UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING

BSc (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2009/2010

DESIGN OF STRUCTURAL ELEMENTS

MODULE NO: BLT 1006

Date: Thursday 3 June 2010 **Time: 2.00 pm – 4.00 pm**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 75 marks.

Candidates should bring unmarked tables of steel design data and concrete design data [EC2 BASE DATA FOR SIMPLE RC DESIGN FOR BEAMS AND SLABS] to the examination.

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Module No. BLT1006

Question 1

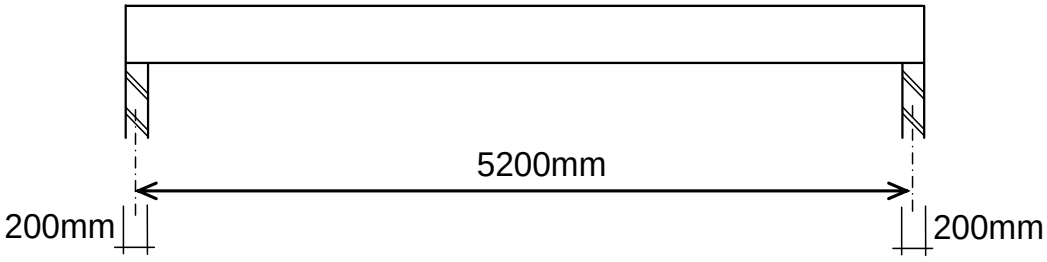

Figure Q1

Figure Q1 shows a simply supported in-situ reinforced concrete beam 400mm wide x 500mm deep with a span of 5200mm. The beam is supported on walls 200mm thick and is to be in C30/37 concrete with 40mm cover to all bars.

Further information:

Unfactored variable action	30.0 kN/m
Unfactored permanent action	35.0 kN/m + beam self weight
Permanent action due to beam self weight to be determined	
Main bars	H32
Shear links	H12

a) Determine the ultimate load on the beam and the bending reinforcement required at mid-span. Do not consider maximum and minimum reinforcement.

(10 marks)

b) Determine the shear reinforcement required in the beam. (10 marks)

c) Draw a neat sketch of a section through the beam at one support, showing the main bars, the shear reinforcement and relevant dimensions.

(5 marks)

Total 25 marks

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Question 2

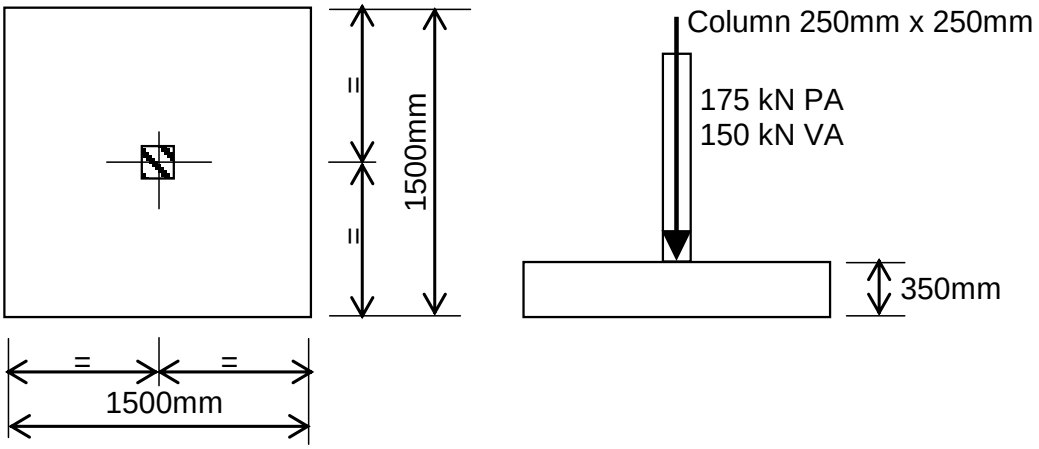

Figure Q2

Figure Q2 shows a square reinforced concrete base that carries a 250mm x 250mm square column. Other design data:

- Concrete grade	C30/37
- Cover to all bars	50mm
- Main bars	H12
- Safe bearing capacity of ground	150 kN/m^2
- Unfactored permanent action	175 kN
- Unfactored variable action	150 kN

a) Check whether the ground bearing pressure is satisfactory. (4 marks)

b) Design the main reinforcement for the base. Check the shear at the column perimeter. Provide a neatly drawn and dimensioned sketch sectional elevation showing the reinforcement in the base.

