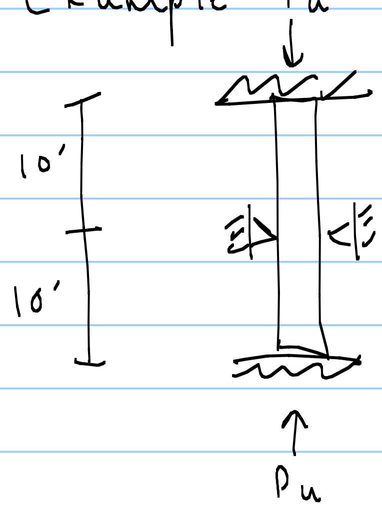
Note Title 3/13/2007

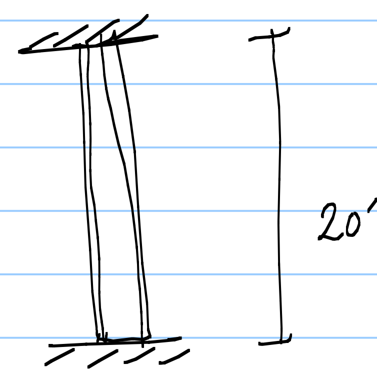
Homework due 3/15 (Th)

Homework due 3/20 (Tues) → Steel Column Design 6.6 and 6.10

Midterm ~~due~~ 3/22 (Th)

Example: P_u





Weak Direction | Strong Direction

Compared $\frac{KL}{r}$ for x and y

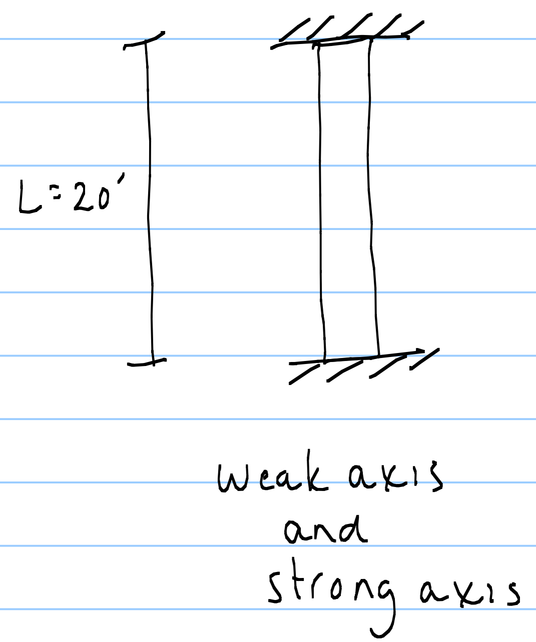
$\left(\frac{KL}{r}\right)_x = 29.5$

$\left(\frac{KL}{r}\right)_y = 31.8$ ← weak axis controls

$\boxed{\phi P_n = 612 \text{ kips}}$

$\phi P_n = 0.85 F_{cr} A_g$

- Column Strength w/out bracing



$K = 0.65$

$r_{min} = r_y = 3.02''$

$$\lambda_{c(y)} = \frac{KL}{r\pi}\sqrt{\frac{F_y}{E}} = \frac{(0.65)(20')(12)}{(3.02)\pi}\sqrt{\frac{36}{29000}}$$

$\lambda_{c(y)} = 0.579 < 1.5 \therefore$ inelastic buckling

$$F_{cr} = \left(0.658^{\lambda_c^2}\right) F_y = 0.658^{0.579^2}(36\text{ ksi})$$

$F_{cr} = 31.3$ ksi

$$\phi P_n = \phi F_{cr} A_g = 0.85(31.3)(21.1) = 561 \text{ kips}$$

Increased strength from bracing: $\frac{612}{561} = 1.09 \Rightarrow$ 9% increase

Strong Axis Capacity: $\lambda_c = \frac{29.5}{\pi}\sqrt{\frac{36}{29000}} = 0.331$

$F_{cr} = 34.4$

$\phi P_n = 617$ kips

Column Design (Steel)

- Find F_{cr} and A_g that gives $\phi F_{cr} A_g > P_u$
- By hand
- With design charts

By Hand

- Trial and error
- Hints for "typical columns" = 10 - 15 ft in length, $P_u < 750$ kips

typical columns $40 < \frac{KL}{r} < 60$ → $.90 F_y \geq F_{cr} \geq 0.75 F_y$

$\frac{KL}{r}$ (< 80) → $F_{cr} = 0.60 F_y$

- Procedure:
  - Use $F_{cr} = 0.75 F_y$ as starting estimate
  - Solve for required area: $A_g \geq \frac{P_u}{\phi F_{cr}}$

- Choose member based on area
- Check trial section → iterate → repeat as necessary

Recommendation for columns : $\frac{KL}{r} < 200$

Design Example 1 (6.1)

Lightest W14 section to support axial compression of:
$P_D = 160$ k and $P_L = 140$ kips

$KL = 15'$ (x and y)
Grade 50 steel

1. Factored Load: $1.2(160) + 1.6(140) = \boxed{416 \text{ kips}}$

$1.4(160) = 224$ kips

2. Estimate F_{cr}: $F_{cr} = 0.75 F_y = 0.75(50) = 37.5$ ksi

3. Estimate A_g: $A_g \geq \frac{P_u}{\phi F_{cr}} = \frac{416}{(0.85)(37.5)} = 13.05 \text{ in}^2$

4. Choose trial section: W14x48 $A_g = 14.1 \text{ in}^2$ $r_y = 1.91$ in

5. Check W14x48

$$\frac{KL}{r} = \frac{(15)(12)}{1.91} = 94.24$$

$$\lambda_c = \frac{KL/r}{\pi}\sqrt{\frac{F_y}{E}} = \frac{94.24}{\pi}\sqrt{\frac{50}{29000}} = 1.24 < 1.5$$

$$F_{cr} = \left(0.658^{\lambda_c^2}\right) F_y = \left(0.658^{1.24^2}\right)(50) = 0.522\,(50) =$$

$F_{cr} = 26.1$ ksi

$$\phi P_n = 0.85\,(26.1 \text{ ksi})(14.1 \text{ in}^2) = 312.8 \text{ kips} < 416 \text{ kips} \times$$

6. Check W14x53 $A_g = 15.6 \text{ in}^2$ $r_y = 1.92$ in

$$\frac{KL}{r} = 93.75$$

$$\lambda_c = 1.239$$

$$F_{cr} = 26.3 \text{ ksi}$$

$\phi P_n = 349 \text{ kips} < 416 \text{ kips}$ ✗

7. Check W14x61 $A_g = 17.9 \text{ in}^2$ $r_y = 2.45 \text{ in}$

$\frac{KL}{r} = 73.5$

$\lambda_c = 0.971$

$F_{cr} = \left(0.658^{0.971^2}\right) 50 = (0.674)(50) = 33.7 \text{ ksi}$

$\phi P_n = 513 \text{ kips} > 416 \text{ kips}$ ✓

8. Select section : **W14x61**

Design Charts

- Table 4-2
- Gives ϕP_n for weak axis buckling (r_y)
- Need to use conversion for strong axis buckling
- Gives capacity for typical column sections (W10, W12, W14)
- Example 1 - using column design charts

  $KL = 15'$ (weak axis buckling)
  $P_u = 416$ kips
  Want W14 section
  Grade 50
  → Use W14x61.

Compare w/ lightest W12 : W12 × 53

" " " W10 : W10 × 49 ← overall lightest