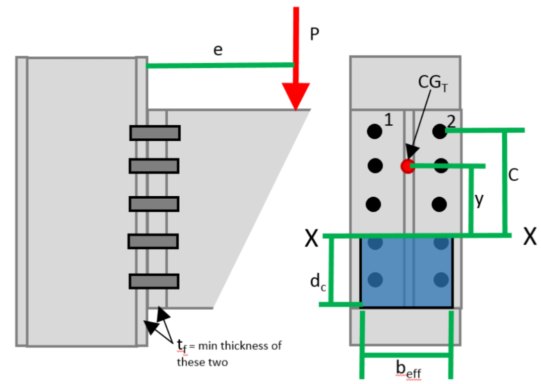
Bolted Connection Design – AISC Spec J

Combined Shear & Tension in Bearing Connections: Bracket Case I



Combined Shear & Tension

- AISC Sec. J3.7 – Combined V&T in Bearing Connections
- AISC Sec. J3.9 – Combined V&T in Slip Crit. Connections

When the required stress in either shear or tension is less the or equal to 30% of the available stress, the effects of combined stress need not be investigated.

Available tensile strength of bolts w/ tension & shear (R_n)

$R_n = F'_{nt} A_b$ $\qquad$ $\emptyset R_n = 0.75 R_n$ for LRFD

Where: $F'_{nt} = 1.3F_{nt} - \left(\frac{F_{nt}}{\emptyset F_{nv}}\right) f_{rv} \leq F_{nt}$

$F_{nt} = nominal\ tensile\ stress\ from\ AISC\ Table\ J3.2$

$F_{nv} = nominal\ shear\ stress\ from\ AISC\ Table\ J3.2$

$f_{rv} = required\ shear\ stress\ using\ LRFD$

A_b = nominal unthreaded body area of bolt or threaded part

Method of Design

AISC Ch 7
Case I (N.A. not @ C.G) or II (N.A. @ C.G.)

AISC Ch. 7 Case I

Shear force Per Bolt:

$r_{uv} = \frac{P_u}{n}$

Tension per Bolt:

1) Estimate NA @ d_c= depth/6
2) Establish horizontal size of compression block
   $b_{eff} = 8t_f \leq b_f$
3) Verify by taking moment about proposed NA
   $(\sum A_b)y = b_{eff} d_c \left(\frac{d_c}{2}\right)$ $\quad$ *Adjust NA accordingly*
4) Establish I_x
   $I_x = A_b(\sum d_y)^2 + \frac{b_{eff}(d_c)^3}{3}$ $\quad$ Where: d_y= bolt distance to NA
5) Tensile force in farthest bolt
   $r_{ut} = \left(\frac{P_u\, e\, c}{I_x}\right) A_b$

Shear & Tensile Stress in Bolts at 30% Threshold?:

$f_{rv} = \frac{r_{uv}}{A_b}$ $\qquad$ $f_t = \frac{r_{ut}}{A_b}$

Is $f_{rv} \geq 0.3\ \emptyset F_{nv}$? $\qquad$ $\emptyset = 0.75\ for\ both\ cases$

Is $f_t \geq 0.3\ \emptyset F_{nt}$?

If either exceed 30% ➔ Consider combined V&T.

If not ➔ Done.

Available Tensile Strength (Revisited for Combined V&T):

$F'_{nt} = 1.3F_{nt} - \left(\frac{F_{nt}}{\emptyset F_{nv}}\right) f_{rv} \leq F_{nt}$

New Design Tension Strength:

$\emptyset R_n = 0.75 F'_{nt} A_b$

$f_t(A_b) < \emptyset R_n$ ➔ Good

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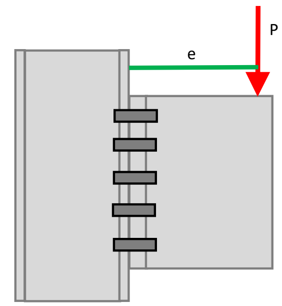
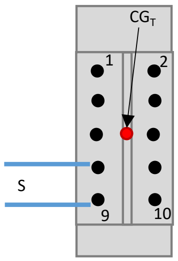
Combined Shear & Tension in Bearing Connections: Bracket Case II





Combined Shear & Tension

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Available tensile strength of bolts w/ tension & shear (R_n)

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Where: $F'_{nt} = 1.3F_{nt} - \left(\frac{F_{nt}}{\emptyset F_{nv}}\right) f_{rv} \leq F_{nt}$

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$F_{nv} = nominal\ shear\ stress\ from\ AISC\ Table\ J3.2$

$f_{rv} = required\ shear\ stress\ using\ LRFD$

A_b = nominal unthreaded body area of bolt or threaded part

Method of Design

AISC Ch 7
Case I (N.A. not @ C.G) or II (N.A. @ C.G.)