(16 marks)

c) Elsewhere on the same site, a 200mm square reinforced concrete column carrying an unfactored vertical load of 250kN requires an efficiently designed mass concrete base. The safe bearing capacity of the ground remains the same (150 kN/m^2). Provide an efficient mass concrete design using C25/30 concrete

(5 marks)

Total 25 marks

Please turn to next page for additional information

Question 2 continued over the page…

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Question 2 continued

Additional Information for Question 2

The two tables and the formula for the limiting shear stress are taken from the IStructE Manual for the design of concrete building structures to Eurocode 2, September 2006

Unfactored ground pressure σ (kN/m^2)	$\frac{h_f}{a}$			
	(C20/25)	(C25/30)	(C30/37)	(C35/45)
≤200	1.2	1.1	1.1	1.0
300	1.5	1.4	1.3	1.2
400	1.7	1.6	1.5	1.4

Table 5.22 Depth / projection ratios for unreinforced footings

Unfactored ground pressure σ (kN/m^2)	$\frac{d}{a}$									
	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.70	≥ 0.80
50	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
100			0.16	0.13	0.13	0.13	0.13	0.13	0.13	0.13
150					0.17	0.13	0.13	0.13	0.13	0.13
200						0.22	0.13	0.13	0.13	0.13
250								0.16	0.13	0.13
300									0.13	0.13

Table 5.23 Reinforcement percentages, depth / projection ratios and unfactored ground pressures for reinforced footings for f_{ck} = 25 MPa

Note: The shaded areas indicate combinations of σ and $\frac{d}{a}$ that should not be used

d average of the effective depth of the tension reinforcement in both directions in the footing
a projection of footing from column face
h_f depth of footing

The shear stress at the column perimeter should not exceed $0.2\left(1-\frac{f_{ck}}{250}\right)f_{ck}$ MPa

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Question 3

a) Give an example of how a steel beam is considered to be with full lateral restraint.

(5 marks)

b) A cantilever beam is required to resist the loading shown in Figure Q3.
The beam is provided with full lateral restraint to the compression flange.

(i) Select a suitable UB section in grade S275 to satisfy bending and shear strength.

(12 marks)

(ii) Check the web shear buckling of the beam.

(3 marks)

(iii) Calculate the deflection at point B due to unfactored variable load. Is the deflection satisfactory? (5 marks)

Maximum deflection at point B is $\delta_B = \frac{wL^4}{8EI}$
Where *w* is the unfactored load.
Assume the limiting value of deflection is L/180.
The elastic modulus of steel E = 210 kN/mm^2

Maximum bending moment at support A is: $M = \frac{Fl}{2}$ kNm

Maximum shear force at support is: $V = F$
F is the total ultimate load in kN.

Total 25 marks

UNFACTORED LOADS

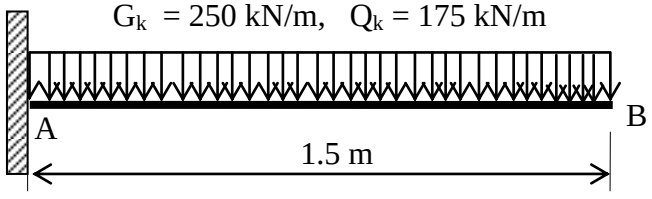

Figure Q3

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Question 4

Figure Q4 shows a base plate supporting an internal 254 × 254 × 73 UKC in S275 steel. The design value of axial compressive load is N_{Ed} = 1253 kN.
Design compressive strength of foundation concrete is f_{cd} = 20 N/mm^2.

Column details

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

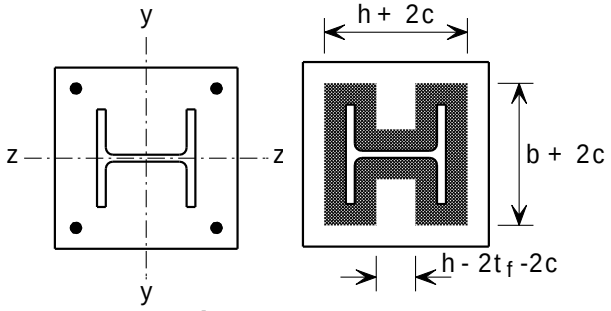

Figure Q4

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

(15 marks)

(b) What is the minimum size (*widthxdepth*) of the column base plate?

(5 marks)

(c) 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

Effective Area Method:

Effective area $\approx 4c^2$ + *(Column section perimeter)* × *c* + *column section area*
Where c is the cantilever outstand of the effective area, as shown in Figure Q4.

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

$(Ac^2 + Bc + C = 0)$

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

$$c = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

The minimum thickness of base plate (t_p) is given by:

$$t_p \geq \frac{c}{\sqrt{f_{yp} / 3 f_{cd}}}$$

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

END OF QUESTIONS