Basic Steel Tube Example:
Modeling and Analysis of Columns

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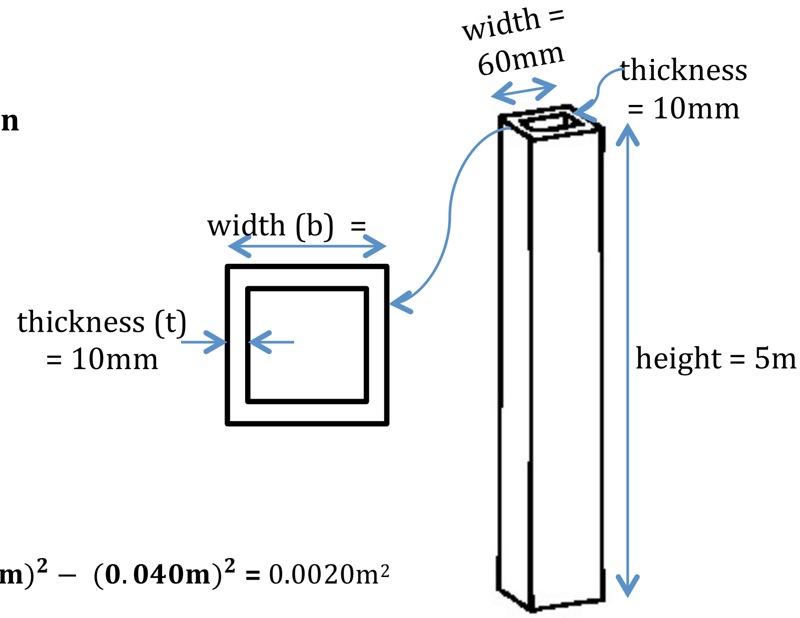
Let's start with a basic column made out of steel with a hollow tube as the cross-section. The column is 5m tall (this is a fairly tall column, maybe for use in or a two-story atrium). It has an outside width of 60mm and walls that are 10mm thick. The cross-section is shown here:

My goal is to determine whether this column is able to support a total load of 200kN.



The cross-sectional properties of this square, hollow column are as follows:

A = cross-sectional area = $b^2 - (b-2t)^2 = (\mathbf{0.060m})^2 - (\mathbf{0.040m})^2 = 0.0020\text{m}^2$

$$I = \text{moment of inertia} = \frac{b^4}{12} - \frac{(b-2t)^4}{4} = 8.67\text{x}10^{-7}\text{m}^4$$

Let's start with compression. The compressive stress at the base of the column may be calculated as the total force divided by the cross-sectional area as follows:

$$\sigma_{column} = 200\text{kN}/0.0020\text{m}^2 = 100{,}000\text{kN/m}^2$$

We can look up the allowable stress for steel, which is 250,000kN/m^2:

$$\sigma_{allowable,\ steel} = 250{,}000\ \text{kN/m}^2$$

The actual stress, σ_{column}, is less than the allowable stress, $\sigma_{allowable}$, so this column can support the 200kN load without yielding, or failing in compression.

Now let's check buckling. I'll need the moment of inertia as calculated above, the length of the column, which is 5m, and the modulus of elasticity of steel, which I can look up and is 200x10^6 kN/m^2. Then the buckling load for this column may be calculated as follows:

$$P_{cr,steel\ column} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2(200x10^6 kN/m^2)(8.67\text{x}10^{-7}m^4)}{(5m)^2} = \mathbf{68\ kN}$$

The applied load (200kN) is greater than the buckling load (68kN) thus this column will fail by buckling. To support 200kN we'll need to re-design the column.