



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:

$$N = 0.4f_{cu}A_c + 0.75f_yA_{sc} \quad 1.1$$

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 this expression.

(6 marks)

- (b) Calculate the ultimate axial load of a 400 mm x 200 mm column section having 6 No. size 25 mm bars if $f_{cu} = 40 \text{ N/mm}^2$ and $f_y = 460 \text{ N/mm}^2$.

(5 marks)

- (c) Design the longitudinal reinforcement for a braced short column of dimensions 400 x 200 mm if:

- (i) Axial ultimate load $N = 1500 \text{ kN}$ and moment $M_x = 50 \text{ kNm}$,
 (ii) Axial ultimate axial load $N=1500 \text{ kN}$, moments $M_x = 50 \text{ kNm}$ and $M_y = 30 \text{ kNm}$.
 Characteristic strengths: $f_{cu} = 40 \text{ N/mm}^2$ and $f_y = 460 \text{ N/mm}^2$.

(19 marks)

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

Chart No. 38

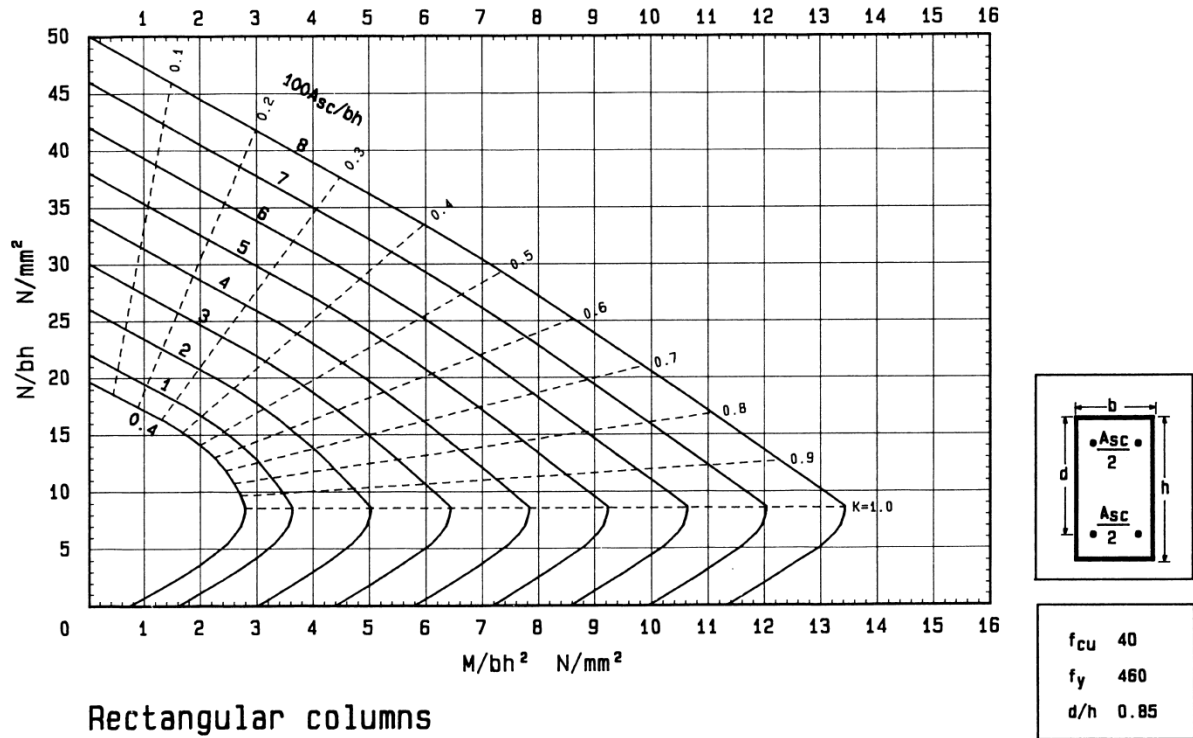


Fig.1.1: Column design chart – BS 8110

Question Two

The design moment for a beam, width 200 mm and effective depth 600 mm is 200 kNm. If $f_{cu} = 40 N/mm^2$ and $f_y = 460 N/mm^2$, design the reinforcement using chart Figure 2.1.

