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Fundamentals of Connection Design

Session 1: Fundamental Concepts, Part 1

October 23, 2019



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Course Description

Fundamental Concepts, Part I
October 23, 2019

This session will provide an overview of basic connection types including tension, compression, framing, and moment connections. How to classify beam-to-column connections will be discussed, followed by a review of limit states in the load path. Bolt-related limit states and detailing will be reviewed, including discussions on different types of bolts, bolt installation, bolt shear strength, and combined shear plus tension strength. Fillet weld-related limit states will also be discussed.



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Learning Objectives

- Describe basic structural steel connection types.
- Explain limit states in the load path of a tension connection.
- Identify limit states related to bolts.
- Identify limit states related to welded connections.



Fundamentals of Connection Design

Session 1: Fundamental Concepts, Part I
October 23, 2019



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Schedule

- October 23, 2019 Fundamental Concepts Part I
- October 30, 2019 Fundamental Concepts Part II
- November 6, 2019 Shear Connections Part I
- November 13, 2019 Shear Connections Part II



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FUNDAMENTAL CONCEPTS PART I



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Today's Topics

- Reference Documents
- Nomenclature
- Steel Properties
- Connection Types
- Classification of Beam-to-Column Connections
- Limit States in the Load Path
- Bolt Related Limit States and Detailing
- Fillet Weld Related Limit States and Detailing



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REFERENCE DOCUMENTS
NOMENCLATURE
STEEL PROPERTIES



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Reference Documents

AISC/ANSI 360-16 *Specification for Structural Steel Buildings*,
2016

Chapter B Design Requirements

Chapter D Design of Members for Tension

Chapter J Design of Connections

AISC *Steel Construction Manual*, 15th Ed., 2017

Research Council on Structural Connections (RCSC)

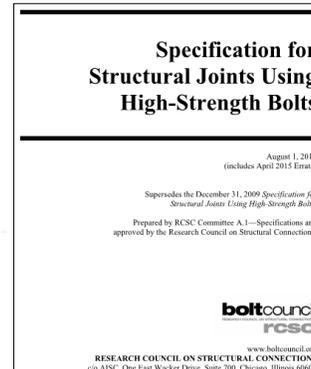
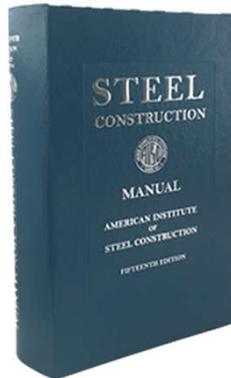
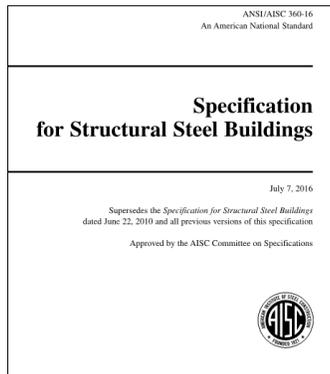
Specification for Structural Joints Using High Strength Bolts,
2014



AWS D1.1 *Structural Welding Code - Steel*, 2015

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Reference Documents



“Specification”
or “Spec.”



“Manual”

“RCSC Spec.”

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Nomenclature

Load and Resistance Factor Design (LRFD)

$$R_u \leq \phi R_n$$

where R_u = Required Strength using LRFD Load
Combinations

ϕ = Resistance Factor

R_n = Nominal Strength

ϕR_n = Design Strength



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Nomenclature

Allowable Strength Design (ASD)

$$R_a \leq R_n / \Omega$$

where R_a = Required Strength using ASD Load
Combinations

R_n = Nominal Strength

Ω = Safety Factor

R_n / Ω = Allowable Strength



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Nomenclature

- Generic

Required Strength \leq Available Strength

- Specific for LRFD

$$R_u \leq \phi R_n$$

- Specific for ASD

$$R_a \leq R_n / \Omega$$



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Nomenclature

LRFD Resistance Factors

Ductile Limit States: $\phi = 0.9$

Example: Tension Yielding

Non-Ductile Limit States: $\phi = 0.75$

Example: Tension Rupture



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Steel Properties

Plates: A36 Steel

$$F_y = 36 \text{ ksi (Tensile Yield Stress)}$$

$$F_u = 58 \text{ ksi (Tensile Rupture Strength)}$$

Angles: A529, Gr. 50 Steel

$$F_y = 50 \text{ ksi} \quad F_u = 65 \text{ ksi}$$

Beams and Columns: A992 Steel

$$F_y = 50 \text{ ksi} \quad F_u = 65 \text{ ksi}$$

Note:

$$\text{Shear Yield Stress} = 0.6 F_y$$

$$\text{Shear Rupture Stress} = 0.6 F_u$$



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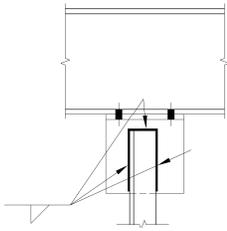
CONNECTION TYPES

- Tension Connections
- Compression Connections
- Shear Connections
- Moment Connections



