Structural Steel Design

Material Properties

NAME: ____________________

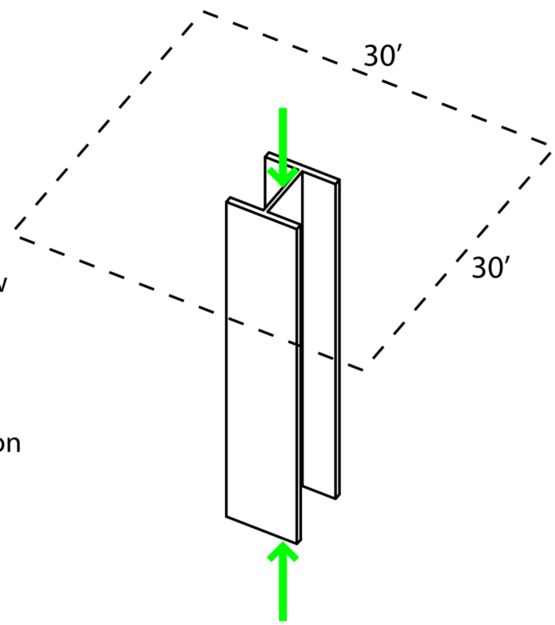
Using ASTM A36 steel, $F_y = 36$ ksi and $E = 29.6 \times 10^3$ ksi.

Using ASTM A992 steel, $F_y = 50$ ksi and $E = 29.6 \times 10^3$ ksi.

$$F = \frac{P}{A} \qquad \varepsilon = \frac{\Delta L}{L} \qquad E = \frac{F}{\varepsilon}$$

SOLVE THE FOLLOWING SCENARIOS...

1 Tributary area for column = 900 sq ft
DEAD LOAD = 30 psf
LIVE LOAD = 50 psf
PARTITION LOAD = 20 psf
Using ASTM A36 Steel.



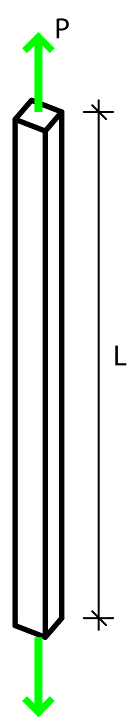
Using a W12x65 with a total length of 20 ft, how much does the column shorten under load (in inches)? Assume buckling is not a factor.

HINT: Find the cross sectional area for the section in the AISC steel section properties table.

HINT: It's a small number.

Repeat the same for a W14x99.

2 What minimum cross sectional area for a steel bar is required so that the internal stresses present to not exceed the yield stress given the following conditions? How much does each bar elongate?



(a) P = 100,000 lb, L = 100 ft, A992 steel
(b) P = 240,000 lb, L = 85 ft, A36 steel
(c) P = 300,000 lb, L = 50 ft, A992 steel
(d) P = 150,000 lb, L = 120 ft, A36 steel

3 What cross sectional area is required to limit the elongation of a 100 ft long steel cable made of A992 steel to 1.5″ if it is under 100 kips of load?

SOLUTIONS

1 Calculate the total load psf:
Dead + Live + Partition = 50 psf + 30 psf + 20 psf = 100 psf

Total axial load = 100 psf x 900 sf = 90,000 lb = 90 k. Call this value P.

From the AISC table, a W12x65 has a cross-sectional area of $A = 19.1\ in^2$

Calculate the stress inside the column.

STEP 1

$$F = \frac{P}{A} = \frac{90\ k}{19.1\ in^2} = 4.71\ ksi$$

Calculate the strain inside the column using the definition of modulus of elasticity.

STEP 2

$$E = \frac{F}{\varepsilon} \qquad \varepsilon = \frac{F}{E} = \frac{4.71\ ksi}{29{,}600\ ksi} = 0.000159$$

Using the definition of strain, calculate the value of ΔL.
Note that L = 20 ft = 240 inches

STEP 3

$$\varepsilon = \frac{\Delta L}{L} \qquad \Delta L = \varepsilon L = 0.000159\ (240\ in) = 0.0382\ in\ (shorter)$$

In order to repeat this for a W14x99, we simply need to look for the value of A (cross-sectional area) in the AISC table, then repeat the steps above.

From the AISC table, a W12x65 has a cross-sectional area of $A = 29.1\ in^2$

After repeating the steps above with this new value, we get ΔL = 0.0251 inches shorter.

2 For each scenario, the first step is to use the definition of stress to calculate A, given the yield stress for the grade of steel.

For part (a), $F_{yield} = 50ksi$.

$$F = \frac{P}{A} \qquad A = \frac{P}{F} = \frac{100\ k}{50\ ksi} = 2\ in^2$$

Since we have the stress (50 ksi, given!), we can repeat Steps 2-3 in Problem #1 to calculate ΔL. With L = 100 ft = 1200 inches, we get ΔL = 2.03 inches longer. Repeat the same for parts b, c, d, being careful to keep track of the proper yield stress value.

Part (b), $A = 6.7\ in^2$, ΔL = 1.24 in (longer)
Part (c), $A = 6.0\ in^2$, ΔL = 1.01 in (longer)
Part (d), $A = 4.2\ in^2$, ΔL = 1.75 in (longer)

3 This problem asks us to consider deformation limitations on a cable element. Given the length of the cable (100 ft = 1200 in) and the ΔL = 1.5 in limitation, we can start by solving for the strain in the cable under those conditions.

$$\varepsilon = \frac{\Delta L}{L} = \frac{1.5\text{ in}}{1200\text{ in}} = 0.00125$$

After calculating strain, we can use the definition of modulus of elasticity (assuming the cable is in the elastic zone) to calculate the stress inside the cable.

$$E = \frac{F}{\varepsilon} \qquad F = E\varepsilon = (29{,}600\text{ ksi})(0.00125) = 37\text{ ksi}$$

The stress is less than the yield stress for A992 steel (50 ksi), so we can continue with our elastic calculations. The next step is to solve for the appropriate cross-sectional area using the load given and this value of stress.

$$F = \frac{P}{A} \qquad A = \frac{P}{F} = \frac{100\text{ k}}{37\text{ ksi}} = 2.7\text{ in}^2$$