[ESS020]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

HNC CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

STRUCTURAL DESIGN AND FURTHER MATHEMATICS

MODULE NO: CIE4006

Date: Wednesday 22nd May 2019 **Time: 2:00pm – 4:00pm**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer ANY THREE questions. Marks for each question are shown.

Sketches should be neat and drawn to scale.

All answers are to be written in the answer book or on the additional paper and graph paper provided. Pre-prepared material will not be accepted.

Candidates should bring unmarked tables of steel design, extract from EC3, and concrete design to the examination.

Total 75 marks for the paper.

School of Engineering
HNC Civil Engineering
Semester Two Examination 2018/2019
Structural Design and Further Mathematics
Module No. CIE4006

Question 1: Steel Beam Design

Figure Q1 shows a simply supported steel beam with a point load.
The top flange of the beam is fully restrained against lateral torsional buckling.
The loading data are shown in Figure Q1, all loads are UNFACTORED.
Size of the steel beam is UKB 457x191x89 with steel grade S275.

a) What is the classification of the beam section in bending? **(5 marks)**

b) Check the steel beam to satisfy the following design criteria:

i. Bending strength **(5 marks)**
ii. Shear strength **(5 marks)**
iii. Web-shear buckling **(3 marks)**

c) Calculate the deflection of the beam at mid-span under total UNFACTORED load.
Is the deflection satisfactory? **(7 marks)**
Assume admissible deflection to be *L*/360.
The deflection of the beam at mid-span is given by:

$$\delta = \frac{FL^3}{48EI}$$ Where *E = 210 kN/mm²*

Total 25 marks

Design bending moment is $M_{Ed} = \frac{PL}{4}$

Design shear force is $V_{Ed} = \frac{P}{2}$

Where *P* is the total FACTORED load ($P = 1.35G_k + 1.5Q_k$) in kN

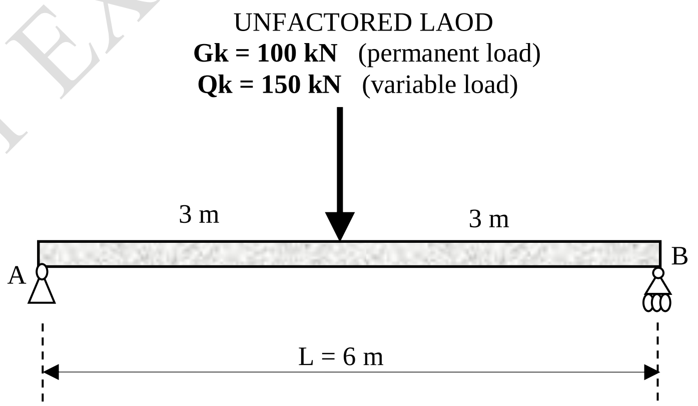

Figure Q1

Question 2: Steel Column Base Plate

a) State three factors that affect the thickness of column base plates. **(2 marks)**

b) Figure Q2 shows a column base plate supporting an internal steel column with a size of: 254 × 254 × 73 UKC in S275 steel.

The design value of axial compressive load is N_{Ed} = 1253 kN.

Design of compressive strength of foundation concrete is f_{cd} = 16 N/mm^2.
Assume the column base plate is with steel grade S275.

<u>Column details</u>

Height of section h = 254.1 mm
Breadth of section b= 254.6 mm
Thickness of flange t_f = 14.2 mm
Thickness of web t_w = 8.6 mm
Cross sectional Area A= 93.1 cm^2
Section perimeter = 1490 mm

