**Architecture 324**
**Structures II**

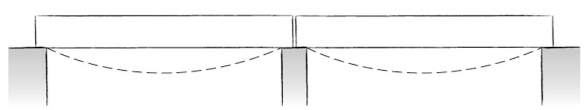
# Gerber Beams

- Continuity in Beams
- Gerber Beams

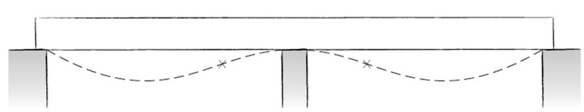


## Continuous Beams

- Continuous over one or more supports
  - Most common in monolithic concrete
  - Steel: continuous or with moment connections
  - Wood: as continuous beams, e.g. long Glulam spans
- Statically indeterminate
  - Cannot be solved by the three equations of statics alone
  - Internal forces (shear & moment) as well as reactions are affected by movement or settlement of the supports



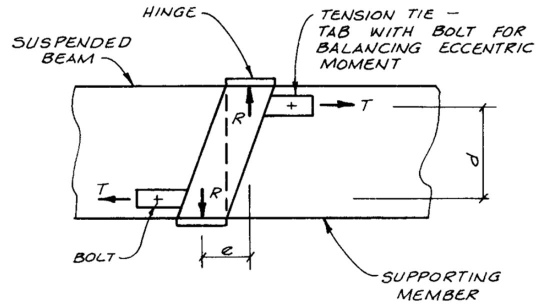
two spans - simply supported

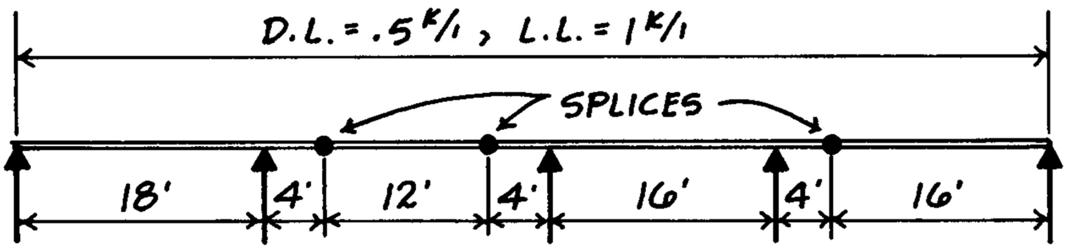


two spans - continuous

## Splice or Hinge

- Can add one hinge for each redundant reaction
- Reduces length for transport
- Moment = 0 at hinge
- Can be used to balance – and + moments for optimization

