Architecture 324: Structures II
Wood Column Analysis - SOLUTIONS
Problem 3: Capacity Analysis — Eastern Softwoods

Given Data: Species: EASTERN SOFTWOODS **Grade:** Select Structural **Load:** Snow Load (C_D)
Section: 2×6 nominal **M.C.:** 15% ($C_t = C_i = 1.0$) **End Cond:** Pinned ($K_e = 1.0$)
Lengths: Strong Axis (L_1) = 14 FT Weak Axis (L_2) = 4.67 FT (1/3 point bracing)

Part 1: Reference Design Values

Q1 Tabulated Allowable Compressive Stress (F_c)

Formula: Lookup in NDS Table 4A

1. **Action:** Open **NDS Table 4A** (Reference Design Values).
2. **Locate:** Row for "Eastern Softwoods", Grade "Select Structural".
3. **Extract:** Value from F_c column (Parallel): **1200** PSI

Final F_c: 1200 PSI

Q2 Tabulated Min. Modulus of Elasticity (E_{min})

Formula: Lookup in NDS Table 4A

1. **Action:** In the same row as above, move to the E_{min} column.
2. **Extract:** Value for E_{min}: **440,000** PSI

Final E_{min}: 440,000 PSI

Part 2: Adjustment Factors

Q3 Load Duration Factor (C_D)

Formula: Lookup in NDS Table 2.3.2

1. **Identify:** Load Type is **"Snow".**
2. **Action:** Find factor in **Table 2.3.2**: **1.15**

Final C_D: 1.15

Q4 Size Factor (C_F)

Formula: Lookup in NDS Table 4A Adjustment Factors

1. **Identify:** Nominal Width (d_1) = **6** inches.
2. **Action:** Refer to "Adjustment Factors" (Size Factor) in Table 4A.
3. **Extract:** Factor for F_c (Dimension Lumber): **1.1**

Final C_F: 1.1

Q5 Factored Allow. Modulus of Elasticity (E'_{min})

$$E'_{min} = E_{min} \cdot C_M \cdot C_t \cdot C_T \cdot C_i$$

1. **Determine:** C_M (M.C. 15%): **1.0** C_t (Temp): **1.0**
2. **Calculate:** E_{min} **440,000** $\times$ C_M **1.0** $\times$ C_t **1.0**

Final E'_{min}: 440,000 PSI

Part 3: Slenderness

Q6 Strong Axis ($x-x$) Slenderness (l_{e1}/d_1)

$$\text{Ratio} = \frac{L_1 \times 12}{d_1}$$

1. **Convert:** $L_1 = 14$ ft $\times 12 =$ **168** inches.
2. **Identify:** Actual Depth d_1: **5.5** inches.
3. **Divide:** Length **168** / Depth **5.5**

Ratio: 30.55

Q7 Weak Axis ($y-y$) Slenderness (l_{e2}/d_2)

$$\text{Ratio} = \frac{L_2 \times 12}{d_2}$$

1. **Convert:** $L_2 = 4.67$ ft $\times 12 =$ **56** inches.
2. **Identify:** Actual Width d_2: **1.5** inches.
3. **Divide:** Length **56** / Width **1.5**

Ratio: 37.33

Q8 Controlling Slenderness Ratio (l_e/d)

Formula: Max(Ratio x-x, Ratio y-y)

1. **Compare:** Look at Q6 and Q7.
2. **Select:** The larger (critical) value: **37.33**

Final l_e/d: 37.33

Part 4: Column Stability

Q9 Critical Buckling Design Value (F_{cE})

$$F_{cE} = \frac{0.822 \cdot E'_{min}}{(l_e/d)^2}$$

1. **Step A:** Denominator $(l_e/d)^2 = (\mathbf{37.33})^2 = \mathbf{1393.5}$
2. **Step B:** Numerator $0.822 \times E'_{min}$ **(440,000) = 361,680**
3. **Calculate:** Step B / Step A

Final F_{cE}: 259.5 PSI

Q10 Reference Compression Design Value (F_c^*)

$$F_c^* = F_c \cdot C_D \cdot C_F \cdot C_M \cdot C_t$$

1. **Instructions:** Multiply Tabulated stress by adjustment factors (except C_P).
2. **Input:** F_c **1200** $\times C_D$ **1.15** $\times C_F$ **1.1**

Final F_c^*: 1518 PSI

Q11 Constant for Sawn Lumber (c)

Formula: NDS Standard Constant

1. **Rule:** Standard interaction constant for visually graded lumber.

Value c: 0.8

Q12 Column Stability Factor (C_P)

$$C_P = \frac{1 + (F_{cE}/F_c^*)}{2c} - \sqrt{\left[\frac{1 + (F_{cE}/F_c^*)}{2c}\right]^2 - \frac{F_{cE}/F_c^*}{c}}$$

1. **Ratio X:** $F_{cE}/F_c^* =$ **259.5** / **1518** = **0.1709**
2. **Term A:** $(1+X)/2c =$ **0.7318**
3. **Term B:** $X/c =$ **0.2136**
4. **Solve:** $C_P = A - \sqrt{A^2 - B} =$ **0.7318** - **0.5674**

Final C_P: 0.164

Part 5: Capacity

Q13 Factored Allow. Compressive Stress (F'_c)

$$F'_c = F_c^* \cdot C_P$$

1. **Formula:** F_c^* (Ref Value) $\times$ C_P (Stability Factor).
2. **Input:** **1518** $\times$ **0.1644**

Final F'_c: 249.6 PSI

Q14 Column Area (A)

$$A = b \times d$$

1. **Formula:** Actual Width (d_2) $\times$ Actual Depth (d_1).
2. **Input:** **1.5** $\times$ **5.5**

Final Area: 8.25 IN^2

Q15 Maximum Allowable Axial Load (P_{max})

$$P_{max} = F'_c \cdot A$$

1. **Formula:** Allowable Stress (F'_c) $\times$ Area (A).
2. **Input:** **249.6** $\times$ **8.25**

Final P_{max}: 2,059 LBS