UNIVERSITY OF RUHUNA
FACULTY OF ENGINEERING

Final

End - Semester 6 Examination in Engineering - February 2020
TIMETABLE

DATE	TIME	MODULE NO.	MODULE NAME	NO OF STUDENTS	VENUE
24.02.2020	1.30 p.m. - 4.30 p.m.	CE6302	Design of Concrete structures II (N/C)	75	AUD
24.02.2020	1.30 p.m. - 4.30 p.m.	EE6205	Energy and Environment (N/C)	77	AUD
25.02.2020	1.30 p.m. - 4.30 p.m.	IS6203	Entrepreneurship and Project Management (N/C)	100	DO1
26.02.2020	9.00 a.m. - 12.00 noon	CE6251	Building Services Engineering (N/C)	01	DO2
26.02.2020	1.30 p.m. - 4.30 p.m.	CE6252	Dynamic & Control of Structures (N/C)	58	AUD
26.02.2020	1.30 p.m. - 4.30 p.m.	CE6254	Coastal Engineering (N/C)	16	AUD
27.02.2020	9.00 a.m. - 12.00 noon	ME6302	Automatic Control Engineering (N/C)	65	DO2
27.02.2020	1.30 p.m. - 4.30 p.m.	CE6301	Construction Processes and Technology (N/C)	75	AUD
28.02.2020	9.00 a.m. - 12.00 noon	EE6206	Operating Systems and Programming (N/C)	12	DO2
28.02.2020	9.00 a.m. - 12.00 noon	EE6208	Introduction to Hardware Description Language(N/C)	09	DO2
28.02.2020	9.00 a.m. - 12.00 noon	EE6207	Wireless and Mobile Communications (N/C)	48	DO2
28.02.2020	2.30 p.m. - 5.30 p.m.	CE6304	Environmental Engineering Design (N/C)	76	AUD
28.02.2020	2.30 p.m. - 5.30 p.m.	ME6211	Nanotechnology (N/C)	29	AUD
29.02.2020	1.30 p.m. - 4.30 p.m.	IS6301	Mathematical Modeling (N/C)	221	AUD/ DO1
02.03.2020	9.00 a.m. - 12.00 noon	CE6303	Engineering Hydrology (N/C)	77	DO2
02.03.2020	1.30 p.m. - 4.30 p.m.	ME6303	Computer Aided Manufacturing (N/C)	70	DO2
03.03.2020	1.30 p.m. - 4.30 p.m.	EE6303	Electric Machines and Drives (N/C)	95	AUD
04.03.2020	1.30 p.m. - 4.30 p.m.	ME6304	Production Planning and Control (N/C)	65	AUD
04.03.2020	1.30 p.m. - 4.30 p.m.	EE6304	Embedded System Design (N/C)	80	AUD
05.03.2020	9.00 a.m. - 12.00 noon	CE6305	Geotechnical Engineering (N/C)	75	DO2
06.03.2020	2.30 p.m. - 5.30 p.m.	EE6301	Communication Systems (N/C)	83	AUD
07.03.2020	1.30 p.m. - 4.30 p.m.	ME6301	Advanced Fluid Mechanics (N/C)	70	DO2
07.03.2020	1.30 p.m. - 4.30 p.m.	EE6302	Control System Design (N/C)	100	AUD
08.03.2020	1.30 p.m. - 4.30 p.m.	IS6304	Management and Organizational Behavior(N/C)	79	DO1

Exam Venue for IS 6301(Mathematical Modeling)(N/C)
Auditorium – CEE students + CEE repeat students + MME students + MME repeat students (No. of students141)
Drawing Office -1(DO1) –EIE students + EIE repeat students (No. of students80)

Assistant Registrar
Faculty of Engineering
18.02.2020

UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: February 2020

Module Number: CE 6302 **Module Name: Design of Concrete Structures II**

[Three Hours]

[Answer all questions]

Code of Practice BS 8110 Part 1: 1997 and BS 8007: 1987 are provided

Q1. a) List out various applications of prestressed concrete (PC).

[2.0 Marks]

b) Discuss merits and demerits of designing prestressed concrete members using Class 1, Class 2 and Class 3 for applications in Sri Lanka.

[3.0 Marks]

c) Derive the expressions for Prestressing forces (P_e and P_i) applied eccentrically in a concrete member based on the most critical stresses at service and transfer states. Clearly indicate all necessary stress and strain diagrams required in the derivation. Consider rectangular beam with usual notations for above derivation.