AISC Ch. 7 Case II

Shear force Per Bolt:

$r_{uv} = \frac{P_u}{n}$

Moment Effect per Bolt:

1) $M_u = P_u e$

2) There is no compression block. Bolt get "compressive load". Not exceeding clamping force.

3) Establish I_x

$I_x = A_b\left(\sum d_y\right)^2$ Where: d_y= bolt distance to NA

4) Tensile force in worst case bolts

$r_{ut} = \left(\frac{P_u\, e\, c}{I_x}\right) A_b$

Shear & Tensile Stress in Bolts at 30% Threshold?:

$f_{rv} = \frac{r_{uv}}{A_b}$ $\qquad f_t = \frac{r_{ut}}{A_b}$

Is $f_{rv} \geq 0.3\ \emptyset F_{nv}$? $\qquad \emptyset = 0.75\ for\ both\ cases$

Is $f_t \geq 0.3\ \emptyset F_{nt}$?

If either exceed 30% ➔ Consider combined V&T.

If not ➔ Done.

Available Tensile Strength (Revisited for Combined V&T):

$$F'_{nt} = 1.3F_{nt} - \left(\frac{F_{nt}}{\emptyset F_{nv}}\right) f_{rv} \leq F_{nt}$$

New Design Tension Strength:

$\emptyset R_n = 0.75 F'_{nt} A_b$

$f_t(A_b) < \emptyset R_n$ ➔ Good

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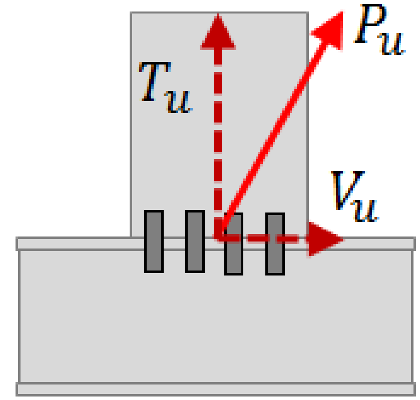
Combined Shear & Tension in **Slip Critical** Connections



Combined Shear & Tension

- AISC Sec. J3.7 – Combined V&T in Bearing Connections
- AISC Sec. J3.9 – Combined V&T in Slip Crit. Connections

When a slip-critical connection is subject to tension that reduces the net clamping force, the available slip resistance per bolt shall be multiplied by the factor k_{sc}

- $k_{sc} = 1 - \frac{T_u}{D_u T_b n_b}$ (LRFD)
    - Where: T_u = required tension force using LRFD
      n_b = number of bolts carrying the applied tension
      $D_u = 1.13$
      T_b = min. fastener tension AISC Table J3.1

The Reduction Factor Depends on the Holes

- For Standard & short-slotted holes perpendicular to load direction
    - $\emptyset = 1.00\ R_n$
- For Oversized & short-slotted holes parallel to load direction
    - $\emptyset = 0.85\ R_n$
- For Long-Slotted Holes
    - $\emptyset = 0.70\ R_n$
- Finger shims up to ¼" are allowed per AISC J3.2.

Part 1: Identify Design Loads

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Identify Initial Parameters
$\mu, D_u, h_f, T_b, n_s, \emptyset$ & n_b

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Convert P_u Into Shear (T_u) & Tension (V_u) Vectors

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Available Tensile Bolt Strength (AISC J3.6)
$R_n = F_{nt} A_b$ $\quad with\ \emptyset = 0.75$ (J3.6) F_{nt} (Table J3.2)
Just use AISC Table 7-2
Check: $\emptyset R_n > \frac{T_u}{\#_{bolts}}$

↓

Available Slip Resistance Per Bolt (if $T_u\ were\ 0$)
$\emptyset R_{n1bolt} = \emptyset \mu D_u h_f T_b n_s$ (see previous slide)

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Available Slip Resistance of the Connection

- Include Reduction Factor k_{sc} w/ $P_{ut} = T_u$
    - $k_{sc} = 1 - \frac{T_u}{D_u T_b n_b}$
- $\emptyset R_{n(connection)} = (\emptyset R_{n1bolt})(k_{sc})(n_b)$

Check: $(\emptyset R_{n1bolt})(k_{sc})(n_b) > V_u$

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CHECK ALL ADDITIONAL LIMIT STATES FROM PREVIOUS SLIDE!!!!