Student Number: _____ Name: _____

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING
FINAL EXAMINATIONS, DECEMBER 2018

1	
2	
3	
4	
Total	

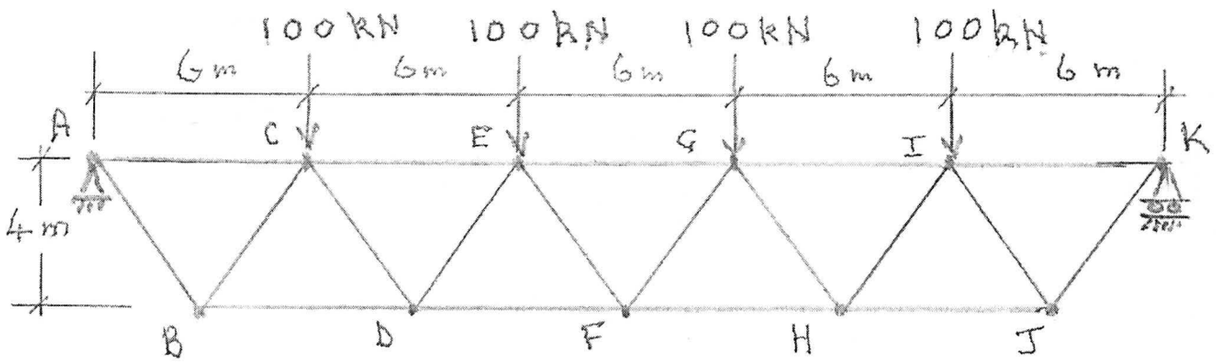
CIV102H1F – Structures and Materials-
An Introduction to Engineering Design

Examiner --- M.P.Collins

Permissible Aids: Notebook, calculator and set-square.

1. The truss shown below supports a pedestrian bridge and is made from steel hollow structural sections with a yield stress of 350 MPa. The truss spans 30 m and when the bridge is crowded with people supports the four 100 kN loads shown.

1(a). Calculate the axial force in each member of the truss due to the 100 kN loads. Neatly write your calculated forces above the appropriate members in the drawing. Use the convention +ve for tension and –ve for compression. (10 marks)



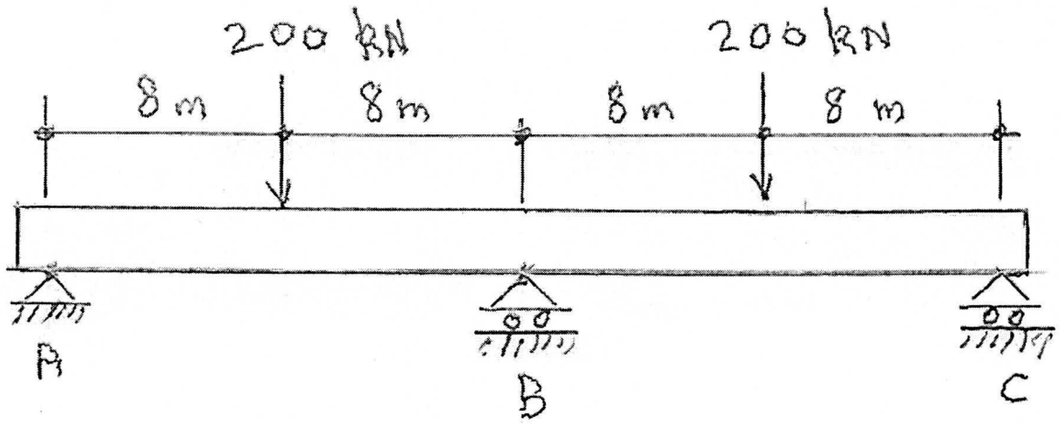
1(b). The five top members of the truss are HSS 203x203x6.4, the four bottom members are HSS 152x152x4.8 while the ten diagonal members are HSS 127x127x8.0. Is the truss safe under the 100kN loads? Yes or no? At what value of the loads will the truss be on the boundary between safe and unsafe? (6 marks)

1(c). Using the method of virtual work calculate the vertical deflection of joint E due to the application of the 80 kN loads. Fill in the table below. Note that the table lists the members for only one half of the truss. (10 marks)

Member	P (kN)	ε (mm/m)	L (m)	Δ (mm)	P* (kN)	Work (J)
AC			6			
CE			6			
EG			3			
BD			6			
DF			6			
AB			5			
BC			5			
CD			5			
DE			5			
EF			5			

1(d). Calculate the natural frequency of the bridge when crowded with people and comment on the stiffness of the bridge. (4 marks)

2. A steel W760 x 257 I beam is continuous over two 16 m spans and supports two 200 kN point loads as shown in the figure below.



