

UNIVERSITY OF BOLTON

**SCHOOL OF THE BUILT ENVIRONMENT &
ENGINEERING – RAK CAMPUS**

BSc (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2008/2009

DESIGN OF STRUCTURAL ELEMENTS

MODULE NO: BLT 1006

Date: Thursday 28 May 2009

Time: 5.00 pm – 7.00 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.

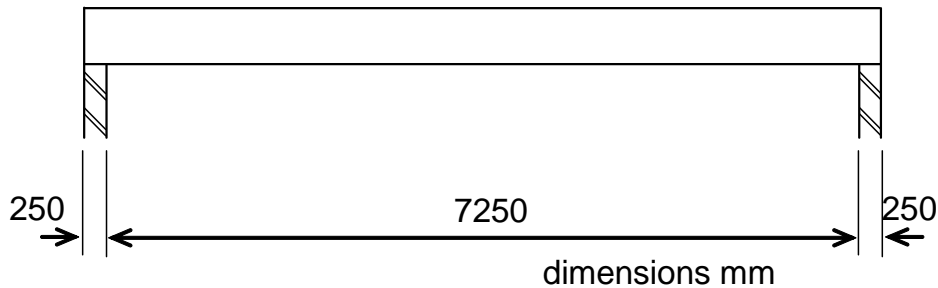
Question 1**Figure Q1**

Figure Q1 shows a simply supported in-situ reinforced concrete beam 300mm wide x 550mm deep with a clear span of 7250mm. The beam is supported on walls 250 mm thick, and is to be in C30/37 concrete with 25mm cover to all bars.

Further information:

Unfactored variable action	16.0 kN/m
Unfactored permanent action	20.0 kN/m + beam self weight
Permanent action due to beam self weight to be determined	
Main bars	H32
Shear links	H10

- Determine the ultimate load on the beam and the bending reinforcement required at mid-span. Do not consider maximum and minimum reinforcement
(12 marks)
- Determine the shear reinforcement required in the beam
(8 marks)
- 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 marksAdditional information:

For a simply-supported beam of span L metres carrying a uniformly distributed load of w kN/m over its full length:

- Maximum Bending Moment $M = wL^2/8$ kNm
- Reaction, R $R = wL/2$ kN
- The density of reinforced concrete is 25kN/m^3

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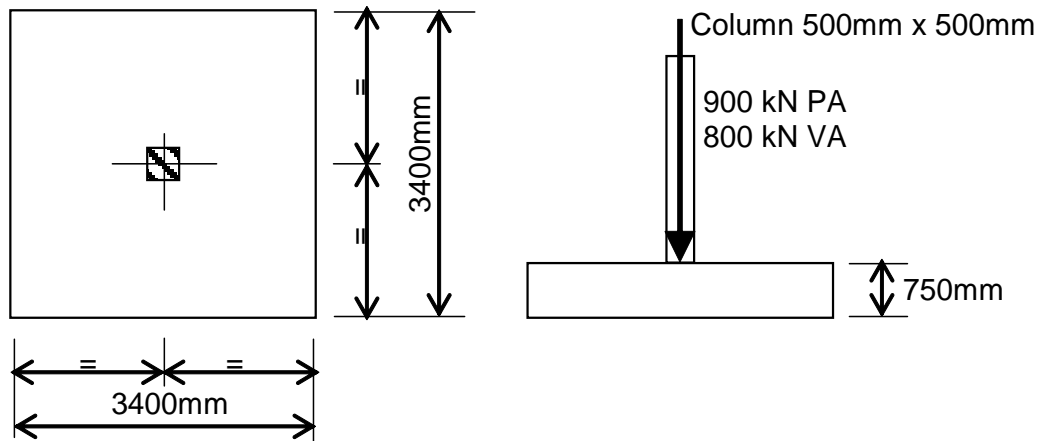
Question 2**Figure Q2**

Figure Q2 shows a square reinforced concrete base that carries a 500mm x 500mm square column. Other design data:

- Concrete grade	C40/50
- Cover to all bars	50mm
- Main bars	H20
- Safe bearing capacity of ground	250 kN/m ²
- Unfactored permanent action	900 kN
- Unfactored variable action	800 kN

- Check whether the ground bearing pressure is satisfactory (4 marks)
- 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)
- Provide an efficient alternative mass concrete design for the foundation using C30/37 concrete (5 marks)

Total 25 marks

Please turn to next page for additional information

Question 2 continued over the page...