[5.0 Marks]

d) A newly constructed prestressed concrete bridge has a post-tensioned solid concrete slab as the deck. This solid slab is designed to carry service load of 5 kN/m^2. The effective span of the slab is 16.0 m and is simply supported at the two edge beams. Take immediate losses and long term losses to be 7.5% and 15.0%, respectively. The concrete strength at 7 days (at transfer) and at 28 days of casting are 40 N/mm^2 and 60 N/mm^2, respectively. The unit weight of concrete is 25 kN/m^3. The slab is expected to design as a class II member.

i) Determine the required minimum depth of the bridge deck slab.

[6.0 Marks]

ii) If the bridge deck has a depth of 525 mm and the maximum eccentricity of the tendons at mid-span 75 mm above the soffit, determine the required minimum value of the prestressed force to resist the above loading. Use inequality expressions to solve above calculations.

[6.0 Marks]

iii) Construct a Magnel diagram for the bridge slab and find the required minimum prestressing force required for a tendon with eccentricity of 188 mm. Explain briefly, what would be the effect on the minimum prestressing force if the eccentricity reduced to 125 mm and increased it to 250 mm (No calculation required)?

[8.0 Marks]

Q2. A rectangular concrete beam of cross-section 300 mm deep and 200 mm wide is prestressed by means of 15 wires of 5 mm diameter located 65 mm from the bottom of the beam and 3 wires of diameter of 5 mm, 25 mm from the top as shown in Figure Q2. State clearly any assumptions used.

(a) Assuming the prestress in the steel is 840 N/mm^2, calculate the stresses at the extreme fibers of the mid-span section when the beam is supporting its own weight over a span of 6 m.

[10.0 Marks]

(b) If a uniformly distributed live load of 6 kN/m is imposed, evaluate the maximum working stress in concrete. The density of concrete is 25 kN/m^3.

[10.0 Marks]

(c) Draw the resultant stress diagram.

[5.0 Marks]

Q3. A 10 m span post tensioned concrete beam with a cross section of 200 x 300 mm (as shown in Figure Q3) is pre-stressed by a cable carrying an initial pre-stressing force of 300 kN. The cross-sectional area of the wires in the cable is 308 mm^2.
Assume $E_s = 210\ kN/mm^2$, $E_c = 30\ kN/mm^2$, $E_{ci} = 28\ kN/mm^2$ and age of concrete at transfer @ 8 days. f_{cu}: 50 MPa, f_{ci}: 40 MPa (8 days),

(a) Identify possible losses in the beam

[5.0 Marks]

(b) Calculate the total percentage loss of stress in the beam.

[12.0 Marks]

(c) Determine effective pre-stressing (*Pe*) force in the beam after all losses and possible Jacking (*Pj*) force for the beam.

[8.0 Marks]

Q4. A reinforced concrete underground water storage sump is to be designed for the new hostel complex in the Faculty of Engineering, Hapugala, Galle. A tank of overall size 10.0 m x 10.0 m x 4.0 m deep is proposed for this purpose with the bottom side of the floor slab at a level of 3.5 m below ground level. The density of soil (moist) is 20 kN/m^3. Active soil pressure coefficient (Ka) is 0.217 and design bearing capacity of soil is about 230 kN/m^2. Assume that thickness of 300 mm for all sump walls including top and bottom slabs. The top slab is free to move with Neoprene pad connection between top roof slab and sump wall.

The following additional information are also available.

Grade of concrete to be used for the water tank: C35A
Density of concrete: 24 kN/m^3
Density of water: 9.81 kN/m^3
Reinforcement steel: Grade 460 (type 2 Deformed bars)
$E_{concrete}$ = 28 GPa and E_{steel} = 200 GPa
Coefficient of thermal expansion of concrete: $10 \times 10^{-6}/^0C$
Fall in temperature between hydration peak and ambient (T_1): 32 ^0C
Fall in temperature due to seasonal variations (T_2): 10 ^0C

a) What is the Grade 35A concrete? Explain the limitations for the design of Grade 35A concrete for the water retaining structures?

[1.0 Mark]

b) Explain briefly the BS8007 recommendations of "Deemed to satisfactory" approach for controlling crack width in water retaining structures.

[1.0 Mark]

c) Explain briefly how you evaluate the stability of the underground water sump against different load combination and practical situations.

[1.0 Mark]

d) Determine the effective length and effective height of the water sump wall.

[1.0 Mark]

e) Determine the stability against flotation if the ground water level is 0.5 m below the ground level, GL. Assume that factor of safety against flotation is 1.15.