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Tension Connections



Tee Hanger

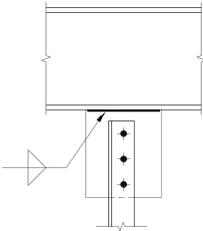
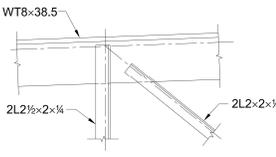


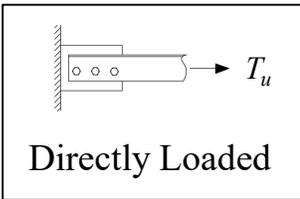
Plate Hanger



Truss



Bracing



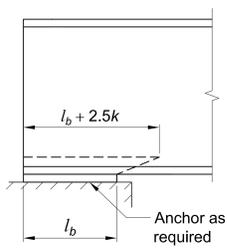
Directly Loaded


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Compression Connections



Column Splice



Beam Bearing



Column Base Plate


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Simple Shear Connections

- Types in the *Manual*
 - Double-Angle
 - Single-Angle
 - Single-Plate (Shear Tab)
 - Shear End-Plate
 - Seated Connections
 - Tee Connections



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Simple Shear Connections



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Simple Shear Connections



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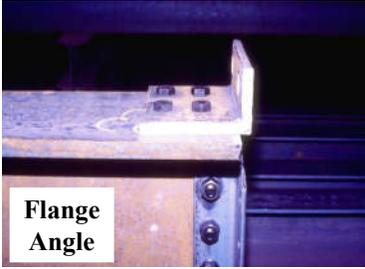
Moment Connections

- Flange Welded Moment Connection
- Flange Plate Welded or Bolted Moment Connection
- Tee-Stub Moment Connection
- Flange Angle Moment Connection
- Moment End-Plate Connection



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Moment Connections

 <p>Flange Welded</p>	 <p>Flange Plate Bolted</p>
 <p>Tee Stub</p>	 <p>Flange Angle</p>



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Moment Connections

 <p>Flush Moment End-Plate</p>	 <p>Extended Moment End-Plate</p>
--	--



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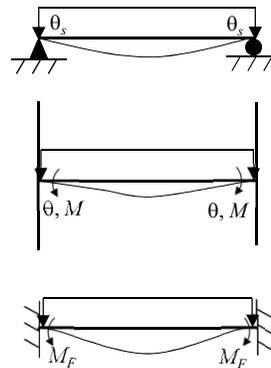
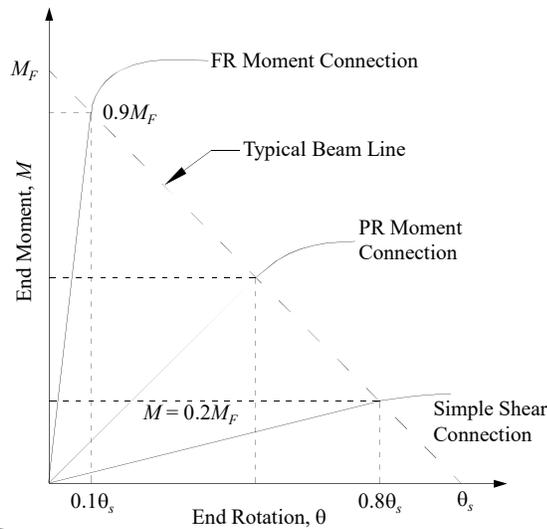
CLASSIFICATION OF CONNECTIONS

- Fully Restrained (FR) Moment Connections
- Partially Restrained (PR) Moment Connections
- Simple Shear Connections



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Classification of Connections



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Classification of Connections	
<ul style="list-style-type: none">• Fully Restrained – FR<ul style="list-style-type: none">- Flange Welded- Flange Plate Welded or Bolted- Tee-Stub- Moment End-Plate	
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Classification of Connections	
<ul style="list-style-type: none">• Partially Restrained – PR<ul style="list-style-type: none">- Flush End-Plate- Flange Angles- Double Angles	
	32



Classification of Connections

- Simple Shear Connections
 - Double-Angle
 - Single-Angle
 - Single-Plate
 - Shear End-Plate
 - Seated Connections
 - Tee Framing Connection



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LIMIT STATES IN THE LOAD PATH



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Load Paths / Limit States

Example: Directly Loaded Tension Connection

Section A-A



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Load Paths / Limit States

1. Angle Yielding
2. Angle Rupture
3. Angle Block Shear
4. **Shear Transfer**
5. Plate Rupture
6. Plate Yielding
7. Weld Rupture

Plate Block Shear



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BASIC BOLT RELATED LIMIT STATES AND DETAILING



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Bolt Types

A307 Machine Bolts – $F_u = 60$ ksi

Group A – High Strength Bolts – $F_u = 120$ -125 ksi

ASTM F3125 Grades A325, F1852

ASTM A354 Grade BC*

Group B – High Strength Bolts – $F_u = 150$ ksi

ASTM F3125 Grades A490, F2280 (new in the *Manual*)

