Student Number: ________________ Name: ____________________________

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING
FINAL EXAMINATIONS, DECEMBER 2019

CIV102H1F – Structures and Materials-
An Introduction to Engineering Design

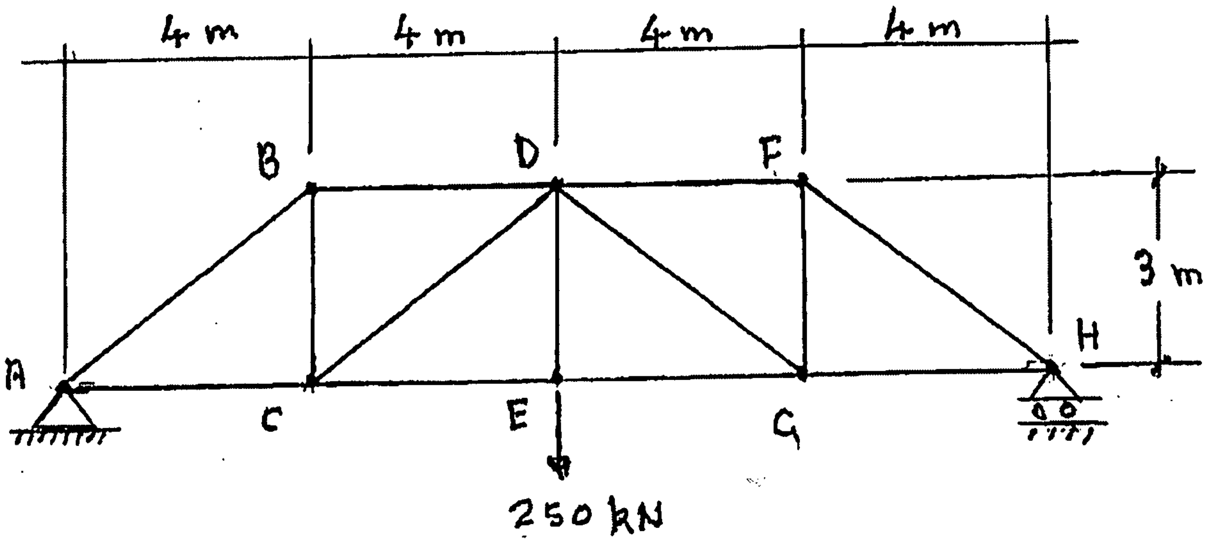
Examiner --- M.P. Collins

Permissible Aids: Notebook, calculator and set-square.

1	
2	
3	
4	
Total	

1. The steel truss shown below supports a point load of 250 kN and spans 16 m.

10 mks (a) Calculate the axial force in each member of the truss due to the 250 kN load applied at joint E. List your results in the table on page 2. Use the convention +ve for tension and –ve for compression.



6 mks (b) All members of the truss are HSS 127 x 127 x 6.4, made from steel with a yield stress of 350 MPa. Are the truss members safe under the 250 kN load at E? At what value of the load at joint E will the truss be on the boundary between safe and unsafe?

10 mks (c) Calculate the downwards deflection of joint C due to the 250 kN load applied at joint E. Use the method of virtual work. Fill in the table on page 2.

6 mks (d) The 250 kN load is to be applied to joint C rather than joint E. Calculate the downwards deflection of joint E due to the 250 kN load applied at joint C. Hint: Think before calculating.

Member	P (kN)	ε (mm/m)	L (m)	Δ (mm)	P* (kN)	Work (J)
BD DF						
AB CD DG FH						
BC DE FG						
AC CE EG GH						

2. To make a demonstration a professor has bought 6 nearly identical, high quality, white pine sticks. Each stick has a rectangular cross-section 30 mm wide and 5 mm thick and is 1.830 m long. The defect free white pine has a flexural failure stress of 60 MPa and a modulus of elasticity of 9380 MPa. He glues 3 of the sticks together to make a beam 30 mm wide and 15 mm thick. As shown below this beam is simply supported over a span of 1800 mm and loaded with a 30 N weight at the third point of the span. Ignore the small self weight of the beam.

