TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT BUILDING AND CIVIL ENGINEERING

UNIVERSITY EXAMINATION FOR:

BSC IN CIVIL ENGINEERING

ECE 2415: STRUCTURAL DESIGN II (REINFORCED CONCRETE DESIGN)

END OF SEMESTER EXAMINATION

SERIES:APRIL2016

TIME:2HOURS

DATE:17May2016

Instructions to Candidates

You should have the following for this examination

-*Answer Booklet, Drawing Instruments, Scientific calculator, examination pass and student ID*

This paper consists of five questions. Attemptquestion ONE (Compulsory) and any other TWO questions.

Question **ONE**

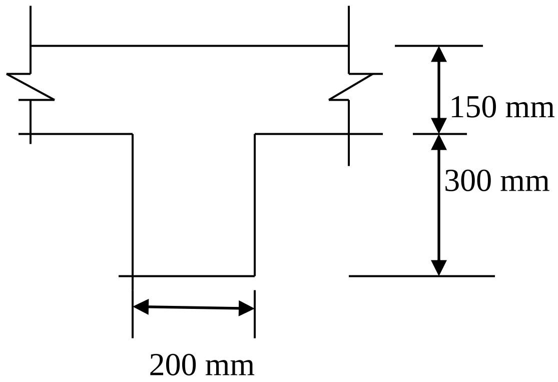


Figure 1.1: Beam and slab construction

Figure 1.1 shows a section of a beam and slab construction in concrete (T- beam may be considered continuous).

The beam effective span l = 8.0 m,

Characteristic strength of concrete f_{cu} = 40 N/mm^2,

Design moment m = 415 kNm.

Design the beam for the following limit states:

(i) Ultimate (follow the approximate method),

(ii) Deflection ,

(iii) Shear (total u.d.l. on the span = 415 kN).

(30 marks)

Table 1.1: Basic span/effective depth ratios (BS 8110: cl. 3.4.6.3)

Support conditions	Rectangular sections	Flanged sections $\frac{b_w}{b} \leq 0.3$
Cantilever	7	5.6
Simply supported	20	16.0
continuous	26	20.8

Table 1.2: Modification factor for tension reinforcement (BS 8110: clause 3.4.6.5)

Service stress		$\frac{M}{bd^2}$ (N/mm^2)								
f_s (N/mm^2)		0.50	0.75	1.00	1.50	2.00	3.00	4.00	5.00	6.00
(f_y=250)	156	2.00	2.00	1.96	1.66	1.47	1.24	1.10	1.00	0.94
(f_y = 460)	288	1.68	1.50	1.38	1.21	1.09	0.95	0.87	0.82	0.78

Table 1.3: Values of As_v/s_v (mm) for various link- bar sizes φ and link spacings s_v

	φ			
s_v	8	10	12	16
100	1.00	1.57	2.26	4.02
150	0.67	1.05	1.51	2.68
200	0.50	0.79	1.13	2.01
250	0.40	0.63	0.90	1.61
300	0.33	0.52	0.75	1.34

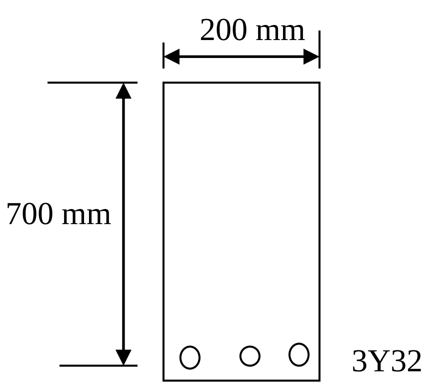
Question **TWO**

Determine the ultimate moment of resistance M of the beam section Figure 2.1 using:

a) Beam design chart Figure 2.2,

b) The BS 8110 simplified stress block.

(20 marks)



