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 #6

Problem Number	Comments
Use only LRFD method to solve the following questions.	
15.2	Bolt size=M20, angle thickness= 0.8 cm, beam section= IPE500, use ST37 steel for beam and angle, convert other dimensions to cm.
15.9	Bolt size=M22, P_D=20 ton, P_L=10 ton, beam section= IPE400, girder section=IPB700, use ST37, convert other dimensions to cm.
15.15	Bolt size=M22, beam section= IPE500, use ST37 steel, R_D=12 ton, R_L=15 ton, column section=IPE600, column gage=14 cm.
15.17	W_D=3 ton/m, W_L=3.75 ton/m, beam length=9m, use ST52 steel.

LRFD $\phi = 0.90$	ASD $\Omega = 1.67$
$\phi R_n = (0.90)(253.1) = 227.8\text{ k} > 216\text{ k}$ **OK**	$\frac{R_n}{\Omega} = \frac{253.1}{1.67} = 151.6\text{ k} > 150\text{ k}$ **OK**

Use W12 × 96 column.

(b) Design of web stiffeners using a W12 × 87 column and the suggested rules presented before this example. The author shows only the LRFD solution for this part of problem.

$$\text{Reqd stiffener area} = \frac{216\text{ k} - 184.5\text{ k}}{50\text{ ksi}} = 0.63\text{ in}^2$$

$$\text{Min width} = \frac{1}{3}b_f - \frac{t_w}{2} = \frac{6.06}{3} - \frac{0.515}{2} = 1.76\text{ in}$$

$$\text{Min } t \text{ of stiffeners} = \frac{0.63\text{ in}^2}{1.76\text{ in}} = 0.358\text{ in } \textbf{say, 3/8 in}$$

$$\text{Reqd width} = \frac{0.63\text{ in}^2}{0.375\text{ in}} = 1.68\text{ in } \textbf{say, 4 in for practical purposes}$$

$$\text{Minimum length} = \frac{d}{2} - t_f = \frac{12.5}{2} - 0.810 = 5.45\text{ in } \textbf{say, 6 in}$$

Design of welds for stiffener plates

Minimum weld size as reqd by AISC Table J-2.4

$$= \frac{3}{16}\text{ in based on the column web } t_w = 0.515\text{ in}$$

$$\text{Reqd length of weld} = \frac{216\text{ k} - 184.5\text{ k}}{(0.75)(0.60 \times 70\text{ ksi})(0.707)\left(\frac{3}{16}\text{ in}\right)} = 7.54\text{ in } \textbf{say, 8 in}$$

15.13 PROBLEMS FOR SOLUTION

For Problems 15-1 through 15-15 use the tables of Part 10 of the AISC Manual.

15-1. Determine the maximum end reaction that can be transferred through the A36 web angle connection shown in the accompanying illustration. Solve by LRFD and ASD. The beam steel is 50 ksi, and the bolts are 3/4-in A325-N and are used in standard-size holes. The beam is connected to the web of a W30 × 90 girder with A36 angles. (*Ans.* 126 k, 83.9 k)

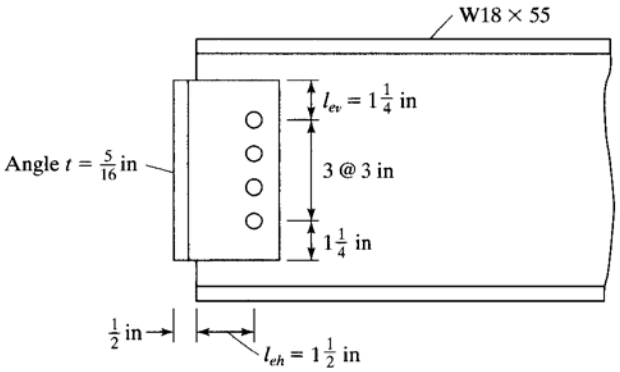

FIGURE P15-1

15-2. Repeat Prob. 15-1 if the bolts are 1-in A325-X.

15-3. Repeat Prob. 15-1 if the bolts are 7/8-in A325-N. (*Ans.* 122 k, 81.6 k).

15-4. Using the AISC Manual, select a pair of bolted standard web angles (LRFD and ASD) for a W33 × 141 connected to the flange of a W14 × 120 column with a dead load service reaction of 75 k and a live load service reaction of 50 k. The bolts are to be 7/8-in A325-N in standard-size holes, and the steel is A36 for the angles and A992 for the W shapes.

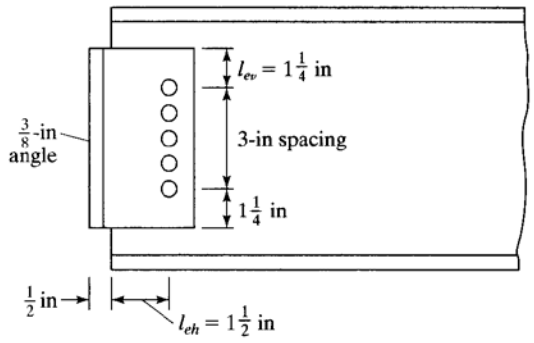

FIGURE P15-4

15-5. Repeat Prob. 15-4 if 1-in A325-N bolts are to be used. (*Ans.* 6 row conn. with 2Ls $4 \times 3\frac{1}{2} \times \frac{3}{8} \times 1$ ft $- 5\frac{1}{2}$ in)

15-6. Repeat Prob. 15-1 if 3/4-in A325 SC Class A bolts are to be used.

