[ENG28]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) CIVIL ENGINEERING

2023/2024 SEMESTER 2 EXAM

STRUCTURAL ANALYSIS & CONCEPTUAL DESIGN

MODULE NO: CIE4023

Date: Friday 17th May 2024 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES:

There are THREE Questions.

Answer ALL questions.
Marks for each question are shown.

Sketches should be drawn neat.

Answer books are provided.

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

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

Total 100 marks for the paper.

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Question 1: Concrete one-way slab design

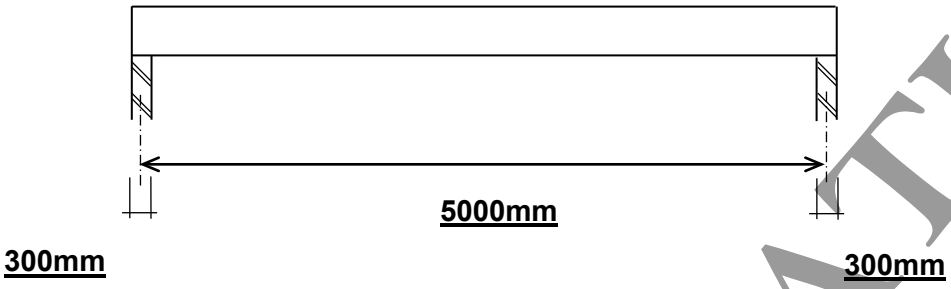

Figure Q1

Figure Q1 shows a one-way spanning in-situ reinforced concrete slab, in an office building, with a clear span of 4700 mm. The slab is supported on walls 300 thick and is to be in C25/30 concrete with 25mm cover to all bars. The overall thickness of the slab is 250mm.

Further information:

Unfactored variable action 6.0 kN/m^2

Unfactored permanent action Self-weight of slab plus 5.0 kN/m^2 allowance for fixed partition walls, ceiling and services

Main bars H16

a) Calculate the bending reinforcement required at mid-span (13 marks)

b) Find the minimum and the maximum reinforcement required (12 marks)

c) Produce a cross-section of the slab showing the position of steel reinforcements (5 marks)

Total 30 marks

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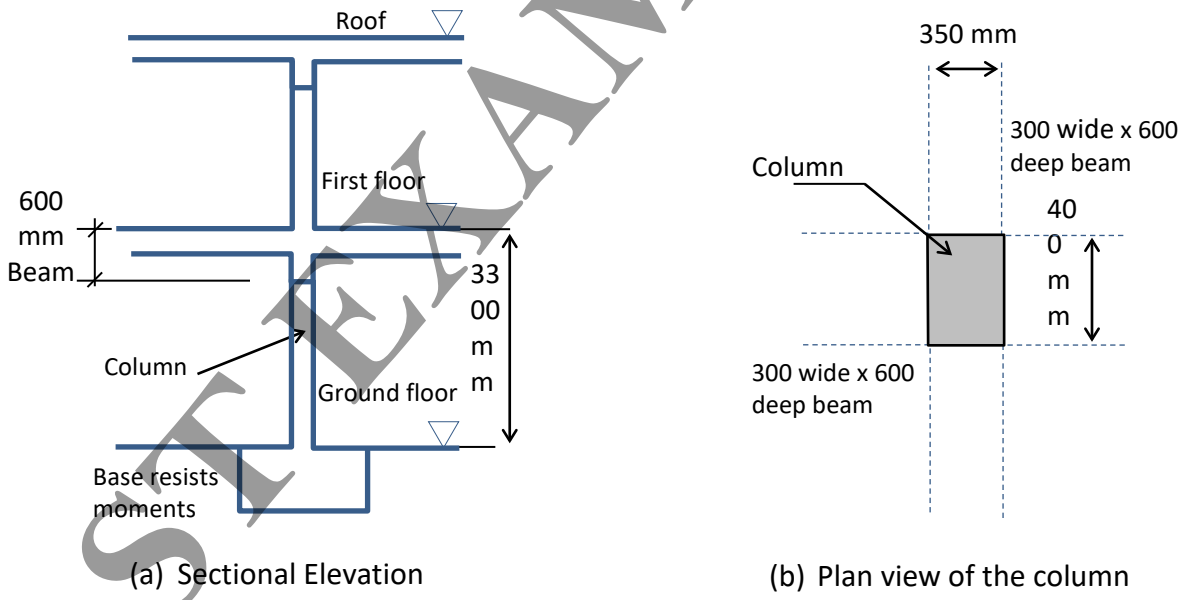
Question 2: Concrete column design

