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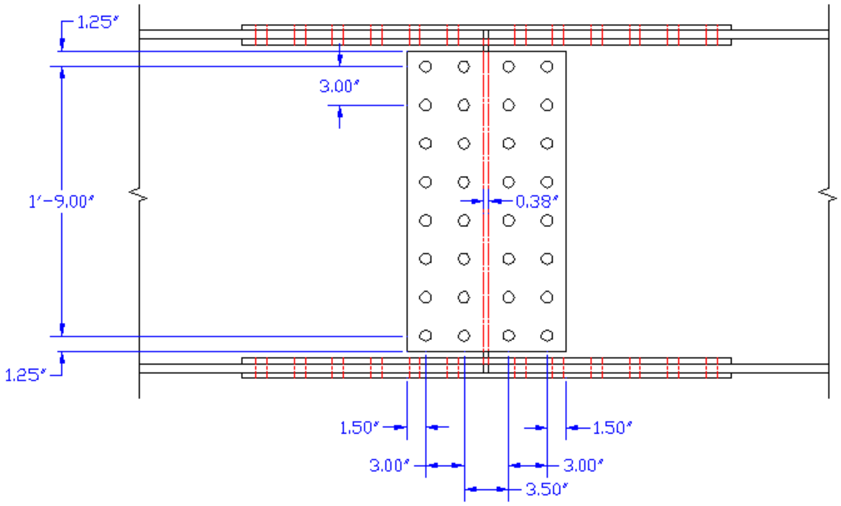
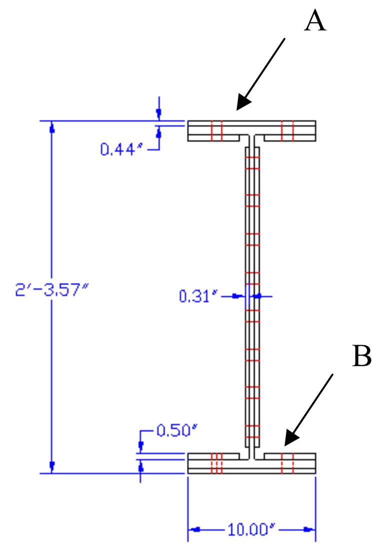
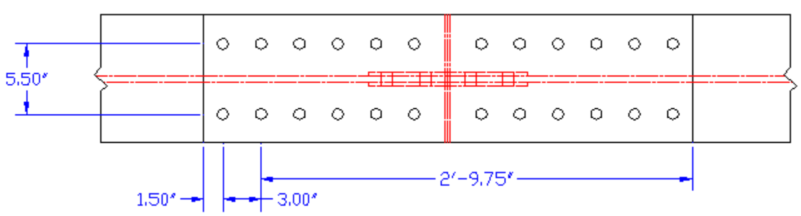
Sample calculations – connection 23







Notes:

F_y = 50 ksi (Wide Flange Section)

F_y = 36 ksi (Splice Plate)

Use 7/8" high strength bolts

Area of holes in excess of 15% of gross area are deducted

Drawings show field example. Only the shear splice is to be analyzed.

Component	Qt. per Connection	Details
Bolts	80	7/8" High Strength
W Section	2	W 27x84
Shear Splice	1	5/16 x 23-1/2 x 12-1/2 (inches)
Moment Splice A	2	7/16 x 10 x 38-1/4
Moment Splice B	4	½ x 4 x 38-1/4

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Capacities for Mn/DOT Bridge No. 81518 Shear Splices Along Lower Chord

Shear Splice for Lower Chord

5/16 x 23-1/2 x 12-1/2 Plate Properties

$A_g = 7.34\ in^2$

Steel Properties

$F_y = 36\,ksi$

$F_u = 58\,ksi$

W 27x84 Properties

$A_g = 24.8\ in^2$

$t_w = 0.460\,in$

$t_f = 0.640\,in$

Steel Properties

$F_y = 50\,ksi$

$F_u = 65\,ksi$

Bolted Connection

Use 32 – 7/8" dia. A490N Bolts
For construction purposes bolts will be as follows:

$Table\ J3.2 \Rightarrow F_n = 60ksi$

$Table\ J3.4 \Rightarrow L_e = 1\tfrac{1}{2}\,in$

$\Rightarrow L_e' = 1\tfrac{1}{8}\,in$

$S = 3d = 2.63\,in \Rightarrow use\ S = 2.75\,in$

Bolt Shear

$$\phi F_n A_b = 0.75\left(60\,ksi\right)\left(\frac{\pi}{4}\right)\left(7/8\,in\right)^2\left(16\,bolts\right)\left(2\,shear\ planes\right) = 865.9\,kip$$

