Night School 27:
Fundamentals of
Welding and Bolting

Thank you for joining our live webinar. We will begin shortly. Please standby.

Bolting Part 2 – Organizations, Specifications, and Connections
November 9, 2021 | Chad Larson

Smarter.
Stronger.
Steel.

AISC Night School

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Course Description

Fundamentals of Bolting and Welding

Session 2: - Bolting Pt. 2: Organizations, Specifications, and Connections

November 9th, 2021

This session will review of standards organizations related to bolted connections and an overview of recent changes to structural bolt standards. An explanation will be given regarding how the connection design relates to bolt selection and use. Design limit states, such as shear and bearing and slip-critical connections will be discussed, including practical suggestions for economical use and practices to minimize the potential for bolt related problems.

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Learning Objectives

- List standards organizations responsible for bolted connection specifications.
- List important recent changes to fastener standards.
- Gain an understanding of the basic connection.
- Gain an understanding of how connection design relates to fasteners.
- Describe practical suggestions to keep costs down and projects on schedule.

Night School 27: Fundamentals of Welding and Bolting

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Night School 27: Fundamentals of Welding and Bolting

Bolting Part 2: Organizations, Specifications, and Connections

November 9th, 2021

Chad Larson, LeJeune Bolt Company

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Session 1

- **Bolting Background and Basic Concepts**
  - Terms
  - How they are made
    - Cold Forming
    - Hot Forming
    - Thread Rolling
  - Threads and dimensions
    - Shear plane location
  - Lubrication
    - K – Factor

Session 2

- **Organizations, Specifications, and Connections**
  - Standards Organizations
  - Key events in structural bolting history
  - Structural bolt standards
  - Engineer responsibility
  - Failure modes
  - Basic Connections
  - Practical tips

Session 3

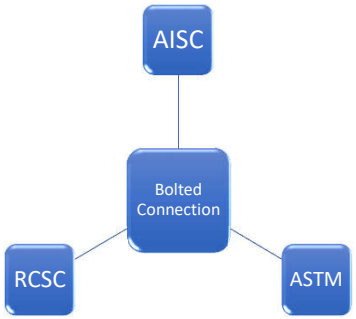
- **Ordering, Storing, Installing, and Inspecting**
  - Ordering information
  - Storage and Handling
  - Pre-installation testing
  - Turn of Nut Method of Pretensioning
  - Twist-off Bolt Method of Pretensioning
  - DTI Method of Pretensioning
  - Calibrated Wrench Method of Pretensioning
  - Combined Method of Pretensioning
  - Inspection and arbitration inspection

Session 4

- **Supplementary Requirements, Rotational Capacity Testing, New Standards and Changes to Existing Standards**
  - Rotational capacity testing
  - Coatings on structural bolts
  - Storage and Handling
  - A325T - fully threaded bolts
  - A325S - Special
  - Surface discontinuities
  - Non-conforming material handling
  - Bolt banging
  - Problem solving and prevention

It Takes an Army……

Bolted Connection



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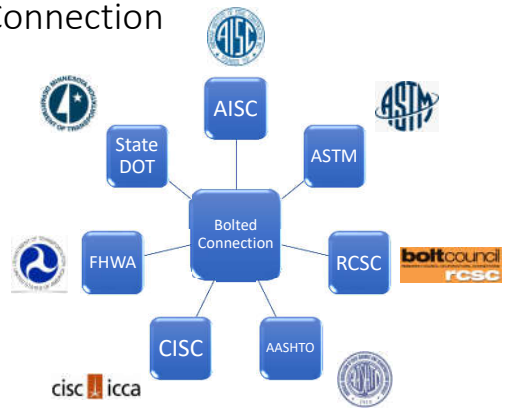
Bolted Connection



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Organizations

- AISC – American Institute of Steel Construction
  - Not-for-profit technical institute and trade association established in 1921 to serve the structural steel design community and construction industry in the United States. AISC's mission is to make structural steel the material of choice by being the leader in structural-steel-related technical and market-building activities. Selected volunteers and AISC technical staff.
  - Research
  - Standardize
  - Educate
  - Promote

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Organizations

- RCSC – Research Council on Structural Connections
  - The RCSC is a non-profit, volunteer organization, comprised of over 80 leading experts in the fields of structural steel connection design, engineering, fabrication, erection and bolting. Research projects funded by the RCSC serve to provide safety, reliability, and standard practice for the steel construction industry throughout the world.
  - Research
  - Convert that research to practical application
  - "Specification for Structural Joints Using High-Strength Bolts"
  - Can be found in your AISC manual or http://www.boltcouncil.org

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Organizations

- ASTM International – Formerly American Society for Testing and Materials
  - Globally recognized leader in the development and delivery of international voluntary consensus standards. Today, some 12,000 ASTM standards are used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence.
  - F16 Fastener Committee is 225 of the 30,000 ASTM members.
    - Maintain Structural Bolt, Nut, Washer and related standards
  - All Volunteer
  - No Technical Staff

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Organizations

- ASTM and RCSC are all volunteer.
- Standards are never aligned in real time.
- Often there are discrepancies in standards, updates and balloting to align them take a long time.

