Text: Jack C. McCormac, Stephen F. Csernak; Structural Steel Design – Fifth Edition, Pearson International Education

In all of the following problems, $F_y = 2400$ daN/ cm^2 and $F_u = 3700$ daN/cm^2, unless noted otherwise.

All answers are to be provided in Iranian customary units (tons, Kgf or daN, m, cm, etc.) using steel sections available in Iran (IPE, IPB, L, U, etc.). Derive metric properties of steel and use 1MPa≈10daN/cm^2, unless noted otherwise. Also, if necessary, convert the US customary units to metric units:

1 yd = 3 ft	1 ft = 12 in	1 in ≈ 2.5 cm	1 kip ≈ 454 daN	1 ksi ≈ 70 daN/cm^2
	1 ft ≈ 30 cm	1 kip/ft=1488 kgf/m		1 psf ≈ 4.9 daN/m^2

Homework Set #4

Problem Number	Comments
Use only LRFD method to solve the following questions.	
12-2	Bolt size=M24, convert dimensions to cm.
12.6	Bolt size=M22, convert dimensions to cm.
12.12	P_D=25 ton, P_L=50 ton, plate thickness=16 mm, bolt size=M20, Fy=3500kg/cm^2, Fu=4900kg/cm^2, convert other dimensions to cm.
12.15	Bolt size=M20, upper & lower plate thickness=1.4 cm, middle plate thickness= 20 mm
12.18	Use UNP300, gusset plate thickness=25 mm, bolt size=M20, convert other dimensions to cm.
12.21	P_u=180 ton, bolt size=M22, Plates are 40x2.2 cm & 40x1.6 cm, convert other dimensions to cm.
12.24	Bolt size=M22, PL22x1.8 cm, use IPB700, W_D=15 ton/m, W_L=20 ton/m, span=7.5 m.
12.26	V_u=300 ton, bolt size=M24, L_c=3.8 cm, plates are 50x1.2 cm & 135x1.6 cm, use L20x20x1,2cm, the web plate is just connected to the angles, Fy=2400kg/cm^2, Fu=3500kg/cm2, convert other dimensions to cm and take 1 in ≈ 2.5 cm.

Example 12-5

Repeat Example 12-4 if the plates have long-slotted holes in the direction of the load. Assume that deformations of the connections will cause an increase in the critical load. Therefore, design the connection to prevent slip at the limit state of slip.

Solution

$P_u = 97$ k and $P_a = 67.5$ k from Example 12-4 solution.

Nominal strength of 1 bolt

$$R_n = \mu D_u h_f T_b n_s$$
$$\mu = 0.30 \text{ for Class A surface}$$
$$D_u = 1.13 \text{ multiplier}$$
$$h_f = 1.00 \text{ factor for filler}$$
$$T_b = 51 \text{ k minimum bolt pretension}$$
$$n_s = 1.0 = \text{number of slip planes}$$
$$R_n = (0.30)(1.13)(1.0)(51)(1.0) = 17.29 \text{ k/bolt}$$

Number of bolts required for long-slotted holes

LRFD $\phi = 0.70$	ASD $\Omega = 2.14$
$\phi R_n = (0.70)(17.29) = 12.10$ k	$\frac{R_n}{\Omega} = \frac{17.29}{2.14} = 8.08$ k
No. reqd. $= \frac{97}{12.10} = 8.02$ bolts	No. reqd. $= \frac{67.5}{8.08} = 8.35$ bolts

Note: Shear and bearing were checked in Example 12-4 and are obviously ok here as they are higher than they were before.

Ans. **Use 9 bolts.** **Use 9 bolts.**

12.15 PROBLEMS FOR SOLUTION

For each of the problems listed, the following information is to be used, unless otherwise indicated (a) AISC Specification; (b) standard-size holes; (c) members have clean mill-scale surfaces (Class A); (d) $F_y = 36$ ksi and $F_u = 58$ ksi unless otherwise noted, (e) deformation at service loads is a design consideration. Do not consider block shear, unless specifically requested.

12-1 to 12-5. *Determine the LRFD design tensile strength and the ASD allowable tensile strength for the member shown, assuming a bearing-type connection.*

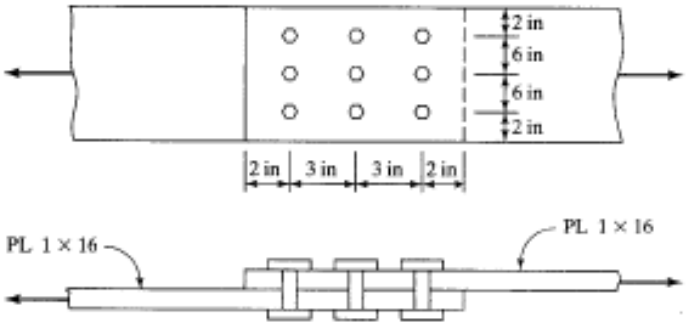

FIGURE P12-1 to 12-5

12-1. A325 $\frac{3}{4}$-in bolts, threads excluded from shear plane. (*Ans.* 202.0 k, 134.7 k)

12-2. A325 1-in bolts, threads excluded from shear plane.

