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

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 significantly 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.

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

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 short-slotted 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 connections, 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 configurations (reference Section 6.2.4 and Figure C-8.1 in the RCSC Specification)
- ➜ when the direct-tension-indicator pretensioning method is used
- ➜ when oversized holes are used in the outer ply

Table 6.1 in the RCSC Specification 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 on-site 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

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