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KEY EVENTS IN STRUCTURAL CONNECTIONS

- AISC formed in 1921
- The Research Council on Riveted and Bolted Joints (RCRBSJ) was formed in 1947 as high strength bolt use was on the horizon.
- The original ASTM A325 standard was approved in 1949.
- In January,1951, the "Specification for Structural Joints Using High-Strength Bolts" was issued by the RCRBSJ, permitting replacement of rivets with bolts on a one-to-one basis. The RCRBSJ later became the RCSC, Research Council on Structural Connections.
- In the 1950's & 1960's research in the US, Germany and Great Britain lead to the development of the various standards and specifications, many still in use today.

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KEY EVENTS IN STRUCTURAL CONNECTIONS

- In 1964, high strength A490 bolt research was approved, resulting in a newly titled and modified RCSC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
- In 1970, the RCSC recognized the use of Hot Dipped Galvanized (HDG) coated A325 bolts and the use of Type 3 high-strength weathering steel.
- In 1974, the RCSC sponsored book "Guide to Design Criteria for Bolted and Riveted Joints" by J. Fisher and J. Struik, was first published. The second edition by G. Kulak, J. Fisher and J. Struik was published in 1987 and the third edition in 2002. An updated version is in draft form.
- In 1998, the ASTM F1852 standard was approved for Twist-off Tension Control Structural Bolt/Nut/Washer Assemblies.

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KEY EVENTS IN STRUCTURAL CONNECTIONS

- In 2006, the ASTM F2280 standard was approved for Twist-off Tension Control Structural Bolt/Nut/Washer Assemblies.
- In 2014, the ASTM F3043 and F3111 200 ksi standards were approved
- In 2015, the ASTM F3125 was published, which combines six structural bolt specifications into one document.
- In 2015, the ASTM F3148 144 ksi standard was approved.
- In 2020, the RCSC approved the Combined Method of pretensioning and ASTM F3148.

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Material Standards

Structural Bolts, Nuts and Washers

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What is ASTM F3125?

- *ASTM F3125 was approved by the ASTM F16 Fastener Committee and cleared for publication by ASTM on January 1st, 2015. F3125 replaced six existing ASTM specifications; A325, A325M, A490, A490M, F1852 and F2280.*
- *Just added to RCSC 2020 edition, already in many other standards, but not all.*

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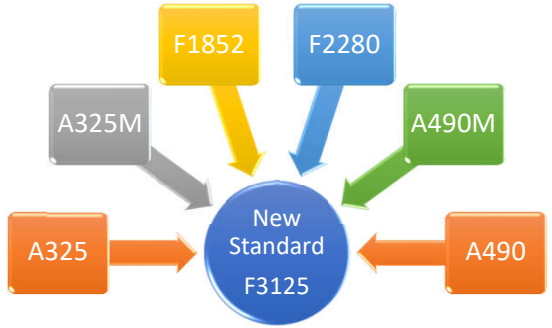
What is ASTM F3125?



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ASTM F3125

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Why

- *The intent of the combined specification is to streamline and unify language and requirements for structural bolts and to simplify specification maintenance moving forward.*
- *F3125 - nearly all previous technical requirements of the six individual standards remain but new specification adds many needed changes and improvements.*

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A few of the 100+ changes

- *Reduction in the total page count from 45 pages down to 13 pages*
- *Reduction in the number of tables from 54 tables down to 7 tables*
- *Elimination of 32 cross references*
- *Increase in minimum tensile strength, proof load and hardness of 1-1/8" and larger A325 bolts, from 105 ksi to 120 ksi*
- *Addition of a "Type 3" chemistry based on a corrosion index*
- *Addition of a more defined and useful rotational capacity test*

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https://studylib.net/doc/18286153/six-into-one---modern-steel-construction
https://www.aisc.org/globalassets/modern-steel/archives/2015/11/six.pdf

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RCSC 2020 – New Edition

Bolt Council

- 937 total changes
- Significant effort by RCSC specification committee and all volunteer membership

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Where is the RCSC Specification?

The 2014 Edition is
- In the AISC 15th Edition (current) Manual - Section16.2
- On the AISC website
  - www.aisc.org/publications/steel-standards/
- On the RCSC website
  - *www.boltcouncil.org/files/2014RCSCSpecification-withErrata.pdf*

The 2020 Edition is
- On the AISC website
  - www.aisc.org/publications/steel-standards/
- On the RCSC website
  - *www.boltcouncil.org/files/2020RCSCSpecification.pdf*

The 2020 edition will be printed in the 2023 AISC Manual - Section 16.2

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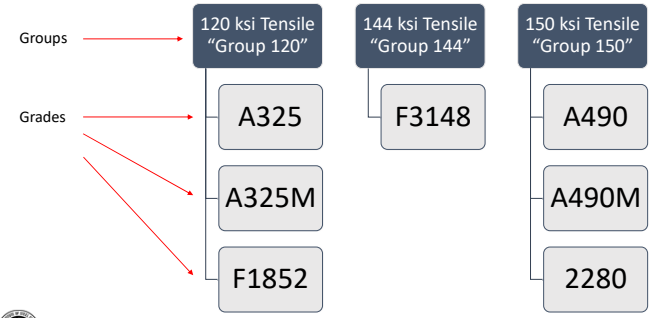
Structural Bolt Grades and Groups



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RCSC Strength "Group"

Table 2.1
Group Designations for Bolts and Matched Bolting Assemblies

Group	Tensile Strength	Bolts	Matched Bolting Assemblies
Group 120	120 ksi	ASTM F3125 Grade A325	ASTM F3125 Grade F1852
Group 144	144 ksi	—	ASTM F3148 Grade 144
Group 150	150 ksi	ASTM F3125 Grade A490	ASTM F3125 Grade F2280

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New Specifications to Consider

- F3148 144 ksi Fixed Spline bolt assemblies, Combined Method
- We are seeing the first North American implementation of the Combined Method of pretensioning, also known as torque and angle pretensioning
  - Common in Europe
  - Common in other fastening industries
  - Now approved in RCSC

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ASTM F3148

Designation: F3148 – 17a

Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144ksi Minimum Tensile Strength, Inch Dimensions[1]

This standard is issued under the fixed designation F3148; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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Why 144 ksi?