[4.0 Marks]

f) Explain briefly two methods on how you can improve the stability against flotation of a water storage sump as shown in Figure Q4.

[2.0 Marks]

g) Calculate moments and shear forces acting on the sump walls under serviceability and ultimate limit states. Clearly state any assumptions you make in finding moments and shear forces.

[2.0 Marks]

h) Calculate the amount of reinforcement required for the sump wall to resist serviceability bending moment and ultimate bending moment due to water pressure. You may assume appropriate values for the diameters of the main and the distribution reinforcements.

[4.0 Marks]

i) Explain briefly how you carried out designing and detailing of movement joints for the sump wall according to BS 8007 recommendation.

[2.0 Marks]

j) Design amount of reinforcements and movement joint spacing to control cracking due to shrinkage and thermal movement in immature concrete in the sump wall. Assuming that type of construction is close movement joint spacing and freedom of movement is allowed to control thermal contraction and restrained shrinkage.

[2.0 Marks]

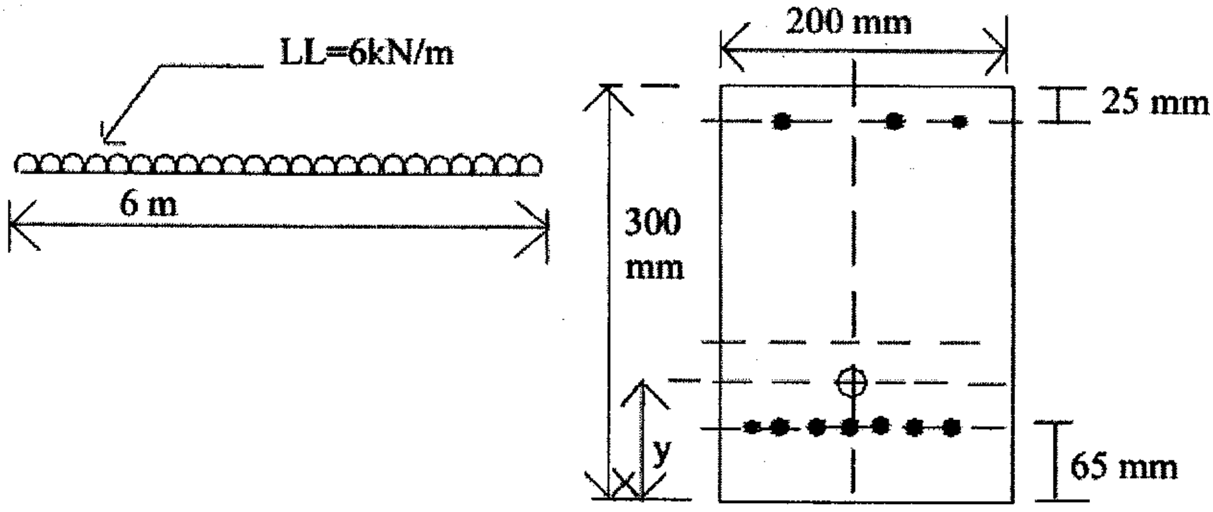


Figure Q2: Cross sectional view

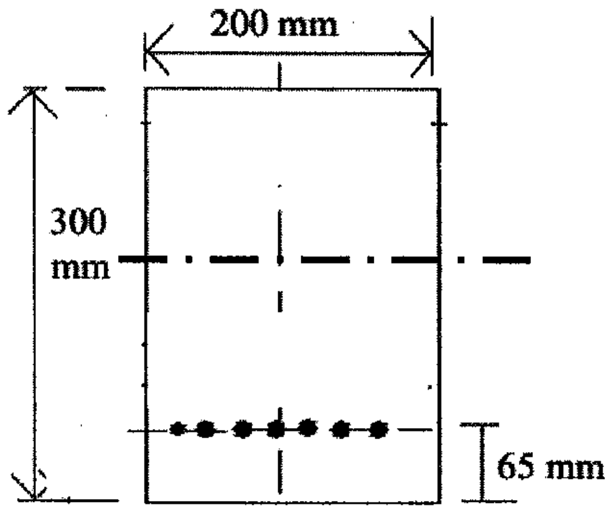


Figure Q3: Cross sectional view

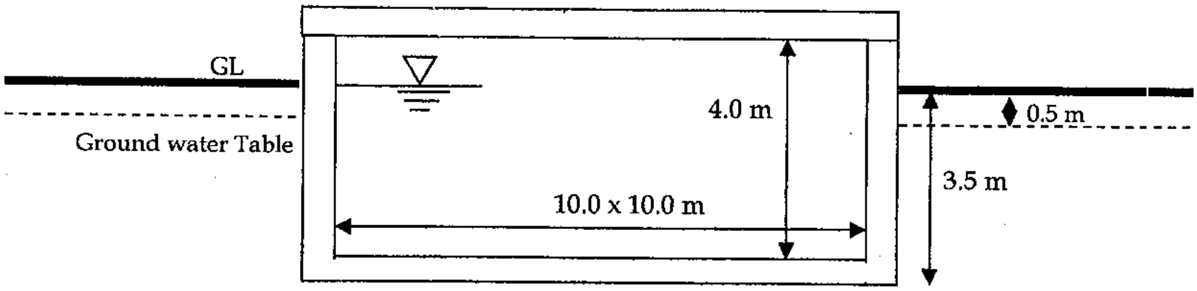


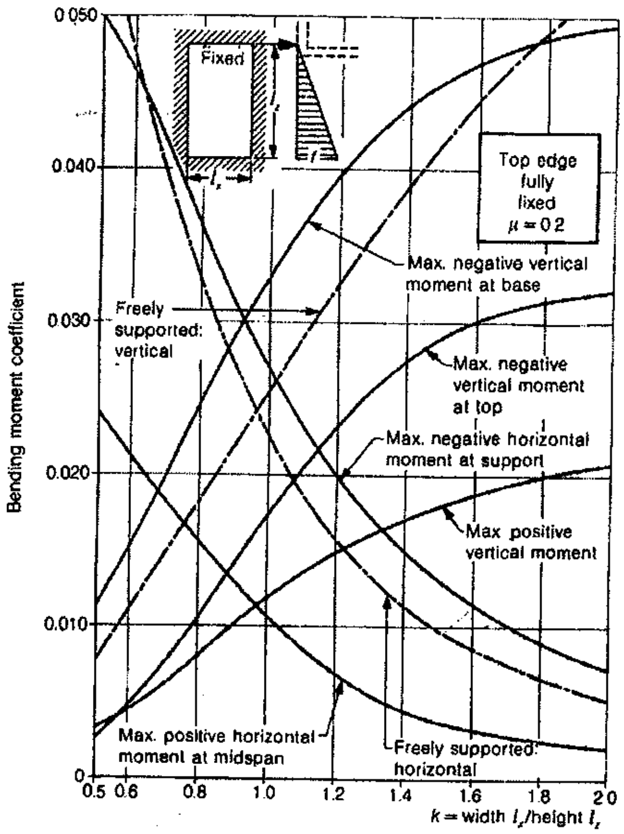
Figure Q4

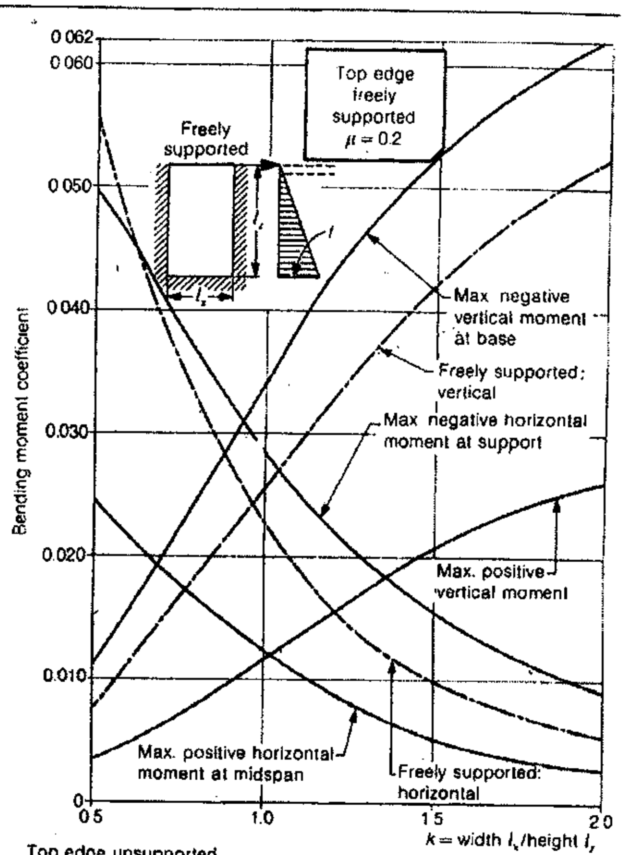
Annex_1_Steel Properties

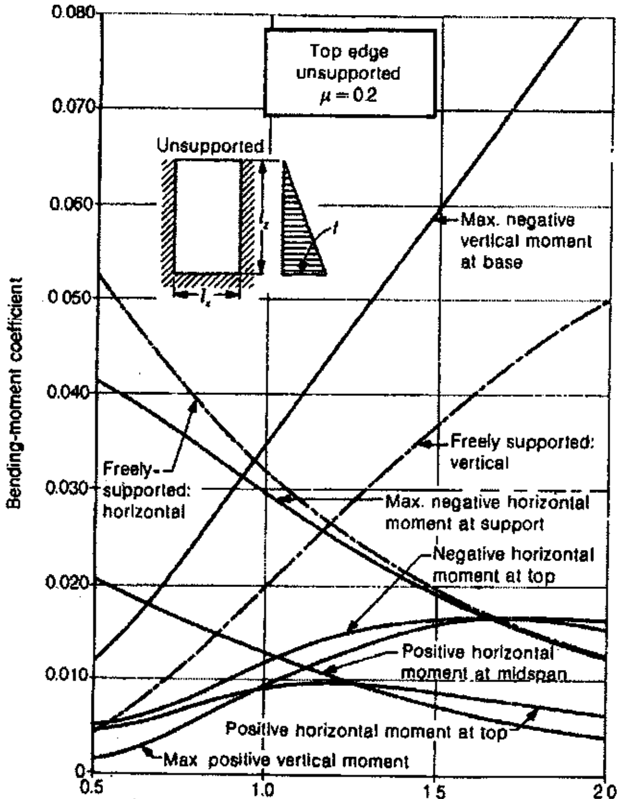
