9.10 PROBLEMS FOR SOLUTION

9-1 to 9-8. Using both LRFD and ASD, select the most economical sections, with \( F_y = 50 \text{ ksi} \), unless otherwise specified, and assuming full lateral bracing for the compression flanges. Working or service loads are given for each case, and beam weights are not included.

9-1.

\[ D = 1.50 \text{ k/ft} \]
\[ L = 3.25 \text{ k/ft} \]

28 ft

FIGURE P9-1  (Ans. W24 \(	imes \) 76 LRFD and ASD)

9-2.

\[ P \]
\[ P \]
\[ w \]

\[ P_D = 12 \text{ k} \]
\[ P_L = 20 \text{ k} \]

8 ft 8 ft 8 ft

24 ft

w = beam self-weight

FIGURE P9-2

9-3.

\[ P_L = 12 \text{ k} \]
\[ D = 1.0 \text{ k/ft} \]
\[ L = 1.5 \text{ k/ft} \]

10 ft 10 ft

20 ft

FIGURE P9-3  (Ans. W18 \(	imes \) 40 LRFD and ASD)

9-4. Repeat Prob. 9-3, using \( P_L = 20 \text{ k} \).

9-5.

\[ P_L = 6 \text{ k} \]
\[ P_L = 6 \text{ k} \]
\[ P_L = 3 \text{ k} \]
\[ w_D = 2.0 \text{ k/ft} \]

6 ft 6 ft 6 ft

18 ft

FIGURE P9-5  (Ans. W24 \(	imes \) 68 LRFD, W24 \(	imes \) 76 ASD)
9-6. \( P_L = 15 \text{k} \)

9-7. \( P_{DL} = 20 \text{k} \)

9-8. The accompanying figure shows the arrangement of beams and girders that are used to support a 5 in reinforced concrete floor for a small industrial building. Design the beams and girders assuming that they are simply supported. Assume full lateral support of the compression flange and a live load of 80 psf. Concrete weight is 150 lb/ft\(^3\).

9-9. A beam consists of a W18 \( \times \) 35 with 3/8 in \( \times \) 8 in cover plates welded to each flange. Determine the LRFD design uniform load, \( w_u \), and the ASD allowable uniform load.
that the member can support in addition to its own weight for a 28 ft simple span. (Ans. 2.85 k/ft LRFD, 3.02 k/ft ASD)

9-10. The member shown is made with 36 ksi steel. Determine the maximum service live load that can be placed on the beam if, in addition to its own weight, it is supporting a service dead load of 0.80 klf. The member is used for a 20 ft simple span. Use both LRFD and ASD methods.

FIGURE P9-10

9-11 to 9-14. Use both LRFD and ASD methods for these beams for which full lateral bracing of the compression flange is provided.

9-11. Select a W section for a 24 ft simple span to support a service dead uniform load of 1.5 k/ft and a live service load of 1.0 k/ft if two holes for 3/4-in φ bolts are assumed present in each flange at the section of maximum moment. Use AISC Specification and A36 steel. Use both LRFD and ASD methods. (Ans. W21 × 44 LRFD, W21 × 48 ASD)

9-12. Rework Prob. 9-11, assuming that four holes for 3/4-in φ bolts pass through each flange at the point of maximum moment. Use A992 steel.

9-13. The section shown in Fig. P9-13 has two 3/4-in φ bolts passing though each flange and cover plate. Find the design load, \( w_a \), and factored load, \( w_f \), that the section can support, in addition to its own weight, for a 22 ft simple span if it consists of a steel with \( F_y = 50 \text{ ksi} \). Deduct all holes for calculating section properties. (Ans. Net \( w_x = 4.74 \text{ k/ft} \), Net \( w_a = 3.14 \text{ k/ft} \))

FIGURE P9-13
9-14. A 36 ft simple span beam is to support two movable service 20 kip loads a distance of 12 ft apart. Assuming a dead load of 1.0 k/ft including the beam self-weight, select a 50 ksi steel section to resist the largest possible moment. Use LRFD method only.

9-15 to 9-28. For these problems, different values of \( L_b \) are given. Dead loads do not include beam weights. Use both LRFD and ASD methods.

9-15. Determine \( \Phi M_n \) and \( M_c/\Omega \) for a W18 \( \times \) 46 used as a beam with an unbraced length of the compression flange of 4 ft and 12 ft. Use A992 steel and \( C_b = 1.0 \).

(Ans. \( L_b = 4 \) ft, 340 ft-k LRFD; 226 ft-k ASD)
(Ans. \( L_b = 12 \) ft, 231.4 ft-k LRFD; 154.3 ft-k ASD)

9-16. Determine the lightest satisfactory W shape to carry a uniform dead load of 4.0 k/ft plus the beam self-weight and a uniform live load of 2.75 k/ft on a simple span of 12 ft. Assume bracing is provided at the ends only. Obtain \( C_b \) from Fig. 9.10 in text.

9-17. Select the lightest satisfactory W-shape section if \( F_y = 50 \) ksl. Lateral bracing is provided at the ends only. Determine \( C_b \). (Ans. W14 \( \times \) 61 LRFD, W12 \( \times \) 65 ASD)

FIGURE P9-17

9-18. Repeat Prob. 9-17 if lateral bracing is provided at the concentrated load as well as at the ends of the span. Determine \( C_b \).

9-19. A W18 \( \times \) 55 of A992 steel is used on a simple span of 15 ft and has lateral support of compression flange at its ends only. If the only dead load present is the beam self-weight, what is the largest service concentrated live load that can be placed at the 1/3 points of the beam? Determine \( C_b \). (Ans. 41.7 k LRFD, 44.3 k ASD)

9-20. Repeat Prob. 9-19 if lateral bracing is supplied at the beam ends and at the concentrated loads. Determine \( C_b \).