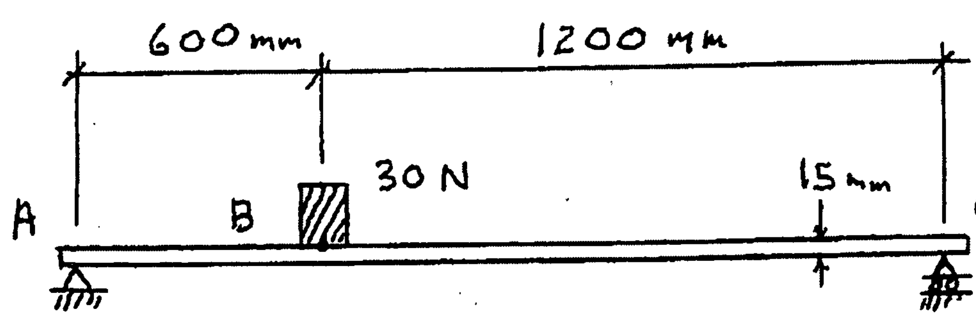
8 mks (a) Draw the shear force and the bending moment diagrams. Calculate the maximum tensile stress in the wood and the maximum shear stress in the glue.

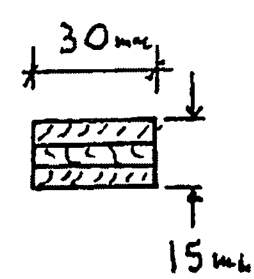
4 mks (b) By determining the tangential deviation of point C from a tangent drawn at A find the angle of rotation of the beam at support A.

4 mks (c) By determining the tangential deviation of point B from a tangent drawn at A find the deflection of point B.

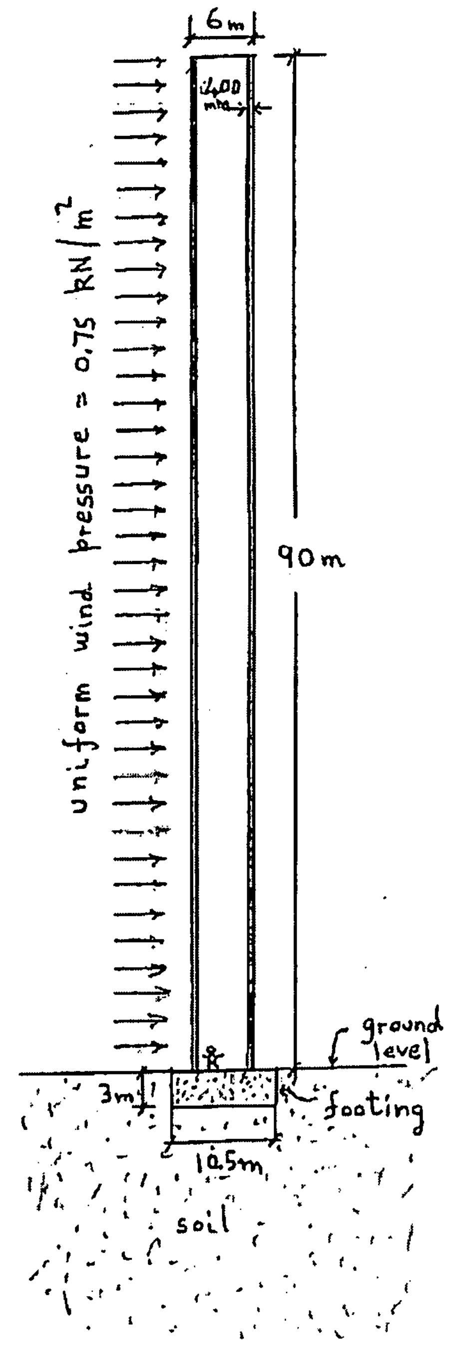
3 mks (d) Estimate the natural frequency of the beam when it is supporting the 30 N weight.

6 mks (e) For the second beam the professor uses the 3 remaining sticks to make an apparently identical beam except in this case the 3 sticks are not glued together. What will be the deflection under the load at point B and what will be the natural frequency for this beam.