ASTM A354 Grade BD*

Group C – High Strength Bolts – $F_u = 200$ ksi**

ASTM F3043 and F3111

*Lower F_u for large diameters

**Currently not readily available (Fall of 2019)



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Grade A325 and A490 Bolts

3/4 in. Diameter



7/8 in. Diameter



1-1/4 in. Diameter



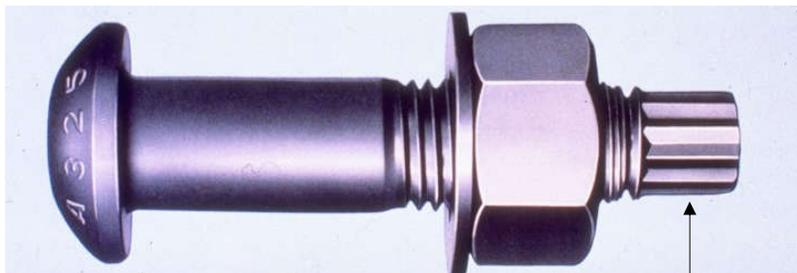
Note:

Thread length is a function of bolt diameter,
not the bolt length.



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Grade F1852 and F2280 Twist-Off Bolt



Spline

Note: Requires a special tightening tool.



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Bolts: Connection Types

Types of Connections (Not Types of Bolts)

(a) Bearing Type

N - threads included in shear plane

X - threads excluded from shear plane

(b) Slip Critical

SC - slip critical (friction)

Example Designations: 3/4 in. Gr A325 – N

1 in. Gr A490 – SC



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Bolts: Tightening

-N or -X Bearing Type Connections

Snug Tight per *RCSC Spec.* “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.”



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Bolts: Tightening

-SC Slip Critical Type Connections

- Requires clean mill scale (Class A) or faying surface preparation (Class B) and field inspection.
- Pretensioning:
 - Turn of Nut Method
 - Calibrated Wrench
 - Direct Tension Indicator (DTI)
 - Twist-Off Bolt

Pretensioned Bolt Connections

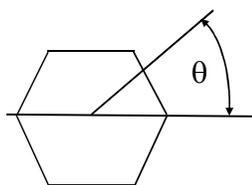
- Pretensioning: same as for -SC connections
- No surface preparation or inspection required.



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Bolts: Pretensioned Installation

Turn-of-Nut Tightening



θ from *RCSC Spec.* Table 8.2

Example: Bolt Length $\leq 4d$, $\theta = 1/3$ Turn



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Bolts: Pretensioned Installation

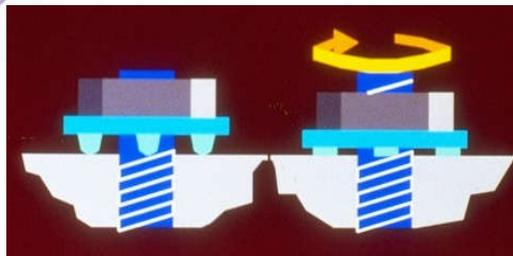
Calibrated Wrench Tightening



45

Bolts: Pretensioned Installation

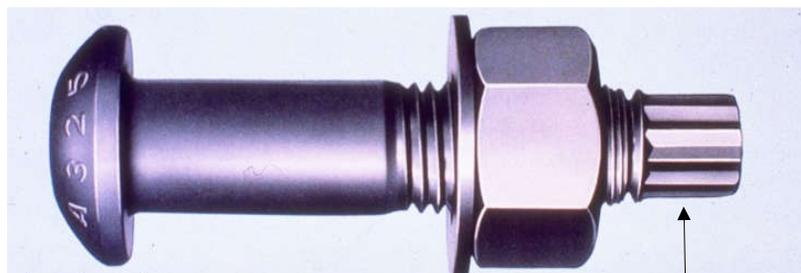
Direct Tension Indicator (DTI) Tightening ASTM F959



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Bolts: Pretensioned Installation

Twist Off Bolt Tightening



Spline



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Bolt Holes

Hole Types and Dimensions (*Spec.* Table J3.3)

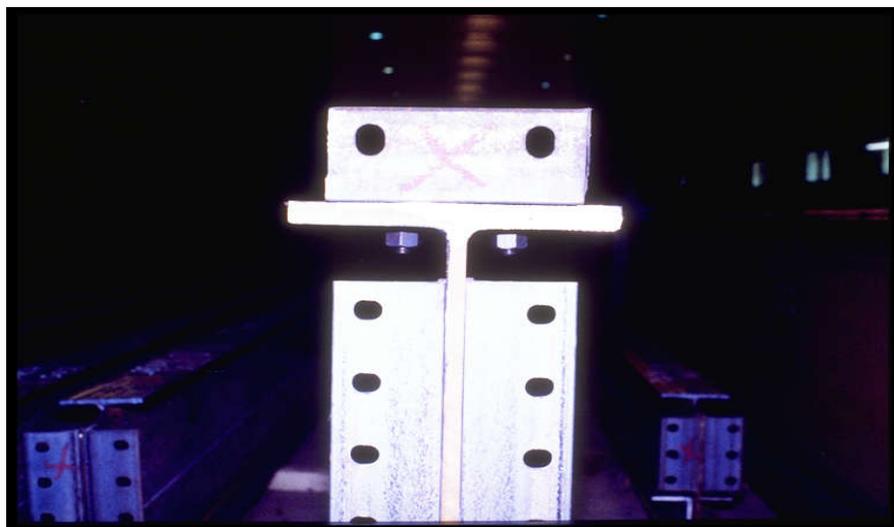
- Standard (STD) If $d \leq 7/8$ in. then $d + 1/16$ in.
If $d > 7/8$ in. then $d + 1/8$ in. (new)
- Oversized (OVS) $d + (1/8$ in. to $5/16$ in.)
- Short Slots (SS) STD by (OVS + $1/16$ in.)
- Long Slots (LS) STD by up to $2.5d$

(Standard Hole, STD, is Default for Course.)