9-21. The cantilever beam shown in Fig. P9-21 is a W18 \( \times \) 55 of A992 steel. Lateral bracing is supplied at the fixed end only. The uniform load is a service dead load and includes the beam self-weight. The concentrated loads are service live loads. Determine whether the beam is adequate using LRFD and ASD methods. Assume \( C_b = 1.0 \). (Ans. LRFD OK, 363 ft-k > 335 ft-k; ASD OK, 241 ft-k > 212.5 ft-k)

FIGURE P9-21
9-22. The given beam in Fig. P9-22 is A992 steel. If the live load is twice the dead load, what is the maximum total service load in k/ft that can be supported when (a) the compression flange is braced laterally for its full length, and (b) lateral bracing is supplied at the ends and centerline only?

![Figure P9-22](Image)

9-23. A W21 × 68 beam of A992 steel carries a uniformly distributed service dead load of 1.75 k/ft plus its self-weight and two concentrated service live loads at the third points of a 33 ft simply supported span. If lateral bracing is provided at the ends and the concentrated loads, determine the maximum service live load, \(P_L\). Assume the concentrated loads are equal in value, determine \(C_b\). (Ans: 12.26 k LRFD, 8.50 k ASD)

9-24. A beam of \(F_y = 50\) ksi steel is used to support the loads shown in Fig. P9-24. Neglecting the beam self-weight, determine the lightest W shape to carry the loads if full lateral bracing is provided.

![Figure P9-24](Image)

\(P; P_D = 8.5\) k, \(P_L = 6.0\) k

9-25. Redesign the beam of Prob. 9-24 if lateral bracing is only provided at the supports and at the concentrated loads. Determine \(C_b\). (Ans: W16 × 26 LRFD, W14 × 30 ASD)

9-26. Design the lightest W shape beam of 50 ksi steel to support the loads shown in Fig. P9-26. Neglect the beam self-weight. The beam has continuous lateral bracing between A and B, but is laterally unbraced between B and C. Determine \(C_b\).

\(w_D = 2.0\) k/ft
\(w_L = 1.0\) k/ft

![Figure P9-26](Image)
9-27. A W16 × 36 beam of A992 steel is fixed at one support and simply supported at the other end. A concentrated load of dead load of 9.25 k and live load of 6.50 k is applied at the center of the 32 ft span. Assume lateral bracing of the compression flange is provided at the pinned support, the load point, and the fixed support. You may neglect the beam self-weight and assume that $C_h = 1.0$. Is the W16 adequate? *(Ans. LRFD OK, 129.0 ft-k ≤ 136.6 ft-k; ASD N.G., 94.5 ft-k ≥ 90.9 ft-k)*

9-28. A W24 × 104 beam is used to support the loads shown in Fig. P9-28. Lateral bracing of the compression flange is supplied only at the ends. Determine $C_h$. If $F_y = 50$ ksi, determine if the W24 is adequate to support these loads.

![Diagram of W24 × 104 beam with loadings](image)

$P_D = 10.5 \text{ k}$
$P_L = 14.0 \text{ k}$
$w_D = 1.0 \text{ k/ft includes self-weight}$
$w_L = 1.75 \text{ k/ft}$

**FIGURE P9-28**

9-29. An A992, W18 × 60 steel beam is used on a 36 ft simple span to carry a uniformly distributed load. Determine the location of the lateral support, $L_h$, in order to provide just enough strength to carry a design moment. Use $M_u = 416.8 \text{ ft-k}$ for LRFD method and $M_u = 277.5 \text{ ft-k}$ for ASD method. Assume $C_h = 1.0$. *(Ans. 9 ft LRFD and ASD)*

9-30. The two steel beams shown in Fig. P9-30 are part of a two-span beam framing system with a pin (hinge) located 4.5 ft left of the interior support, making the system statically determinate. Determine the sizes (lightest) of the two W shape beams. Assume A992 steel and continuous lateral support of the compression flanges. The beam self-weight may be neglected. Use LRFD and ASD methods.

![Diagram of two-span beam framer system](image)

$P: P_D = 5.0 \text{ k}, P_L = 7.5 \text{ k}$

**FIGURE P9-30**
9.10 Problems for Solution 301

9.31. A built-up shape steel beam consists of a ½ in × 12 in web, and ½ in × 4 in top and bottom flanges. The member has the compression flange fully braced, therefore the moment capacity, ΦMₚ, using LRFD method was calculated to be 103.4 ft-k using Fₚ = 50 ksi steel. During design it was thought that the factored moment, Mₚ, was 100 ft-k, but after the member was fabricated it was found that the actual design moment, Mₚ, should have been 130 ft-k. A brilliant and resourceful young engineer suggested adding a ¾ in × 6 in cover plate to the bottom flange of the member to increase its capacity. Compute the new moment capacity, ΦMₚ, and state whether or not it will safely support the design moment, Mₚ = 130 ft-k. (Ans. Yes, ΦMₚ = 131.5 ft-k > Mₚ = 130 ft-k)

9.32. A W21 × 93 has been specified for use on your design project. By mistake, a W21 × 73 was shipped to the field. This beam must be erected today. Assuming that ½ in thick plates are obtainable immediately, select cover plates to be welded to the top and bottom flanges to obtain the necessary section capacity. Use Fₚ = 50 ksi steel for all materials and assume that full bracing is supplied for the compression flange. Use LRFD and ASD methods.