- Optimize strength
- Same materials and processes - tighter controls
- Japan JIS B1186 F10T/S10T common strength in Asia 1000 N/mm2 = 145 ksi
- Permit numerous coatings, including HDG, below critical threshold for hydrogen embrittlement
- Probably would not write A325 today, but we are stuck with the legacy in design and inventory

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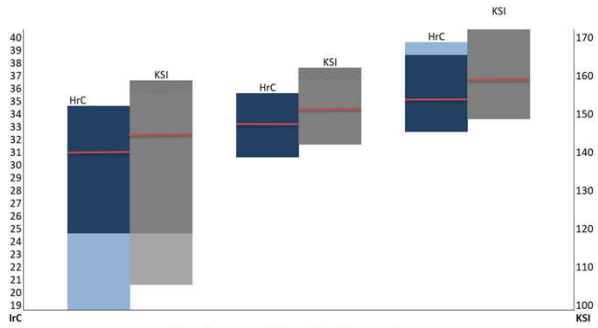

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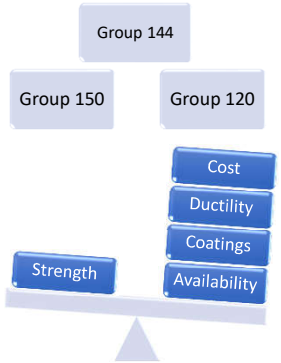
Structural Bolts



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New Coatings for Structural Bolts

- **F2833** - Standard Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
  https://www.astm.org/Standards/F2833.htm
- **F3019** - Standard Specification for Chromium Free Zinc-Flake Composite, with or without Integral Lubricant, Corrosion Protective Coatings for Fasteners
  https://www.astm.org/Standards/F3019.htm
- **A1059** - Standard Specification for Zinc Alloy Thermo-Diffusion Coatings (TDC) on Steel Fasteners, Hardware, and Other Products
  https://www.astm.org/Standards/A1059.htm

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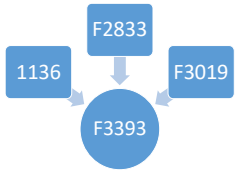
New Coatings – New Zn/Al Combined Specification

- ASTM F1136
- ASTM F2833
- ASTM F3019



Combined into F3393-20

Zinc-Flake Coating Systems for Fasteners

https://www.astm.org/Standards/F3393.htm

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Other Standards Commonly Used

- Heavy hex nuts
  - A563 Grade C, C3 - Group 120, plain only
    - C3 for weathering applications
  - A563 Grade DH - Group 120 or 150, plain or coated
  - A563 Grade DH3
    - For weathering applications
- Washers
  - F436 T1 - plain or coated
  - F436 T3 –weathering applications
  - F959 Direct Tension Indicators – T1 plain or coated
  - F959 Direct Tension Indicators – T3 weathering applications

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Other Standards Used

- When to use other bolt grades
  - A449
  - A354
- Head dimensions, configuration or geometry (can also use “S” in F3125)
- Over 1-1/2” A325 or A490
- Thread length deviation (sometimes)
- Coatings

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What you should know about A354BD

- Dimensions not heavy hex unless you specify
- Consider specifying max tensile strength
- Consider Carb/Decarb testing
- Consider Magnetic Particle testing
- Be careful with thread length
- Be careful with coatings

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- Sometimes very special and unique fasteners are needed to suit design challenges.
- Decision tree should include many items
  - Strength
  - Availability
  - Familiarity
  - Commonality
  - Steel type
  - Coatings
  - Need for substitutions

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Structural Bolt Types

- Type 1 Carbon Steel
- Type 3 Weathering Steel

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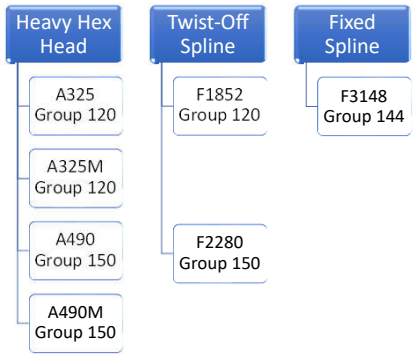
Structural Bolt Styles



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RCSC Length Selection

Table C-2.2
Bolt Length Selection

Nominal Bolt Diameter, d_b, in.	To Determine the Required Bolt Length, Add to *Grip + Washer + Direct tension indicator*, in.
½	1 1/16
⅝	⅞
¾	1
⅞	1⅛
1	1¼
1⅛	1⅜
1¼	1⅝
1⅜	1¾
1½	1⅞