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Example Use of Slotted Holes



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Bolt Tensile Strength

Design Tensile Strength of One Bolt, ϕr_n

(Specification J3.6)

$$\phi = 0.75$$

$$r_n = F_{nt} A_b$$

F_{nt} = nominal strength from *Spec.* Table J3.2

A_b = nominal bolt area

$$\phi r_n = \phi F_{nt} A_b = \text{Design Tensile Strength}$$

Note: Using LRFD for the course. ASD nominal strengths are the same.

Note: net tensile area at the threads is accounted for in F_{nt}



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Bolt Shear Strength

Design Shear Strength of One Bolt, ϕr_n
 (Specification J3.6)

$$\phi = 0.75$$

$$r_n = F_{nv} A_b$$

F_{nv} = nominal strength from *Spec.* Table J3.2

A_b = nominal bolt area

$$\phi r_n = \phi F_{nv} A_b = \text{Design Shear Strength}$$

Note: net shear area at the threads is accounted
 for in F_{nv}



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Bolt Nominal Strengths

TABLE J3.2
Nominal Strength of Fasteners and
Threaded Parts, ksi (MPa)

Description of Fasteners	Nominal Tensile Strength, F_u , ksi (MPa) ^[a]	Nominal Shear Strength in Bearing-Type Connections, F_{nv} , ksi (MPa) ^[b]
A307 bolts	45 (310)	27 (188) ^{[c][d]}
Group A (e.g., A325) bolts, when threads are not excluded from shear planes -N	90 (620)	54 (372)
Group A (e.g., A325) bolts, when threads are excluded from shear planes -X	90 (620)	68 (457)
Group B (e.g., A490) bolts, when threads are not excluded from shear planes -N	113 (780)	68 (457)
Group B (e.g., A490) bolts, when threads are excluded from shear planes -X	113 (780)	84 (579)



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Bolt Nominal Strengths

Table J3.2 Continued

Group C (e.g., F3043) bolt assemblies, when threads and transition area of shank are excluded from the shear plane	150 (1040)	113 (779)
Threaded parts meeting the requirements of Section A3.4, when threads are not excluded from shear planes	$0.75F_u$	$0.450F_u$
Threaded parts meeting the requirements of Section A3.4, when threads are excluded from shear planes	$0.75F_u$	$0.563F_u$

^(b) For high-strength bolts subject to tensile fatigue loading, see Appendix 3.
^(c) For end loaded connections with a fastener pattern length greater than 38 in. (950 mm), F_{nv} shall be reduced to 83.3% of the tabulated values. Fastener pattern length is the maximum distance parallel to the line of force between the centerline of the bolts connecting two parts with one faying surface.
^(d) For A307 bolts, the tabulated values shall be reduced by 1% for each $\frac{1}{16}$ in. (2 mm) over five diameters of length in the grip.
^(e) Threads permitted in shear planes.

Anchor Rods

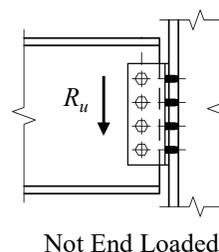
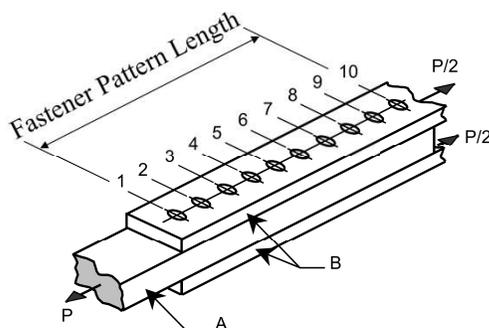


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Bolts: Connection Length Effect

Specification Table J3.2 Footnote [b]

^(b) For end loaded connections with a fastener pattern length greater than 38 in. (965 mm), F_{nv} shall be reduced to 83.3% of the tabulated values. Fastener pattern length is the maximum distance parallel to the line of force between the centerline of the bolts connecting two parts with one faying surface.



