

Revised RCSC Specification: Simplified, Clarified, and Improved

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From reformatting the entire document for simplicity, ease of use and clarity to adding better guidance on the proper specification of joint type, the new RCSC Specification is a major improvement for all who are concerned with the design and construction of bolted structures. This new edition (see Figure 1) supersedes both the June 3, 1994 LRFD and June 3, 1994 ASD versions of the Research Council on Structural Connections (RCSC) Specification for Structural Joints Using ASTM A325 or A490 Bolts. Dated June 23, 2000, it is the fourteenth revision since the specification was first published in 1951.

It may be helpful to have the new RCSC Specification handy when reading this article. The new RCSC Specification is available as a free download from the RCSC web site:

www.boltcouncil.org

It is also available as a printed (paper) document for a fee of \$10 + s/h from the AISC bookstore at www.aisc.org or by calling 800/644-2400.

What's New in the Updated RCSC Specification?

The following is a summary of the major changes that have been made in this 2000 edition of the RCSC Specification.

- The previously separate LRFD and ASD versions of this Specification have been unified, with

LRFD as the basis in the main body and ASD as an alternative in Appendix B. Actually, very little is different between LRFD and ASD in the design and construction of bolted joints. One look at Appendix B and you'll see that it is really just a matter of what equations get used in strength calculations. With one set of consistent requirements, this will definitely make bolting easier in both design and construction – no matter which provisions you follow to determine strength.

- A Symbols (nomenclature) section and glossary have been added to provide a quick reference to definitions of variables and commonly used terms. The glossary terms are italicized in the specification and commentary to alert the user that the terms are defined in the glossary.
- Commentary information, when available, has been placed in shaded boxes immediately following its corresponding Specification provision. The Commentary often provides guidance and insight into the background that surrounds a particular Specification provision or requirement. This new format gives the user immediate access to additional information and further explanation, which

can be invaluable when applying and interpreting the RCSC Specification.

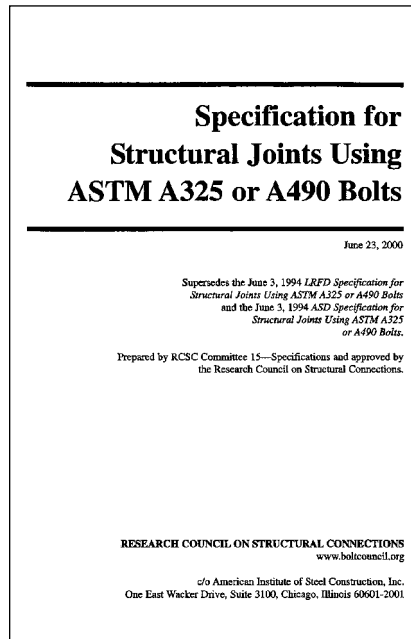
- As has been the case in previous revisions, it is occasionally indicated in the RCSC Specification that information must be shown on the design drawings or in other contract documents. Similarly, the RCSC Specification indicates when the approval of the Engineer of Record is required for some aspect of a bolted joint. As a convenience to the user, a summary of the drawing information and approvals required from the Engineer of Record has been added in Section 1.4. This subject is discussed in greater detail later in this article.
- All requirements specific to fastener components used in bolted joints have been collected into Section 2. These include material and geometry requirements for bolts, nuts, washers, direct-tension-indicator washers and alternative-design fasteners, as well as requirements for manufacturer certification and storage. Explicit coverage of the material and geometric requirements for washer-type indicating devices, twist-off-type tension-control bolt assemblies (ASTM F1852) and alternative design fasteners has been added in Sections 2.6, 2.7 and 2.8, respectively. ASTM F1852 twist-

off-type tension-control bolt assemblies, now directly recognized, were previously covered in general as alternative-design fasteners.