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RCSC Group and Grade Designations

Table 2.1
Group Designations for Bolts and Matched Bolting Assemblies

Group	Tensile Strength	Bolts	Matched Bolting Assemblies
Group 120	120 ksi	ASTM F3125 Grade A325	ASTM F3125 Grade F1852
Group 144	144 ksi	—	ASTM F3148 Grade 144
Group 150	150 ksi	ASTM F3125 Grade A490	ASTM F3125 Grade F2280

Table 2.2
Permitted Nut Grades

Group Designation	Bolt Type	Coating	ASTM A563 Nut Grade
120	1	Plain	C, C3, D, DH, and DH3
		Coated in compliance with 2.8	DH
	3	Plain	C3 and DH3
144 and 150	1	Plain	DH and DH3
		Coated in compliance with 2.8	DH
	3	Plain	DH3

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EOR Responsibility

1.6. Structural Design Drawings and Specifications
The *Engineer of Record* shall specify the following information in the contract documents:

(1) The Group designation (Section 2.1) of bolt or *bolting assembly* and steel type (Section 2 Commentary) to be used;

(2) The *joint* type (Section 4); and

(3) The required class of slip resistance if *slip-critical joints* are specified (Section 4).

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And Also….. (See RCSC Commentary)

(1) *Bolting assembly* grade, type (type 1 or type 3), *style* (heavy hex or twistoff), coating (hot-dip galvanized, mechanically galvanized, etc.), and any other considerations on special components or installation methods related to the *bolting assembly* (Section 2);
(2) Specifying when threads must be excluded from the shear plane, if applicable (Section 5);
(3) Use of *faying surface* coatings in *slip-critical joints* that provide a *mean slip coefficient* determined in accordance with Appendix A, but differing from Class A or Class B coatings (Section 3.2.2(2);
(4) Use of any materials other than steel within the *joint* (outside of the scope of the Specification, discussed in Commentary to Section 1.1);
(5) Use of alternative-design *bolting components*, *assemblies*, or installation methods, including the corresponding installation and inspection requirements that are provided by the *Manufacturer* (Section 2.12);
(6) *Reuse* of bolts (Section 2.11);
(7) If *re-pretensioning* of galvanized *bolting assemblies* is required by the *Engineer of Record*, this must be clearly specified in the contract documents (see Commentary to Section 8.2);
(8) Use of thermal cutting of bolt holes produced free hand or for use in cyclically loaded *joints* (Section 3.3);
(9) Use of oversized (Section 3.3.2), short-slotted (Section 3.3.3), or long slotted holes (Section 3.3.4) in lieu of standard holes;
(10) Use of a value of *Du* other than the value provided in Section 5.4;
(11) Restrictions on the use of hole types (Section 3.3);
(12) Use of hole sizes larger than permitted in Section 3.3.

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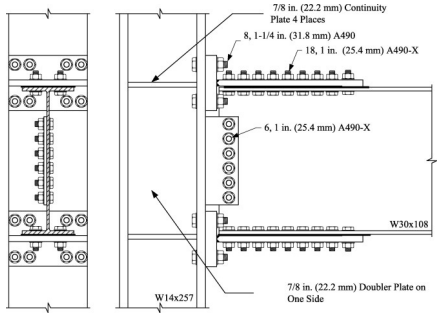
Bolted Connection Basics



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What do we need to know about bolted connections?

Connections depend on…

- Type of loading
- Strength and serviceability requirements
- Economy
- Difficulty or ease of erection

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What do we need to know about bolted connections?

- Steel connections have a direct influence on the cost of the framing system.
- Steel connections are directly related to structural integrity.
- While a connection may be efficient in the use of material, it may still be very expensive to erect.
- Repetitive connection design may save costs but can be boring.

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What do we need to know about bolted connections?

- To know what is needed to make a safe connection, we need to first understand the connection limit states, or how they might fail. Typical bolt related limit states are:
  - Bolt Tensile Rupture
  - Bolt Shear Rupture
  - Plate/Member Bearing/Tear-out
  - Plate/Member Block shear
  - Plate/Member Tensile Strength
  - Plate/Member Yield

The details of connection design and the calculations of limit states are the subjects of other AISC courses. This course is concentrating on the bolt assemblies that are a part of bolted connection design.

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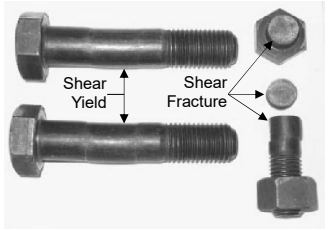
Bolt Failure

Photo provided by RCSC from *Guide to Design Criteria for Bolted and Riveted Joints*

Tension Failure



Shear Failure

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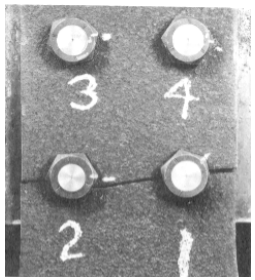
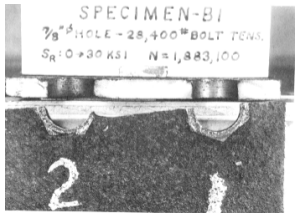
Plate Failures





Photos provided by RCSC from *Guide to Design Criteria for Bolted and Riveted Joints*

Plate Rupture - Net Section

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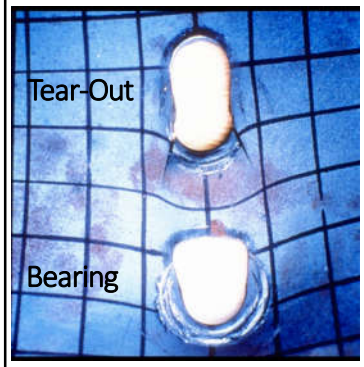
Plate Failures



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Joint Types

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Snug Tight – What is it?

