Solu

July 2008

BY JACINDA L. COLLINS, P.E.

What part do you play in the continuing saga of bolted connections?

story that includes intrigue (fastener component selection), drama (design of the connection), mystery (pre-installation veri cation), action (installation), thrills (inspection), horror (arbitration), history (references), and the occasional miracle. The AISC *Speci cation for Structural Steel Buildings* (ANSI/AISC-360-05), the RCSC *Speci cation for Structural Joints Using ASTM A325 or A490 Bolts*, and numerous other publications provide a detailed account of the "hole" story from start (manufacture) to nish (recycling). The intent of this article is not to replicate those references, but to give you a clear view of your own chapter in the bolted connection story. So think of it not as a design guide, but as your handy set of crib notes for the tome that is Bolted Connections.

It is a

The choice between welded and bolted connections depends upon a variety of factors. A few of these factors include shop preference, connection geometry, and additional attachments that are to be placed on a structural steel member. When bolted connections are the choice, bolt holes are made as part of the automated fabrication of the structural steel pieces. These holes provide a method of locating pieces of structural steel quickly, as well as reduce the time necessary for the steel piece to be held in place by a crane at the erection site. In fact, OSHA requirements state that at least two bolts must be provided, as positive attachment of a steel member before the crane can be unhooked from it during erection.

The most commonly used high-strength bolts are those that are manufactured to ASTM A325, A490, F1852, and F2280 speci cations. However, it should be noted that there are other high-strength bolts with unique characteristics that make them ideal for speci c types of connections. Some of these high-strength bolts include:

ASTM A193 – for use in elevated-temperature service

ASTM A320 – for use in low-temperature service

ASTM A354 Grade BD – properties similar to A490, but can be obtained in larger diameters

ASTM A449 – properties similar to A325, but can be obtained in larger diameters

There are three types of joints that are available for bolted connections: snug-tightened, pretensioned, and

4, 1 1

and the second		an Einen an			
Applicable except when a pretensioned or slip-critical joint is required	As required by the AISC Specification (s)	Joints that are subject to fatigue load with reversal of loading direction			
	Joint subjected to significant load reversal	Joints with oversize holes			
	Joint subjected to fatigue with no reversal of loading direction	Joints with slotted holes, except those with applied load approximately normal to the dimension of the long slot			
	Joint with A325 or F1852 subjected to tensile fatigue	Joints in which slip of the joint would be detrimental to the performance of the structure			
	Joints with A490 9t				

making the holes in all plies, the preparation of surfaces (if required), the installation of the bolts, and the inspection of the connection. These costs can increase signi cantly when comparing snug-tightened joints to slip-critical or pretensioned joints.

Snug-tightened joints are more economical when compared to pretensioned or slip critical joints. The reduction in the comparative cost of snug-tightened joints comes from the absence of faying surface preparation requirements and a reduction of inspection requirements. Therefore, if allowed, remember to specify snug-tightened joints whenever possible.

For applications in which seismic design is performed using R = 3, if given the choice, pretensioned joints are more economical than slip-critical joints. Slip-critical joints have special faying surface preparation requirements that do not apply to pretensioned joints. Thus, the reduction in the comparative cost of pretensioned joints results comes from the reduction in the overall fabrication cost of the connection.

The choice of faying surface selection in slip-critical joints may depend upon whether the steel member is (or is not) blast-cleaned and coated for other reasons. If the steel is to be blast-cleaned or blasted and coated with a coating rated for Class B slip resistance, then it is more economical to use a Class B faying surface. Otherwise, a Class A design may be a more appropriate choice.

and the second second

After you have selected the joint type, the next step is to design the connection itself. Table 2 illustrates some general design guidelines for each of the three joint types.

In general, the type of bolt hole selected for a joint should be based upon constructability. Standard holes and shortslotted holes can be used in each of the joint types. Long-slotted holes are permitted in each of the joint types with the approval of the Engineer of Record, while oversized holes can be used only in slip-critical joints. The selection of the type of bolt hole selected is a great topic of conversation with a steel fabricator. It is considered good practice, when using standard and oversized holes, to specify the same hole type in all plies so that the plies can be aligned using a spud wrench and drift pins during erection.

OSHA requires at least two bolts (or an equivalent attachment) in all connec-

the second se				
	.	· • • • • • • •		
Design shear or tensile strength of a bolt				
Strength of the bolt when subject to combined shear and tension				
Design Bearing strength at bolt holes of connected material and bolt				
Design Slip Resistance (faying surfaces and bolt pretension)				

Additional considerations for the design of the joint include:

- → shear and/or tension yielding
- → shear and/or tension rupture
- → block shear rupture
- → shear lag
- → prying action

tions, and these bolts must remain in place after the member has been released from the crane. It is considered good practice to have connections that do not share bolts through a support. If this is not possible, a discussion with the steel fabricator should occur to determine a solution. Some examples of typical solutions to this situation can include providing temporary erection seats, offsetting connections, making one connection deeper than the other to make sure that some bolts are not shared by both connections, or another solution that will address erection safety.

Washers are required for all joint types that have sloped surfaces or use slotted holes in the outer ply. For pretensioned and slip-critical joints, washers are required for the following types of connections:

- → when using ASTM A490 bolts and the connection material is less than 40ksi (not required under the head for the ASTM F2280 bolts)
- → under the turned element when using the calibrated wrench pretensioning method
- → under the nut when the twist-off-type tension-control bolt pretensioning method is used in certain bolt con gurations (reference Section 6.2.4 and Figure C-8.1 in the RCSC Speci cation)
- → when the direct-tension-indicator pretensioning method is used
- → when oversized holes are used in the outer ply Table 6.1 in the RCSC Speci cation il-

-

away from the work. After pretensioning, routine observation is necessary to verify that the appropriate feeler gage is refused entry into at least half of the spaces between the protrusions.

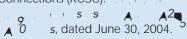
Pre-installation veri cation is used to check that the fastener assemblies and pretensioned installation procedures perform as required prior to installation. The RCSC Speci cation provides detailed procedures for the pre-installation veri cations methods available for each of the installation types. It should be noted that pre-installation veri cation is required onsite daily for the calibrated wrench pre-tensioning procedure. In addition, it should be noted that detailed inspection instructions should be provided by the manufacturer(s) for the chosen fastener components.

In the instance where there is valid reason to believe that the installed bolts do not have the required pretension, arbitration may be required. The RCSC Speci cation provides a detailed procedure for arbitration of pretensioned and slip-critical joints.

During arbitration it should be noted that reliability concerns may occur due to the nature of the testing procedure used. Conditions that are present at the installation site are not wholly present at the arbitration testing site. These conditions can include the use of hardened washers, the lubrication condition, and the effect of the passage of time/exposure of the joints. If it is found that the RCSC procedure is not appropriate for the speci c situation of the

$x + x + x + \cdots + x + \cdots$

Research Council on Structural Connections (RCSC):



ANSI/AISC 360-05: *s*, dated March 9, 2005.

ANSI/AISC 341-05: s s, dated March 9, 2005, and 1, dated November 16, 2005.

AISC 303-05: s, dated March 18, 2005.

AISC s s -1 1

Steel Structures Technology Center, Inc. (SSTC):