15-7. Design framed beam connections for a W27 × 84 connected to a W30 × 116 girder web to support a dead load reaction of 40 k and a live load reaction of 50 k, using the LRFD and ASD methods. The bolts are to be 7/8-in A325 SC Class A in standard-size holes. Angles are A36 steel, while beams are A992. The edge distances and bolt spacings are the same as those shown in the sketch for Prob. 15-4. (*Ans.* 5 row connection with 2Ls $5 \times 3\frac{1}{2} \times \frac{3}{8} \times 1$ ft $- 2\frac{1}{2}$ in)

15-8. Repeat Prob. 15-1 if the bolts are 3/4-in A490-SC Class A and are used in $1\frac{1}{16} \times 1\frac{5}{16}$ in short slots with long axes perpendicular to the transmitted force. Angle t is 1/2 in.

15-9. Design a framed beam connection for a W18 × 50 to support a dead load reaction of 30 k and a live load reaction of 20 k, using the LRFD and ASD methods. The beam's top flange is to be coped for a 2-in depth, and 7/8-in A325-X bolts in standard-size holes are to be used. The beam is connected to a W27 × 146 girder. Connection is A36, while W shapes are A992. (*Ans.* 4 row connection 2Ls 5 × $3\frac{1}{2}$ × $\frac{1}{4}$ × 0 ft − $11\frac{1}{2}$ in)

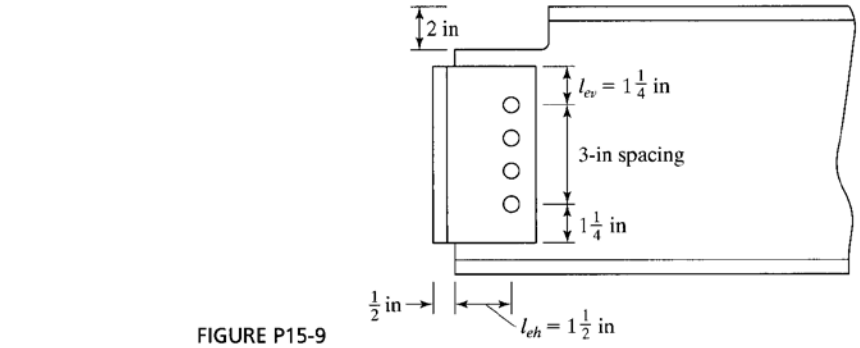

FIGURE P15-9

15-10. Repeat Prob. 15-7 if the dead load reaction is 80 k and the live load reaction is 110 k, and if 1-in A325-N bolts and A572 steel (F_y = 50 ksi and F_u = 65 ksi) are to be used.

15-11. Select a framed beam connection, using LRFD and ASD, for a W33 × 130 beam (A992 steel) with a dead load reaction = 45 k and a live load reaction = 65 k. It is to be connected to the flange of a W36 × 150 column. The A36 web angles are to be welded with E70 electrodes (weld A in the Manual) and are to be field-connected to the girder with 3/4-in A325-N bolts. (*One ans.* 2Ls 4 × $3\frac{1}{2}$ × $\frac{5}{16}$ × 1 ft $5\frac{1}{2}$ in, $\frac{3}{16}$-in weld A and 6-row bolt connection to girder.)

15-12. Repeat Prob. 15-11 using SMAW shop and field welds (welds A and B in the Manual).

15-13. Select an A36 framed beam connection from the AISC Manual (LRFD and ASD) for a W30 × 124 consisting of 50 ksi steel, using SMAW E70 shop and field welds. The dead load reaction is 60 k, while the live load one is 80 k. The beam is to be connected to the flange of a 50 ksi W14 × 145 column. (*Ans.* 2Ls 4 × 3 × $\frac{3}{8}$ × 1 ft − 8 in weld A = $\frac{3}{16}$ in, weld B = $\frac{5}{16}$ in)

15-14. Repeat Prob. 15-13 if R_D = 90 k and R_L = 100 k.

15-15. Select unstiffened A36 seated beam connections (LRFD and ASD) bolted with 7/8-in A325-N bolts in standard-size holes for the following data: Beam is W16 × 67, column is W14 × 82, both consisting of 50 ksi steel, R_D = 25 k, R_L = 30 k, and the column gage is $5\frac{1}{2}$ in. (*Ans.* 1L 6 × 4 × $\frac{3}{4}$ × 0 ft − 8 in)

15-16. Design SMAW welded moment-resisting connections LRFD and ASD for the ends of a W24 × 76 to resist R_D = 30 k, R_L = 60 k, M_D = 60 ft-k, and M_L = 80 ft-k. Use A36 steel and E70 electrodes. Assume that the column flange is 14 in wide. The moment is to be resisted by full-penetration groove welds in the flanges, and the shear is to be resisted by welded clip angles along the web. Assume that the beam was selected for bending with $0.9F_y$.

15-17. The beam shown in the accompanying illustration is assumed to be attached at its ends with moment-resisting connections. Select the beam, assuming full lateral support, and E70 SMAW electrodes. Use a connection of the type used in Prob. 15-16. F_y = 50 ksi. Use ASD and LRFD. (*Ans.* W21 × 55, shear welds $10\frac{1}{2}$ in each side LRFD, 11 in ASD.)

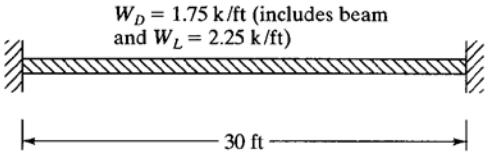

FIGURE P15-17