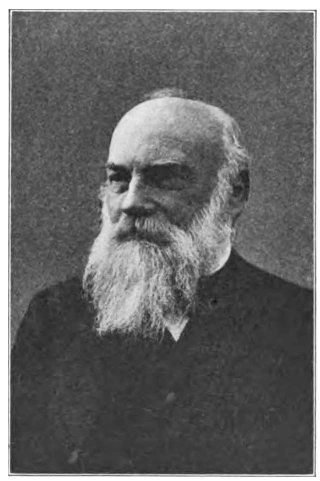


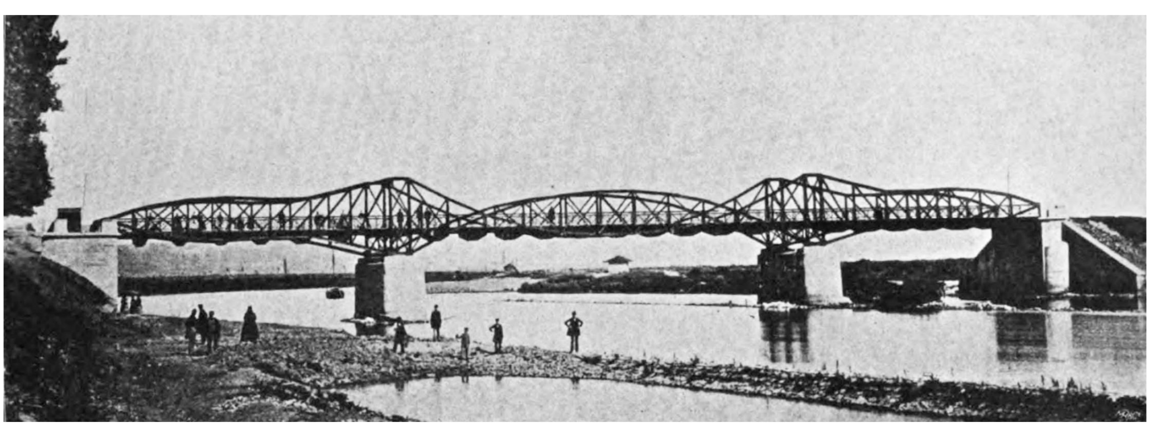



## Gottfried Heinrich Gerber
(1832-1912)

Developed a cantilever bridge spanning system used in many bridges worldwide. The system became know as the "Gerber Beam" and uses cantilever segments to support a simple span.



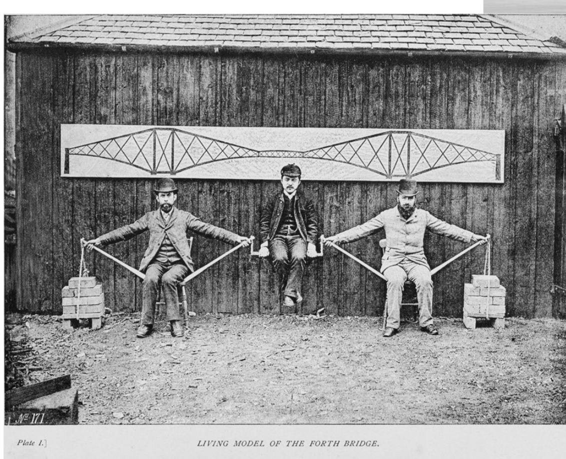
Haßfurter Brücke, 1864. Span of 38 m over the Main River.



# Examples of the Gerber system

Firth of Fourth Bridge, 1890

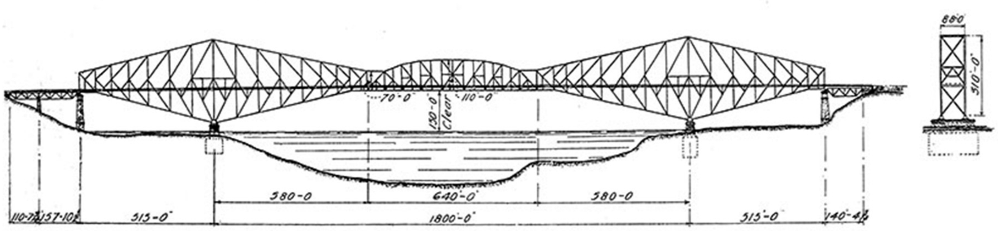
- total length 8094 ft.
- central span 1700 ft.
- Design Fowler & Baker
- Construction 1882 - 1889