2(a) If the support at point B is removed, calculate the downwards deflection of point B due to the two 200 kN point loads. (10 marks)

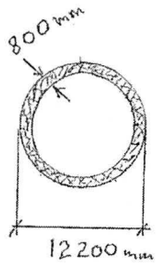
2(b) How far up would point B move if an upwards force of 1 kN was applied at point B? (5 marks)

2(c) Calculate how much of the 400 kN applied load will be carried by support B and draw the shear force and bending diagrams for beam ABC. (10 marks)

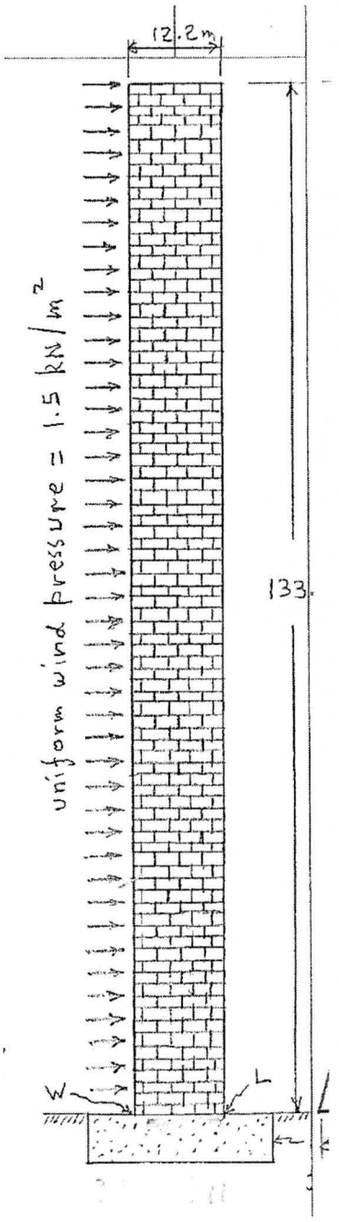
2(d) If the yield stress of the steel is 350 MPa is the beam safe under the given loading? (5 marks)

3. In 1860 the then tallest brick chimney in the world was constructed near Glasgow for Tennant and Company who made chlorine bleach. Shown below is a preliminary design for this 133 m high chimney. It is a hollow, circular tube with an external diameter of 12.2 m and a wall thickness of 800 mm.

3(a) What will be the uniform compressive stress in the bricks at the base of the chimney caused by the self-weight of the bricks? (4 marks)



3(b) During a severe wind storm the chimney is subjected to a uniform wind pressure of 1.5 kN/m^2 applied to the 12.2 m wide by 133 m high frontal area of the chimney. What will be the magnitude of the bending moment at the base of the chimney caused by this wind? (4 marks)

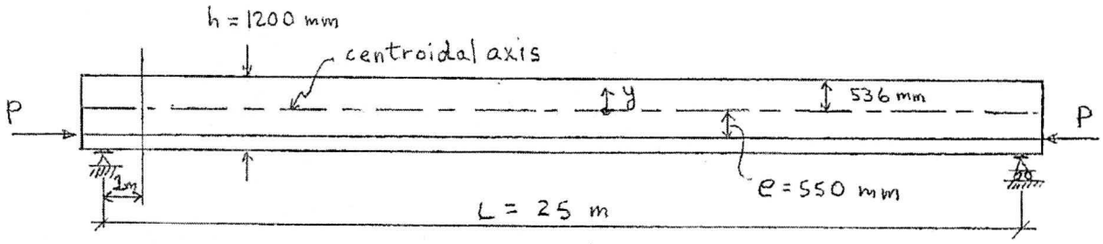


3(c) Calculate the vertical stresses in the bricks on the windward side, W, and the leeward side, L, at the base of the chimney due to the combined effect of the self-weight of the bricks and the moment due to the wind storm. (6 marks)

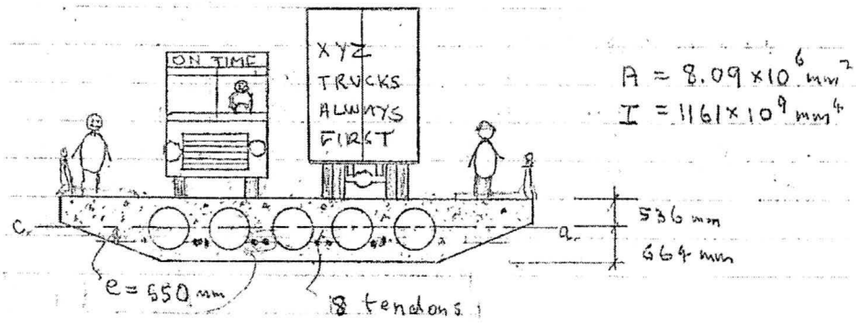
3(d) If the large concrete footing which supports the chimney is assumed to be fixed against rotation, what will be the horizontal deflection at the top of the chimney caused by the wind storm? (6 marks)

3. (e) Suggest how the design of the 133 m high chimney can be improved so that fewer bricks are used and higher wind pressures can be resisted. (6 marks)

4. The cross-section of a prestressed concrete voided slab bridge is shown in the figure below which also gives the location of the centroidal axis, the cross-sectional area of the beam and the value of I. The simply supported bridge spans 25 m, has a self-weight of 194 kN/m and must carry a live load of 50 kN/m. The initial design for the prestressing is to provide 8 straight tendons with a constant eccentricity of 550 mm which will prestress the concrete with a total compressive force, P, of 24640 kN.



elevation of bridge



cross-section of voided slab

4(a) For the section at mid-span calculate the concrete stress at on the bottom face due to the combined effect of the prestress, the self-weight of the bridge and the live load on the bridge. (7 marks)

4(b) For the section 1 m out from the center of the support calculate the concrete stress on the top face when there is no live load on the bridge. (7 marks)

4. (c) The main purpose of prestressing is to prevent tensile stresses in the concrete at service loads so that cracking of the concrete at this load level can be avoided. Suggest how the current design of the prestressing can be improved to achieve this objective. (9 marks).