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 #1

Problem Number	Comments
Use only LRFD method to solve the following questions.	
10.2	P_D=4 ton and P_L=6 ton, W_D=1.8 ton/m, W_L=3.5 ton/m, use ST37 steel properties, design an IPB section, use 0.9 rule method and compare the result with plastic method. Elastic analysis may be done with a computer program.
10.27	Use IPE330 with ST37 steel, each concentrated load is 45 ton, check the beam for all possible local modes of failure, do not check shear, Convert lengths to meters.
10.28	Live load=30 ton, use ST52 steel, select an IPE or IPB section, no need to check for shear, Convert lengths to meters.
10.33	Use ST52 steel, beam section=IPE550, R_D=15 ton, R_L=20 ton, wall thickness is 25 cm, f'_c=210kgf/cm^2.

Output:

Beam Bearing Plate Design Summary
N = 8 in
B = 10 in

Area Provided = 80 sq. in
Required Thickness t = 1.15268 in

Bearing Capacity = 0.6Rn = 0.6(204) = 122.4 kips
Capacity-Local Web Yielding = 1.0Rn = 1.0(196.466) = 196.466 kips
Capacity-Web Crippling = 075Rn = 0.75(221.721) = 166.29 kips

PROBLEMS

10-1 to 10-5. *Considering moment only and assuming full lateral support for the compression flanges, select the lightest sections available using 50 ksi steel. The loads shown include the effect of the beam weights. Use elastic analysis, factored loads, and the 0.9 rule.*

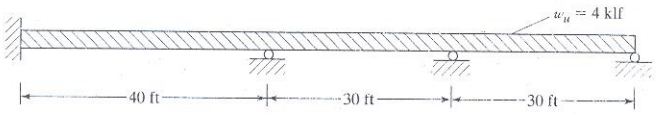

FIGURE P10-1 (*Ans.* W21 × 62)

10-2.

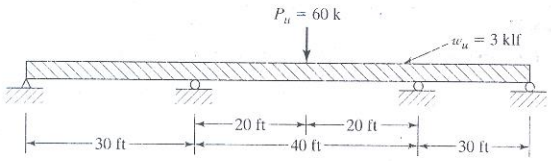

FIGURE P10-2

10-3.

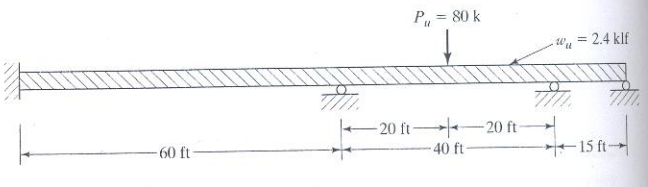

FIGURE P10-3 (*Ans.* W24 × 76)

10-4.

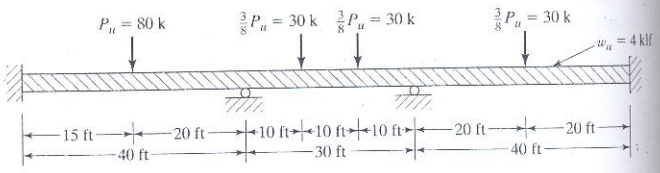

FIGURE P10-4

10-5.

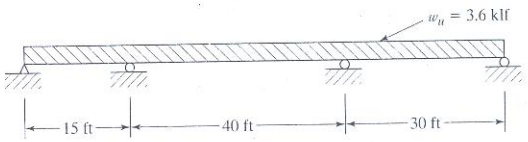

FIGURE P10-5 (*Ans.* W21 × 55)

10-6. Repeat Prob. 10-1 using plastic analysis.

10-7. Repeat Prob. 10-3 using plastic analysis. (*Ans.* W24 × 68)

10-8. Repeat Prob. 10-5 using plastic analysis.

10-9. Three methods of supporting a roof are shown in the accompanying illustration. Using an elastic analysis with factored loads, F_y = 50 ksi, and assuming full lateral support in each case, select the lightest section if a dead uniform service load (not

including beam weight) of 1 klf and a live uniform service load of 1.2 klf is to be supported. Consider moment only.

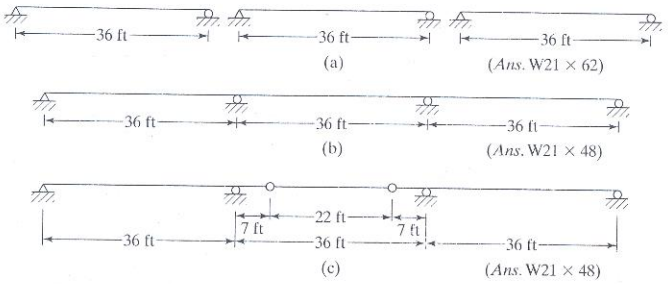

FIGURE P10-9

10-10. The welded section shown, made from 50 ksi steel, has full lateral support for its compression flange and is bent about its major axis. If C_b is 1.0, determine its design moment and shear strengths.