Static modeling of the Firth of Forth Bridge
by Fowler & Baker




# Quebec Bridge Final Completion 1917

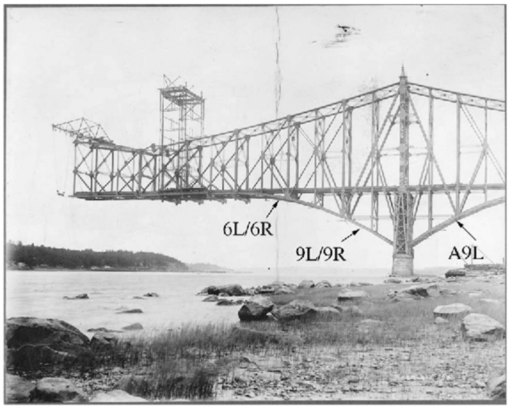


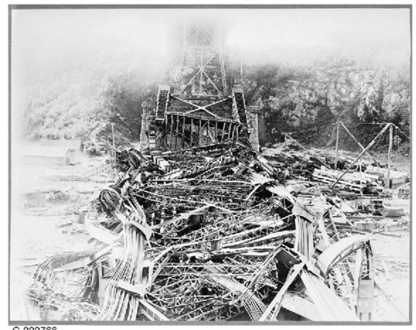

ST. LAWRENCE BRIDGE COMPANY DESIGN AS FINALLY APPROVED AND BUILT

Final successful completion 1917

# Quebec Bridge failure – 1907 and 1916

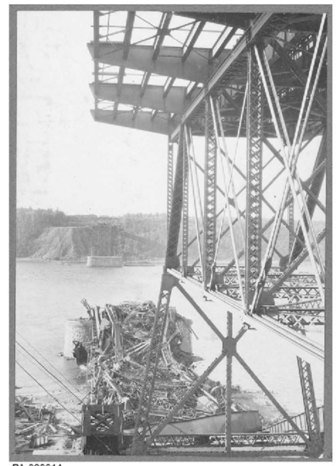
Compression members that failed in 1907



C-009786

1916 hoisting failure

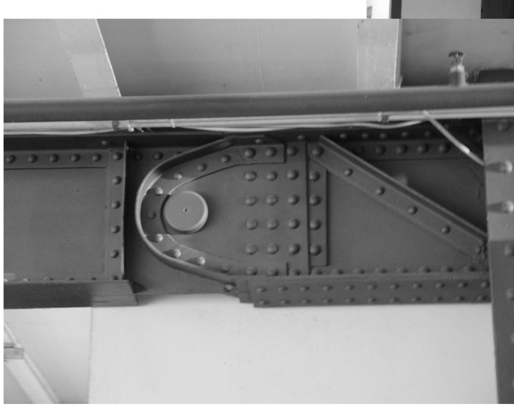


PA-020614

1907 failure due to miscalculation of the steel strength and dead load.