f_{cu} = 40 N/mm^2, f_y = 460 N/mm^2

Figure 2.1: RC beam section

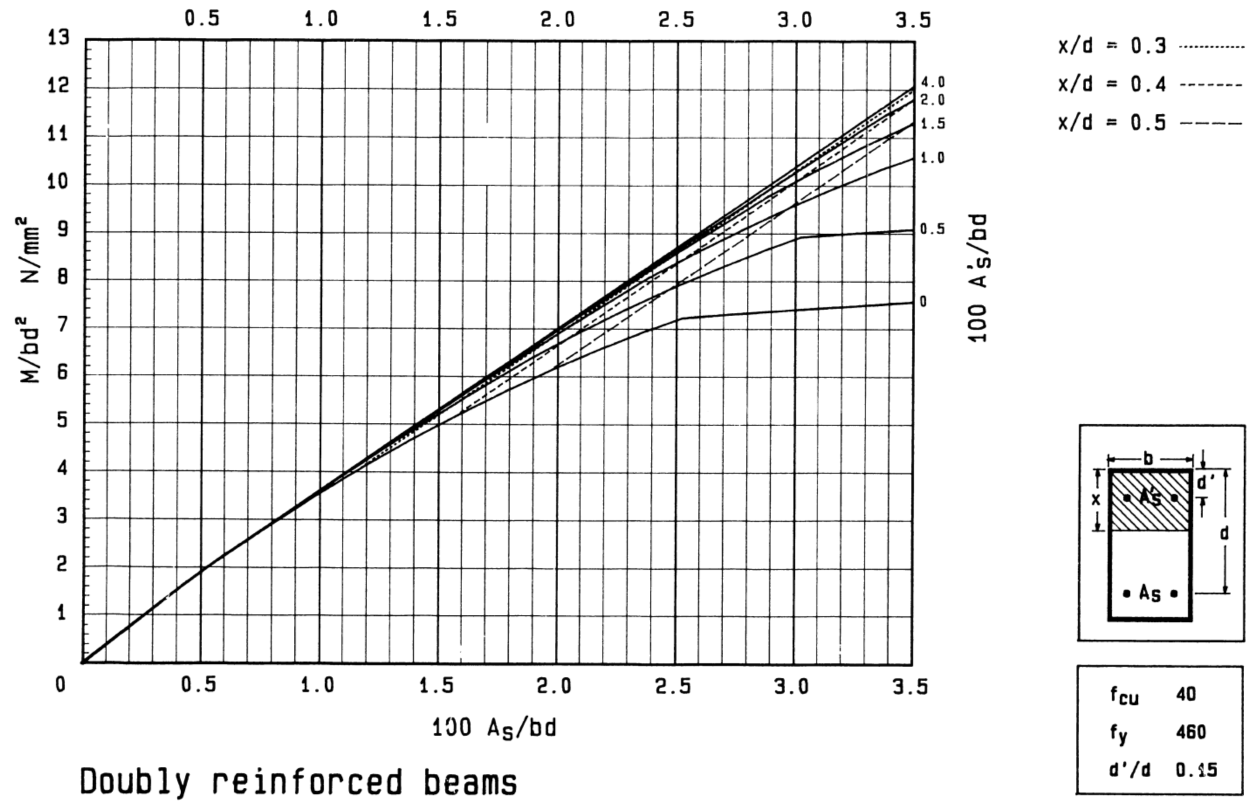


Figure 2.2: R.C. beam design chart

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 = 34.5 kN/m^2, slab initial trial thickness = 150 mm, f_{cu} = 40 N/mm^2, f_y= 460N/mm^2.

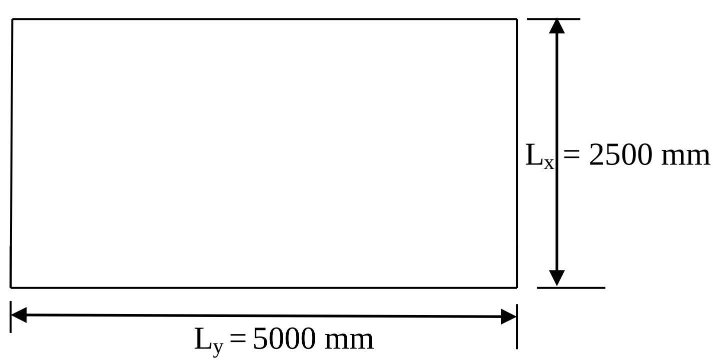


Fig. 3.1: Interior solid reinforced concrete floor slab panel

(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

$K = M/(bd^2f_{cu})$	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
		%	%
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) Calculate the ultimate axial load of a 200 x 500 mm column section having 6Y32 bars, if f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2

(6 marks)

(b) Using chart Figure 4.1, design the longitudinal reinforcement for a 500 x 200 mm column section if:

(i) N = 2000 kN and M_x = 250 kNm

(ii) N = 2000 kN, M_x = 200 kNm and M_y = 50 kNm.

Given: f_{cu} = 40 N/mm^2 and f_y = 460 N/mm^2 in both (i) and (ii)

Where M_x is the bending moment about the major axis and M_y is the bending moment about the minor axis.

