

## 4.5 COMPOSITE STEEL AND CONCRETE

### 4.5.1 RULES OF THUMB

- **Typical starting point**

Overall concrete depth           130mm (Grade 30)  
 Depth of profiled decking       60mm  
 Size beam with  $Z = (Z \text{ for non-composite beam}) \times F$  where  $F = 1.6 - 2.0$

- **Typical maximum slab spans (m)<sup>1</sup>**

Figures based on:           "Ribdeck AL" (Richard Lees Ltd)  
 Imposed load of  $4+1 \text{ kN/m}^2$  (unfactored)  
 (including floor, ceiling and services =  $6.7 \text{ kN/m}^2$ )  
 Unpropped  
 For other profiles see section D2

Decking gauge	Slab depth (mm)	Lightweight concrete		Normal Weight Concrete	
		Simply Supported	Continuous	Simply Supported	Continuous
0.9 (A142 mesh)	130	2.95	3.11	2.78	3.03
	150	2.88	3.22	2.66	3.00
1.2 (A193 mesh)	130	3.20	3.73	3.02	3.55
	150	3.08	3.62	2.89	3.41

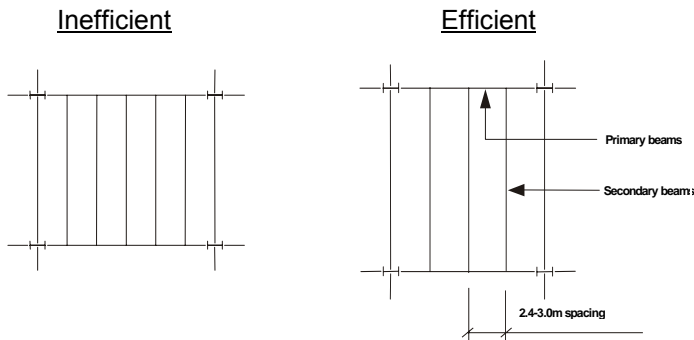
Design assumes 60 minute fire resistance, provided that the slab is continuous (decking need not be)

- **Choice of beam system**

Scheme	Likely span range (m)		Economic and practical maximum ratios of span to structural depth		Accommodation of major services. Maximum x-sectional area for 15m span $\text{m}^2$	Estimated unit cost index for fabricated and erected steelwork
	As primary beams	As secondary beams				
Simple construction with rolled sections	6-10.5	8-18	20 28		1.7 -	1.0 1.3 with reinforced openings
Fabricated sections	Above 12	Above 12	15 25		1.9 0.9	1.2
Haunched Beams	Above 12	Above 12	25 (support) 32(midspan)		5.3 3.6	1.3
Parallel Beam approach	Spans up to 10.5	Ribs up to 15	21 30	14 18	5.0 2.8	0.9
Castellated sections	N/A	up to 16	17 20		1.5 1.3	1.3
Stub girders	10-15	N/A	13 16		3.0 2.5	1.4
Composite trusses	Above 12	Above 12	12 16		1.5 1.0	1.5
Slimfloor	-	4.5 to 9	20		-	
Slimdek	-	5 to 7	-		-	