BS	*Type of tendon*	*Nominal diameter and steel area*		*Nominal tensile strength f_{pu}*	*Specified characteristic load (kN)*		Maximum relaxation (%) after 1000 h	
					Breaking load (A)	*0.1% proof load or load at 1% elongation*	*at 70% of A*	*at 80% of A*
	Wire	*mm*	*mm²*	*N/mm²*		*0.1% proof load*		
5896	Cold-drawn steel wire (pre-straightened)	7	38.5	1670	64.3	53.4	Class 1	12
		7		1570	60.4	50.1	8	
		6	28.3	1770	50.1	41.6		4.5
		6		1670	47.3	39.3	Class 2	
		5	19.6	1770	34.7	28.8	2.5	
		5		1670	32.7	27.2		
		4.5	15.9	1620	25.8	21.4		
		4	12.6	1770	22.3	18.5		
		4		1670	21	17.5		

Annex 2

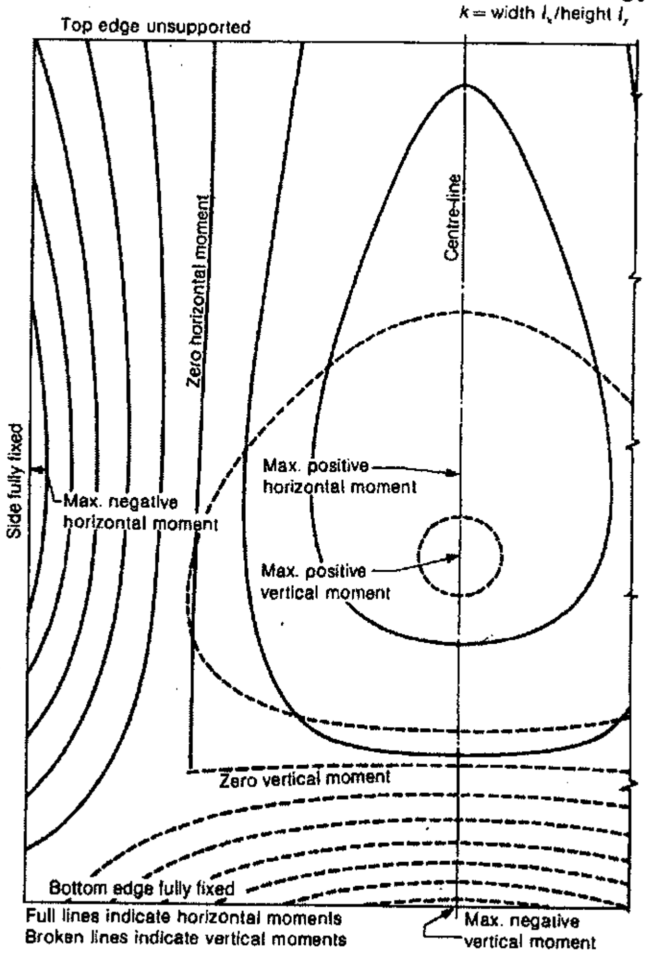
Two-way slabs: triangularly distributed loads: elastic analyses