Design Guide 17 Figure 5.2



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Connection Slip (-SC Connections)

Specification J3.8. High-Strength Bolts in Slip-Critical Connections

$$r_n = \mu D_u h_f T_b n_s \quad (\text{Spec. J3-4})$$

- $\phi = 1.00$ for STD and SSLT (Transverse)
- $= 0.85$ for OVS and SSLP (Parallel)
- $= 0.70$ for LSL (Long Slots T or P)

Design Strength:

$$\phi r_n = \phi \mu D_u h_f T_b n_s$$



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Connection Slip (-SC Connections)

Specification J3.8. High-Strength Bolts in Slip-Critical Connections

$$r_n = \mu D_u h_f T_b n_s \quad (\text{Spec. J3-4})$$

μ = mean slip coefficient depending on faying surface:

Class A – 0.30 Class B – 0.50

T_b = minimum bolt pretension, Table J3.1

$D_u = 1.13$ = avg pretension / min. pretension



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Connection Slip (-SC Connections)

TABLE J3.1
Minimum Bolt Pretension, kips^[a]

Bolt Size, in.	Group A ^[a] (e.g., A325 Bolts)	Group B ^[a] (e.g., A490 Bolts)	Group C, Grade 2 ^[b] (e.g., F3043 Gr. 2 bolts)
1/2	12	15	—
5/8	19	24	—
3/4	28	35	—
7/8	39	49	—
1	51	64	90
1 1/8	64	80	113
1 1/4	81	102	143
1 3/8	97	121	—
1 1/2	118	148	—

^[a] Equal to 0.70 times the minimum tensile strength of bolts as specified in ASTM F3125/F3125M for Grade A325 and Grade A490 bolts with UNC threads, rounded off to nearest kip.

^[b] Equal to 0.70 times the minimum tensile strength of bolts, rounded off to nearest kip, for ASTM F3043 Grade 2 and ASTM F3111 Grade 2.

Increased in the 2016 Specification



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Connection Slip (-SC Connections)

Specification J3.8. High-Strength Bolts in Slip-Critical Connections

$$r_n = \mu D_u h_f T_b n_s \quad (\text{Spec. J3-4})$$

h_f = factor for fillers
 = 1.0 for no fillers or one filler
 = 0.85 for two or more fillers

n_s = number of slip planes



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Connection Slip (-SC Connections)

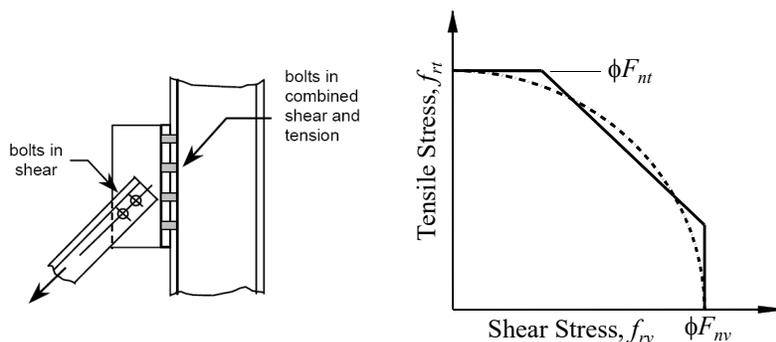
IMPORTANT

- Slip Critical Connections
 - Expensive because of surface preparation, tightening, and inspection requirements.
 - Not needed for typical shear connections and most moment connections.
 - May be needed for dynamic or vibration loads.
 - May be used to control drift in frames.
 - Are required in some moment connections (especially for seismic applications).



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Bearing Bolts: Combined Shear and Tension Strength



Bearing Bolt Interaction Diagram
(Specification Equation J3-3)



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Bolts: Combined Tension and Shear Strength in Bearing Conn. (*Spec. J3.7*)

$$r_{ut} \leq \phi F'_t A_b$$

$$r_{uv} \leq \phi F_{nv} A_b \text{ or in terms of stress: } f_{rv} \leq \phi F_{nv}$$

where

r_{uv} r_{uv} = required tension and shear per bolt

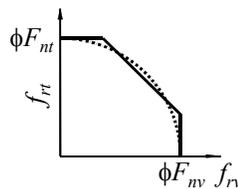
$$\phi = 0.75$$

$$F'_t = 1.3F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_{rv} \leq F_{nt}$$

F_{nt} = nominal tensile stress

F_{nv} = nominal shear stress

f_{rv} = required shear stress = r_{uv} / A_b



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Diameters Used in Calculations

- *Specification* Section B4.3b, for all hole related limit states except tearout, use the **effective hole diameter** (or “dimension” for slots).

$$d'_h = d_h + 1/16 \text{ in.}$$

The additional 1/16 in. accounts for damage from punching and drilling.

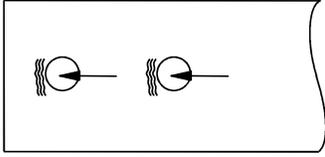
- For tearout, the nominal hole diameter, d_h , is used.
- For bearing, the bolt diameter, d , is used.



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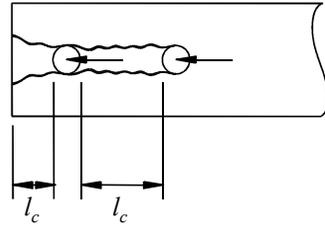
Bolt Holes: Bearing and Tearout

Bearing



The diagram shows a cross-section of a steel plate with two bolt holes. A horizontal arrow labeled T_u points to the right, indicating the direction of tensile force. The bolt heads are shown on the left side of the holes.

Tearout



The diagram shows a cross-section of a steel plate with two bolt holes. A horizontal arrow labeled T_u points to the right. The material between the bolt holes has been torn out, indicated by jagged lines. Vertical dimension lines below the holes are labeled l_c , representing the distance from the edge of the plate to the center of each hole.



