This method normally requires less manipulation of the members in order to fit the diaphragms and cross frames.

For straight girders on narrow bridges with significant skews you might see the plans call for **Total Dead Load Fit.** This means the diaphragms and cross frames are designed to fit when the girder is fully deflected from both the steel dead load and deck dead load. This option requires additional manipulation of the girders, essentially forcing the girders to an out-of-plumb position in order to connect the diaphragms and cross frames. The contractor may have to use come alongs to produce this.

The last alternate is **No-Load Fit**. Normally this is not called for unless there is a significant horizontal curve in the deck. This option assumes the girder is completely undeflected while the diaphragms and cross frames are installed. Since you can't turn gravity off, the girders will have to be supported in the undeflected condition in order to make them fit. While girders with a significant curve will likely be supported by erection towers or temporary bents during erection the contractor will still likely have to raise the adjacent girders with cranes in order to make the connection.

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If you have a topic you would like to see addressed in a future edition of the Structure Bulletin, please email us at either acochran@ncdot.gov or aearwood@ncdot.gov