4.5.1 RULES OF THUMB (CONT'D)

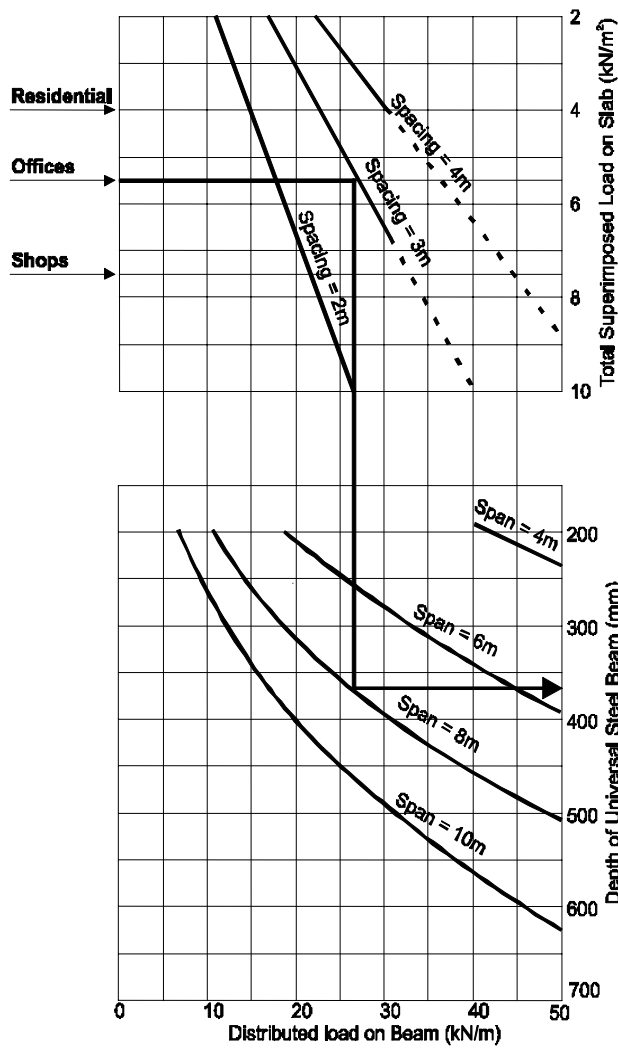
- Preferred beam layout<sup>2</sup>



For maximum structural efficiency:

$$\frac{L_{\text{secondary}}}{L_{\text{primary}}} = 4/3$$

- Initial scheming chart  
 Universal beams, 125mm concrete slab  
 (Dotted Line on upper graph indicates that a 150mm slab may be required).



## 4.5.1 RULES OF THUMB (CONT'D)

## Fabricated beams

Castellated cellular beams (not very good for point loads):

Span/depth < 20

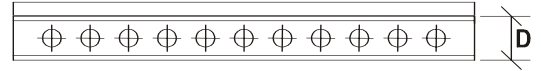
Castellated beams, hole =  $0.67D$

centres =  $0.72D$

Cellular beams holes diameter =  $0.6D - 0.8D$

centres =  $1.1 - 1.5$

diameter



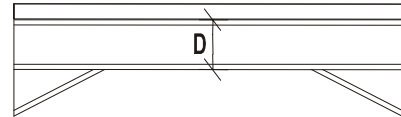
Haunched beams (use as part of frame action):

$D$  = midspan depth

Span/depth  $\leq 35$  (span/depth including slab =  $26 - 28$ )

Maximum overall depth at haunch =  $2D$

Haunch length typically 7 - 10% of span

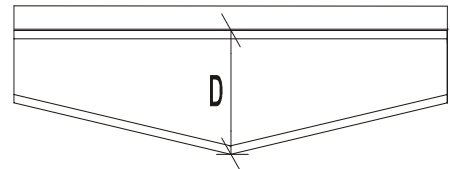


Tapered beams:

$D$  = midspan depth

Span/depth 15 - 25

Depth at support =  $0.5D$  or maximum taper of 6 degrees



- **Openings in beams (non-seismic applications)**

Geometrical constraints :