Vertical span: bending moment $= \text{coefficient} \times f l_z^2$
Horizontal span: bending moment $= \text{coefficient} \times f l_x^2$

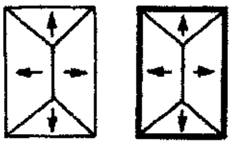


Full lines indicate horizontal moments
Broken lines indicate vertical moments

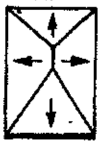
Annex 3

Two-way slabs: rectangular panels: loads on beams: common coefficients

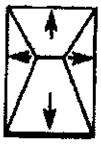
Panels supported along four edges



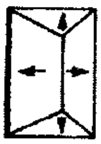
$k > 1$: $R_1 = R_3 = \frac{1}{4}wl_x^2$
$R_2 = R_4 = \frac{1}{2}(k - \frac{1}{2})wl_x^2$
$\alpha = \beta = 1/2k$
$k = 1$: $R_1 = R_2 = R_3 = R_4 = \frac{1}{4}wl_x^2$



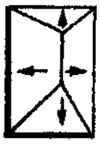
$k \not< 4/3$: $R_1 = \frac{1}{4}wl_x^2$ (min.) $\quad \alpha = 1/2k$ (min.)
$R_2 = R_4 = \frac{1}{2}(k - \frac{2}{3})wl_x^2$
$R_3 = \frac{5}{12}wl_x^2$ (max.) $\quad \beta = 5/6k$ (max.)



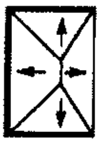
$k \leqslant 4/3$: $R_1 = \frac{3}{5}R_3$ approx. (min.) $\quad \alpha = 3/8$ (min.)
$\beta = 5/8$ (max.)
$R_2 = R_4 = \frac{3}{16}k^2wl_x^2 \quad \psi = \xi = 3k/8$
$R_3 = \frac{5}{8}k(1 - \frac{3}{8}k)wl_x^2$ approx. (max.)



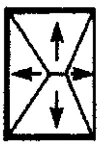
$R_1 = R_3 = \frac{3}{16}wl_x^2$
$R_2 = \frac{3}{5}R_4$ (min.)
$R_4 = \frac{5}{8}(k - \frac{3}{8})wl_x^2$ (max.)
$\alpha = \beta = 3/8k \quad \psi = \frac{5}{8}$ (max.)



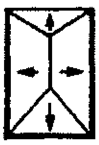
$R_1 = \frac{3}{16}wl_x^2$ (min.) $\quad \alpha = 3/8k$ (min.)
$R_2 = \frac{3}{5}R_4$ (min.) $\quad \beta = 5/8k$ (max.)
$R_3 = \frac{5}{16}wl_x^2$ (max.) $\quad \psi = 5/8$ (max.)
$R_4 = \frac{5}{8}(k - \frac{1}{2})wl_x^2$ (max.)



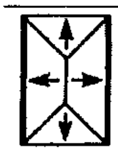
$k \not< 5/4$: $R_1 = R_3 = \frac{5}{16}wl_x^2 \quad \alpha = \beta = 5/8k$
$R_2 = \frac{3}{5}R_4$ (min.) $\quad \psi = 5/8$ (max.)
$R_4 = \frac{5}{8}(k - \frac{5}{8})wl_x^2$ (max.)



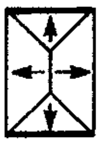
$k \leqslant 5/4$: $R_1 = R_3 = \frac{1}{2}k(1 - \frac{2}{5}k)wl_x^2 \quad \alpha = \beta = 1/2$
$R_2 = \frac{3}{20}k^2wl_x^2$ (min.)
$R_4 = \frac{1}{4}k^2wl_x^2$ (max.) $\quad \psi = k/2$
$\xi = 3k/10$



$R_1 = \frac{3}{20}wl_x^2$ (min.) $\quad \alpha = 3/10k$ (min.)
$R_2 = R_4 = \frac{1}{2}(k - \frac{2}{5})wl_x^2$
$R_3 = \frac{1}{4}wl_x^2$ (max.) $\quad \beta = 1/2k$ (max.)