(14 marks)

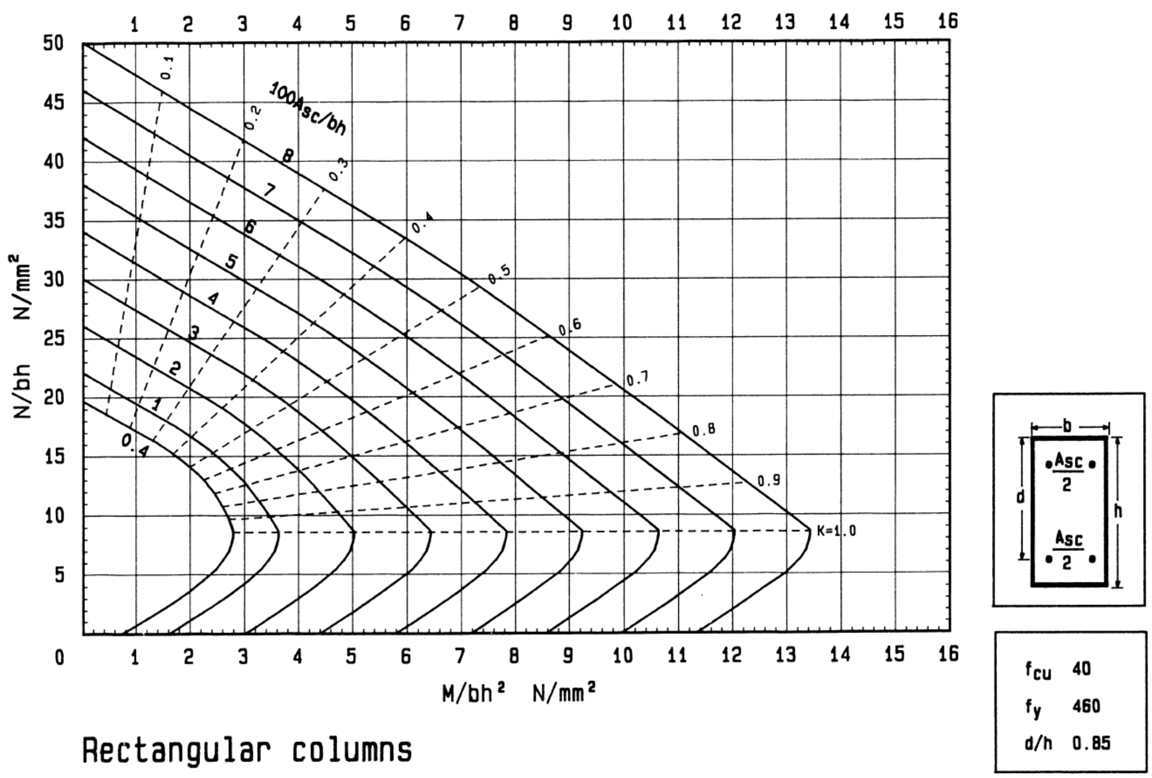


Figure 4.1: Rectangular columns design chart

Table 4.1: 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

Bar	*Number of bars*									
Size (mm)	1	2	3	4	5	6	7	8	9	10
8	50	101	151	201	251	302	352	402	452	503
10	79	157	236	314	393	471	550	628	707	785
12	113	226	339	452	565	679	792	905	1017	1131
16	201	402	603	804	1005	1206	1407	1608	1809	2011
20	314	628	942	1257	1571	1885	2199	2513	2827	3142
25	491	982	1473	1963	2454	2945	3436	3927	4418	4909
32	804	1608	2412	3216	4021	4825	5629	6433	7237	8042
40	1256	2513	3769	5026	6283	7539	8796	1050	11310	2570

DESIGN TABLES

Table A1: Areas of groups of reinforcement bars (mm^2)

Table A2: Reinforcement - bar areas (mm^2) per metre width for various bar spacings

Bar	*Bar spacing* (mm)									
Size (mm)	75	100	125	150	175	200	225	250	275	300
8	671	503	402	335	287	252	223	201	183	168
10	1047	785	628	523	449	393	349	314	286	262
12	1508	1131	905	754	646	566	503	452	411	377
16	2681	2011	1608	1340	1149	1005	894	804	731	670
20	4189	3142	2513	2094	1795	1571	1396	1257	1142	1047
25	6545	4909	3927	3272	2805	2454	2182	1963	1785	1636
32	-	8042	6434	5362	4596	4021	3574	3217	2925	2681
40	-	-	10050	8378	7181	6283	5585	5027	4570	4189

Table A3: Design concrete shear stress v_c – for $f_{cu} \geq 40\ N/mm^2$ (BS 8110: clause 3.4.5.4)

$\frac{100A_s}{b_v d}$	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
0.75	0.85	0.83	0.80	0.77	0.76	0.72	0.67
1.00	0.95	0.91	0.88	0.85	0.83	0.80	0.74
1.50	1.08	1.04	1.01	0.97	0.95	0.91	0.84
2.00	1.19	1.15	1.11	1.08	1.04	1.01	0.94
≥ 3.00	1.36	1.31	1.27	1.23	1.19	1.15	1.07