- The requirements for the parts that are connected in bolted joints have been collected into Section 3. They include requirements for connected plies, faying surfaces, boltholes and burrs. Provisions allowing the thermal cutting of boltholes with the approval of the Engineer of Record have also been added in Section 3.3. Previously silent on this subject, the new RCSC Specification allows the use of flame cutting, plasma cutting and other thermal cutting processes if approved by the Engineer of Record. Requirements for the treatment of burrs have been clarified and expanded in Section 3.4.
- New information has been added in Section 4 to address the applicability and suitability of the various joint types: snug-tightened joints, pretensioned joints and slip-critical joints. The requirements in this Section also serve to identify the applicable design, installation and inspection requirements for each of the joint types. This item is discussed in greater detail later in this article.
- All design requirements for bolted joints have been collected into Section 5. Provisions have been added to Section 5.1 to address the design implications of the presence of fillers or shims. These added requirements are consistent with those that have been in the AISC Specification for Structural Steel Buildings for some time now. In Section 5.5, the limitation on prying force for applications that involve tensile fatigue has been reduced from 60% of the total applied load to 30%. This change was made based upon review of the avail-

able research and engineering judgment.

- Washer requirements have been simplified and clarified in Section 6, particularly for those applications that involve plate washers.
- Provisions for pre-installation verification of fastener assemblies have been clarified in Section 7. These provisions apply as they are invoked in Section 8.2 for pretensioned joints and slip-critical joints.
- The intent and applicability of the installation requirements and inspection requirements have been simplified, clarified and expanded significantly in



Sections 8 and 9, respectively. These topics are discussed in greater detail later in this article.

- Arbitration provisions to be used in the case of a dispute for pretensioned joints and slip-critical joints have been clarified in Section 10.

Although there are other changes, these are the major ones. The following sections of this article deal with three issues in greater detail: (1) drawing information

requirements; (2) the proper specification of joint type; and (3) the installation and inspection requirements that apply for each joint type.

Drawing Information Requirements

As a convenience to the user, a summary of the drawing information and approvals required from the Engineer of Record has been added in Section 1.4. The section name "Drawing Information" implies that this information should be shown in the design drawings. However, the letter of the requirements in that section indicates that the information can be included in any of the contract documents at the discretion of the Engineer of Record.

The information required to be included in the contract documents has been simplified significantly. The ASTM designation and type of bolt to be used and the joint type must be indicated. If a slip-critical joint is specified, two additional requirements may apply. First, the required class of slip resistance (i.e., Class A, Class B or Class C) must be indicated. Second, if the connections are to be selected and/or completed by someone other than the Engineer of Record for subsequent review and approval by the Engineer of Record, it must be indicated whether slip resistance should be checked at the factored-load level or the service-load level. It should be recognized that both checks are set up to prevent slip in the service-load range, regardless of the load level at which the check is made. Thus, for simplicity, this will generally mean that the factored-load criteria should be used when factored loads are provided and the service-load criteria should be used when service loads are provided. Note the importance of clarity as to whether factored loads or service loads are provided.

The Commentary on this section also provides a summary of the

cases when the approval of the Engineer of Record is required. Such approval is required for the:

- Reuse of non-galvanized ASTM A325 bolts;
- Use of washer-type indicating devices other than those covered by ASTM F959;
- Use of fastener assemblies other than those with bolts covered by ASTM A325, A490 or F1852;
- Use of faying-surface coatings in slip-critical joints with a slip coefficient that is intermediate between 0.33 (Class A) and 0.5 (Class B);
- Use of thermal cutting in the production of bolt holes;
- Use of oversized, short-slotted or long-slotted holes in lieu of standard holes; and,
- Use of a value of D_u (pretension multiplier in LRFD) or D (slip probability factor in ASD) other than the default value of 1.13 or 0.80, respectively, in calculations of slip resistance.

Proper Specification of Joint Type

Section 4 provides a clear basis for the proper specification of joint type by the Engineer of Record as snug tightened, pretensioned or slip-critical, based upon the type of load that the fasteners in the joint transmit. For joints with fasteners loaded in shear or combined shear and tension, the joint type can be specified as snug tightened, pretensioned or slip-critical. For joints with fasteners loaded in tension only, the joint can be specified as snug tightened or pretensioned. Table 1 (a reprint of RCSC Specification table 4.1) provides a more detailed summary of the appropriate joint types given the type of load transmitted. Once the joint type is specified, the remaining requirements for design (Section 5), as well as installation (Section 8) and inspection (Section 9) are also defined. See the next section in this article for further information

about installation and inspection requirements.