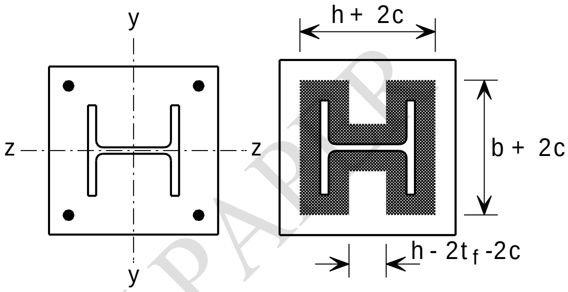

Figure Q2

i. Use the effective area method to calculate the minimum thickness of the column base plate to resist the design axial compressive load. **(15 marks)**

ii. What is the minimum size (*WidthxDepth*) of the column base plate? **(3 marks)**

iii. Draw to a suitable scale, the cross-section of the base plate showing part of the column and the holding down bolts. **(5 marks)**

Total 25 marks

<u>*Effective Area Method:*</u>

Effective area ≈ $4c^2$ + *(Column section perimeter)* × c + *Column section area*

Where c is the cantilever outstand of the effective area, as shown in Figure Q2.

Effective area = N_{Ed}/f_{cd}

($Ac^2 + Bc + C = 0$) *where* *A =4, B = Column perimeter*
C = (Column section area – Effective area)

The value of c can be obtained by solving the above quadratic equation:

$$c = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$ With no overlap: h – 2t$_f$ – 2c > 0

The minimum thickness of base plate (t_p) is given by: $$t_p \geq \frac{c}{\sqrt{f_{yp}/3f_{cd}}}$$

f_{cd} is the design compressive strength of concrete
f_{yp} is the yield strength of the base plate

PLEASE TURN THE PAGE…..

School of Engineering
HNC Civil Engineering
Semester Two Examination 2018/2019
Structural Design and Further Mathematics
Module No. CIE4006

Question 3: Concrete Design

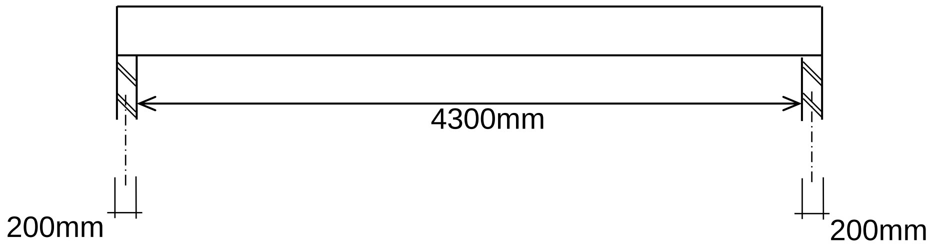

Figure Q3

Figure Q3 shows a one-way spanning in-situ reinforced concrete slab, in an office building, with a clear span of 4300mm. The slab is supported on walls 200 thick, and is to be in C30/37 concrete with 35mm cover to all bars. The overall thickness of the slab is 225mm.

<u>Further information:</u>

Unfactored variable action	4.5 kN/m^2
Unfactored permanent action	Self-weight of slab plus 3.2 kN/m^2 allowance for fixed partition walls, ceiling and services
Main bars	H12

a) Show how the ultimate load on the slab amounts to 18.66 kN/m^2 and calculate the bending reinforcement required at mid-span. State the minimum reinforcement required. Without doing any further calculations (or changing the calculated rebar), comment on the spacing of the rebar.

(13 marks)

b) Show that the slab does not require shear reinforcement

(4 marks)

c) Draw a neat sketch sectional elevation of the slab at one support, showing the main bars, curtailment, the distribution reinforcement and relevant dimensions

(4 marks)

d) Calculate the mass of carbon (CO2e) for 1m width (measurement perpendicular to the page) of the above slab given that:
WRAP rate for waste reinforced concrete is 4%,
Unit weight of reinforced concrete is 2500 kg/m^3
Reinforcement in one way spanning slab is 75 kg/m^3 of concrete
The embodied carbon for steel and concrete are 1.40 kg eCO2/kg and 0.126 kg eCO2/kg, respectively.

(4 marks)

Total 25 marks

School of Engineering
HNC Civil Engineering
Semester Two Examination 2018/2019
Structural Design and Further Mathematics
Module No. CIE4006

PLEASE TURN THE PAGE…..

