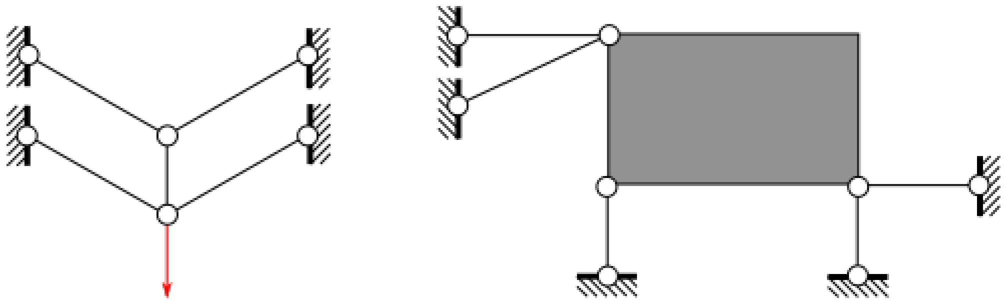
Tension

1. Determine the static and kinematic indeterminacy of the structures in Fig. below. (Assume the vertical symmetry in the structure on the left).



Answ.: a) s1, k2, b) s2, k3

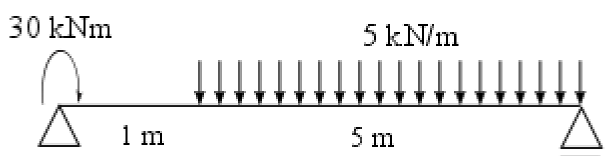
2. An initial strain of a prestressed steel bar was $\varepsilon = 0.003$. Determine the strain in concrete after the bonding and releasing the steel bar, if $\frac{A_s}{A_c} = 0.05$, $\frac{E_s}{E_c} = 7.5$.

Answ.: $8.18 \cdot 10^{-4}$

3. Define the BVP for tension and derive its solution.

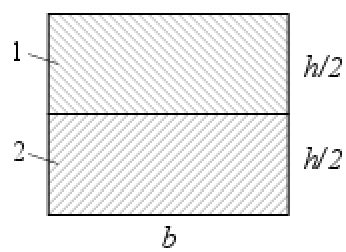
Bending

4. Choose an appropriate profile for the beam in Fig. below, if $R = 220$ MPa.



Answ.: INP200.

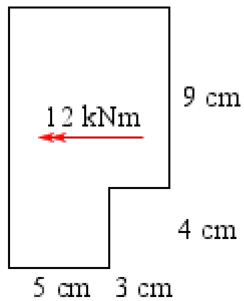
5. Specify the conditions of symmetry needed for plane cross-sections of a loaded bar.
6. A cross-section is composed of two rectangular parts $b \times \frac{h}{2}$, each made from a different material. Determine the normal stress distribution generated by the hogging bending moment M, if $E_1 = 2E_2$.



Answ.: $\sigma_x(0.417h) = 7.27$, $\sigma_x(-0.0833h) = -1.45$, and -0.72, $\sigma_x(-0.5833h) = -5.09$, $\left[\times\left(\frac{M}{bh^3}\right)\right]$

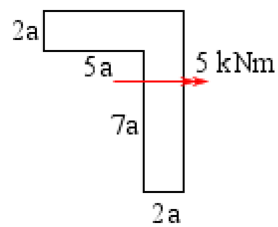
Biaxial bending

7. Determine the maximum value of the normal stress.



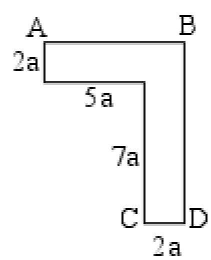
Answ.: 118.0 MPa

8. Determine the parameter a of the angle cross-section, if $R_c = 18$ MPa, $R_t = 30$ MPa.



Answ.: $a = 2.2$ cm.

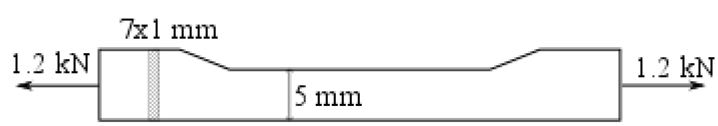
9. Determine σ_D if $\sigma_A = 15$ MPa, $\sigma_B = -10$ MPa, and $\sigma_C = 7$MPa.