Figures Q2(a) and (b) show a reinforced concrete column in ground floor 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 **350mm x 400mm**, and it is to be in **C30/37** concrete with **30mm** cover to all bars. Both of the beams framing into the column are **600mm** deep and **300mm** width as shown in Figure Q2(b). The thickness of the slab supported by the beams is **250mm**. Floor to floor height is **3300mm**. $\mathbf{f_{yk}}$ is **500 N/mm²**.

In your calculations, assume that longitudinal bars are **H25** and ties are **H10**. 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 **1500 kN** and framing action applies a factored bending moment of **50 kNm** in the direction of the **400mm** dimension (Assume Column's strong axis with factor for braced columns to be taken as 0.9).



(a) Sectional Elevation

(b) Plan view of the column

Figure Q2

Question 2 continues over the page ….

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Question 2 continued ….

Answer the following questions:

(a) Determine whether the column is short (not slender) and calculate the design bending moment applied to the column.

(10 marks)

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

(6 marks)

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

(12 marks)

(d) Draw an annotated transverse section through the column at around mid-height showing details of longitudinal reinforcement and ties.

(7 marks)

Total 35 marks

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Question 3: Steel Beam Design

Figure Q3 shows a fully restrained cantilever steel beam AB.
The size of the steel beam and loading data are shown in Figure Q3.
The size of the beam is **UB 457x191x74** with steel grade **S275**.

1. What is the classification of the beam section in bending? (6 marks)
2. Check the steel beam for the following design criteria:

   (a) Bending strength (7 marks)

   (b) Shear strength (7 marks)

   (c) Web shear buckling (5 marks)

3. Calculate the deflection of the beam at point B under total UNFACTORED load.
   Is the deflection satisfactory?
   Assume admissible deflection to be **L**/250. (10 marks)
   The deflection of the beam at point B is given by:

$$\delta_B = \frac{FL^4}{8EI_y} \qquad E = 210kN/mm^2$$

F = Unfactored total load in (kN/m)

I_y = Second moment of area of the beam section about y-y axis.

Design bending moment is given by: $M_{Ed} = \frac{wL^2}{2}$

Design Shear forces is given by: $V_{Ed} = wL$

L is the span of the beam
w is the total factored design load (kN/m):

$$w = 1.35G_k + 1.5Q_k$$

UB 457x191x74

$W_{pl,y}$ = 1663*10^3 mm^3
h = 457 mm
b = 190 mm
t_w = 9.0 mm
t_f = 14.5 mm
I_y = 335.4*10^6 mm^4

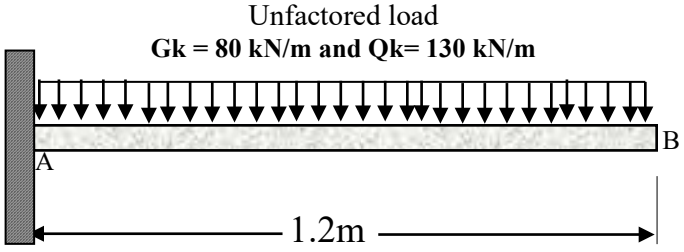

Figure Q3

Total 35 marks

END OF QUESTIONS