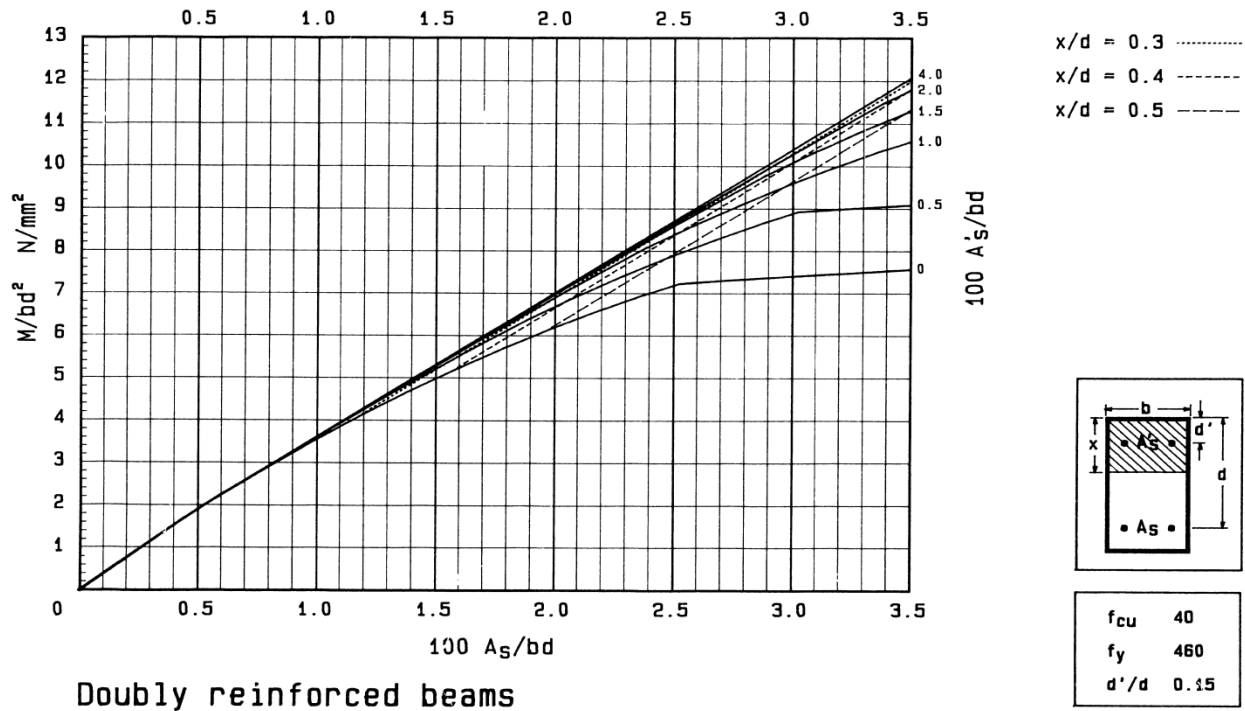


Figure 2.1: Beam design chart - ultimate limit state (BS8110)

(4 marks)

(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:

$$M_u = 0.156f_{cu}bd^2 \quad 2.1$$

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.

marks)

The design moment M for a rectangular reinforced concrete beam of width 200 mm and effective depth 700 mm is 250 kNm. If $f_{cu} = 40 \text{ N/mm}^2$ and $f_y = 460 \text{ N/mm}^2$, design the reinforcement (Institute of structural Engineer's Manual procedure may be followed).

Table 2.1: Lever arm and neutral axis depth factors

$K = \frac{M}{f_{cu}bd^2}$	0.05	0.06	0.07	0.08	0.09	0.10	0.104	0.11	0.119	0.13	0.132	0.14	0.144	0.15	0.156
z/d	0.94	0.93	0.91	0.90	0.89	0.87	0.87	0.86	0.84	0.82	0.82	0.81	0.80	0.79	0.775
x/d	0.13	0.16	0.19	0.22	0.25	0.29	0.30	0.32	0.35	0.39	0.40	0.43	0.45	0.47	0.50

(8 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. The factored design load $n = 36.0 \text{ kN/m}^2$, slab initial trial thickness = 150 mm, $f_{cu} = 40 \text{ N/mm}^2$, $f_y = 460 \text{ N/mm}^2$.

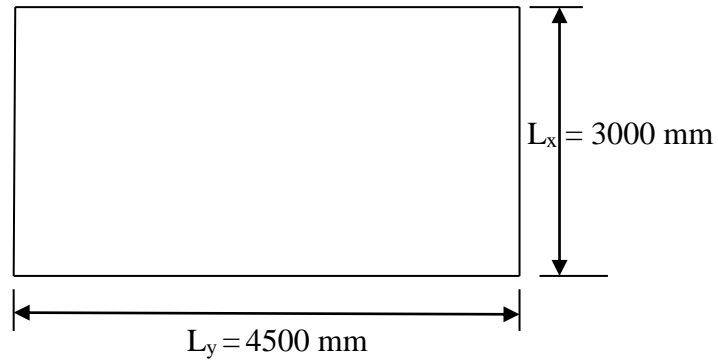


Fig. 3.1: Interior solid reinforced concrete floor slab panel

(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	
<i>Interior panels</i>									
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

$K = M/(bd^2f_{cu})$	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
		%	%
<i>Tension reinforcement</i>			
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/m², $f_{cu} = 40$ N/mm² and $f_y = 460$ N/mm².

Design the footing to include the following checks

- (i) Dowel anchorage
- (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/mm²

$\frac{100A_s}{b_v d}$	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/mm²)

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