# Flexural Design Example

## Table of contents

# Computation - Cover Sheet

**Structures Calculations**

---

**Project:** Your Project Name
**Subject:** Project Subject
**Task:** Task of Project

**Project Number:** 0



**Preliminary Calculation:** **Final Calculation:**

**Description:**

**Design Methodology:**

Allowable Stress Design: Load Factor Design: Load & Resistance Factor Design: N/A

Combination of Methodologies (describe)

**Codes/References:**

AASHTO
Edition: 9th
Interims Through:
Applicable Sections: 6

AREMA
Chapter:
Last Update:
Applicable Sections: 6

Other
Title:
Year/Edition:
Applicable Sections: 6

**Original Designer:**

Name: Initials: Date:

**Checker:**

Name: Initials: Date:

**Check Method:**

For Hand Calculations: Backchecked original calculations: Independent calculations:

For Computer Calculations: Checked input & output: Reran same software: Ran different software:

Does this calculation supersede a previous calculation? Yes: No:

**Checker's Comments:**

No Changes: Minor Corrections: original design satisfactory:

Revise desgin as shown on Sheets: of

Other comments/conclusions:

## Flexural Example Problem

## Flexural Example Problem

Determine the LRFD flexural design strength for a W10x12 beam with an unbraced length of 10 ft.

### Section Properties of W33X118

$h = 29.98\ \text{inch}$  $t_f = 0.74\ \text{inch}$  $b_f = 11.5\ \text{inch}$  $t_w = 0.55\ \text{inch}$

$E = 29000\ \text{ksi}$  $F_y = 50\ \text{ksi}$  $S_x = 359\ \text{inch}^3$  $Z_x = 415\ \text{inch}^3$

$L_b = 10\ \text{ft}$

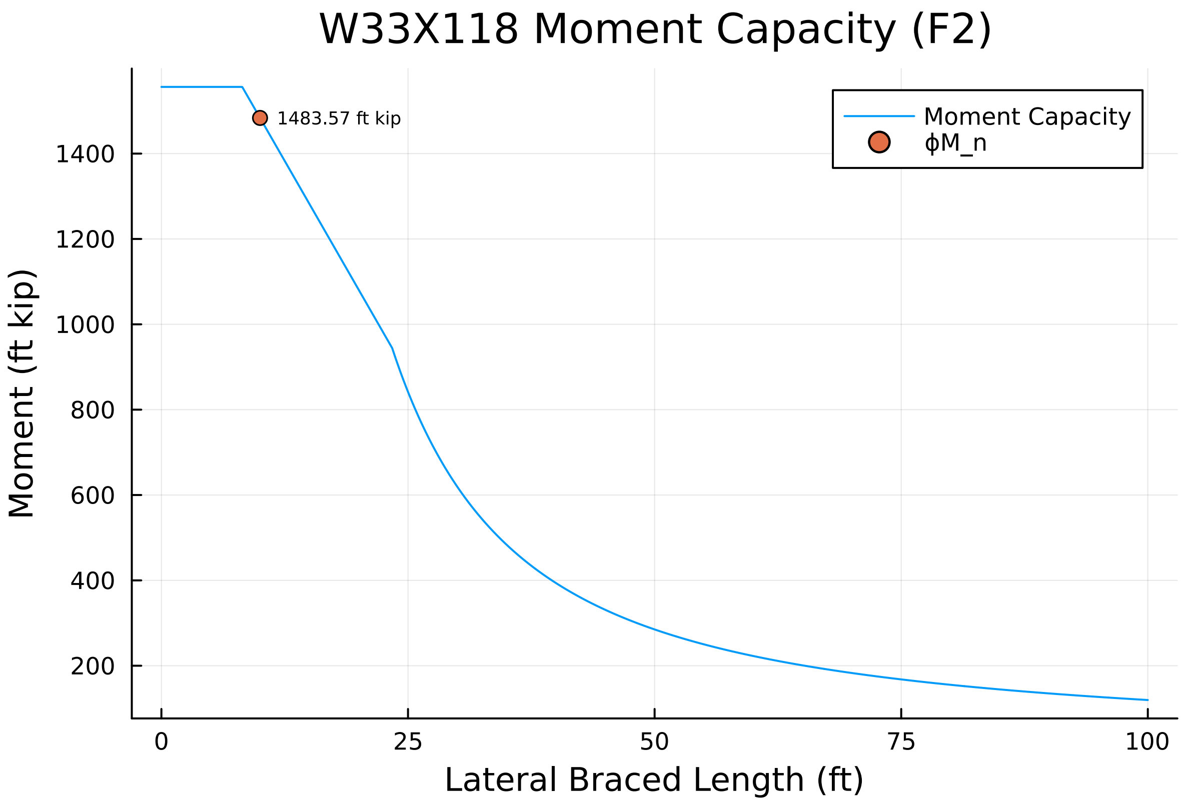


Figure 1: W-Shape: Flexural Strength

## Determine if Section is Compact

## Determine the limiting ratios (AISC Table B4.1b)

### Check Flange

$$b = \frac{b_f}{2} = \frac{11.5 \text{ inch}}{2} = 5.75 \text{ inch}$$

$$t = t_f = 0.74 \text{ inch}$$

$$\lambda = \frac{b}{t} = \frac{5.75 \text{ inch}}{0.74 \text{ inch}} = 7.77$$

$$\lambda_p = 0.38 \cdot \sqrt{\frac{E}{F_y}} = 0.38 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 9.15$$

$$\lambda_r = 1 \cdot \sqrt{\frac{E}{F_y}} = 1 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 24.08$$

$$class = \begin{cases} compact & \text{if } \lambda \leq \lambda_p \\ noncompact & \text{if } \lambda_p < \lambda \leq \lambda_r \\ slender & \text{otherwise} \end{cases} = \begin{cases} compact & \text{if } 7.77 \leq 9.15 \\ noncompact & \text{if } 9.15 < 7.77 \leq 24.08 \\ slender & \text{otherwise} \end{cases} = compact$$