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Bolt Holes: Bearing and Tearout

Tearout



The photograph shows a blue metal plate with a grid pattern. Two bolt holes are visible. The top hole shows a jagged, irregular tearout of the metal, while the bottom hole shows a smooth, rounded bearing failure.

Bearing



The photograph shows a blue metal plate with a grid pattern. Two bolt holes are visible. The bottom hole shows a smooth, rounded bearing failure, while the top hole shows a jagged, irregular tearout of the metal.



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Bolt Holes: Bearing and Tearout

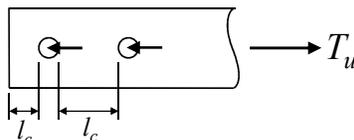
Specification J3.10 Bearing and Tearout Strength at Bolt Holes

For standard, oversized, and short-slotted holes where deformation at a bolt hole is a consideration:

Bearing Strength: $r_n = 2.4 d t F_u$ (Spec. J3-6a)

Tearout Strength: $r_n = 1.2 l_c t F_u$ (Spec. J3-6c)

l_c = clear distance to edge or between holes, in direction of the force



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Shear Transfer for Bearing Connections

Clarified Method for Bolt Shear Rupture, Bearing, and Tearout. User Note in Spec. J3.6.

- Effective Strength of Individual Fastener, r_n

$$r_n = \min \begin{cases} r_n & \text{for bolt shear rupture} \\ r_n & \text{for bearing (connected part 1)} \\ r_n & \text{for tearout (connected part 1)} \\ r_n & \text{for bearing (connected part 2)} \\ r_n & \text{for tearout (connected part 2)} \end{cases}$$

$$R_n = \sum r_n \quad \phi = 0.75$$



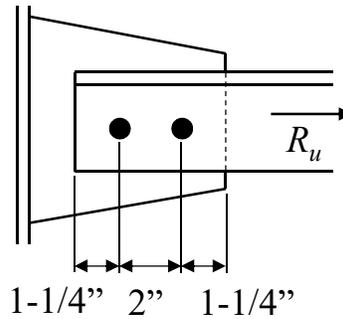
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Shear Transfer Example

Compute the design strength for shear transfer.

- PL5/8, A36
- 2L3-1/2x2-1/2x1/4, A529 Gr. 50
- 3/4 in. F3125 Gr. A325-N bolts
- Standard holes.

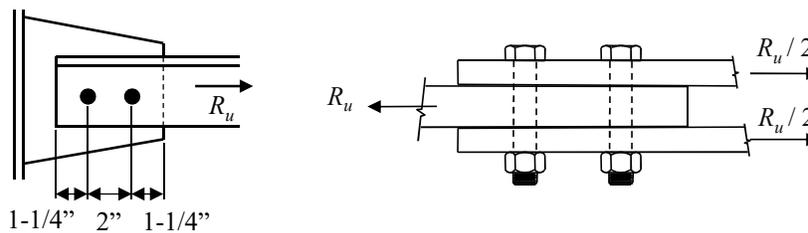
Manual Table 2-5
A529 Gr. 50
 $F_y = 50$ ksi
 $F_u = 65$ ksi



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Shear Transfer Example

Bolt Shear Rupture



$$\begin{aligned}
 r_n &= F_{mv} A_b \\
 &= (54 \text{ ksi})(0.442 \text{ in.}^2 / \text{ shear plane})(2 \text{ shear planes}) \\
 &= 47.7 \text{ kips}
 \end{aligned}$$



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Shear Transfer Example

Angle Bearing

1-1/4" 2" 1-1/4"

$$\begin{aligned}
 r_n &= 2.4dtF_u \\
 &= (2.4)(3/4 \text{ in.})(1/4 \text{ in.})(65 \text{ ksi})(2 \text{ angles}) \\
 &= 58.5 \text{ kips}
 \end{aligned}$$
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Shear Transfer Example

Angle Tearout

- Bolt A

$$l_c = 1.25 \text{ in.} - 13/32 \text{ in.} = 0.844 \text{ in.}$$

$$r_n = 1.2l_c t F_u$$

$$= (1.2)(0.844 \text{ in.})(1/4 \text{ in.})(65 \text{ ksi})(2 \text{ angles})$$

$$= 32.9 \text{ kips}$$
- Bolt B

$$l_c = 2 \text{ in.} - 13/16 \text{ in.} = 1.19 \text{ in.}$$

$$r_n = 1.2l_c t F_u$$

$$= (1.2)(1.19 \text{ in.})(1/4 \text{ in.})(65 \text{ ksi})(2 \text{ angles})$$

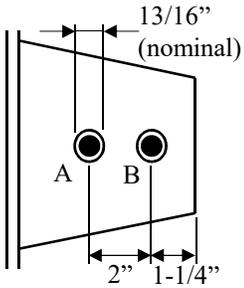
$$= 46.3 \text{ kips}$$

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Shear Transfer Example

Plate Bearing and Tearout

- Bearing
 - $r_n = 65.3$ kips
- Tearout at Bolt A
 - $r_n = 51.7$ kips
- Tearout at Bolt B
 - $r_n = 36.7$ kips




