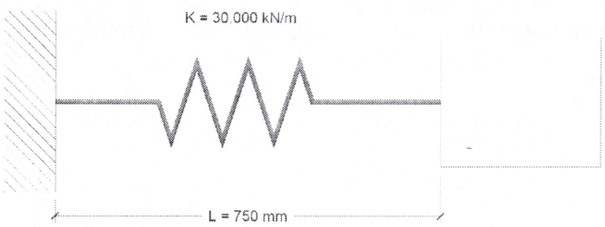
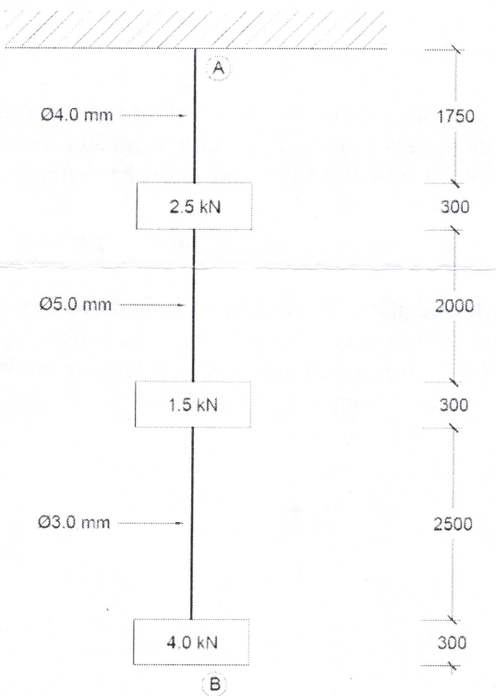
CIV102F Problem Set # 2 - September 19 and 20, 2019

1. In class, we learned that using Hooke's law and the definitions of stress and strain, we can derive the spring constant "K" for a system by adjusting the choice of material and geometry. For the spring shown below, calculate the required cross-sectional area and hence volume of material required to obtain the desired value of K for each of the three materials suggested below. Identify which material should be used to obtain the (i) cheapest, (ii) lightest, (iii) strongest and (iv) toughest equivalent springs.

a. Low Alloy Steel
b. Aluminum Alloy
c. Carbon Fibre



2. The undeformed lengths of the system of cables and blocks are given below. What is the total length of AB including the deformation due to the load? Assume that the blocks are rigid and that the cables are weightless. The Young's Modulus of the cables is 200,000 MPa. Calculate the total energy stored in the three cables. Note that all measurements provided are in mm unless otherwise noted and ⌀ denotes a diameter measurement (i.e. ⌀4.0 mm = 4.0 mm diameter).



3. The longest bridge span in the world is the main span of the Akashi Kaikyo bridge in Japan completed in 1998. The central span of this suspension bridge is 1991 metres long (a half hour walk). Assuming that the loading per unit length of bridge is the same as the Golden Gate bridge, design the main cables of this bridge. The drape of the main cables between the towers and the centre of the bridge is 201.2 metres. The two main cables which support the deck are to be made of a collection of small wires 5.23 mm in diameter with a rupture stress of 1770 MPa. Calculate the number of wires needed in each cable if the maximum allowable stress is 708 MPa (i.e. a factor of safety of 2.50).

Reminder: Please report all final answers using slide-rule precision (ie, four significant figures if the first digit is a "1", three otherwise). Submit your completed assignment on engineering computation paper and write only on the non-grid side. Staple all pages together.

4a. Consider the following block of concrete shown in Figure 1a which is rigidly attached to a thick wall on its left side only. The block is pulled with an axial force P which causes tensile stresses to the develop in the member. At the same time, the ambient temperature increases by $\Delta T = +15°C$.

i. Calculate the stress in the concrete, σ_P and the strain, ε_σ, caused by the force P.
ii. Calculate the stress in the concrete, σ_{th}, and the strain, ε_{th}, caused by the increase in temperature, ΔT. Recall that the thermal strains can be calculated as $\varepsilon_{th} = \alpha \Delta T$.
iii. What is the total change in length, Δl, and corresponding total strain $\varepsilon_{total} = \Delta l / l_o$?

4b. Now consider the block of concrete shown in Fig. 1b which is rigidly attached to thick walls on both sides which prevent it from changing length. Explain why the member develops stresses if the temperature is lowered, even though there is no applied load. Calculate how much colder it needs to get to cause the block to fail.

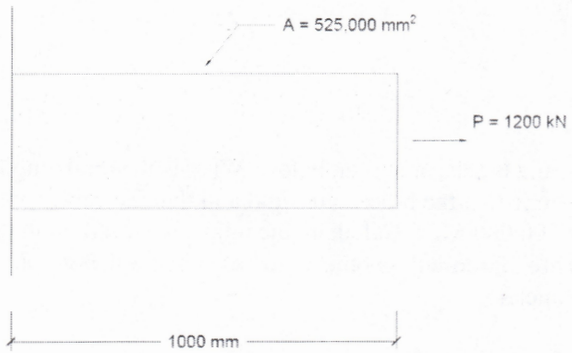


Fig. 1a – Unrestrained member for 4a

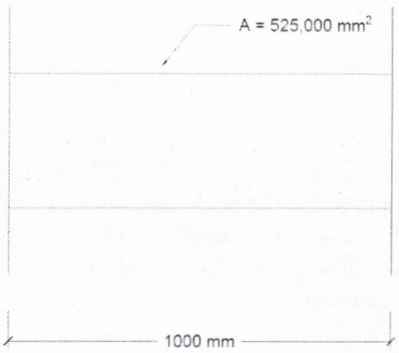
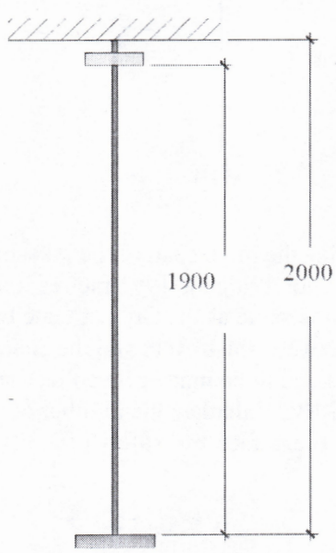


Fig. 1b – Restrained member for 4b

5. The following 2000 m long steel wire is attached to a ceiling and has a rigid catch-plate securely attached to the other end. The diameter of the wire is 6 mm. Neglect the self-weight of the wire and the flange. The wire has a yield stress of $\sigma_y = 400$ MPa, and strain-hardening effects may be neglected.

a. Draw the stress-strain plot for this material, labelling key parameters including the yield stress σ_y and yield strain ε_y.
b. Calculate the energy which can be absorbed by the wire before yielding occurs in joules.
c. If a 5 kg weight is dropped from a height of 1900 mm above the catch-plate, calculate the maximum extension of the wire caused by the weight landing on the catch-plate.
d. Suppose the weight is removed from the system after being dropped in part c. What is the final length of the wire?



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