Snug-Tightened Joints

Snug-tightened joints are permitted except when pretensioned joints or slip-critical joints are required (these cases are identified in the sections on pretensioned joints and slip-critical joints). Essentially, that means that most joints can be specified as snug tightened, except when pretensioned is required in the fasteners (with or without faying surfaces that are prepared to achieve slip resistance).

Bolts in snug-tightened joints must be designed to provide the required resistance in shear, tension or combined shear and tension on the fasteners and bearing on the connected material. Installation and inspection requirements are as described in the next section of this article.

It is also worthy of note that, with this edition of this Specification and based upon the historic usage of ASTM A307 bolts and recent research on high-strength fasteners, snug-tightened joints are also permitted for statically loaded applications involving ASTM A325 bolts and ASTM F1852 twist-off-type tension-control bolt assemblies in direct tension. However, snug-tightened installation is not permitted for these fasteners in applications involving non-static tensile loading, nor for tensile applications involving ASTM A490 bolts.

Pretensioned Joints

Pretensioned Joints are only required in the following applications:

- Joints in which fastener pretension is required in the specification or code that invokes the RCSC Specification (AISC LRFD Specification Section J1.11 and AISC Seismic Provisions Section I-7.2a, for example);

- Joints subject to significant load reversal (application of near-full or full load in one direction followed by near-full or full load in the other direction, as is characteristic of seismic loads, but not wind loads);
- Joints subject to fatigue load with no reversal of the loading direction (i.e., cycled loading that does not involve a change in the sign of the load);
- Joints with ASTM A325 or F1852 bolts subject to tensile fatigue; and,
- Joints with ASTM A490 bolts subject to tension or combined shear and tension, with or without fatigue.

Bolts in pretensioned joints must be designed to provide the required resistance in shear, tension or combined shear and tension on the fasteners, bearing on the connected material and tensile fatigue, if applicable. Installation and inspection requirements are as described in the next section of this article.

Slip-Critical Joints

Slip-Critical Joints are only required in the following applications involving shear or combined shear and tension (but not applicable for applications involving tension only):

- Joints subject to fatigue load with reversal of the loading direction (i.e., cycled load that does involve a change in the sign of the load);
- Joints utilizing oversized holes;
- Joints utilizing slotted holes, except those with applied load approximately normal (within 80 to 100 degrees) to the direction of the long dimension of the slot; and,
- Joints where slip at the faying surfaces would be detrimental to the performance of the structure.

Bolts in slip-critical joints must be designed to provide the required slip resistance and the

required resistance to shear or combined shear and tension on the fasteners, bearing on the connected material and tensile fatigue, if applicable. Installation and inspection requirements are as described in the next section of this article.

Installation and Inspection Requirements

The requirements in the RCSC Specification for installation and inspection are invoked by the joint type specification. In all cases, proper storage of the fastener components is required per Section 2.

Snug-Tightened Joints

For proper installation of fastener assemblies in snug-tightened connections, all boltholes must be aligned so that the bolts are not damaged during insertion. Once bolts are placed with washers as required and nuts, the assembly compacts the joint progressing systematically from the most rigid part of the joint to the snug-tight condition. The snug-tight condition is defined as “the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the plies into firm contact.” The connected plies must be solidly seated against each other but need not be in continuous contact. Note that when compacting a joint to bring the connected plies into firm contact, any tightening of fasteners should always be done progressing systematically from the most rigid part of the joint.

For proper inspection of snug-tightened bolted joints, it must be ensured that the proper fastener components were used, the connected elements were fabricated properly and the bolted joint was drawn into firm contact. Because pretension is not required for the proper performance of a snug-tightened joint, the installed bolts should not be inspected to determine the actual installed preten-