# Gerber system in building frames

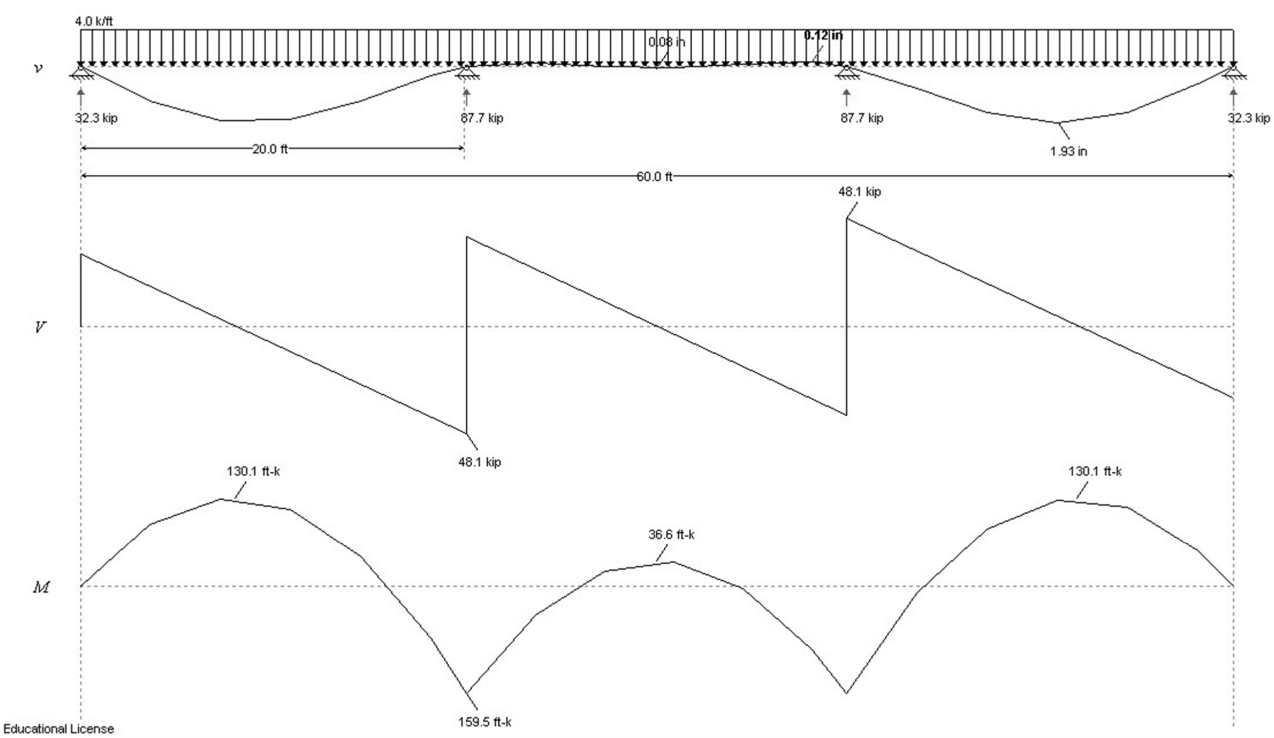


Speicherstadt Hamburg Kaffeerösterei 1888

# Gerber Beams in Detroit

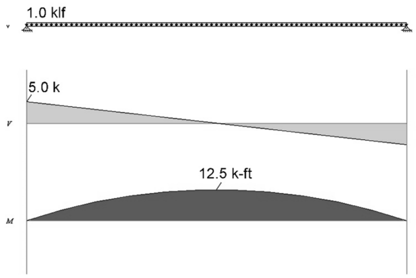


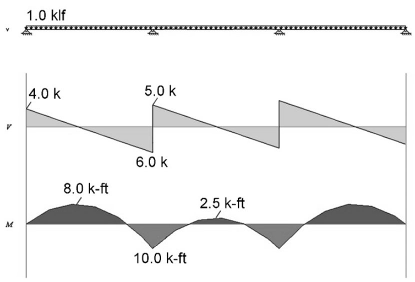
# Moment control in beams

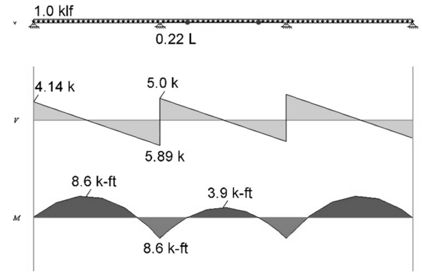


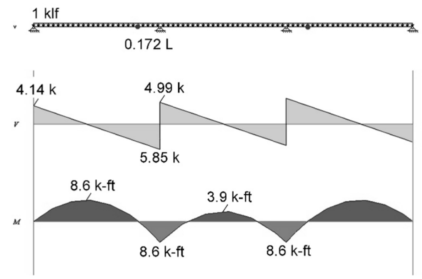
# Moment control in beams

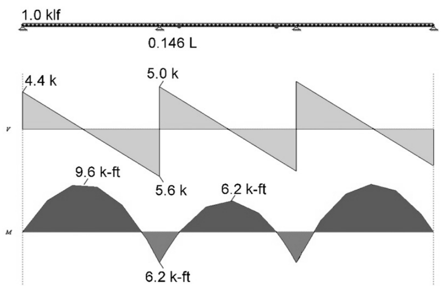
Spans = 10 ft






# Example Problem

Given:

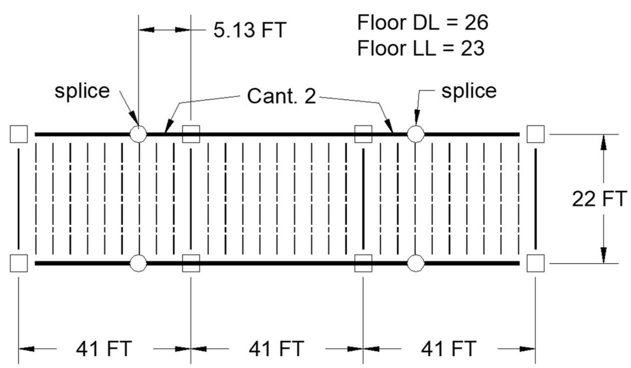
Span and loading

- D + L = 49 psf
- 49 psf x 11 ft = 539 plf

Find:

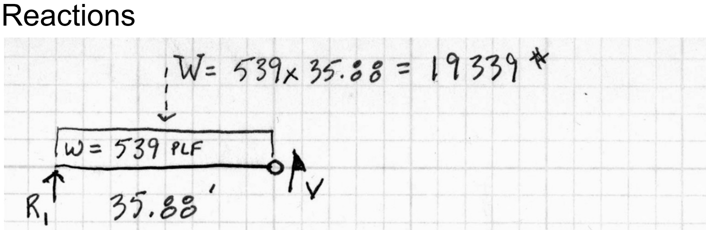
shear and moment

beam section




FBD 1

Reactions




$\Sigma M @ R_1 = 0 = 19.34^k (17.94') - V\ (35.88)$

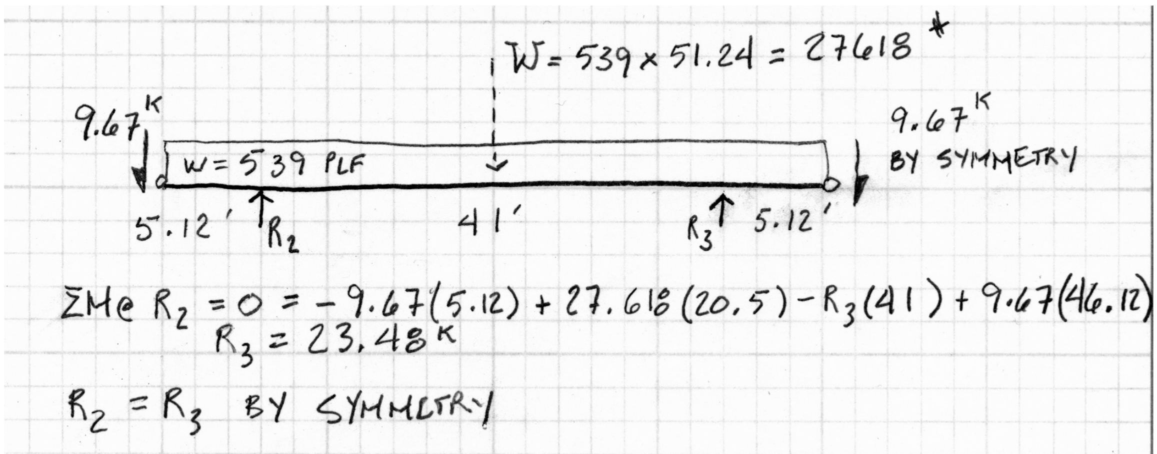
$V = 9.67^k$

$\Sigma M @ V = 0 = -19.34\ (17.94') + R_1\ (35.88)$

$R_1 = 9.67^k$

# Example Problem cont.

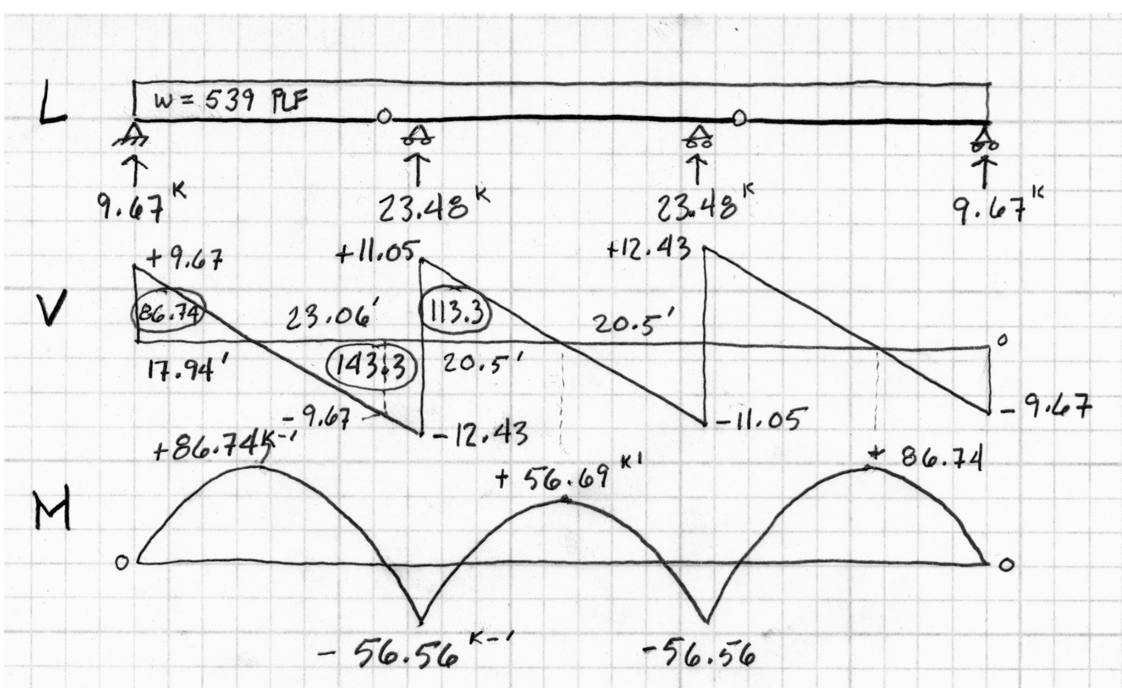
FBD 2
Reactions






# Example Problem cont.

Force Diagrams



# Example Problem cont.

STEEL BEAM DESIGN

$M_U = 86.74$ K-FT  $V_U = 12.43$ K

$M_U = \phi M_n$

$M_n = \frac{M_U}{\phi} = \frac{86.74}{0.9} = 96.38$ K-FT

$M_n = F_y Z_x$

$Z_x = \frac{M_n}{F_y} = \frac{96.38^{K-'}(12)}{50^{KSI}} = 23.13 \text{ in}^3$

LOOK UP SECTION IN $Z_x$ TABLE

CHOOSE W12×19

$Z_x = 24.7 > 23.13$ ✓

$\phi M_n = 92.6 > 86.74$ ✓

CHECK SHEAR

$h/t_w = 46.2 < 59$ ✓

$A_w = t_w d = 0.235(12.5) = 2.87 \text{ in}^2$

$\phi V_n = (1.0)\, 0.6 F_y A_w = 0.6(50)(2.87)$

$\phi V_n = 86.01 > 12.43 = V_U$ ✓OK

**Table 3-2 (continued)**
**W-Shapes**
**Selection by $Z_x$**

$F_y = 50$ ksi

$Z_x$

| Shape | $Z_x$ | $M_{px}/\Omega_b$ | $\phi_b M_{px}$ | $M_{rx}/\Omega_b$ | $\phi_b M_{rx}$ | $BF/\Omega_b$ | $\phi_b BF$ | $L_p$ | $L_r$ | $I_x$ | $V_{nx}/\Omega_v$ | $\phi_v V_{nx}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kip-ft | kip-ft | kip-ft | kip-ft | kips | kips | | | | kips | kips |
| | in.³ | ASD | LRFD | ASD | LRFD | ASD | LRFD | ft | ft | in.⁴ | ASD | LRFD |
| **W14×26** | **40.2** | **100** | **151** | **61.7** | **92.7** | **5.33** | **8.11** | **3.81** | **11.0** | **245** | **70.9** | **106** |