Question 4: Concrete Column Design

Figures Q4 (a) and (b) show a reinforced concrete column supporting the first floor and roof of an office building. The column is supported on a base that is designed to resist moments. The plan dimensions of the column are 400mm x 500mm, and it is to be in C30/37 concrete with 35mm cover to all bars. Both of the beams framing into the column are 600mm deep. The beam widths are 400mm and 600mm and align with the plan dimensions of the column as shown in Figure Q4(b). The thickness of the slab supported by the beams is 280mm. Floor to floor height is 3800mm.

In your calculations, assume that longitudinal bars are H25 and ties are H8. In your final design, you may use different bars. It is necessary to design the column for bending and axial loads.

At ultimate limit state (ULS), the column supports an axial load of 1800 kN and framing action applies a factored bending moment of 350 kNm in the direction of the 500 mm dimension (Column's strong axis). You may ignore the nominal moments in the weak axis of the column.

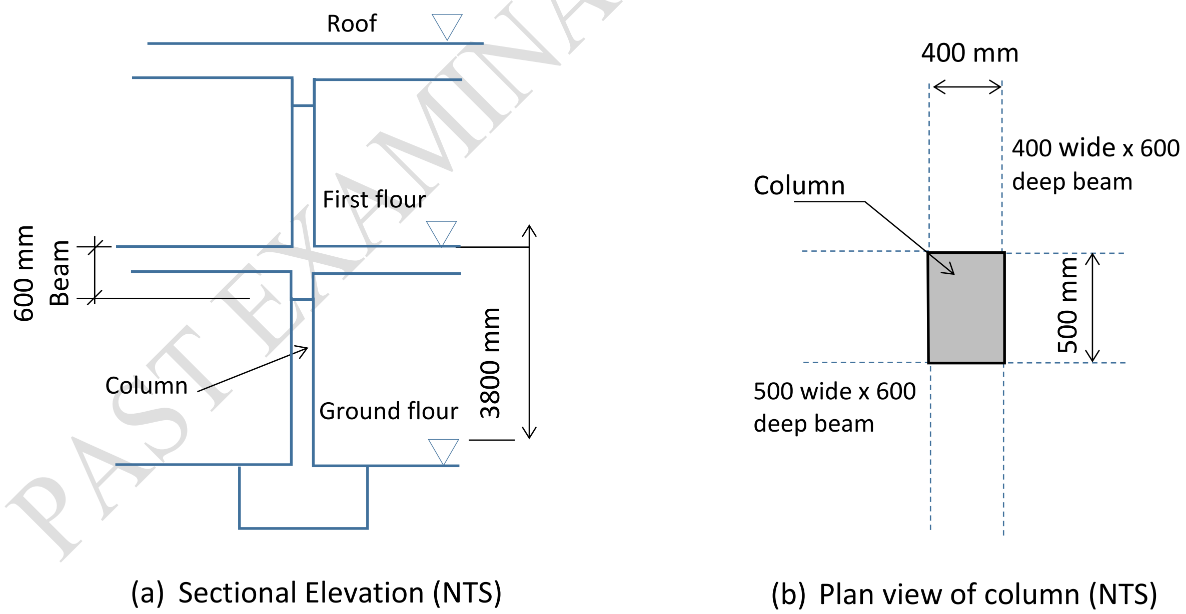

Figure Q4

Q4 continued on next page …

PLEASE TURN THE PAGE…..

Q4 continued…

Answer the following questions:

a) Show that the column is stocky and calculate the design bending moment applied to the column.

(7 marks)

b) State which column design chart(s) should be used to design the reinforcement in the column and justify your choice.

(5 marks)

c) Calculate the amount of longitudinal reinforcement and ties required for the column to support its design loads.

(8 marks)

d) Draw an annotated transverse section through the column at around mid-height showing longitudinal reinforcement and ties (use a scale of 1:10)

(5 marks)

Total 25 marks

END OF PAPER