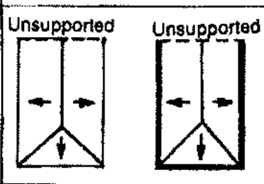


$R_1 = R_3 = \frac{3}{20}wl_x^2$ (min.)
$R_2 = R_4 = \frac{1}{2}(k - \frac{3}{10})wl_x^2$ (max.)
$\alpha = \beta = 3/10k$ (min.)

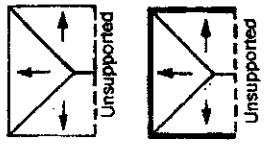


$k \not< 5/3$: $R_1 = R_3 = \frac{5}{12}wl_x^2$ (min.)
$R_2 = R_4 = \frac{1}{2}(k - \frac{5}{6})wl_x^2$ (max.)
$\alpha = \beta = 5/6k$ (min.)

Panels unsupported along one edge

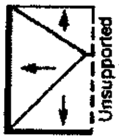


$R_1 = 0$
$R_2 = R_4 = \frac{1}{2}(k - \frac{1}{4})wl_x^2$
$R_3 = \frac{1}{4}wl_x^2$
$\beta = 1/2k$

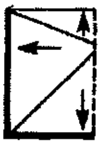


$k \not> 2$: $R_1 = R_3 = \frac{1}{2}k(1 - \frac{1}{4}k)wl_x^2$
$R_2 = 0$
$R_4 = \frac{1}{4}k^2wl_x^2$
$\psi = k/2$

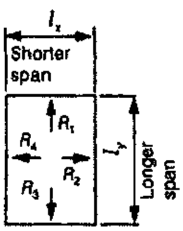
$R_1 = 0 \quad \beta = 5/8k$
$R_2 = \frac{3}{5}R_4$ (min.) $\quad \psi = 5/8$
$R_3 = \frac{5}{16}wl_x^2$
$R_4 = \frac{5}{8}(k - \frac{5}{16})wl_x^2$ (max.)



$k \not> 8/5$: $R_1 = \frac{3}{5}R_3$ (min.) $\quad R_2 = 0$
$R_3 = \frac{5}{8}k(1 - \frac{5}{16}k)wl_x^2$ (max.)
$R_4 = \frac{5}{16}k^2wl_x^2 \quad \alpha = 3/8k$ (min.)
$\psi = 5k/8$ (max.)



$k \geqslant 8/5$: $R_1 = \frac{3}{10}wl_x^2$ (min.) $\quad R_2 = 0$
$R_3 = \frac{1}{2}wl_x^2$
$R_4 = (k - \frac{4}{5})wl_x^2$ (max.)
$\alpha = 3/5k \quad \beta = 1/k$



$$k = \frac{l_y}{l_x} = \frac{\text{longer span}}{\text{shorter span}}$$

w = intensity of uniformly distributed service load per unit area

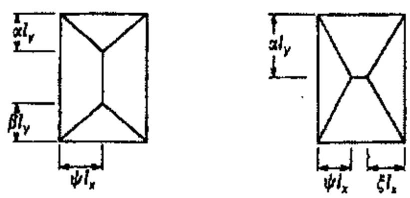
If analysis due to ultimate loads is undertaken, substitute n for w in appropriate formulae

R_1, R_2, R_3, R_4 = total load carried by each support of panel

Condition of supports

- - - - - - - no support
———— freely support
━━━━ continuity or fixity

Loads marked (min.) apply if panel is entirely freely supported along edge indicated: if partially restrained, load will be slightly greater than given and load marked (max.) on opposite edge will be correspondingly reduced.