Question 2 continuedAdditional 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

Figure Q3 shows a simply-supported 305x127x37 UB section in grade S275, with an overhang BC, and carrying FACTORED full length UDL of 60 kN/m.

- a) The beam is provided with full lateral restraint to the compression flange, and deflection calculations do not need to be considered
1. Find the maximum shear force and bending moment in the beam. (3 marks)
 2. What is the overall classification of the beam section? (5 marks)
 3. Check the moment capacity of the beam. (5 marks)
 4. Check the shear capacity of the beam. (5 marks)
- b) Assuming the beam sits on 100 mm bearing plate at support B.
1. Check the web bearing capacity of the beam at support B.
 2. What is the contact stress at support B?
- (7 marks)

The web bearing capacity of the beam is given by:

$$P_{bw} = (b_1 + 5k)tp_{yw}$$

The contact stress at support is given by:

$$P_{cs} = (b_1 \times 2k)p_y$$

where

b_1 = bearing length

$k = (T_f + r)$

r = root radius

T_f = thickness of flange

t = web thickness

p_{yw} = design strength of web

Total 25 marks

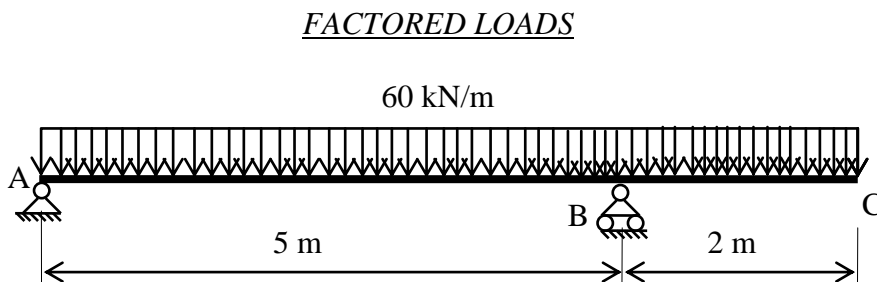


Figure Q3

Question 4

Figure Q4 shows a single storey 203x203x52 UC column in grade S275, supporting reactions from four roof beams. The beams are held at their remote ends in a suitable bracing system to provide restraint at the beam connection position.

The beam reactions and column weight are FACTORED, and are on the main axis of the column.

- Produce all the required calculations to show the suitability of the above column to carry the indicated loadings.
(20 marks)
- Show a sketch detail, to a suitable scale, of the column base plate anchorage connection to a concrete pad foundation. Include any necessary notes and sizes.
(5 marks)

Total 25 marks

ALL LOADS ARE FACTORED

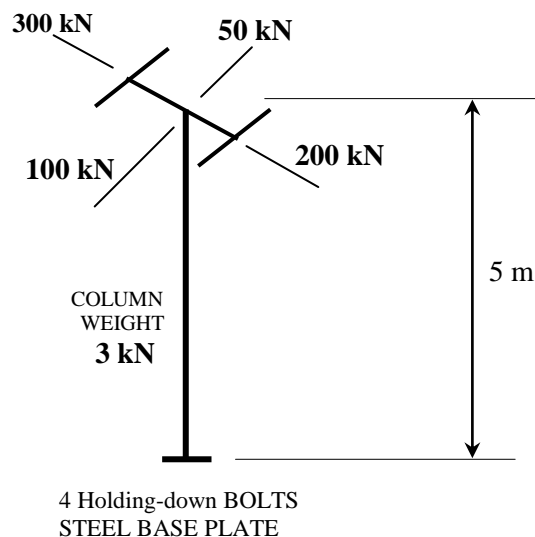


Figure Q4

END OF QUESTIONS