TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING & CIVIL ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECE 2415 : STRUCTURAL DESIGN II

END OF SEMESTER EXAMINATION

SERIES: DECEMBER 2016

TIME: 2 HOURS

DATE: 15 Dec 2016

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

-Drawing instruments.

This paper consists of five questions.

Attempt question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

Question One (Compulsory)

(a) The BS 8110 design formula for an axially reinforced concrete column is the equation 1.1:

$$N = 0.4 f_{cu} A_c + 0.75 f_y A_{sc} \qquad 1.1$$

Where:

$f_{cu} = the\ characteristic\ strength\ of\ the\ concrete,$

$f_y = the\ characteristic\ strength\ of\ the\ reinforcing\ steel,$

$A_c = area\ of\ concrete,$

$A_{sc} = area\ of\ reinforcing\ bars\ in\ compression$

From basic concepts derive equation 1.1

(6 marks)

(b) Calculate the ultimate axial load of a 500 mm x 250 mm column section having 6 No. size 20 mm bars if f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2.

(5 marks)

(c) Design the longitudinal reinforcement for a braced short column of dimensions 500 x 250 mm if:

(i) Axial ultimate load N = 2300 kN and moment M_x = 290 kNm,

(ii) Axial ultimate axial load N = 2000 kN, moments M_x = 290 kNm and M_y = 50 kNm.

Characteristic strengths: f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2.

Table 1.1: values of β (BS 8110: cl.3.8.4.5)

$\frac{N}{f_{cu}bh}$	0.0	0.1	0.2	0.3	0.4	0.5	≥ 0.6
β	1.00	0.88	0.77	0.65	0.53	0.42	0.30

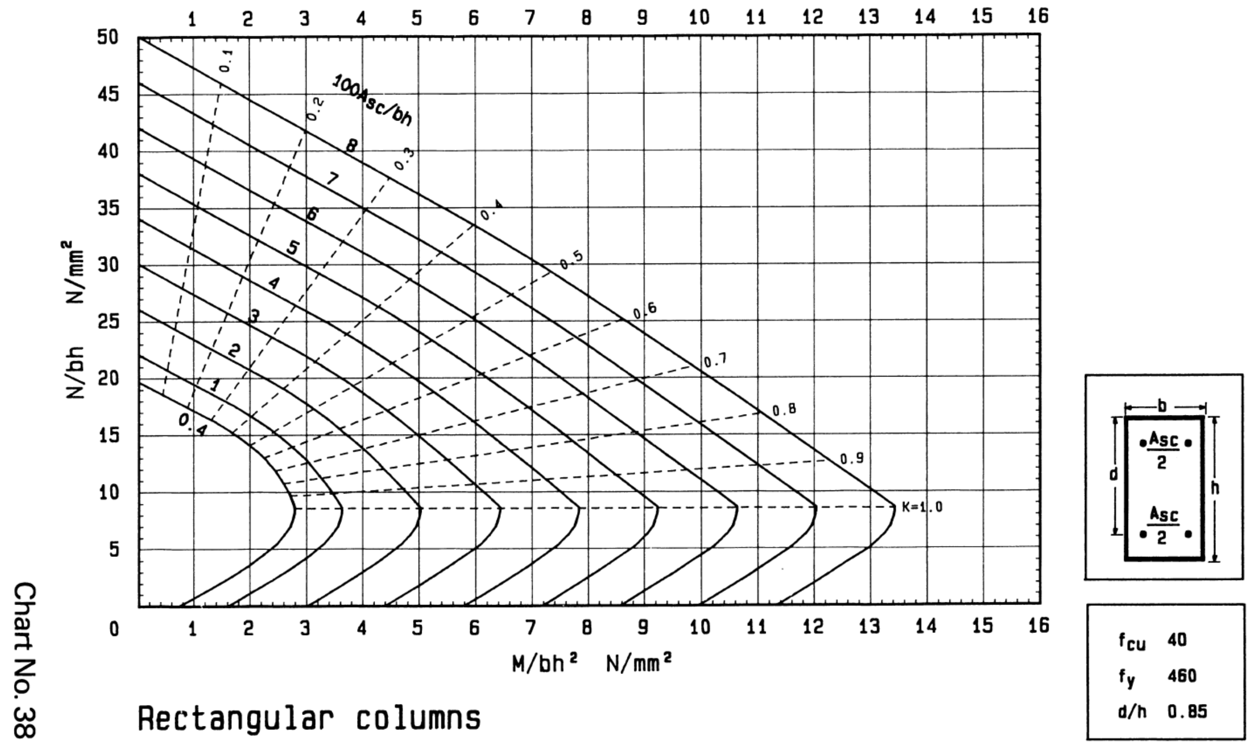

Fig.1.1: Column design chart – BS 8110

(14 marks)

Question Two

(a) The design moment for a beam, width 300 mm and effective depth 600 mm is 300 kNm. If f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2, design the reinforcement using chart Figure 2.1.