Annex 4

Reinforcement: metric bar data

		Bar size in millimetres									
		6	8	10	12	16	20	25	32	40	50
Cross-sectional areas of bars at specific spacings	Bar spacing in millimetres (non-preferred spacings shown in italics)										
	75	376	670	1047	1507	2680	4188	6544	—	—	—
	80	*353*	*628*	*981*	*1413*	*2513*	*3926*	*6135*	—	—	—
	90	*314*	*558*	*872*	*1256*	*2234*	*3490*	*5454*	—	—	—
	100	282	502	785	1130	2010	3141	4908	8042	—	—
	110	*257*	*456*	*713*	*1028*	*1827*	*2855*	*4462*	*7311*	—	—
	120	*235*	*418*	*654*	*942*	*1675*	*2617*	*4090*	*6702*	*10471*	—
	125	226	402	628	904	1608	2513	3926	6433	10053	—
	130	*217*	*386*	*604*	*869*	*1546*	*2416*	*3775*	*6186*	*9666*	—
	140	*201*	*359*	*560*	*807*	*1436*	*2243*	*3506*	*5744*	*8975*	—
	150	188	335	523	753	1340	2094	3272	5361	8377	13090
	160	*176*	*314*	*490*	*706*	*1256*	*1963*	*3067*	*5026*	*7853*	*12272*
	175	161	287	448	646	1148	1795	2804	4595	7180	11220
	180	*157*	*279*	*436*	*628*	*1117*	*1745*	*2727*	*4468*	*6981*	*10908*
	200	141	251	392	565	1005	1570	2454	4021	6283	9817
	220	*128*	*228*	*356*	*514*	*913*	*1427*	*2231*	*3655*	*5711*	*8925*
	225	125	223	349	502	893	1396	2181	3574	5585	8727
	240	*117*	*209*	*327*	*471*	*837*	*1308*	*2045*	*3351*	*5235*	*8181*
	250	113	201	314	452	804	1256	1963	3216	5026	7854
	275	102	182	285	411	731	1142	1784	2924	4569	7140
	300	94	167	261	376	670	1047	1636	2680	4188	6545
	Number of bars										
	1	28.3	50.3	78.5	113.1	201.1	314.2	490.9	804.2	1257	1963
	2	56.5	100.5	157.1	226.2	402.1	628.3	981.7	1608	2513	3927
	3	84.8	150.8	235.6	339.3	603.2	942.5	1473	2413	3770	5890
	4	113.1	201.1	314.2	452.4	804.2	1257	1963	3217	5027	7854
	5	141.4	251.3	392.7	565.5	1005	1571	2454	4021	6283	9817
	6	169.6	301.6	471.2	678.6	1206	1885	2945	4825	7540	11781
	7	197.9	351.9	549.8	791.7	1407	2199	3436	5630	8796	13744
	8	226.2	402.1	628.3	904.8	1608	2513	3927	6434	10053	15708
	9	254.5	452.4	706.9	1018	1810	2827	4418	7238	11310	17671
	10	282.7	502.7	785.4	1131	2011	3142	4909	8042	12566	19635
	11	311.0	552.9	863.9	1244	2212	3456	5400	8847	13823	21598
	12	339.3	603.2	942.5	1357	2413	3770	5890	9651	15080	23562
	13	367.6	653.5	1021	1470	2614	4084	6381	10455	16336	25525
	14	395.8	703.7	1100	1583	2815	4398	6872	11259	17593	27489
	15	424.1	754.0	1178	1696	3016	4712	7363	12064	18850	29452
	16	452.4	804.2	1257	1810	3217	5027	7854	12868	20106	31416
	17	480.7	854.5	1335	1923	3418	5341	8345	13672	21363	33379
	18	508.9	904.8	1414	2036	3619	5655	8836	14476	22619	35343
	19	537.2	955.0	1492	2149	3820	5969	9327	15281	23876	37306
	20	565.5	1005	1571	2262	4021	6283	9817	16085	25133	39270
Perimeters of specific numbers of bars	Number of bars										
	1	18.8	25.1	31.4	37.6	50.2	62.8	78.5	100.5	125.6	157.1
	2	37.6	50.2	62.8	75.3	100.5	125.6	157.0	201.0	251.3	314.2
	3	56.5	75.3	94.2	113.0	150.7	188.4	235.6	301.5	376.9	471.2
	4	75.3	100.5	125.6	150.7	201.0	251.3	314.1	402.1	502.6	628.3
	5	94.2	125.6	157.0	188.4	251.3	314.1	392.6	502.6	628.3	785.4
	6	113.0	150.7	188.4	226.1	301.5	376.9	471.2	603.1	753.9	942.5
	7	131.9	175.9	219.9	263.8	351.8	439.8	549.7	703.7	879.6	1100
	8	150.7	201.0	251.3	301.5	402.1	502.6	628.3	804.2	1005	1257
	9	169.6	226.1	282.7	339.2	452.3	565.4	706.8	904.7	1130	1414
	10	188.4	251.3	314.1	376.9	502.6	628.3	785.3	1005	1256	1571

Areas are given in square millimetres: perimeters in millimetres.
For additional notes see *Table 89*.

Annex 5

Design data for singly-reinforced sections: SI units

Modular ratio **118**