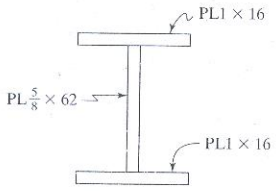

FIGURE P10-10

10-11 to 10-13. *Using F_y = 50 ksi select the lightest available section for the span and loading shown. Consider moment and shear only and neglect beam weight in all calculations. The member is assumed to have full lateral bracing.*

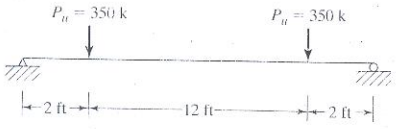

FIGURE P10-11 (*Ans.* W30 × 90)

10-12.

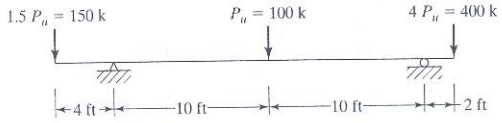

FIGURE P10-12

10-13. Repeat Prob. 10-11 using $F_y = 36$ ksi. (*Ans.* W33 × 118)

10-14. If a fully braced W14 × 34 section consisting of 50 ksi steel is used for a simple span of 6 ft 6 in., determine the maximum uniform load w_u that it can support in addition to its own factored weight. Use elastic analysis and consider shear and moment only.

10-15. A W16 × 40 consisting of 50 ksi steel is used as a simple beam for a span of 8 ft. If it has full lateral support determine the maximum uniform load w_u which it can support in addition to its own factored weight. Use an elastic analysis and consider shear and moment only. (*Ans.* 32.95 klf)

10-16. A fully braced W36 × 245 consisting of A992 steel is used as a simple beam for a span of 16 ft. Considering moment and shear only determine the maximum uniform load w_u it can support in addition to its own factored weight using an elastic analysis.

10-17. A 30-ft simply supported beam is to support a moving concentrated load $P_u = 80$ k. Using 50 ksi steel, select the most economical section considering moment and shear only. Use an elastic analysis and neglect beam weight. (*Ans.* W21 × 68)

10-18. A 40-ft simple beam that supports a service concentrated load $P_L = 30$ k at midspan is laterally unbraced except at its ends and center line. If the maximum permissible center line deflection under service loads equals 1/1000 of the span, select the most economical W section of 50 ksi steel considering moment, shear, and deflection. Neglect beam weight.

10-19. Design a beam for a 24-ft simple span to support the working uniform loads $w_D = 1.2$ klf (includes beam weight) and $w_L = 2.8$ klf. The maximum permissible deflection under working loads is 1/1200 of the span. Use 50 ksi steel and consider moment, shear, and deflection. The beam is to be braced laterally for its full length. (*Ans.* W30 × 108)

10-20. Select the lightest available W section of A992 steel for the span and service loads shown. The beam will have full lateral support for its compression flange. Its maximum service load center-line deflection may not exceed 1/1500 of the span under working loads. Consider moment, shear, and deflection only.

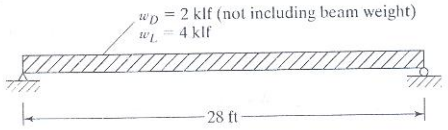

FIGURE P10-20

10-21. Select the lightest section available if $F_y = 50$ ksi for the span and working loads shown if the section is to be fully braced laterally and have a maximum factored load deflection of 1/800 of its span length. Neglect beam-weight in all calculations. Consider moment, shear and deflection. (*Ans.* W44 × 230)

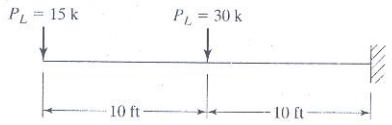

FIGURE P10-21

10-22. If the maximum permissible service load deflection for the fully braced beam shown is 1/1200 of the span, select the lightest available section using 50 ksi steel. Consider moment, shear, and deflections. Working loads are shown.