Answ.: $\sigma_x = -0.1429$ MPa

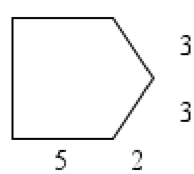
Composed bending

10. Find the maximum value of the normal stress in the steel flat bar.



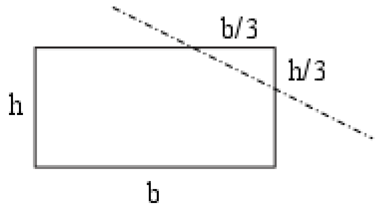
Answ.:459.4 MPa

11. Demonstrate that the neutral axis position doesn't depend on a value of an eccentric force.
12. Sketch the cross-section core and determine the point of the core outline which lies beyond the principal axes.



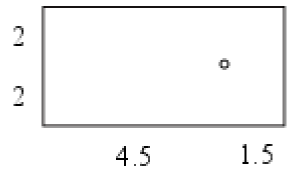
Answ.: (0.4616, -0.7971)

13. Given the neutral axis, find the point of an eccentric force application.



Answ.: $\left(\frac{h}{8}, -\frac{b}{8}\right)$ (coord. set turned by 90 deg.)

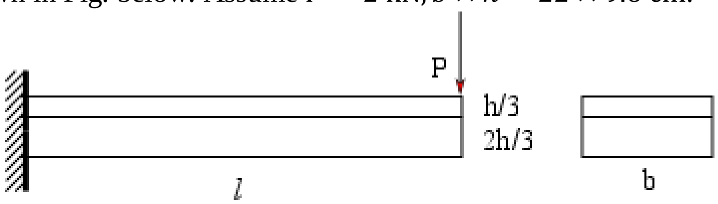
14. A rectangular cross-section in the Fig. below, (the dimensions in cm), is loaded on the longer symmetry axis by an eccentric force $P = 12$ kN. Determine the extreme value of the normal stress if the material works in compression only.



Answ.: 13.33 MPa

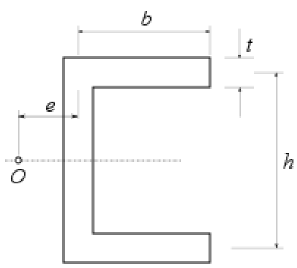
Transverse bending

15. Give the reasons why the cross-sections of transverse bent beam cannot be plane?
16. Derive the formula for mean shear stresses.
17. Determine a shear flow (a horizontal shear force per running meter between the beam parts) in a cantilever beam shown in Fig. below. Assume $P = 2$ kN, $b \times h = 22 \times 9.6$ cm.



Answ.: 27.78 kN/m

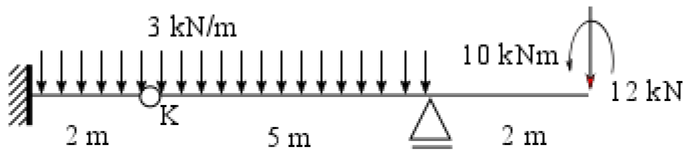
18. Determine the shear center O of a channel section of uniform thickness (Fig. below), knowing that $b = 100$ mm, $h = 150$ mm and $t = 4$ mm.



Answ.: 40 mm

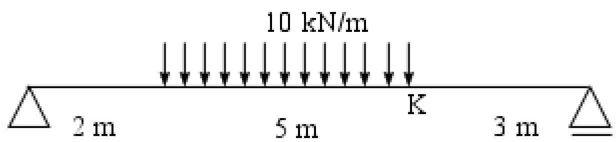
Deflections

19. Derive the relationship between the curvature and bending moment of the beam.
20. Find a deflection at point K using the Mohr method.



Answ.: $w_K = 18.53/EI$

21. Find a deflection at point K of the beam using the Macauley method.



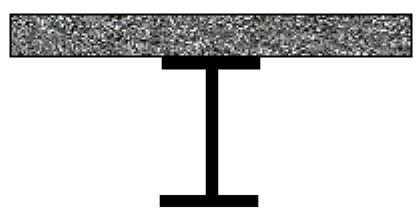
Answ.: $w_K = \frac{725.3}{EI}$

Torsion

22. Compare $\tau_{\max}$ in the ring D/d and the cut ring (an open profile) of the same geometry and torque.

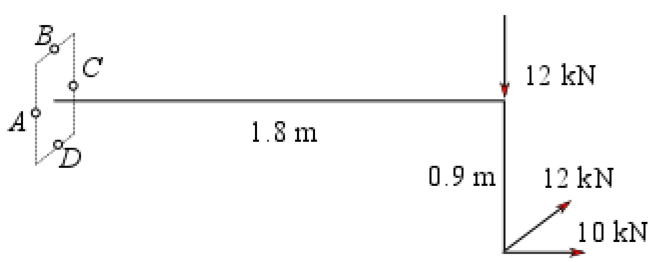
Answ.: $\frac{\tau_{\max}^{(\text{ring})}}{\tau_{\max}^{(\text{rect})}} = \frac{16D}{\pi(D^4-d^4)} \frac{\pi(D+d)(D-d)^2}{24} = \frac{2}{3} \frac{D(D+d)(D-d)^2}{(D^4-d^4)}$

23. Describe the way out of the torsion of a composite cross-section (the steel I-beam with a concrete plate).



Exertion

24. In the frame with a rectangular cross-section, find the substitute stress σ_{HMH} (σ_{CTG}) at point A (B, C, or D) on the fixed end (rectangle $b \times h = 0.2 \times 0.3$ m).