Tension Limiting States

Bearing Strength at Bolt Holes in Web
Web of W section is thinner than the splices
Deformation at Bolt Hole at service load is a design consideration
Interior Bolt Bearing

$$\phi R_n = \min\begin{cases}0.75(1.2)L_C t F_u \\ 0.75(2.4)dtF_u\end{cases} = \min\begin{cases}0.75(1.2)(3\,in - 7/8\,in - 1/8\,in)(0.460\,in)(65\,ksi)(8\,locations) \\ 0.75(2.4)(7/8\,in)(0.460\,in)(65ksi)(8\,locations)\end{cases}$$

$$\phi R_n = \min\begin{cases}430.6\,kip \\ 376.7\,kip\end{cases} = 376.7\ kips$$

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Exterior Bolt Bearing Capacity

$$\phi R_n = \min\begin{cases}0.75(1.2)L_C tF_u \\ 0.75(2.4)dtF_u\end{cases} = \min\begin{cases}0.75(1.2)(1.5\,in - 1/2(7/8\,in + 1/8\,in))(0.460\,in)(65\,ksi)(8\,locations) \\ 0.75(2.4)(7/8\,in)(0.460\,in)(65ksi)(8\,locations)\end{cases}$$

$$\phi R_n = \min\begin{cases}215.3\,kip \\ 376.7\,kip\end{cases} = 215.3\ kips$$

$$\phi R_{n,total} = 376.7\,kips + 215.3\,kips = 592.0\,kips$$

Yielding in Splices

Cross-Sectional Area is smaller in Splices

$$\phi P_n = 0.9F_y A_g = 0.9(36\,ksi)(2\,Areas)7.34\,in^2 = 475.6\,kips$$

Fracture in Splices

$$Table\,D3.1 \Rightarrow U_{Case1} = 1.0$$

$$A_n = 7.34\,in^2 - 8(5/16\,in)(7/8\,in + 1/8\,in) = 4.84\,in^2$$

$$\phi P_n = 0.75F_u A_n U = 0.75(58\,ksi)(4.84\,in^2)(2\,Areas)1.0 = 421.1\,kips$$

Block Shear in Web

$$A_{gv} = (L_e + S)(2)t = (1.5\,in + 3)(2)(0.460\,in) = 4.14\,in^2$$

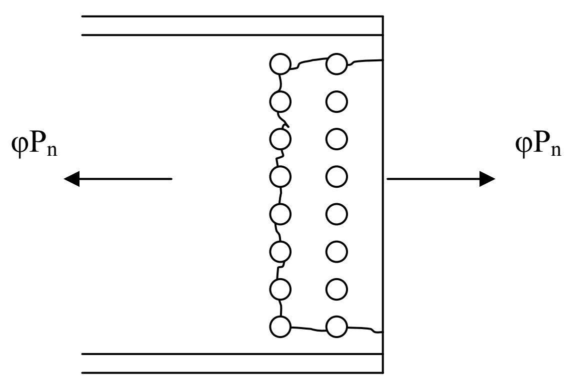
$$A_{nv} = A_{gv} - 3(d + 1/8\,in)t = 4.14\,in^2 - 3(7/8\,in + 1/8\,in)(0.460\,in) = 2.76\,in^2$$

$$A_{gt} = 7Gt = 7(3\,in)(0.460\,in) = 9.66\,in^2$$

$$A_{nt} = A_{gt} - 7(d + 1/8\,in)t = 9.66\,in^2 - 7(7/8\,in + 1/8\,in)(0.460\,in) = 6.44\,in^2$$

$$\phi P_n = \min\begin{cases}0.75(0.6F_y A_{gv} + F_u A_{nt}) = 0.75(0.6(50\,ksi)(4.14\,in^2) + 65\,ksi(6.44\,in^2)) = 407.1\,kips \\ 0.75(0.6F_u A_{nv} + F_u A_{nt}) = 0.75(0.6(65\,ksi)(2.76\,in^2) + 65\,ksi(6.44\,in^2)) = 394.7\,kips\end{cases}$$