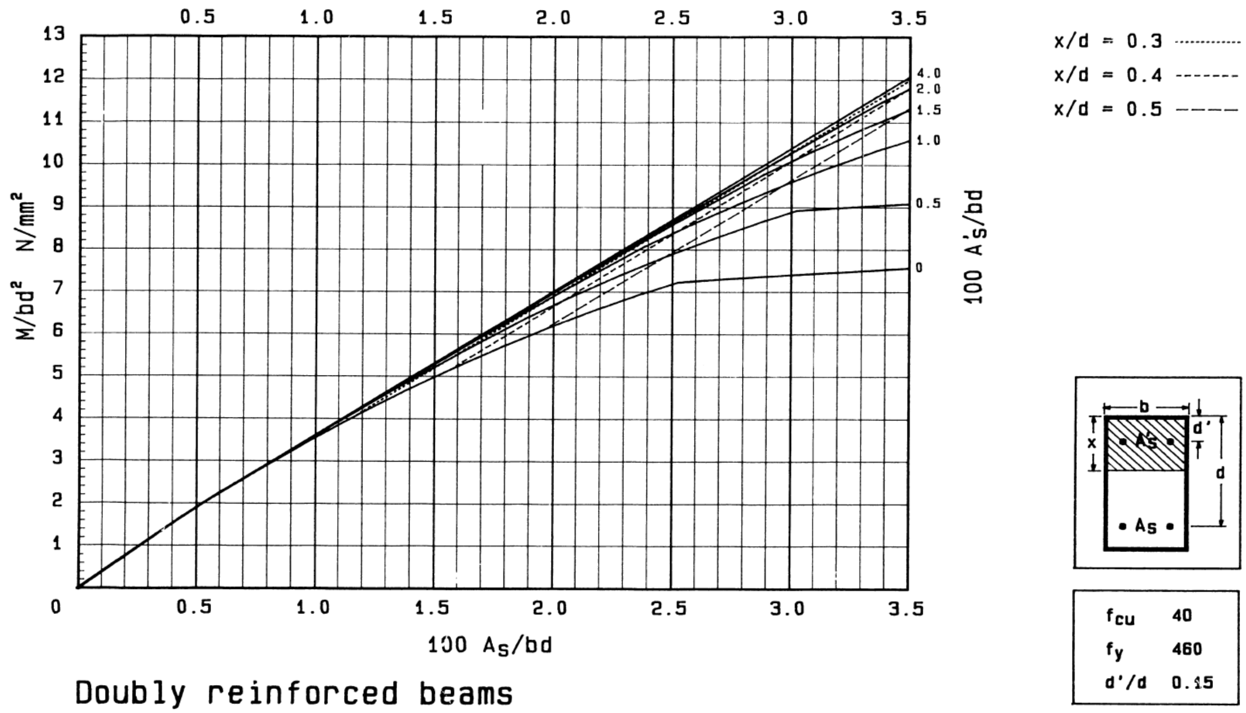

Figure 2.1: Beam design chart - ultimate limit state (BS8110)

(5 marks)

(b) (i) The ultimate moment of resistance, about tension steel, of a singly reinforced rectangular concrete beam subject to flexure is given by equation 2.1:

$$M_u = 0.156 f_{cu} b d^2 \qquad 2.1$$

Where:

$f_{cu} = concrete\ characteristic\ strength,$

$b = beam\ width,$

$d = beam\ effective\ depth.$

Using a neat sketch of BS 8110 simplified rectangular stress block, derive equation 2.1.

(8 marks)

(ii) Using BS 8110 simplified stress block, determine the ultimate moment of resistance of the beam section Figure 2.2, if f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2

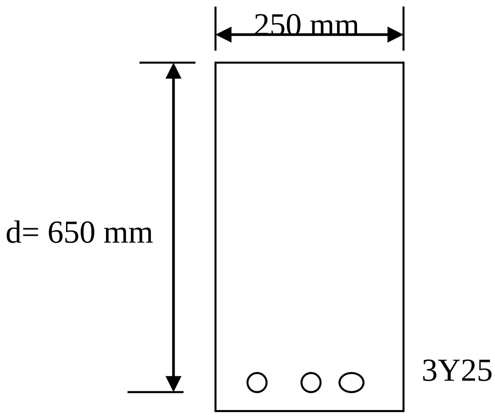

Figure 2.2: Singly reinforced concrete beam section

(7 marks)

Question Three

Fig. 3.1 shows an interior concrete floor slab panel supported on reinforced concrete beams on all four sides, with provision for torsion at the corners. Using the relevant tables attached, design the slab for the ultimate limit state only. The factored design load, that includes self weight, n = 36.0 kN/m^2, slab initial trial thickness = 150 mm, f_{cu} = 40 N/mm^2, f_y= 460N/mm^2.