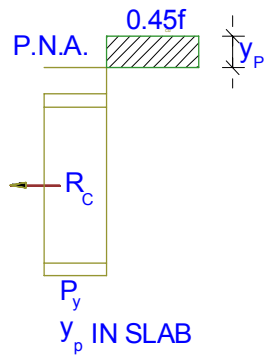
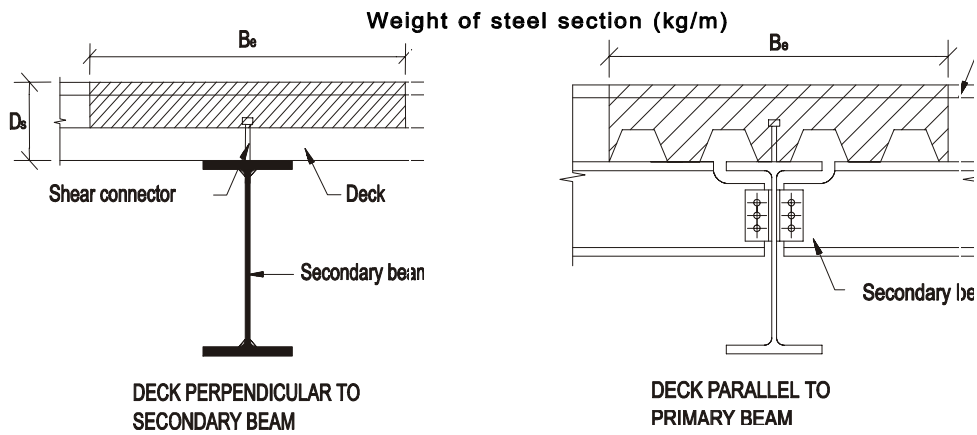
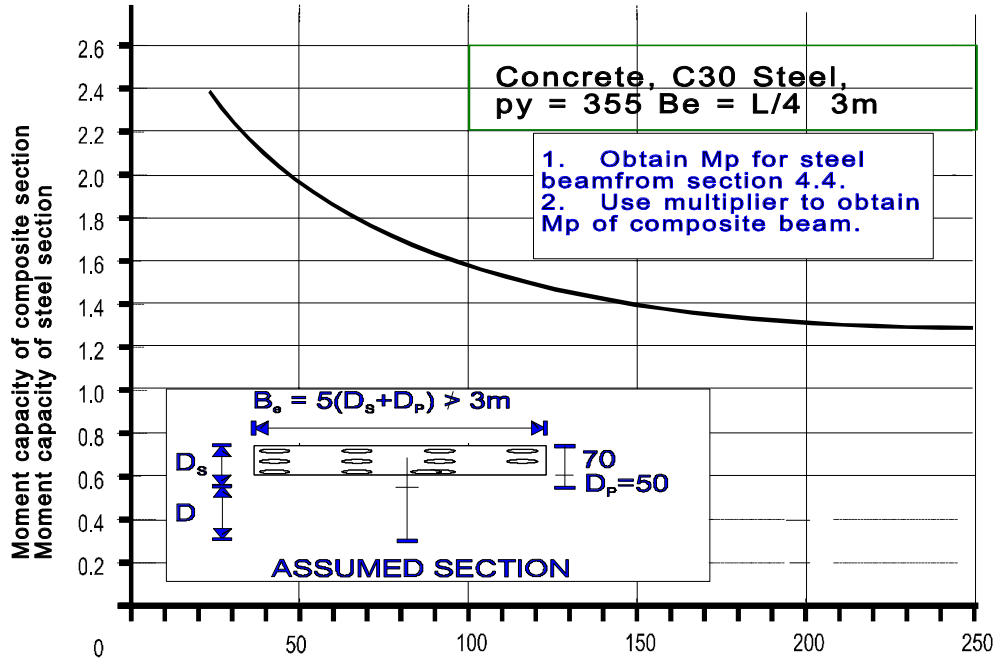
- Limit unstiffened openings to  $0.6D$  depth by  $1.5D$  length
- Limit stiffened openings to  $0.7D$  depth by  $2D$  length
- Space >  $D$  apart
- Ideally positioned between  $L/5$  and  $L/3$  from support for beams with UDL
- Position >  $D$  from any point load
- Position >  $2D$  (or  $L/10$ ) from support
- Openings should ideally be located mid-height. If not, the depths of the upper and lower sections of web should not differ by more than a factor of 2.

4.5.2 LOAD FACTORS

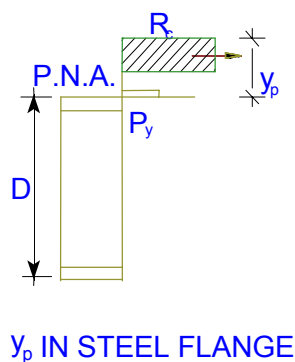
As for non-composite steel (see section 4.4.2)

4.5.3 BENDING RESISTANCE (composite condition)<sup>3</sup>

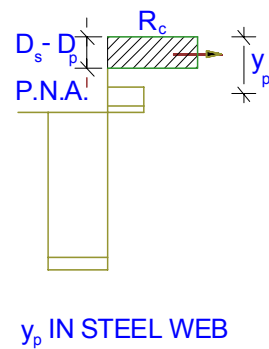
- Approximate moment resistance calculation



Case (c)



Case (b)



Case(c)

**Bending Resistance Formulae** (Assuming 100% interaction)

$$R_s = p_y A$$

$$R_c = 0.45 f_{cu} (D_s - D_p) B_e$$

$$B_e = 0.25 L \not\geq \text{beam spacing}$$

- CASE (a) :  $R_c > R_s$  (P.N.A. in concrete slab)

$$M_{pc} = R_s \left[ \frac{D}{2} + D_s - \frac{R_s}{R_c} \left( \frac{D_s - D_p}{2} \right) \right]$$