12-3. A490 1-in bolts, threads not excluded from shear plane. (*Ans.* 281.6 k, 190.7 k)

12-4. $\frac{7}{8}$-in A325 bolts, threads excluded from shear plane.

12-5. $\frac{3}{4}$-in A490 bolts, threads not excluded from shear plane. (*Ans.* 202.0 k, 134.7 k)

12-6 to 12-10. *Determine the LRFD design tensile strength and the ASD allowable tensile strength for the member and the bearing-type connection.*

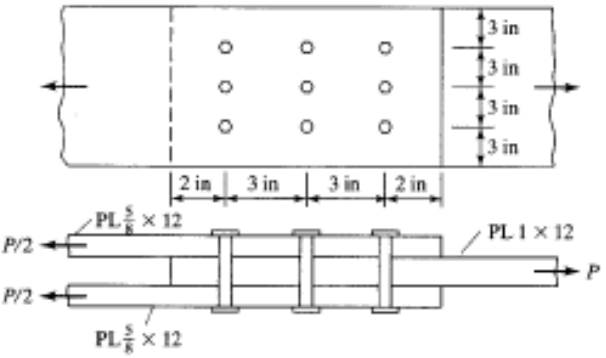

FIGURE P12-6 to 12-10

12-6. A325 $\frac{3}{4}$-in bolts, threads excluded from shear planes.

12-7. A490 $\frac{7}{8}$-in bolts, threads not excluded from shear planes. (*Ans.* 388.8 k, 258.7 k)

12-8. A490 $\frac{3}{4}$-in bolts, threads excluded from shear plane.

12-9. A steel with F_y = 50 ksi, F_u = 70 ksi, $\frac{7}{8}$-in A490 bolts, threads excluded from shear plane. (*Ans.* 472.5 k, 315 k)

12-10. A steel with F_y = 50 ksi, F_u = 70 ksi, 1-in A490 bolts, threads excluded from shear planes.

12-11 to 12-13. *How many bolts are required for LRFD and ASD for the bearing-type connection shown, if P_D = 50 k and P_L = 100 k?*

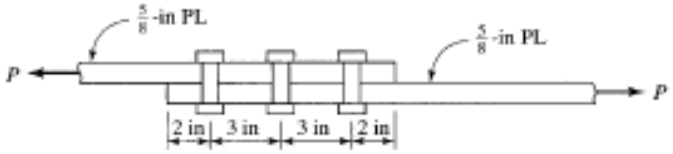

FIGURE P12-11 to 12-13

12-11. A325 $\frac{3}{4}$-in bolts, threads excluded from shear plane. (*Ans.* 10 both LRFD and ASD)

12-12. F_y = 50 ksi, F_u = 70 ksi, $\frac{3}{4}$-in A325 bolts, threads excluded from shear plane.

12-13. A490 1-in bolts, threads not excluded from shear plane. (*Ans.* 6 both LRFD and ASD)

12-14 to 12-16. *How many bolts are required (LRFD and ASD) for the bearing-type connection shown if P_D = 120 k and P_L = 150 k?*

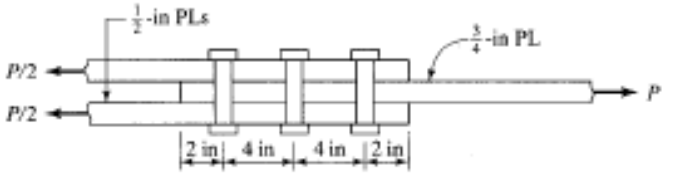

FIGURE P12-14 to 12-16

12-14. A325 $\frac{7}{8}$-in bolts, threads excluded from shear planes.

12-15. A490 $\frac{5}{8}$-in bolts, threads not excluded from shear planes. (*Ans.* 9 or 10 both LRFD and ASD)

12-16. A325 1-in bolts, threads not excluded from shear planes.