Flange is compact

### Check Web

$$h = h = 29.98 \text{ inch}$$

$$t_w = t_w = 0.55 \text{ inch}$$

$$\lambda = \frac{h}{t_w} = \frac{29.98 \text{ inch}}{0.55 \text{ inch}} = 54.5$$

$$\lambda_p = 3.76 \cdot \sqrt{\frac{E}{F_y}} = 3.76 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 90.55$$

$$\lambda_r = 5.7 \cdot \sqrt{\frac{E}{F_y}} = 5.7 \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}} = 137.27$$

$$class = \begin{cases} compact & \text{if } \lambda \leq \lambda_p \\ noncompact & \text{if } \lambda_p < \lambda \leq \lambda_r \\ slender & \text{otherwise} \end{cases} = \begin{cases} compact & \text{if } 54.5 \leq 90.55 \\ noncompact & \text{if } 90.55 < 54.5 \leq 137.27 \\ slender & \text{otherwise} \end{cases} = compact$$

Web is compact

W-Shape is classified as F2

## Determine Flexural Capacity based on Chapter F, Section 2

### Calculate Miscellaneous Variables

$$c = 1$$

$$M_p = F_y \cdot Z_x$$

$$= 50 \text{ ksi} \cdot 415 \text{ inch}^3$$

$$= 1729.17 \text{ ft kip}$$

$$L_p = 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}}$$

$$= 1.76 \cdot 2.32 \text{ inch} \cdot \sqrt{\frac{29000 \text{ ksi}}{50 \text{ ksi}}}$$

$$= 8.19 \text{ ft}$$

$$L_r = 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_0} + \sqrt{\left(\frac{J \cdot c}{S_x \cdot h_0}\right)^2 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E}\right)^2}}$$

$$= 1.95 \cdot 2.89 \text{ inch} \cdot \frac{29000 \text{ ksi}}{0.7 \cdot 50 \text{ ksi}} \cdot \sqrt{\frac{5.3 \text{ inch}^4 \cdot 1}{359 \text{ inch}^3 \cdot 32.2 \text{ inch}} + \sqrt{\left(\frac{5.3 \text{ inch}^4 \cdot 1}{359 \text{ inch}^3 \cdot 32.2 \text{ inch}}\right)^2 + 6.76 \cdot \left(\frac{0.7 \cdot 50 \text{ ksi}}{29000 \text{ ksi}}\right)^2}}$$

$$= 23.44 \text{ ft}$$

$$F_{cr} = \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.08 \cdot \frac{J \cdot c}{S_x \cdot h_0} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$$

$$= \frac{1 \cdot 3.14^2 \cdot 29000 \text{ ksi}}{\left(\frac{10 \text{ ft}}{2.89 \text{ inch}}\right)^2} \cdot \sqrt{1 + 0.08 \cdot \frac{5.3 \text{ inch}^4 \cdot 1}{359 \text{ inch}^3 \cdot 32.2 \text{ inch}} \cdot \left(\frac{10 \text{ ft}}{2.89 \text{ inch}}\right)^2}$$

$$= 171.05 \text{ ksi}$$

### 1. Yielding

$$M_{nFY} = M_p = 1729.17 \text{ ft kip}$$

### 2. Lateral Torsional Buckling

$$M_{nLTB} = \begin{cases} M_p & \text{if } L_b \leq L_p \\ C_b \cdot \left(M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \frac{L_b - L_p}{L_r - L_p}\right) & \text{if } L_p < L_b \leq L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$= \begin{cases} 1729.17 \text{ ft kip} & \text{if } 10 \text{ ft} \leq 8.19 \text{ ft} \\ 1 \cdot \left(1729.17 \text{ ft kip} - \left(1729.17 \text{ ft kip} - 0.7 \cdot 50 \text{ ksi} \cdot 359 \text{ inch}^3\right) \cdot \frac{10 \text{ ft} - 8.19 \text{ ft}}{23.44 \text{ ft} - 8.19 \text{ ft}}\right) & \text{if } 8.19 \text{ ft} < 10 \text{ ft} \leq 23.44 \text{ ft} \\ 171.05 \text{ ksi} \cdot 359 \text{ inch}^3 & \text{otherwise} \end{cases}$$

$$= 1648.41 \text{ ft kip}$$

### Flexure Capacity

$$\phi M_n = \phi_b \cdot \min\left(M_{n1}, M_{n2}\right) = 0.9 \cdot \min\left(1729.17 \text{ ft kip}, 1648.41 \text{ ft kip}\right) = 1483.57 \text{ ft kip}$$