2014 Rev. RCSC Specification

Snug-Tightened Joint. A *joint* in which the bolts have been installed in accordance with Section 8.1. The snug tightened condition is 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*.

2020 Rev. RCSC Specification

Snug-Tight Condition. The *joint* condition in which the plies have been brought into *firm contact* and each *bolting assembly* has at least the tightness attained with either a few impacts of an impact wrench, resistance to a suitable non-impacting wrench, or the full effort of an ironworker using an ordinary spud wrench.

Snug-Tightened Joint. A *joint* in which the *bolting assemblies* have been installed to the *snug-tight condition*.

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Snug Tight – What is it?

- Shear/bearing connections and the bolts in them are required to be at least snug tight
- Pretensioning methods depend on achieving the snug tight condition first

2000 – 2004 Rev. RCSC Specification

"The snug-tightened condition is 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."

2009 Rev. RCSC Specification

"Snug tight is the condition that exists when all of the plies in a connection have been pulled into firm contact by the bolts in the joint and all of the bolts in the joint have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench."

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Joint Types

- For *joints* with bolts that are loaded in shear or combined shear and tension, the *Engineer of Record* shall specify the *joint* type in the contract documents as *snug-tightened*, *pretensioned*, or *slip-critical*. For *slip-critical joints*, the required class of slip resistance in accordance with Section 5.4 shall also be specified. For *joints* with bolts that are loaded in tension only, the *Engineer of Record* shall specify the *joint* type in the contract documents as *snug-tightened* or *pretensioned*. Table 4.1 summarizes the applications and requirements of the three *joint* types.

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RCSC

Table 4.1
Summary of Applications and Requirements for Bolted Joints

Load Transfer	Application	Joint Type[A,b]	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 load by shear/bearing. Bolt *pretension* is required, but for reasons other than slip resistance.	PT	No	8.2	9.2	If req'd to resolve dispute
	Resistance to shear load by friction on *faying surfaces* is required.	SC	3.2.2	8.2	9.3	If req'd 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 req'd to resolve dispute
	Resistance to shear load by friction on *faying surfaces* is required.	SC	3.2.2	8.2	9.3	If req'd 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 req'd 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 Group 144 and 150 bolts in snug-tightened joints with tensile loads is not permitted.

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RCSC Nominal Strengths

Table 5.1
Nominal Strengths per Unit Area of Bolts

Applied Load Condition			*Nominal Strength* per Unit Area, F_n, ksi		
			Group 120	Group 144	Group 150
Tension[a]	Static		90	108	113
	Fatigue		See Section 5.5		
Shear[a,b]	Threads included in shear plane	$L_g \le 38$ in.	54	65	68
		$L_g > 38$ in.	45	54	56
	Threads excluded from shear plane	$L_g \le 38$ in.	68	81	84
		$L_g > 38$ in.	56	68	70

[a] Except as required in Section 5.2.
[b] Reduction for values for $L_g > 38$ in. applies only when the joint is axially end loaded, such as splice plates on a beam or column flange, but it does not apply for web connections in shear.

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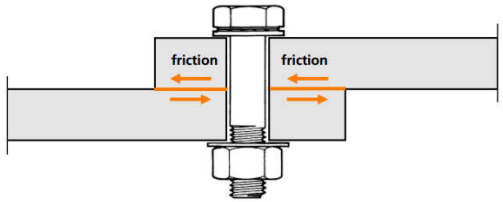
Joint Types

- All connections will have slip resistance as a result of pretension. The pretension present and condition of the faying surfaces will determine the slip resistance. Not all connections are required to be slip-critical. AISC and RCSC detail when a connection should be specified as pretensioned or slip-critical.
- Pretensioning methods (we will discuss in session 3) are the same for pretensioned and slip-critical joints. Slip-critical joints are basically an extension of pretensioned joints, adding specific requirements for faying surfaces to meet a specified level of slip resistance. Slip critical implies any slip is detrimental.

65

Joint Types – Slip Critical



66

Joint Types – Slip Critical

Required per RCSC 4.3:

- Joints subject to fatigue with reversal of the loading direction
- Joints with oversized holes
- Joints with slotted holes except those with applied load approximately normal to the direction of the long dimension of the slot
- Joints in which slip at the faying surfaces would be detrimental to the performance of the structure

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Joint Types – Slip Critical

Characteristics:

- Designed to prevent slip
- Designed for the limit states of bearing-type connections
- Must consider
  - Proper tension
  - Assurance of proper tension
  - Surface preparation
  - Coatings
- See AISC Sections J3.8 and J3.9 and RCSC Section 4.3 for additional requirements

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The Table Formerly Known as 8.1