12-17. The truss member shown in the accompanying illustration consists of two C12 × 25s (A36 steel) connected to a 1-in gusset plate. How many $\frac{7}{8}$-in A325 bolts (threads excluded from shear plane) are required to develop the full design tensile capacity of the member if it is used as a bearing-type connection? Assume U = 0.85. Use both LRFD and ASD methods. (*Ans.* 8 both LRFD and ASD)

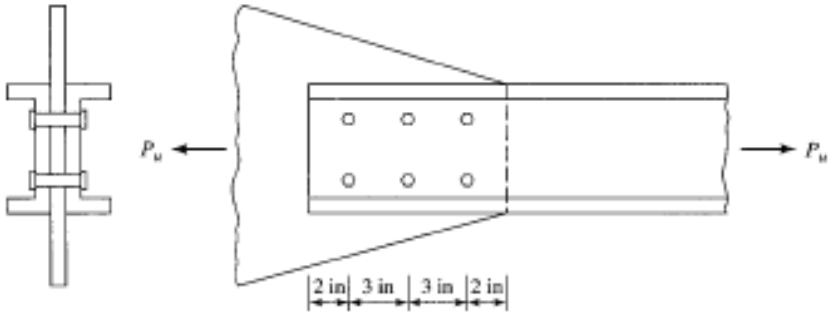

FIGURE P12-17

connection at a section where the external shear $V_D = 80$ k and $V_L = 160$ k? LRFD and ASD. Assume $L_c = 1.50$ in. (*Ans.* 8 in both LRFD and ASD)

12-24. The cover-plated section shown in the accompanying illustration is used to support a uniform load $w_D = 10$ k/ft (includes beam weight effect and $w_L = 12.5$ k/ft for an 24-ft simple span). If $\frac{7}{8}$-in A325 bolts (threads excluded) are used in a bearing-type connection, work out a spacing diagram for the entire span, for LRFD only.

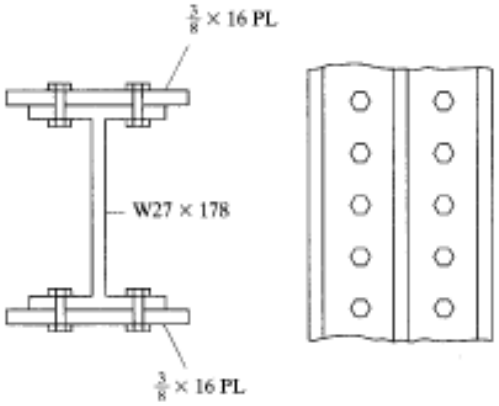

FIGURE P12-24

12-25. For the section shown in the accompanying illustration, determine, for ASD only, the required spacing of $\frac{7}{8}$-in A490 bolts (threads excluded) for a bearing-type connection if the member consists of A572 grade 60 steel ($F_u = 75$ ksi). $V_D = 100$ k and $V_L = 140$ k. Assume Class A surfaces and $L_c = 1.0$ in (*Ans.* 6 in both)

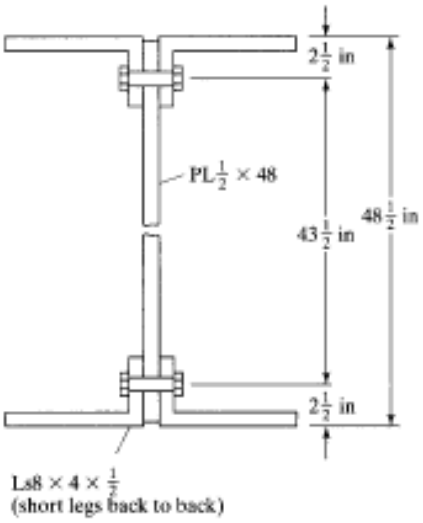

FIGURE P12-25

12-26. For an external shear V_u of 600 k, determine by LRFD the spacing required for 1-in A325 web bolts (threads excluded) in a bearing-type connection for the built-up section shown in the accompanying illustration. Assume that $l_c = 1.5$ in and A36 steel.

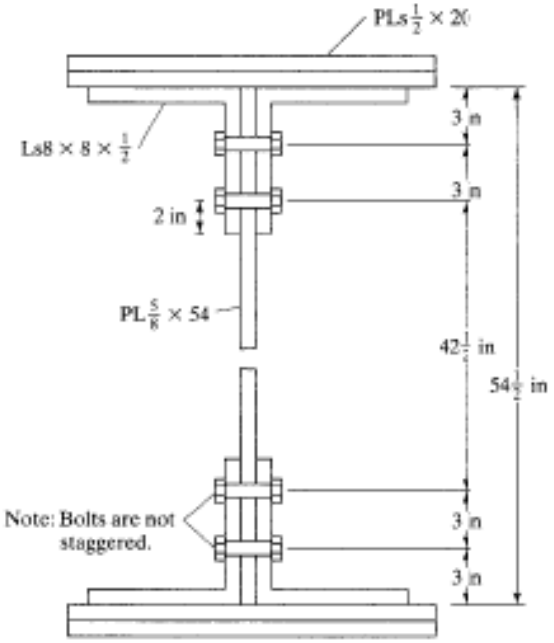

FIGURE P12-26

12-27. Determine the design strength P_u and the allowable strength P_a for the connection shown if $\frac{7}{8}$-in A325 bolts (threads exduded) are used in a slip-critical connection with a factor for fillers, $h_f = 1.0$. Assume A36 steel and Class B faying surface and standard size holes. (*Ans.* 132.2 k, 88.1 k)

