Structural Steel Design

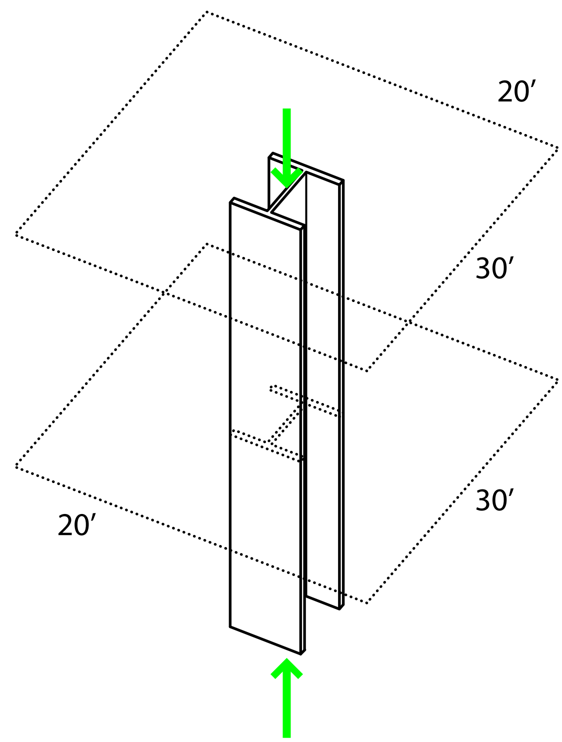
Quizzam Module 2 : Materials

1 A 30-foot long column with a W10x49 cross section supports the tributary area of two floors, each with an area of 600 sq ft. Each story has a floor-to-floor height of 15 ft.

Tributary area for column = 600 sq ft
DEAD LOAD = 80 psf
LIVE LOAD = 100 psf
PARTITION LOAD = 20 psf
Using ASTM A36 Steel.

How much does the column shorten under load (in inches)? Assume buckling is not a factor, and ignore the self-weight of the column.

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



ΔL = ________

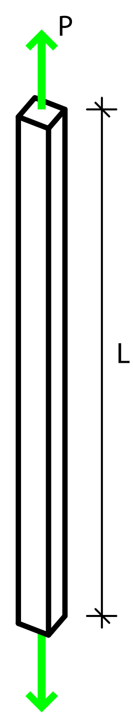
2 What minimum cross sectional area for a steel bar is required so that the internal stresses present to not exceed the yield stress given the following conditions? How much does each bar elongate?

(a) P = 150 k, L = 90 ft, A992 steel

A = ________ ΔL = ________

(b) P = 360 k, L = 100 ft, A36 steel

A = ________ ΔL = ________



3 What cross sectional area is required to limit the elongation of a 90 ft long steel cable made of A992 steel to 1.1″ if it is under 175 kips of load? Remember to check the actual stress against the yield stress.

A = ________

SOLUTIONS

1 Floor area, single floor = 600 sq ft
U = 80 psf + 100 psf + 20 psf
(U is the design load. Ignore any load factors this time.)

Each floor's load = P = 600 sq ft * 200 psf = 120,000 lb = 120 k
We have two floors supported by one column. The top half of the column supports the top floor only. The bottom half of the column supports both floors (think about your load tracing).

Length of half column in inches = L = 15' * 12 = 180 in

From the chart, for a W10x49, A = 14.4 sq in.

Definition of stress: F = P / A.
Definition of modulus of elasticity: E = F / ε
Definition of strain: ε = ΔL / L

Stress in upper half = P / A = 120 k / 14.4 in= 8.33 ksi
Strain in upper half = ε = F / E = 8.33ksi / 29,600 ksi = 0.00028142
ΔL in upper half = ε * L = 0.00028142 * 180 in = 0.0507 in

The lower half supports two floors.
Stress in lower half = 2*P / A = 240 k / 14.4 in = 16.7 ksi
Strain in lower half = ε = F / E = 16.7ksi / 29,600 ksi = 0.00056318
ΔL in lower half = ε * L = 0.00056318 * 180 in = 0.10137 in

Total ΔL = 0.0507 in + 0.10137 in = **0.152 in**

2 These are straightforward calculations from the definitions of stress, strain, and modulus of elasticity.
(a) Given: P = 150 k, L = 90 ft = 1080 in, A992 steel
A = P / F = 150 k / 50ksi = **5 sq in**
ε = F / E = 50 ksi / 29,600 ksi = 0.001689
ΔL = εL = 0.001689 * 1080 in = **1.824 in**

(b) Given: P = 360 k, L = 100 ft = 1200 in, A36 steel
A = P / F = 360 k / 36 ksi = **10 sq in**
ε = F / E = 36 ksi / 29600 ksi = 0.001216
ΔL = εL = 0.001216 * 1200 in = **1.459 in**

3 This is also a straightforward calculation from definitions. However, we don't use the yield stresses for the material... Given ΔL = 1.1", P = 175 k, A992 steel (E = 29,600 ksi, Fy = 50 ksi)

strain = ε = ΔL / L = 1.1" / 1080" = 0.0010185

actual stress = F = εE = 0.0010185 * 29,600 ksi = 30.148 ksi
Check to see if the actual stress is less than the yield stress. 30.148 ksi < 50 ksi, ***OK***.

Use the *actual stress* to calculate the cross sectional area.
A = P / F = 175 k / 30.148 ksi = **5.8 sq in**