CIV-E4040 Reinforced Concrete Structures

Examination 24.2.2021 (remote examination using My Course)

A precondition for the participation in the examination is the fulfilment of compulsory parts of the course in the spring 2021 or earlier.

Question 1

This question is to be answered using the online option of the assignment within the period given

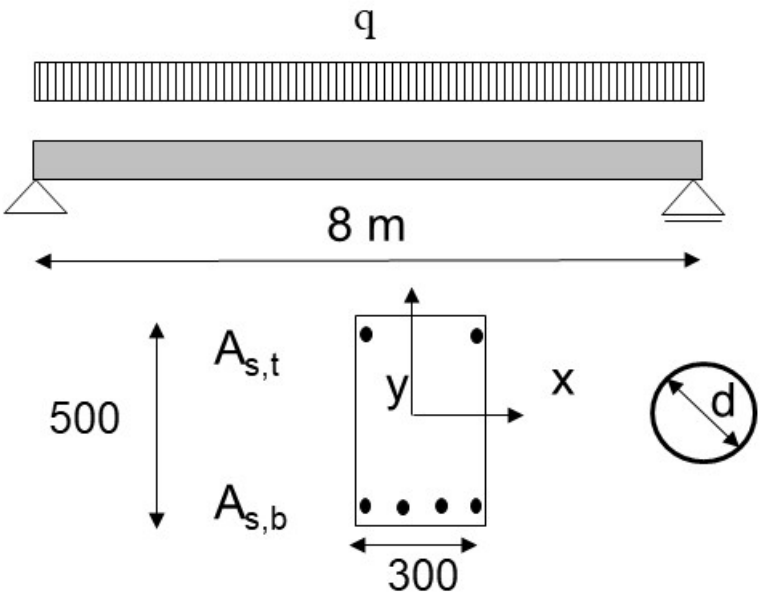
1. Answer the following questions. (**altogether 10p**)

a) What is meant by a closed stirrup (**1p**). Why shall column stirrups be closed (**1p**). Give an example of a beam where unclosed stirrups can be used (**1p**)

b) Why are stirrups for torque usually perpendicular to the beam axis (**1p**), but inclined stirrups can also be used in beams (**1p**).

c) What is meant by ductile behaviour in terms of reinforced concrete beams **(1p)** and how can the ductile behavior be achieved (**1p**)?

d) The figure below represents an existing beam with a rectangular section. In terms of the load bearing capacity, discuss possibilities to make a horizontal circular hole through the beam during a building renovation project. The hole axis is penpendicular to the beam axis. Also specify the optimal locations for the hole and the places where the hole should be avoided. What is your preliminary idea of the maximum diameter d of the hole at its optimal location? (**3p**)



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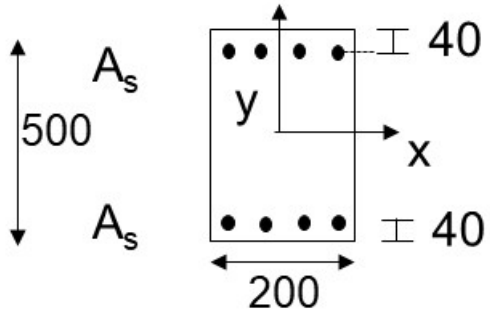
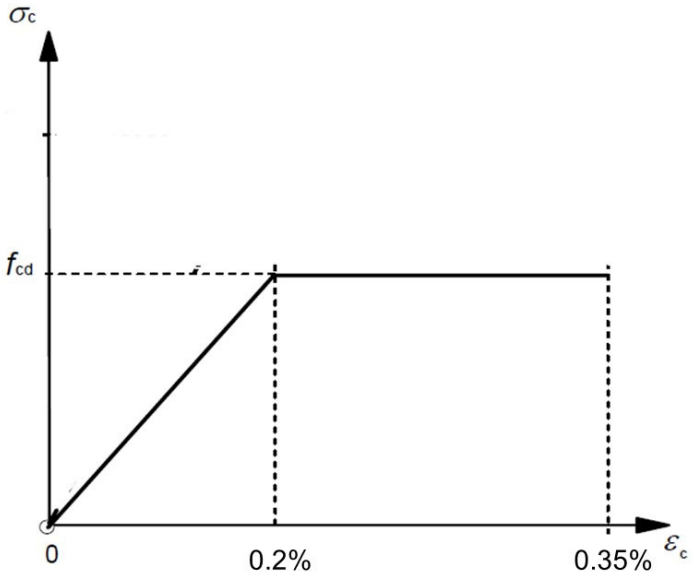
2. The figures below represent a column section and the material model of concrete for designing the section. Using the given material model, determine the maximum moment in the situation when the whole section is under compression. The moment rotates about the x-axis in the figure. The diameter of steel bars is 20 mm, design compressive strength of concrete 14.3 N/mm^2, design strength of steel 435 N/mm^2, and the elastic modulus of steel is 200000 MPa. (N.B. the both steel layers should be considered in the calculation) (**6 p**)





Bi-linear stress-strain relation.

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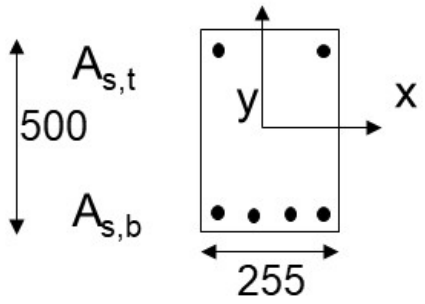
3. The figure below represents a reinforced concrete section loaded by a bending moment that creates tension at the botton fibres of the section. The tensile strength of concrete is 2 MPa. (**altogether 8p**)

   a) considering the both steel layers, define the cracking moment of the section (**4p)**

   b) define the location of the neural axis (**2p**) and strain distribution (**2p**) for the cracked section using the cracking moment determined in the item a. In the calculation the both steel layers should be considered.



- concrete cover 30 mm
- $A_{s,t}$: 402.12 mm^2 (diameter 16 mm)
- $A_{s,b}$: 1963.50 mm^2 (diameter 25 mm)
- diameter of stirrups: 8 mm
- E_s: 200000 MPa
- E_c: 33000 MPa
- ε_{cu}: 0.35%
- f_{cd}: 17 MPa
- f_{yd}: 434.78 Mpa
- f_{yk}:500 MPa