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Shear Transfer Example

Effective Strength at Bolt A

r_n	for bolt shear rupture = 47.7 kips
r_n	for bearing (angles) = 58.5 kips
$r_n = \min$	r_n for tearout (angles) = 32.9 kips ←
r_n	for bearing (plate) = 65.3 kips
r_n	for tearout (plate) = 51.7 kips

Effective Strength at Bolt B

r_n	for bolt shear rupture = 47.7 kips
r_n	for bearing (angles) = 58.5 kips
$r_n = \min$	r_n for tearout (angles) = 46.3 kips
r_n	for bearing (plate) = 65.3 kips
r_n	for tearout (plate) = 36.7 kips ←


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Shear Transfer Example

Total for the Connection

$$\begin{aligned}
 R_n &= \sum r_n \\
 &= 32.9 \text{ kips} + 36.7 \text{ kips} \\
 &= 69.6 \text{ kips}
 \end{aligned}$$

$$\begin{aligned}
 \phi R_n &= (0.75)(69.6 \text{ kips}) \\
 &= 52.2 \text{ kips}
 \end{aligned}$$

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Holes: Min. Spacing and Edge Distance

Specification J3.3 Minimum Spacing

- Standard, oversized, or slotted holes: $s \geq 2\text{-}2/3 d$.
- User Note: $s \geq 3d$ is preferred.
- Clear distance between holes or slots $\geq d$

When $d \leq 1$ in. the typical spacing, s , is 3 in.

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Holes: Min. Spacing and Edge Distance

TABLE J3.4
Minimum Edge Distance^[a] from
Center of Standard Hole^[b] to Edge of
Connected Part, in.

Bolt Diameter, in.	Minimum Edge Distance
1/2	3/4
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2
1 1/4	1 5/8
Over 1 1/4	1 1/4 × <i>d</i>

^[a] If necessary, lesser edge distances are permitted provided the appropriate provisions from Sections J3.10 and J4 are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record.

^[b] For oversized or slotted holes, see Table J3.5.



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BASIC FILLET WELD RELATED LIMIT STATES AND DETAILING



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Fillet Weld Rupture

Specification Section J2.4

Design Strength, $\phi R_n = \phi F_{nw} A_{we}$

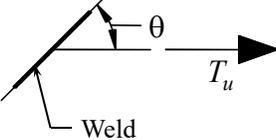
$\phi = 0.75$

$F_{nw} = 0.60 F_{EXX} (1.0 + 0.50 \sin^{1.5}\theta)$

where

F_{EXX} = filler metal classification strength, ksi

θ = angle between the line of action of the required force and the weld longitudinal axis.



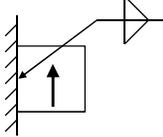

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Fillet Weld Rupture

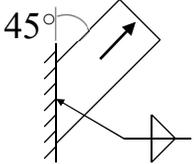
Equation J2-5:

$F_{nw} = 0.60 F_{EXX} (1.0 + 0.50 \sin^{1.5}\theta)$

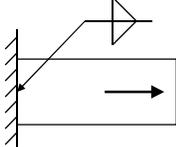
$\theta = 0^\circ \rightarrow F_{nw} = 0.60 F_{EXX} (1.00)$



$\theta = 45^\circ \rightarrow F_{nw} = 0.60 F_{EXX} (1.30)$



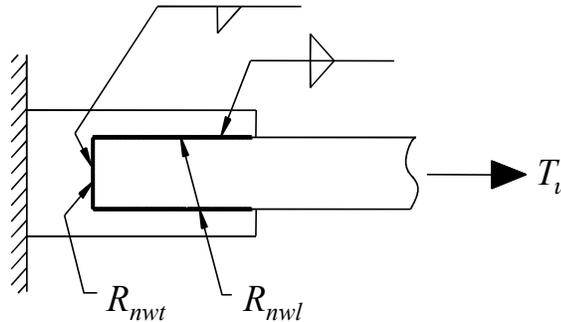
$\theta = 90^\circ \rightarrow F_{nw} = 0.60 F_{EXX} (1.50)$




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Fillet Weld Rupture – Special Case

Specification J2.4(b)(2):



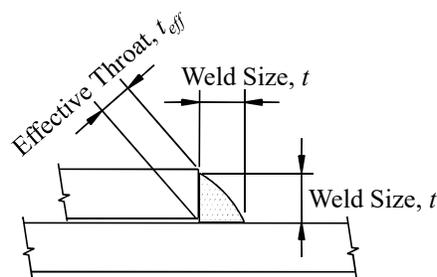
$$R_n = \max \begin{cases} R_{nwl} + R_{nwt} & (\text{Spec. J2-6a}) \\ 0.85R_{nwl} + 1.5R_{nwt} & (\text{Spec. J2-6b}) \end{cases}$$

R_{nwl} and R_{nwt} are the weld strengths with $\theta = 0^\circ$.



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Fillet Weld Rupture – Effective Area

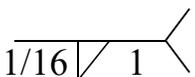


Typical: $t_{eff} = 0.707 t$



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Fillet Weld Rupture

Example: $\theta = 0^\circ$  E70XX

$$\phi R_n = (0.75)(0.6)(70 \text{ ksi})(0.707)(1/16 \text{ in.})(1 \text{ in.})$$

$$= \underline{1.392 \text{ kips} / 1/16 \text{ in.} / \text{in.}}$$

1.392 will be used for the remainder of the course.