- CASE (b) :  $R_s > R_c > R_w$  (P.N.A. in steel flange)

$$M_{pc} = R_s \frac{D}{2} + R_c \left( \frac{D_s + D_p}{2} \right) - \frac{(R_s - R_c)^2 T}{R_f 4}$$

where  $T$  = flange thickness

$R_f$  = axial capacity of **one** steel flange

- CASE (c) :  $R_c < R_w$  (P.N.A. lies in web)

$$M_{pc} = M_s + R_c \left( \frac{D_s + D_p + D}{2} \right) - \frac{R_c^2 D}{R_w 4}$$

where  $M_s$  = plastic capacity of steel section

$R_w$  = axial resistance of web only

**4.5.4 SHEAR CONNECTORS<sup>4</sup>**

Design strength of headed studs in normal weight concrete (kN)

Dimensions of stud shear connectors (mm)			Design strength of concrete (N/mm <sup>2</sup> )			
Diameter	Nominal height	As-welded height	25	30	35	40
25	100	95	117	123	129	134
22	100	95	95	101	106	111
19	100	95	76	80	83	87
19	75	70	66	70	73	77
16	75	70	56	59	62	66
13	65	60	35	38	39	42

For concrete of characteristic strength greater than 40 N/mm<sup>2</sup> use the values for 40 N/mm<sup>2</sup>.  
For connectors of heights greater than tabulated use the values for the greatest height tabulated.

$$r_{con} = 0.9 \text{ for lightweight concrete}$$

$$r_{con} = 1.0 \text{ for normal weight concrete}$$

$$r_{profile} = \frac{0.85 b_a (h - D_p)}{\sqrt{N} D_p D_p} \quad \begin{matrix} \text{min } 0.8 (N = 2) \\ \text{min } 0.6 (N = 3) \end{matrix}$$

$N$  = no studs/trough  
 $h$  = stud height  
 $b_a$  = average trough width  
 $D_p$  = depth profile

Design resistance = Design strength x  $r_{con}$  x  $r_{profile}$

- **Spacing**

$$\begin{matrix} \text{Minimum longitudinal} & = 6\phi \\ \text{transverse} & = 4\phi \end{matrix}$$

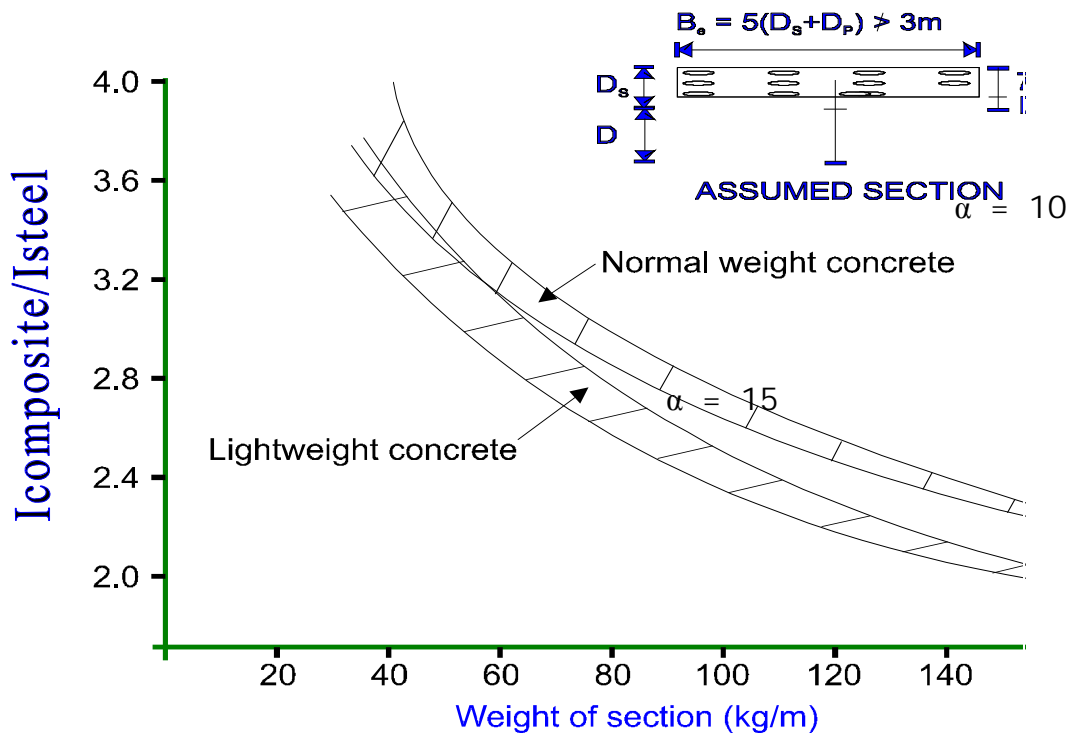
$$\text{Maximum longitudinal} = 600\text{mm}$$