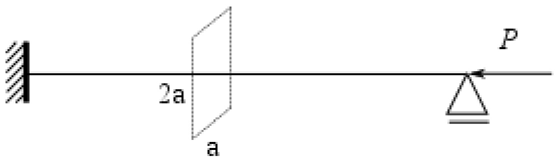
Answ.: $\sigma_{HMH}^{A} = 13.17$ MPa

25. Can be the stresses $\sigma = -5$ MPa and $\tau = 20$ MPa safe if $R_c = 40$ MPa and $R_t = 4$ MPa? Use the (linearized and conservative) Mohr's definition of exertion.

Answ.: slightly exceeds

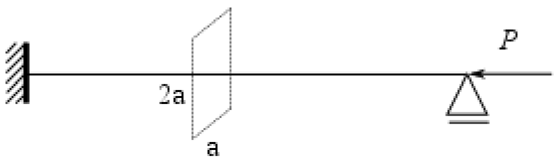
Stability

26. Design the parameter a of the column. Assume $l = 3$ m, $P = 100$ kN, $E = 205$ GPa, $R_H = 160$ MPa, $n = 2.3$.



Answ.: 0.04162 m (range linear elastic)

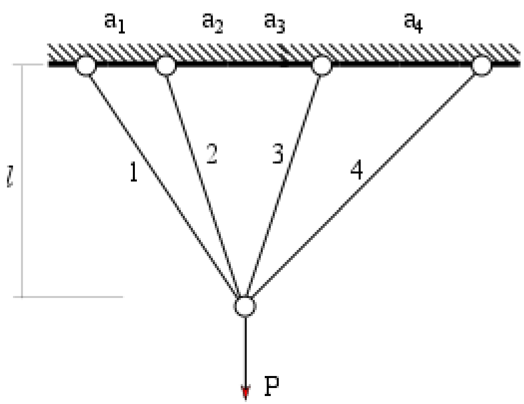
27. Determine P_{acc} using the Gordon-Rankine formula, a = 5 cm, l = 2.5 m, E = 205 GPa, R_e =250 MPa, n = 2.2.



Answ.: $P_{acc} = 202$ kN

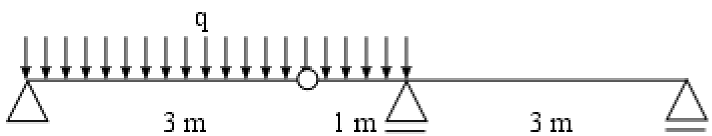
Plasticity

28. Determine limit plastic bearing capacity of the bar structure, a_1= 0.2 m, a_2 = 0.15 m, a_3 = 0.2 m, a_4 = 0.15 m, A_1= 2 cm^2, A_2 = 1.5 cm^2, A_3 = 2 cm^2, A_4 = 1.5 cm^2, l = 1 m, R_e = 420 MPa.



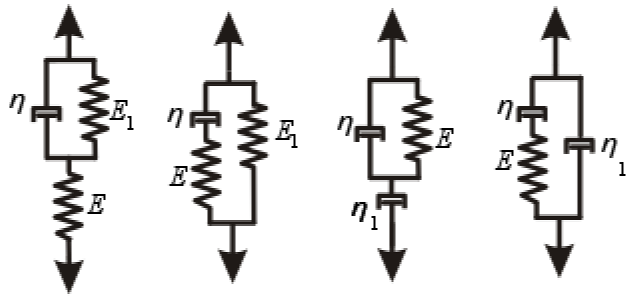
Answ.: $\bar{\bar{P}} = 283$ kN

29. Determine limit plastic capacity of the beam in the Fig. below.



Answ.: $\bar{\bar{q}} = \frac{\bar{\bar{M}}}{2}$

30. Derive the rheology equation of state for the given standard model in Fig. below. Sketch the strain response for loading-unloading impulse.



Answ.: for model VK-H ($E_2, \eta - E_1$): $\eta\dot{\sigma} + (E_1 + E_2)\sigma = E_1\eta\dot{\varepsilon} + E_1E_2\varepsilon$
(instantaneous elasticity, limited creep, elastic return, full recovery)