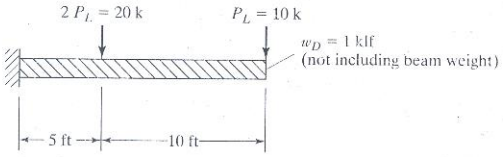

FIGURE P10-22

10-23. Select the lightest available W section ($F_y = 50$ ksi) for the beams shown in the accompanying illustration. The floor slab is 4 in reinforced concrete (weight=150 lb/ft^3) and supports a 100 psf uniform live load. The maximum permissible deflection for the working loads is $\frac{1}{240}L$. Assume continuous lateral bracing is provided. (*Ans.* W21 × 48)

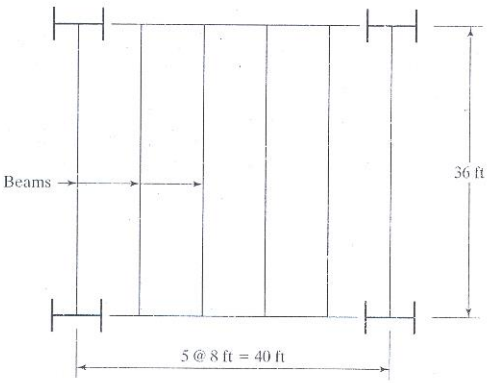

FIGURE P10-23

10-24. Repeat Prob. 10-23 if the live load is 200 psf.

10-25. Repeat Prob. 10-23 if the span is 40 ft. and the maximum beam depth is 20 in. (*Ans.* W18 × 76)

10-26. Select the lightest available W section (50 ksi steel) for the working live loads and span shown in the accompanying illustration. Lateral support is provided only at the 12-ft points and a maximum deflection (under working loads) equal to 1/1500 of the 24-ft span is permitted. Neglect beam weight. Consider moment, shear, and deflections. (*Ans.* W30 × 108)

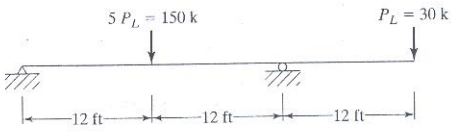

FIGURE P10-26

10-27. Repeat Prob. 10-26 if F_y = 36 ksi. (*Ans.* W30 × 108)

10-28. A simply supported W24 × 146 consisting of 50 ksi steel is supporting a 300-k service live load as shown in the figure. If the length of bearing at the left support is 8 in and at the concentrated load is 12 in, check the beam for shear, web yielding, and web crippling.

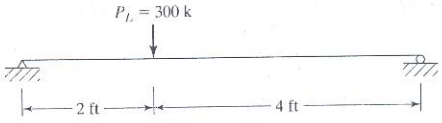

FIGURE P10-24

10-29. A 32-ft beam with full lateral support for its compression flange is supporting a moving service concentrated load of 60 k. Using 50 ksi steel, select the lightest section available for moment. Then check to see if the section is satisfactory in shear and compute the minimum length of bearing required at the supports from the standpoint of web yielding and web crippling. (*Ans.* W24 × 84)

10-30. Select the lightest available W30 section consisting of 50 ksi steel to resist a gravity moment M_{ux} = 500 ft-k and a lateral bending moment of M_{uy} = 200 ft-k. The section is assumed to have full lateral support.

10-31. The 20-ft simple beam shown has full lateral support for its compression flange and consists of 50 ksi steel. The beam supports a gravity service dead load of 1.2 klf (includes beam weight) and a gravity live load of 3.4 klf. The loads are assumed to act

through the e.g. of the section. Select the lightest available W33 section. (*Ans.* W33 × 118)

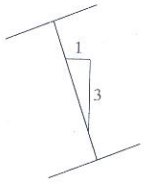

FIGURE P10-31

10-32. Repeat Prob. 10-31 if the gravity live load is 4.8 klf.

10-33. Design a steel bearing plate from A36 steel for a W21 × 68 beam with an end reaction $R_u = 100$ k. The beam will bear on a reinforced-concrete wall with $f'_c = 4$ ksi. In a direction perpendicular to the wall the bearing plate may not be longer than 8 in. (*One ans.* PL 1 × 8 × 0 ft 9 in)

10-34. Design a steel bearing plate of 50 ksi steel for a W30 × 116 beam supported by a reinforced-concrete wall with $f'_c = 3$ ksi. The maximum beam reaction R_u is 170 k. Assume the width of the plate perpendicular to the wall is 8 in.

10-35. Repeat Prob. 10-34, using a steel with $F_y = 36$ ksi. (*One ans.* $1\frac{3}{4} \times 8 \times 1$ ft 2 in)

10-36 to 10-33. *Solve the problems shown using the computer program INSTEP*

10-36. Repeat Prob. 10-33.

10-37. Repeat Prob. 10-34 (One ans. PL $1\frac{1}{2} \times 8 \times 1$ ft 2 in.)