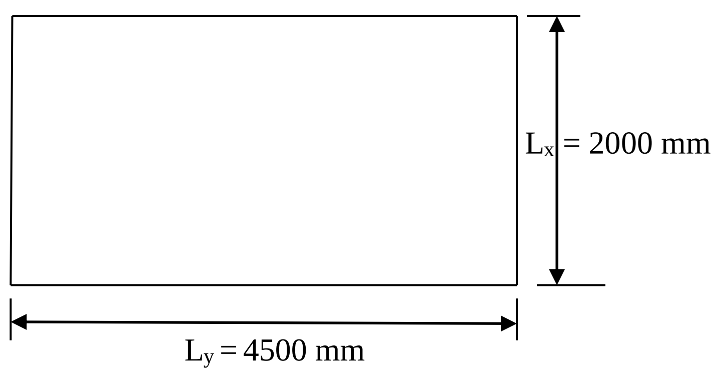

Fig. 3.1: Interior solid reinforced concrete floor slab panel

(20 marks)

Table 3.1: Bending moment coefficients (BS 8110: clause 3.5.3.4)

Bending moment coefficients for rectangular panels supported on four sides with provision for torsion at corners									
Type of panel and moments considered	Short span coefficients, β_{sx}								Long span coefficients, β_{sy}, for all values of l_y/l_x
	Values of l_y/l_x								
	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	

Interior panels									
Negative moment at continuous edge	0.031	0.037	0.042	0.046	0.050	0.053	0.059	0.063	0.032
Positive moment at mid-span	0.024	0.028	0.032	0.035	0.037	0.040	0.044	0.048	0.024

Table 3.2: lever- arm and neutral axis depth factors

$K = M/(bd^2 f_{cu})$	0.05	0.06	0.07
(z/d)	0.94	0.93	0.91
(x/d)	0.13	0.16	0.19

Table 3.3: minimum areas of reinforcement in members (BS 8110: clause 3.12.5.1)

situation	Definition of percentage	Minimum percentage	
		f_y = 250 N/mm^2	f_y = 460 N/mm^2
		%	%
Tension reinforcement Rectangular section (in solid slabs, this minimum should be provided in both directions)	$100A_{sc}/A_c$	0.24	0.13

Question Four

A footing is required to transmit, from a 400 mm x 200 mm column with 16 mm diameter dowels, the following axial loads:

(i) Dead loads G_k= 750 kN,
(ii) Live loads Q_k = 250 kN.

Material characteristics:

Soil bearing pressure = 200 kN/m^2, f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2.

Design the footing to include the following checks

(i) Dowel achorage
(ii) Punching shear,
(iii) Bending
(iv) Local bond stress,

(v) Shear

(20 marks)

Table 4.1: Anchorage lengths

[Anchorage length L = (K_A) (bar size)]

			K_A		
	f_{cu} =	20	25	30	40 or more
Deformed Type 2 (460)					
Tension		46	41	35	30
Compression		31	27	24	20

Table 4.2: Design concrete shear stress v_c – for $f_{cu} \geq 40\ N/mm^2$

$\frac{100A_s}{b_v d}$	Effective depth d (mm)						
	150	175	200	225	250	300	≥ 400
≤ 0.15	0.50	0.48	0.47	0.45	0.44	0.42	0.40
0.25	0.60	0.57	0.55	0.54	0.53	0.50	0.47
0.50	0.75	0.73	0.70	0.68	0.65	0.63	0.59

Table 4.3: lever- arm and neutral axis depth factors

K = M/(bd^2f_{cu})	0.05	0.06	0.07
(z/d)	0.94	0.93	0.91

Table 4.4: Ultimate local bond stress in beams (N/mm^2)

Bar type	Concrete grade			
	20	25	30	40 or more
Deformed, type 2	2.5	3.0	3.4	4.1

Table 4.5: minimum areas of reinforcement in members (BS 8110: clause 3.12.5.1)

situation	Definition of percentage	Minimum percentage	
		f_y = 250 N/mm^2	f_y = 460 N/mm^2
		%	%
Tension reinforcement Rectangular section (in solid slabs, this minimum should be provided in both directions)	$100A_{sc}/A_c$	0.24	0.13