3. Shown below is the preliminary design for a 90 m high circular concrete tower which you plan to erect in the Toronto area. The tower consists of a hollow circular tube with an external diameter of 6.0 m and a wall thickness of 400 mm. The tower sits on a solid circular concrete footing with a diameter of 10.5 m and a depth of 3.0 m.



(a) What will be the uniform compressive stress in the concrete of the tower at ground level caused by the self weight of the tower? (3 marks)

3 mks

(b) What will be the uniform compressive stress applied to the soil by the footing caused by the self weight of the tower and the footing? (3 marks)

3 mks

(c) During a severe wind storm the concrete tower is subjected to a uniform wind pressure of 0.75 kN/m^2 applied to the 6.0 m wide by 90 m high frontal area of the tower. Calculate the stresses in the concrete at the base of the tower on the windward side and on the leeward side due to the combined effect of the self weight of the tower and of the wind. Also calculate the compressive stresses applied by the base of the footing to the soil on the windward side and the leeward side of the footing due to the combined effect of self weight and wind. (8 marks)

8 mks

(d) If the top of the footing is assumed to remain horizontal, what will be the deflection of the top of the concrete tower caused by the wind?

6 mks

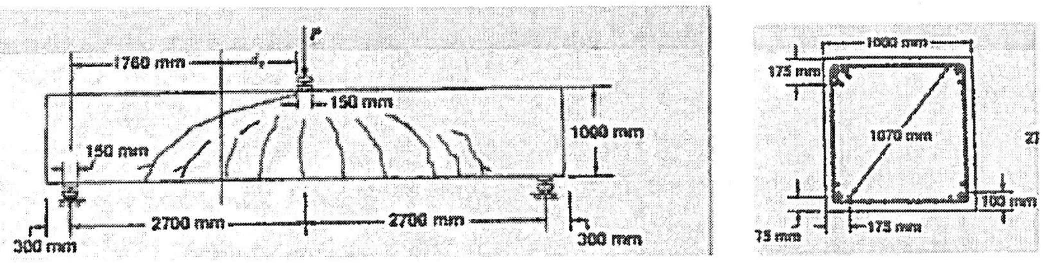
(e) The relationship between the stress applied to the soil by the footing and the amount the soil deforms downwards is called the "modulus of subgrade reaction" which for the proposed tower equals 6000 $kN/m^2/m$. That is if the footing applies 60 kN/m^2 the soil will go down 10 mm. Using the stresses calculated in 4(c) calculate the tilt of the footing caused by the wind and from this determine the additional horizontal deflection that will be caused at the top of the tower by this tilt.

5 mks

(f) Recalculate the stresses in the concrete at the base of the tower allowing for the moment there that will be caused by the weight of the tower when it leans.

5 mks

4. The large concrete beam shown below was loaded to failure under the Baldwin testing machine by a point load applied at midspan. The longitudinal reinforcement consisted of twenty 30M bars with a yield strength of 550 MPa, with five bars in each of the four corners. For simplicity the top longitudinal bars can be ignored and the effective depth of the bottom longitudinal bars can be taken as 925 nm. The transverse reinforcement enclosing the longitudinal bars consisted of 10M bars with a yield strength of 508 MPa spaced at 375 mm along the length of the beam. The concrete strength at the time of testing was 41 MPa.



(a) Use the procedure for Design for Moment on page 173 of the notebook to determine the highest value of moment which can be safely resisted by the beam. Neglecting the self-weight of the beam what is the highest value of P which can be applied without exceeding the safe moment.

8 mks

(b) Use the procedure for Design for Shear on page 173 of the notebook to determine the highest value of shear which can be **safely** resisted by the beam. Neglecting the self-weight of the beam what is the highest value of P which can be applied without exceeding the safe shear.

6
mks

(c) The simplified procedures for moment and shear design of reinforced concrete incorporate safety factors by reducing the concrete contributions by a factor of 0.50 (corresponding to a factor of safety of 2.0) and steel contributions by a factor of 0.6 (corresponding to a factor of safety of 1.67). Use your calculations from 4(a) and 4(b) and the above information on factors of safety to predict the Baldwin load which caused failure of the beam and did the beam fail in flexure or shear?

10
mks