- Table 5.2 "Minimum Bolt Pretension" moved from Table 8.1 to the more appropriate design section Table 5.2
- Increase in pretension for F3125 large diameter from 105 to 120 ksi
- Added strength Group 144 here and Table 5.3

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Increase and Relocation

2014

Table 8.1. Minimum Bolt Pretension, *Pretensioned* and *Slip-Critical Joints*

Nominal Bolt Diameter, d_b, in.	Specified Minimum Bolt Pretension, T_m, kips [a]	
	ASTM A325 and F1852	ASTM A490 and F2280
½	12	15
⅝	19	24
¾	28	35
⅞	39	49
1	51	64
1⅛	56	80
1¼	71	102
1⅜	85	121
1½	103	148

[a] Equal to 70 percent of the specified minimum tensile strength of bolts as specified in ASTM Specifications for tests of full-size ASTM A325 and A490 bolts with UNC threads loaded in axial tension, rounded to the nearest kip.

2020

Table 5.2
Minimum Bolt Pretension, Pretensioned and Slip-Critical Joints

Nominal Bolt Diameter, d_b, in.	Specified Minimum Bolt Pretension, T_m, kips	
	Group 120	Group 144 and Group 150
½	12	15
⅝	19	24
¾	28	35
⅞	39	49
1	51	64
1⅛	64	80
1¼	81	102
1⅜	97	121
1½	118	148

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Group 120 PIV – Increase from 105 ksi to 120 ksi

2014

Table 7.1 Minimum Bolt Pretension for Pre-Installation Verification

Nominal Bolt Diameter, d_b, in.	Minimum Bolt Pretension for Pre-Installation Verification, kips [a]	
	ASTM A325 and F1852	ASTM A490 and F2280
½	13	16
⅝	20	25
¾	29	37
⅞	41	51
1	54	67
1⅛	59	84
1¼	75	107
1⅜	89	127
1½	108	155

2020

Table 7.1
Minimum Bolt Pretension for Pre-Installation Verification

Nominal Bolt Diameter, d^b, in.	Minimum Bolt Pretension for Pre-Installation Verification, kips	
	Group 120	Group 144 and Group 150
½	13	16
⅝	20	25
¾	29	37
⅞	41	51
1	54	67
1⅛	67	84
1¼	85	107
1⅜	102	127
1½	124	155

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Galvanized Faying Surfaces 3.2.2

- Testing long ago demonstrated an improvement in slip resistance when hand wire brushing was performed. RCSC has required hand wire brush roughening and prohibited power wire brushing ever since.
- University of Texas Study (2014) showed no advantage to hand wire brushing. In fact, showed a decrease in performance.
- As a result, RCSC no longer requires and in fact forbids roughening.
- AISC still requires – balloting to remove requirement, but not prohibit.

- https://www.aisc.org/globalassets/aisc/research-library/university-of-texas-report-on-galvanized-slip-coefficients-draft-final-4915.pdf

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Slip Critical Galvanized Faying Surfaces

Between 1 and 9 slip classes over the years
3.2.2 (3)

2014

(3) *Galvanized Faying Surfaces*: *Galvanized faying surfaces* shall first be hot dip galvanized in accordance with the requirements of ASTM A123 and subsequently roughened by means of hand wire brushing. Power wire brushing is not permitted. When prepared by roughening, the galvanized faying surface is designated as Class A for design.

2020

(3) *Galvanized Faying Surfaces: Galvanized faying surfaces* shall be hot dip galvanized in accordance with the requirements of ASTM A123. Power or hand wire brushing is not permitted. *Galvanized faying surfaces* are designated as Class A for design.

2014 RCSC – Roughened by means of hand wire brushing required
2016 AISC – Roughened by means of hand wire brushing required
2017 AASHTO – Roughened by means of hand wire brushing no longer required, but not prohibited
2020 RCSC – Roughened by means of hand wire brushing prohibited
2022 AISC – Roughened by means of hand wire brush no longer required, but not prohibited???

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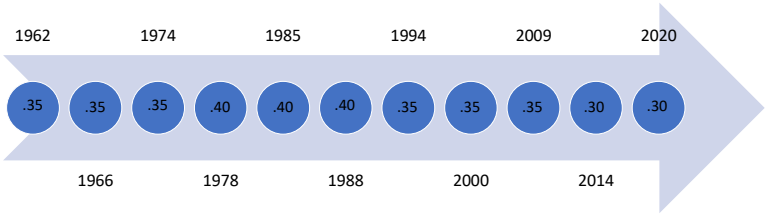
Slip Coefficient for Galvanized Faying Surfaces - Timeline



75

Joint Types – Pretensioned

Required per RCSC 4.2:

- *Pretensioned joints* are required in the following applications:
- (1) *Joints* in which bolt *pretension* is required in the specification or code that invokes the RCSC Specification;
- (2) *Joints* that are subject to significant load reversal;
- (3) *Joints* that are subject to fatigue load with no reversal of the loading direction;
- (4) *Joints* with Group 120 *bolting assemblies* that are subject to tensile fatigue; and
- (5) *Joints* with Group 144 or Group 150 *bolting assemblies* that are subject to tension or combined shear and tension, with or without fatigue.

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Joint Types – Pretensioned

Required per AISC 360-16 J3.1(b):

- As required by the RCSC *Specification.*
- Connection subjected to vibratory loads where bolt loosening is a consideration.
- End connections of built-up members composed of two shapes either interconnected by bolts, or with at least one open side interconnected by perforated cover plates or lacing with tie plates, as required in Section E6.1.