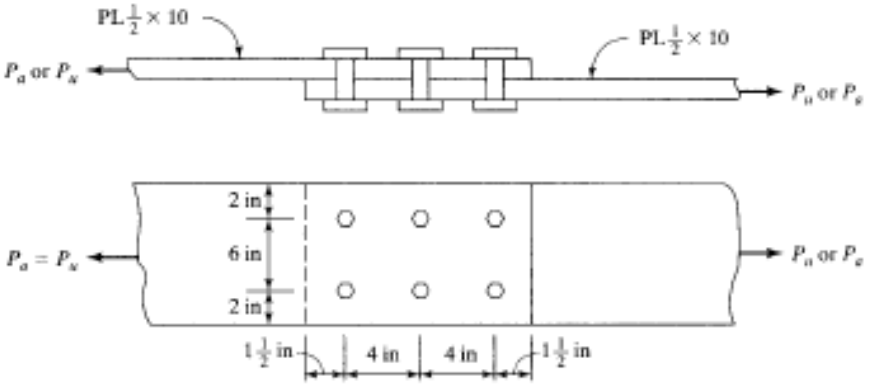

FIGURE P12-27

12-28 to 12-33. *Repeat these problems, using the loads given and determine the number of bolts required for a slip-critical connection. Assume Class A surfaces, standard-size holes, $h_f = 1.00$, and l_c values of 1.50 in*, UNO.

12-28. Prob. 12-6. $P_D = 100$ k, $P_L = 150$ k

12-29. Prob. 12-11. $P_D = 50$ k, $P_L = 100$ k (*Ans.* 24 both LRFD, ASD)

12-30. Prob. 12-13. $P_D = 75$ k, $P_L = 160$ k

12-31. Prob. 12-14. $P_D = 120$ k, $P_L = 150$ k (*Ans.* 16 both LRFD, ASD)

12-32. Prob. 12-16. $P_D = 40$ k, $P_L = 100$ k

12-33. Prob. 12-20. (*Ans.* 11 LRFD, 12 ASD)

12-34 and 12-35. *Using the bearing-type connection from each problem given, determine the number of 1-in A490 bolts required, by LRFD and ASD, for a slip-critical connection. Assume long-slotted holes in the direction of the load, Class A faying surfaces, $h_f = 1.00$, and $l_c = 1.25$ in.*

12-34. Prob. 12-12.

12-35. Prob. 12-15. (*Ans.* 11 or 12 LRFD, 12 ASD)

12-36. Determine the design tensile strength P_u and the allowable tensile strength P_a of the connection shown if eight $\frac{7}{8}$-in A325 bearing-type bolts (threads excluded from shear plane) are used in each flange. Include block shear in your calculations. A36 steel is used.

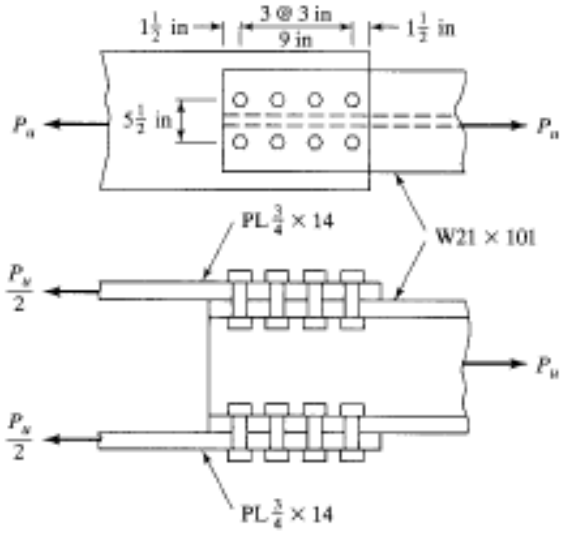

FIGURE P12-36

12-37. Repeat Prob. 12-36, using $\frac{7}{8}$-in A490 bearing-type bolts. $F_y = 50$ ksi and $F_u = 65$ ksi (*Ans.* 604.8 k, 403.2 k)