$$\phi P_n = 394.7\,kips$$



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Shear Limiting States

Shear Rupture in Splices

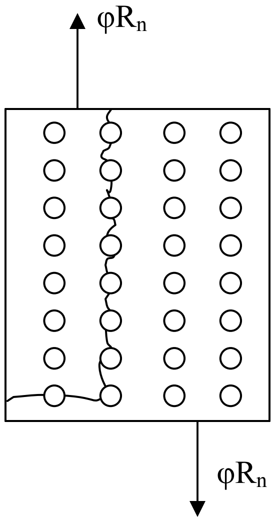
$$\phi R_n = 0.75(0.6)F_u A_n = 0.75(0.6)(58\,ksi)(4.84\,in)(2\,splices)$$
$$= 252.6\,kips$$

Shear Yielding in Splices

$$\phi R_n = 1.0(0.6)(36\,ksi)(7.34\,in^2)(2\,splices) = 317.1\,kips$$

Block Shear in Splices

$$A_{gv} = (L_e + 7(G))t = (1.25\,in + 7(3\,in))(5/16\,in) = 6.95\,in^2$$
$$A_{nv} = A_{gv} - 7.5(d + 1/8\,in)t = 6.95\,in^2 - 7.5(7/8\,in + 1/8\,in)(5/16\,in) = 4.61\,in^2$$
$$A_{gt} = (L_e' + S)t = (1.5\,in + 3\,in)(5/16\,in) = 1.41\,in^2$$
$$A_{nt} = A_{gt} - 1.5(d + 1/8\,in)t = 1.41\,in^2 - 1.5(7/8\,in + 1/8\,in)(5/16\,in) = 0.938\,in^2$$
$$\phi P_n = \min\begin{cases} 0.75(0.6F_y A_{gv} + F_u A_{nt})(2\,splices) = 0.75(0.6(36\,ksi)(6.95\,in^2) + 58\,ksi(0.938\,in^2))(2) = 306.8\,kips \\ 0.75(0.6F_u A_{nv} + F_u A_{nt})(2\,splices) = 0.75(0.6(58\,ksi)(4.61\,in^2) + 58\,ksi(0.938\,in^2))(2) = 322.2\,kips \end{cases}$$
$$\phi P_n = 306.8\,kips$$



Bearing at Bolt Holes

Interior Bolt Bearing Capacity

$$\phi R_n = \min\begin{cases} 0.75(1.2)L_C t F_u \\ 0.75(2.4)dtF_u \end{cases} = \min\begin{cases} 0.75(1.2)(3\,in - 7/8\,in - 1/8\,in)(5/16\,in)(58\,ksi)(14\,locations) \\ 0.75(2.4)(7/8\,in)(5/16\,in)(58ksi)(14\,locations) \end{cases}$$
$$\phi R_n = \min\begin{cases} 456.8\,kip \\ 399.7\,kip \end{cases} = 399.7\ kips$$

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Exterior Bolt Bearing Capacity

$$\phi R_n = \min\begin{cases}0.75(1.2)L_C tF_u \\ 0.75(2.4)dtF_u\end{cases} = \min\begin{cases}0.75(1.2)(1.25\,in - 1/2(7/8\,in + 1/8\,in))(5/16\,in)(58\,ksi)(2\,locations) \\ 0.75(2.4)(7/8\,in)(5/16\,in)(58\,ksi)(2\,locations)\end{cases}$$

$$\phi R_n = \min\begin{cases}40.8\,kip \\ 24.5\,kip\end{cases} = 24.5\ kips$$

$$\phi R_{n,total} = 399.7\,kips + 24.5\,kips = 424.2\,kips$$

Check for Compact Section in Splices

$$\frac{h}{t} \le 3.76\sqrt{E/F_y}$$

$$3.76\sqrt{E/F_y} = 3.76\sqrt{29000\,ksi/36\,ksi} = 106.7$$

$$\frac{h}{t} = \frac{9.5\,in}{5/16\,in} = 30.4 < 106.7 \Rightarrow Splice\ is\ compact$$

Flexural Rupture

$$\phi M_n = \frac{\phi R_n e}{2} = \frac{252.6\,kips(3.25\,in)}{2(12\,in/ft)} = 34.2\,k - ft$$

Flexural Yielding

$$\phi M_n = \frac{\phi R_n e}{2} = \frac{317.1\,kips(3.25\,in)}{2(12\,in/ft)} = 42.9\,k - ft$$