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Joint Types – Pretensioned

Characteristics:

- A pretensioned connection is one in which tension is required but slip is not detrimental.
- Bolt design strength is based on limit states of bolt tension rupture and shear rupture.

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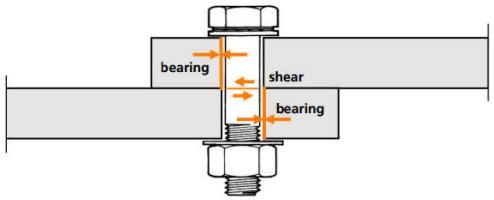
Shear/Bearing Connection



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Joint Types – Snug-Tightened

Permitted per RCSC 4.1:

- Snug-tightened joints may be used whenever pretensioned or slip-critical joints are not required.
- Most bolted connections can be specified as snug-tightened only.
- The design strength of the connection must be checked in accordance with AISC J3.
- **Snug-Tightened Joints**
- Except as required in Sections 4.2 and 4.3, *snug-tightened joints* are permitted. Bolts in *snug-tightened joints* shall be designed in accordance with the applicable provisions of Sections 5.1, 5.2 and 5.3, installed in accordance with Section 8.1, and inspected in accordance with Section 9.1. As indicated in Table 4.1, requirements for *faying surface* condition shall not apply to *snug-tightened joints*.

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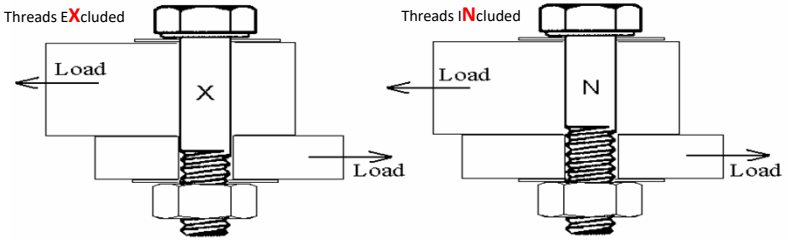
Understanding Shear



Note: Threads included or excluded from the shear plane changes the design bolt shear strength, but not the physical bolt. Do not order X or N Bolts.

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Bolts

- Shear strength is approximately 60%-65% of bolt tensile strength
  - Design takes 90% of 62% (RCSC Table 5.1)
  - Further reduced for threads (or transition) in shear plane
    - Connections with thin outer plies
  - Currently a reduction for long end-loaded joints, over 38”
  - Bolt shear is not dependent on tension
  - Installation can be snug tight only

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Table 6.1
Washer Requirements for Pretensioned and Slip-Critical Bolted Joints with Oversized and Slotted Holes in the Outer Ply

Bolt Group	Nominal Bolt Diameter, d_b, in.	Hole Type in Outer Ply		
		Oversized	Short-Slotted	Long-Slotted
Group 120	½ – 1½	ASTM F436[a]		5/16-in.-thick plate washer or continuous bar[b,c]
Group 144 and 150	≤ 1			
	> 1	ASTM F436 extra thick[a,b,d]		ASTM F436 washer with either a 5/16-in.-thick plate washer or continuous bar[b,c]

[a] This requirement shall not apply at the head at round heads of ASTM F3125 Grades F1852 and F2280, or F3148 Grade 144 *bolting assemblies* with round heads that meet the requirements in Section 2.4 and provide a bearing circle diameter that meets the requirements of the relevant ASTM Standard.
[b] See ASTM F436 Section 1.2. Multiple washers with a combined thickness of 5/16 in. or larger do not satisfy this requirement.
[c] The plate washer or bar shall be of structural-grade steel material, but need not be hardened.
[d] Alternatively, a 5/16-in.-thick plate washer and an ordinary thickness F436 washer may be used. The plate washer need not be hardened.

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The Hole Truth

- Hole size change in Table 3.1 and addressed in 3.3.1 Commentary
- Standard hole size was nominal + 1/16” for all diameters
- This conflicted with ASME B18.2.6 which permits a fin or swell under the bolt head that could exceed the +1/16” hole size
- Many fabricators were oversizing holes to solve this and other fit problems. Pretensioning is required when oversizing holes
- Increased 1” and larger holes to nominal + 1/8” – helps erection tolerance, bolts fit better, but not considered oversized
- This change already done in AISC 360-16

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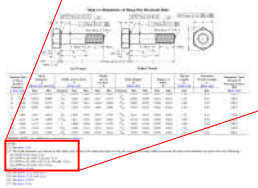
(2) The body diameter are shown in this table.
(a) 0.030 in. for sizes ½ in.
(b) 0.050 in. for sizes ⅝ in. and ¾ in.
(c) 0.060 in. for sizes over ¾ in. through 1¼ in
(d) 0.090 in. for sizes over 1¼ in.



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Hole Sizes

- BOLT HOLES AND TOLERANCE
- Rick Drake, SE, Member AISC, Fluor Enterprises, Inc.
- Tom Hunt, SE, Member AISC, Fluor Enterprises, Inc.