| W8×40 | 39.8 | 99.3 | 149 | 62.0 | 93.2 | 1.64 | 2.46 | 7.21 | 29.9 | 146 | 59.4 | 89.1 |
| W10×33 | 38.8 | 96.8 | 146 | 61.1 | 91.9 | 2.39 | 3.62 | 6.85 | 21.8 | 171 | 56.4 | 84.7 |
| **W12×26** | **37.2** | **92.8** | **140** | **58.3** | **87.7** | **3.61** | **5.46** | **5.33** | **14.9** | **204** | **56.1** | **84.2** |
| W10×30 | 36.6 | 91.3 | 137 | 56.6 | 85.1 | 3.08 | 4.61 | 4.84 | 16.1 | 170 | 63.0 | 94.5 |
| W8×35 | 34.7 | 86.6 | 130 | 54.5 | 81.9 | 1.62 | 2.43 | 7.17 | 27.0 | 127 | 50.3 | 75.5 |
| **W14×22** | **33.2** | **82.8** | **125** | **50.6** | **76.1** | **4.78** | **7.27** | **3.67** | **10.4** | **199** | **63.0** | **94.5** |
| W10×26 | 31.3 | 78.1 | 117 | 48.7 | 73.2 | 2.91 | 4.34 | 4.80 | 14.9 | 144 | 53.6 | 80.3 |
| W8×31[f] | 30.4 | 75.8 | 114 | 48.0 | 72.2 | 1.58 | 2.37 | 7.18 | 24.8 | 110 | 45.6 | 68.4 |
| **W12×22** | **29.3** | **73.1** | **110** | **44.4** | **66.7** | **4.68** | **7.06** | **3.00** | **9.13** | **156** | **64.0** | **95.9** |
| W8×28 | 27.2 | 67.9 | 102 | 42.4 | 63.8 | 1.67 | 2.50 | 5.72 | 21.0 | 98.0 | 45.9 | 68.9 |
| **W10×22** | **26.0** | **64.9** | **97.5** | **40.5** | **60.9** | **2.68** | **4.02** | **4.70** | **13.8** | **118** | **49.0** | **73.4** |
| **W12×19** | **24.7** | **61.6** | **92.6** | **37.2** | **55.9** | **4.27** | **6.43** | **2.90** | **8.61** | **130** | **57.3** | **86.0** |
| W8×24 | 23.1 | 57.6 | 86.6 | 36.5 | 54.9 | 1.60 | 2.40 | 5.69 | 18.9 | 82.7 | 38.9 | 58.3 |
| **W10×19** | **21.6** | **53.9** | **81.0** | **32.8** | **49.4** | **3.18** | **4.76** | **3.09** | **9.73** | **96.3** | **51.0** | **76.5** |
