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### Chapter 4 – Design

- There is a design aid for almost any **W shape** compression member.
- But there are a few exceptions:
  1. For example, **Table 4-1** cannot be used for a **W18** shape.
  2. Also, if the yield strength  $F_y$  for this shape is anything **other than 50 ksi**, **Table 6-1** cannot be used.
- In that case, a **trial-and-error approach** can be used.

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- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  1. Assume a value for the nominal stress  $F_n$ .

Examination of **AISC Equations E3-2** and **E3-3** shows that the theoretically maximum value of  $F_n$  is the yield stress  $F_y$ .

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- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  2. Determine the required area.

For **LRFD**:  $\phi F_n A_g \geq P_n$      $A_g \geq \frac{P_n}{\phi F_n}$

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- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  2. Determine the required area.

For **ASD**:  $0.6F_n \geq \frac{P_a}{A_g}$      $A_g \geq \frac{P_a}{0.6F_n}$

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- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  3. Select a shape that satisfies the area requirement.
  4. Compute  $F_n$  and the strength for the trial shape.

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### Chapter 4 – Design

- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  5. Revise if necessary.

If the available strength is very close to the required value, the next tabulated size can be tried.

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### Chapter 4 – Design

- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (**unsafe**) or too large (**uneconomical**), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  5. Revise if necessary.

Otherwise, repeat the entire procedure.

In **Step 1**, use a value of  $F_n$  that is between the original assumed value and the derived value in **Step 4**.

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### Chapter 4 – Design

- The general procedure is to **assume a shape** and then compute its **strength**.
- If the strength is too small (unsafe) or too large (uneconomical), another trial must be made.
- A systematic approach to making the trial selection is as follows:
  6. Check local stability (check the width-to-thickness ratios).

Revise if necessary.

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### Chapter 4 – Design

- **Example 4-9:** Select a **W18** shape with  $F_y = 70 \text{ ksi}$  that can resist a service dead load of 75 k and a service live load of 225 k. The effective length  $L_c = 20 \text{ ft}$ .

➤ **LRFD** solution:

$$P_u = 1.2D + 1.6L = 1.2(75k) + 1.6(225k) = 450k$$

Try  $F_n = 47 \text{ ksi}$ , about  $\frac{2}{3}$  of  $F_y$ :

$$\text{Required } A_g \geq \frac{P_u}{\phi_c F_n} = \frac{450k}{0.90(47\text{ksi})} = 10.64 \text{ in}^2$$

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### Chapter 4 – Design

- **Example 4-9:** Try a **W18 x 40**

$$A_g = 11.8 \text{ in}^2 \geq 10.64 \text{ in}^2$$

**OK**

$$\begin{aligned} A_g &= 11.8 \text{ in}^2 \\ r_y &= 1.27 \text{ in} \end{aligned}$$

$$\frac{L_c}{r_{\min}} = \frac{20 \text{ ft} (12 \text{ in/ft})}{1.27 \text{ in}} = 188.98$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2 (29,000 \text{ ksi})}{(188.98)^2} = 8.015 \text{ ksi}$$

$$4.71 \sqrt{\frac{E}{F_y}} = 4.71 \sqrt{\frac{29,000 \text{ ksi}}{70 \text{ ksi}}} = 95.87$$

Since  $\frac{L_c}{r} > 4.71 \sqrt{\frac{E}{F_y}}$  Use **AISC Equation E3-3**

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### Chapter 4 – Design

- **Example 4-9:** Try a **W18 x 40**

$$F_n = 0.877 F_e = 0.877 (8.015 \text{ ksi}) = 7.029 \text{ ksi}$$

$$\begin{aligned} A_g &= 11.8 \text{ in}^2 \\ r_y &= 1.27 \text{ in} \end{aligned}$$

$$\phi_c P_n = \phi_c F_n A_g = 0.90 (7.029 \text{ ksi}) 11.8 \text{ in}^2 = 74.65 \text{ k} < 450 \text{ k}$$

**N.G.**

This shape is **slender** for compression, but since it did not work, there is no need to compute a reduced strength.

Because the initial estimate of  $F_n$  was so far off, assume a much lower value.

Increase the derived value of **7.029 ksi** by  $\frac{1}{3}$  of the difference between the initial estimate and **7.029 ksi**.

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### Chapter 4 – Design

➤ **Example 4-9:** Try  $F_n = 7.029 \text{ ksi} + \frac{1}{3}(47 - 7.029)\text{ksi} = 20.4 \text{ ksi}$

$$\text{Required } A_g \geq \frac{P_n}{\phi_c F_n} = \frac{450 \text{ k}}{0.90(20.4 \text{ ksi})} = 24.51 \text{ in}^2$$

Try a **W18 x 86**

$$A_g = 25.3 \text{ in}^2 \geq 24.51 \text{ in}^2 \quad \text{OK}$$

$$A_g = 25.3 \text{ in}^2$$

$$r_y = 2.63 \text{ in}$$

$$\frac{L_c}{r_{\min}} = \frac{20 \text{ ft}(12 \text{ in/ft})}{2.63 \text{ in}} = 91.25$$

$$F_e = \frac{\pi^2 E}{(L_c/r)^2} = \frac{\pi^2 (29,000 \text{ ksi})}{(91.25)^2} = 34.37 \text{ ksi}$$

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### Chapter 4 – Design

➤ **Example 4-9:** Try a **W18 x 86**

Since  $\frac{L_c}{r} < 4.71 \sqrt{\frac{E}{F_y}}$  Use **AISC Equation E3-2**

$$F_n = F_y \left( 0.658^{F_y/F_e} \right) = 70 \text{ ksi} \left( 0.658^{70/34.37} \right) = 29.85 \text{ ksi}$$

$$\phi_c P_n = \phi_c F_n A_g = 0.90(29.85 \text{ ksi})25.3 \text{ in}^2 = 679 \text{ k} > 450 \text{ k} \quad \text{OK}$$

This shape is **not slender** (there is no “c” footnote in the dimensions and properties table).

**Local buckling** need not be investigated.

Use a **W18 x 86**.

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Let's work on some problems



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Any questions?



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