CIV-E4040 Reinforced Concrete Structures

Examination 15.2.2017

A precondition for the participation in the examination is the fulfillment of compulsory parts of the course during the course in the spring 2017.

Mark clearly on your answering paper:
- course code, course name and date of examination
- your name, student number and signature
- the year you enrolled on the course and made its obligatory parts

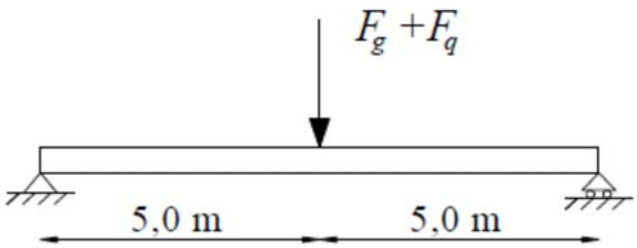
Remember to validate your answers. Illustrate your answers with cross-section or plane drawings if needed. If literature is allowed in the examination, it will be given at the beginning of the examination.

A part of the questions are on the reverse side of the paper

1. Answer the following questions. (**altogether 10 cr**)
   a) Why is transverse reinforcement usually required for lapped splices of longitudinal bars? (2p)
   b) Why are the stirrups against torque perpendicular to the beam axis? (2p)
   c) Explain the main mechanisms of the reinforced beam to resist vertical loading. Explain also why the the vertical loading may produce inclined cracking. (2p)
   $$\boldsymbol{Q = \frac{dM}{dx} = \frac{d}{dx}(F_s z) = z\frac{dF_s}{dx} + F_s\frac{dz}{dx}}$$
   d) Explain the concepts of the balanced failure and the tension-controlled failure of a cross-section under pure bending. (2p)
   e) Explain the reasons for requiring the use of stirrups also in compressed structures such as columns. (2p)

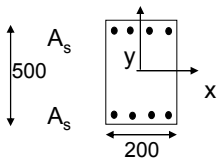
2. The reinforced concrete beam below has a cross-section $b \times h = 280 \times 480$ mm^2. The shear reinforcement is made of stirrups with a diameter of ϕ 8 mm. Concrete cover is 30 mm. The grades of concrete and steel are C25/30 and A 500 HW, respectively. The partial safety coefficients are for the materails $\gamma_c = 1.5$ and $\gamma_s = 1.1$ and for the dead load 1.15 and live load 1.5. The characteristic strengths of concrete and steel are 21.25 MPa and 500 MPa, respectively. The maximum value for the compression of the concrete is 0.35 %.

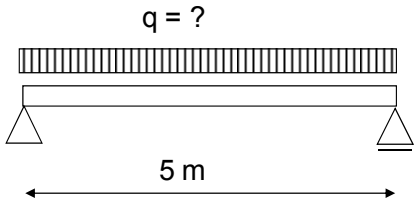
   The dead weight including the mass of the beam is $F_g = 20$ kN. Based on the bending capacity of the beam how large can the live load F_q be if the strain of the tensile reinforcement is about 0.5 % at the moment of assumed failure. (**6 p**)



3. The figure below represents a simply supported beam of reinforced concrete bearing an evenly distributed line-load q. How much can the beam bear the line-load without cracking? It can be assumed that the line-load also includes the dead load of the beam. The

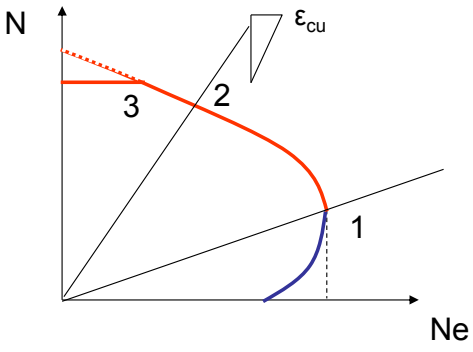
concrete and steel have the moduli of elasticity 33541 MPa and 200000 MPa, respectively. The moment reinforment is produced by the steel bars both at the upper and lower surfaces. In the figure the area A_s is 1256 mm^2. The tension capacity of the concrete is 2.53 MPa. Concrete cover is 20 mm. In the task the characteristic values of materials and loads shall be used. **(4 p)**

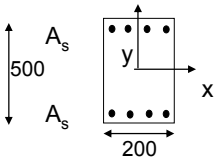




4. The figures below represent a column section and its interaction diagram for the uniaxial bending. Assuming uniaxial bending around a shorter side calculate the design values of normal force and bending moment at the point 2 of the interaction diagram. The bar diameter is 16 mm and its concrete cover is 30 mm.

   Concrete and steel are made of grades C25/30 and A 500 HW, respectively. The partial safety coefficients of the materials are $\gamma_c = 1.5$ and $\gamma_s = 1.1$. The characteric strengths of concrete and steel are 21.25 MPa and 500 MPa, respectively. The modulus of elasticity of steel is 200000 MPa. **(4 p)**





A simplified material model can be used for the concrete