Table 1

Load Transfer	Application	Joint Type ^{ab}	Faying Surface Prep.?	Install per Section	Inspect per Section	Arbitrate per Section 10?
Shear only	Resistance to shear load by shear/bearing	ST	No	8.1	9.1	No
	Resistance to shear by shear/bearing. Bolt pretension is required, but for reasons other than slip resistance.	PT	No	8.2	9.2	No
	Shear-load resistance by friction on faying surfaces is required.	SC	Yes ^d	8.2	9.3	If required to resolve dispute
Combined shear and tension	Resistance to shear load by shear/bearing. Tension load is static only. ^c	ST	No	8.1	9.1	No
	Resistance to shear by shear/bearing. Bolt pretension is required, but for reasons other than slip resistance.	PT	No	8.2	9.2	If required to resolve dispute
	Shear-load resistance by friction on faying surfaces is required.	SC	Yes ^d	8.2	9.3	If required to resolve dispute
Tension only	Static loading only. ^c	ST	No	8.1	9.1	No
	All other conditions of tension-only loading.	PT	No	8.2	9.2	If required to resolve dispute

^a Under Joint Type: ST = snug-tightened, PT = pretensioned and SC = slip-critical; See Section 4.
^b See Sections 4 and 5 for the design requirements for each joint type.
^c Per Section 4.2, the use of ASTM A490 bolts in snug-tightened joints with tensile loads is not permitted.
^d See Section 3.2.2.

sion. Likewise, arbitration (described in RCSC Specification Section 10) is not appropriate.

Pretensioned Joints

There are four approved methods for proper installation of fastener assemblies: turn-of-nut pretensioning, calibrated wrench pretensioning, twist-off-type tension-control bolt pretensioning and direct-tension-indicator pretensioning. In each of these methods, the snug-tightened condition is the starting point for subsequent pretensioning. The pre-installation verification requirements in RCSC Specification Section 7 must be met for pretensioned installation, although note that there are differences in how extensively these requirements apply to each method. Note that, when joints are designated as pretensioned, they are not subject to the same faying-

surface-treatment inspection requirements specified for slip-critical joints.

Turn-of-Nut Pretensioning: For installation, after snug-tightening the joint, the nut (or bolt head) rotation specified in the RCSC Specification Table 8.2 must be applied to all fastener assemblies in the joint, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pretensioned bolts.

For inspection, in addition to meeting the inspection requirements for snug-tightened joints, the inspector should observe the pre-installation verification testing required. Subsequently, the inspector can either ensure by routine observation that the proper rotation is applied to the turned element or visually inspect match-marks after pretensioning.

Calibrated Wrench Pretensioning: For installation, after snug-tightening the joint, the calibrated installation torque (determined as specified using the pre-installation verification testing and not a tabulated or assumed value) must be applied to all fastener assemblies in the joint, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pretensioned bolts.

For inspection, in addition to meeting the inspection requirements for snug-tightened joints, the Inspector should observe the pre-installation verification testing required. Subsequently, the inspector should ensure by routine observation that the proper calibrated installation torque is applied to the turned element.

Twist-Off-Type Tension-Control Bolt Pretensioning: For installation, after snug-tightening the joint without severing the splined end, the installation wrench must be applied to all fastener assemblies in the joint, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pretensioned bolts.

For inspection, in addition to meeting the inspection requirements for snug-tightened joints, the Inspector should observe the pre-installation verification testing required. Subsequently, the inspector should ensure by routine observation that the splined ends are properly severed during installation.

Direct-Tension-Indicator Pretensioning: For installation, after snug-tightening the joint, the direct-tension-indicator gaps should be compressed, progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pretensioned bolts.

For inspection, in addition to meeting the inspection requirements for snug-tightened joints, the

Inspector should observe the pre-installation verification testing required, the protrusions are properly oriented away from the work and the appropriate feeler gage is accepted in at least half of the spaces between the protrusions of the direct tension indicator prior to pretensioning. Subsequently, the inspector should ensure by routine observation that the appropriate feeler gage is refused entry into at least half of the spaces between the protrusions.

In each of these methods, no further evidence of conformity is required. Furthermore, a pretension that is greater than the specified minimum pretension is not cause for rejection.

Slip-Critical Joints

Installation in slip-critical joints is identical to that for pretensioned joints. Inspection is also identical, except that the inspector should also verify that the faying surfaces of slip-critical joints meet the appropriate requirements.

The June 23, 2000 RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts represents a major improvement for its ease of use, simplicity and clarity. It

is the result of the deliberations of a fair and balanced Committee (see box). It also represents the state-of-the-art in the design and construction of bolted structures.

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