| W8×21 | 20.4 | 50.9 | 76.5 | 31.8 | 47.8 | 1.85 | 2.77 | 4.45 | 14.8 | 75.3 | 41.4 | 62.1 |
| **W12×16** | **20.1** | **50.1** | **75.4** | **29.9** | **44.9** | **3.80** | **5.73** | **2.73** | **8.05** | **103** | **52.8** | **79.2** |
| W10×17 | 18.7 | 46.7 | 70.1 | 28.3 | 42.5 | 2.98 | 4.47 | 2.98 | 9.16 | 81.9 | 48.5 | 72.7 |
| **W12×14[v]** | **17.4** | **43.4** | **65.3** | **26.0** | **39.1** | **3.43** | **5.17** | **2.66** | **7.73** | **88.6** | **42.8** | **64.3** |
| W8×18 | 17.0 | 42.4 | 63.8 | 26.5 | 39.9 | 1.74 | 2.61 | 4.34 | 13.5 | 61.9 | 37.4 | 56.2 |
| W10×15 | 16.0 | 39.9 | 60.0 | 24.1 | 36.2 | 2.75 | 4.14 | 2.86 | 8.61 | 68.9 | 46.0 | 68.9 |
| W8×15 | 13.6 | 33.9 | 51.0 | 20.6 | 31.0 | 1.90 | 2.85 | 3.09 | 10.1 | 48.0 | 39.7 | 59.6 |
| **W10×12[f]** | **12.6** | **31.2** | **46.9** | **19.0** | **28.6** | **2.36** | **3.53** | **2.87** | **8.05** | **53.8** | **37.5** | **56.3** |
| W8×13 | 11.4 | 28.4 | 42.8 | 17.3 | 26.0 | 1.76 | 2.67 | 2.98 | 9.27 | 39.6 | 36.8 | 55.1 |
| **W8×10[f]** | **8.87** | **21.9** | **32.9** | **13.6** | **20.5** | **1.54** | **2.30** | **3.14** | **8.52** | **30.8** | **26.8** | **40.2** |

| ASD | LRFD |
|---|---|
| $\Omega_b = 1.67$<br>$\Omega_v = 1.50$ | $\phi_b = 0.90$<br>$\phi_v = 1.00$ |

[f] Shape exceeds compact limit for flexure with $F_y = 50$ ksi; tabulated values have been adjusted accordingly.

[v] Shape does not meet the $h/t_w$ limit for shear in AISC *Specification* Section G2.1(a) with $F_y = 50$ ksi; therefore, $\phi_v = 0.90$ and $\Omega_v = 1.67$.