Example: $\theta = 90^\circ$

Let D = no. of 1/16's  E70XX

$$\phi R_n = 1.392(1.0 + 0.50 \sin^{1.5}\theta) D L_{weld}$$

$$= 1.392 \times 1.5 \times 4 \times 5 = \underline{41.8 \text{ kips}}$$



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Minimum Fillet Weld Sizes

TABLE J2.4
Minimum Size of Fillet Welds

Material Thickness of Thinner Part Joined, in. (mm)	Minimum Size of Fillet Weld, ^[a] in. (mm)
To 1/4 (6) inclusive	1/8 (3)
Over 1/4 (6) to 1/2 (13)	3/16 (5)
Over 1/2 (13) to 3/4 (19)	1/4 (6)
Over 3/4 (19)	5/16 (8)

^[a] Leg dimension of fillet welds. Single pass welds must be used.
 Note: See Section J2.2b for maximum size of fillet welds.

Note: **Thinner** part controls minimum size of fillet weld.

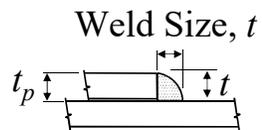


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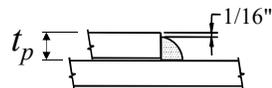
Maximum Fillet Weld Sizes

Specification J2.2b Maximum Fillet Weld Size

$$t_p < 1/4 \text{ in.} \quad t_{max} = t_p$$

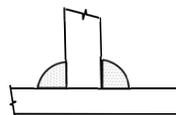


$$t_p \geq 1/4 \text{ in.} \quad t_{max} = t_p - 1/16 \text{ in.}$$



(To prevent under cutting of upper plate)

Limits apply only at edges, not:



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Base Metal Strength at Fillet Welds

Table J2.5 and Specification J4.2 Strength of Elements in Shear

$$\phi R_n = \phi 0.6 F_u A_{gv}$$

where

$$\phi = 0.75$$

F_u = tensile strength of base metal

A_{gv} = shear area of the element at the weld



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Example: Fillet Weld Strength

Ex. Determine ϕT_n .

A36 Steel
 $F_u = 58$ ksi

Weld Rupture:
 $\phi T_n = (1.392)(4)(5 \text{ in.})(2 \text{ welds}) = 55.7 \text{ kips}$

Base Metal:
 $\phi T_n = \phi 0.6 F_u A_{gv}$
 $= (0.75)(0.6)(58)(5/16)(5 \text{ in.})(2) = 81.6 \text{ kips}$
 $\phi T_n = \underline{55.7 \text{ kips}}$

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Use Single Pass Welds When Possible

Leg Size (in.)	No. of Passes (Cost)	Relative Strength
3/16	1	1.0
1/4	1	1.1
5/16	1	1.2
3/8	3	1.4
7/16	4	1.7
1/2	4	1.9
9/16	5	2.1
5/8	6	2.3
11/16	7	2.4
3/4	8	2.5

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End of Session 1

Thank You for
Attending

Next Up



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Next Session

- October 30, 2019 Fundamental Concepts Part II

Topics

- Eccentric Bolted and Welded Connections
- Direct Loaded Tension Connections
- Light Bracing Connection Example
- Beam Bearing Plate Design
- Column Base Plate Design



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Systems Design in Steel	1/1/2000 12:00:00 AM
4-Session Package-Design of Facade Attachments	5/9/2019 1:00:00 PM
105.15 B-Session Package-Night School 15 - Fundamentals of Connection Design	10/3/2017 7:00:00 PM
105.16 B-Session Package-Night School 16 - Systems Design in Steel	2/3/2018 7:00:00 PM
105.17 B-Session Package-Night School 17 - Design of Facade Attachments	7/18/2018 7:00:00 PM
105.18 B-Session Package-Night School 18 - Steel Construction: All The Topics Out	10/15/2018 7:00:00 PM
105.19 B-Session Package-Night School 19 - Connection Design	2/4/2019 7:00:00 PM
105.20 B-Session Package-Night School 20 - Classical Methods of Structural Analysis	8/5/2019 7:00:00 PM
8-Session Package-Systems Design in Steel - Concrete & Brackets	7/16/2018 1:00:00 PM

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Course Resources

Design of Facade Attachments

4-SESSION PACKAGE RESOURCES

Event	Date	Handouts	Videos	Quiz	Attendance
RL: Facade Fundamentals	N/A	Handouts	Video	Pass Score: 100	N/A
L1: Facade Attachments Part 1	May 9 2019 1:30PM EDT	Handouts	Available 05/11/2019 5:00PM EDT	Available 05/11/2019 5:00 PM EDT	Pending
L2: Facade Attachments Part 2	May 18 2019 1:30PM EDT	Handouts	Available 05/18/2019 5:00PM EDT	Available 05/18/2019 5:00 PM EDT	Pending
L3: Facade Attachments - Building Lateral Drifts	May 23 2019 1:30PM EDT	Handouts	Available 05/25/2019 5:00PM EDT	Available 05/25/2019 5:00 PM EDT	Pending
Final Exam	N/A			Available 5/27/2019 5:00 PM EDT	





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