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Increase in Nominal Hole Size – Already Done in AISC 360-16

Table 3.1
Nominal Bolt Hole Dimensions

Nominal Bolt Diameter, d_b, in.	Nominal Bolt Hole Dimensions[a,b], in.			
	Standard (diameter)	Oversized (diameter)	Short-Slotted (width × length)	Long-Slotted (width × length)
½	9/16	5/8	9/16 × 11/16	9/16 × 1 1/4
5/8	11/16	13/16	11/16 × 7/8	11/16 × 1 9/16
3/4	13/16	15/16	13/16 × 1	13/16 × 1 1/8
7/8	15/16	1 1/16	15/16 × 1 1/8	15/16 × 2 3/16
1	1 1/8	1 1/4	1 1/8 × 1 5/16	1 1/8 × 2 1/2
≥ 1 1/8	d_b + 1/8	d_b + 5/16	(d_b + 1/8) × (d_b + 3/8)	(d_b + 1/8) × (2.5d_b)

[a] The detailed hole dimension shall not exceed the nominal. The fabricated hole dimension shall not exceed the nominal +1/32 in. Exception: In the width of slotted holes, gouges not more than 1/16 in. deep are permitted.
[b] The slightly conical hole that naturally results from punching operations with properly matched punches and dies is acceptable.

87

Considerations

- Erector may prefer a certain bolt or joint type because of equipment, QC requirements, experience, cost, etc.
- Inspection requirements increase for slip-critical connections

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The Bolt Effect

- Many connections that do not require pretension have significant pretension
  - Effort required to straighten and compact plies
  - Sequential snugging passes create high levels of clamp load
  - Overzealous snugging
  - Good lubricants or coatings mean high pretension with little effort, especially in small diameters
  - We use bolts to tighten things our entire lives. It is counter-intuitive not to tension them, so we often do, even though design may not specifically require it.

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Efficiency and Practicality

- Start organized
  - Work with erectors for constructability and bolting preferences early on
  - Communicate with the design team and the build team
  - Try to detail your intentions along with your requirements
  - Be careful not to go overboard with requirements
- Use trusted partners whenever possible
- Get good and timely detailing
- Efficiency in design isn't always the most efficient

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Efficiency and Practicality

- Think standard
  - Use standard connections when possible
  - Specify readily available materials
  - Use standard tolerances, they are there for a reason
  - Provide for tolerances like O/S holes, S/S holes, installation tools, etc.
  - Keep load paths simple

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Efficiency and Practicality

- Don't get tripped up
  - Don't combine like diameters of different grades
  - Use common bolt sizes when possible 3/4", 7/8", 1"
  - Get a jumpstart on early sequences, especially anchors and shop bolts
- Everyone want to leave their mark or work on a signature project. It's OK if your mark is just "on time and on budget".

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Thank you!

AISC | Questions

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- All individuals attending at your connection: you will receive an email on how to report their attendance from: registration@aisc.org.
    - Be on the lookout: Check your spam filter! Check your junk folder!
    - Completely fill out online form. Don't forget to check the boxes next to each attendee's name!

8-Session Registrants

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One certificate will be issued at the conclusion of all 8 sessions.

8-Session Registrants

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Note: If you attend the live presentation, you do not have to take the quizzes to receive PDHs

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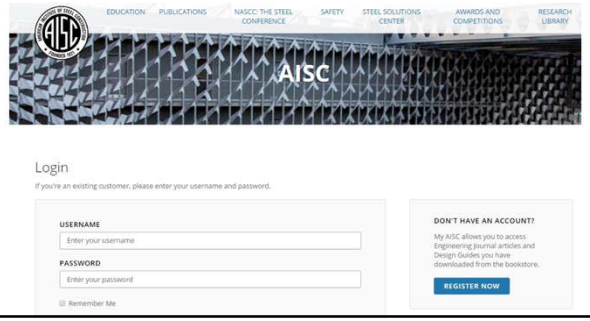

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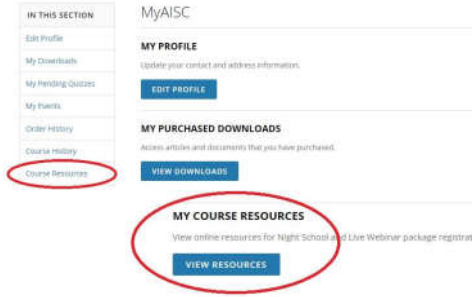

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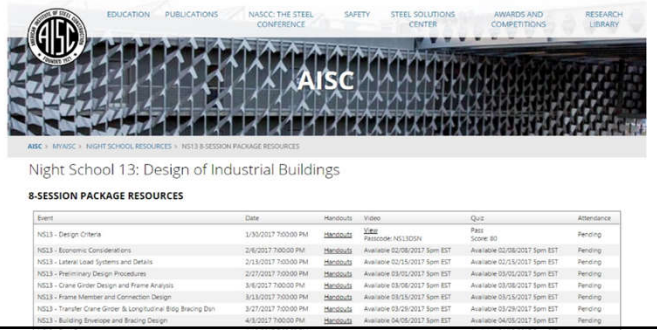

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Night School Resources

- Weekly “quiz and recording” email.
- Weekly updates of the master quiz and attendance record, found at www.aisc.org/nightschool27. Scroll down to Quiz and Attendance records.
  - Updated on Friday mornings.

8-Session Registrants

Night School Resources

- Webinar connection information
  - Reminder email sent out Monday mornings
- Links to handouts also found here