4.5.5 BENDING STRENGTH (DURING CONSTRUCTION)

- Conform with requirements in section 4.4 for non-composite sections.
- Decking perpendicular to beam (secondary) provides restraint to top flange.
- Decking parallel to beam (primary) does not provide restraint.

4.5.6 STIFFNESS<sup>3</sup>

Approximate ratio of second moment of area of composite section to that of the steel section.



## 4.5.7 SAFE LOAD TABLES

<b>Concrete grade</b>	C35
<b>Modular ratio</b>	15
<b>Overall concrete depth</b>	130 mm
<b>Depth of decking</b>	60 mm
<b>Partial interaction</b>	60%
<b>Flange width</b>	as large as possible
<b>Deflection limit</b>	DL : 1/200      LL : 1/350
<b>Dead Load</b>	steelwork            - self weight decking              - 0.18 kPa slab (dense)        - 3.12 kPa slab (lightweight) - 2.34 kPa services + ceiling - 1.00 kPa

## 4.5.8 REFERENCES

1. RICHARD LEES Ltd, Steel Deck Flooring Systems
2. STEEL CONSTRUCTION INSTITUTE, Steel Designers Manual
3. STEEL CONSTRUCTION INSTITUTE, SCI-P-055 Design of Composite Slabs and Beams with Steel Decking
4. BS 5950 Structural use of steelwork in building Part 3: Design in composite construction

**SAFE LOAD TABLES (1)**  
**GRADE 43 - DENSE CONCRETE SLAB**  
 Imposed load = 4.0 + 1.0 kN/m<sup>2</sup>

Bay size (m x m)	No. sec. Beams per grid	Spacing of sec. beams	Minimum Weight			Minimum Depth		
			Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )	Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )
6.0 x 7.2	2	3.00	305 x 127 x 39	457 x 152 x 52	20.22	203 x 203 x 60	254 x 254 x 107	34.86
6.0 x 7.5	2	3.00	356 x 127 x 39	457 x 152 x 60	21.00	203 x 203 x 71	254 x 254 x 107	37.93
6.0 x 8.0	2	3.00	406 x 140 x 39	457 x 152 x 60	20.50	203 x 203 x 86	254 x 254 x 132	45.17
6.0 x 9.0	2	3.00	457 x 152 x 52	457 x 191 x 74	25.56	254 x 254 x 89	254 x 254 x 132	44.33
6.0 x 10.0	2	3.00	457 x 152 x 60	533 x 210 x 82	28.20	254 x 254 x 107	254 x 254 x 167	52.37
6.0 x 12.0	2	3.00	533 x 210 x 82	533 x 210 x 92	35.00	254 x 254 x 167*	305 x 305 x 158	68.83
6.0 x 15.0	2	3.00	610 x 229 x 113 *	610 x 229 x 101	44.40	305 x 305 x 240*	305 x 305 x 198	93.20
6.0 x 18.0	2	3.00	762 x 267 x 147 *	610 x 229 x 125	55.94	356 x 406 x 340*	305 x 305 x 240	126.67
7.2 x 6.0	3	2.40	305 x 102 x 25	457 x 152 x 60	20.42	152 x 152 x 37	254 x 254 x 107	33.25
7.2 x 7.2	3	2.40	305 x 102 x 33	457 x 152 x 67	23.06	203 x 203 x 46	254 x 254 x 132	37.50
7.2 x 9.0	3	2.40	356 x 171 x 45	533 x 210 x 82	27.86	203 x 203 x 71	254 x 254 x 167	48.14
7.2 x 12.0	3	2.40	457 x 152 x 67	610 x 229 x 101	36.33	254 x 254 x 132*	305 x 305 x 198	71.50
7.2 x 18.0	3	2.40	686 x 254 x 125 *	762 x 267 x 147	60.25	356 x 406 x 287*	356 x 406 x 287	135.53
7.5 x 6.0	3	2.50	305 x 102 x 25	457 x 152 x 60	20.00	203 x 203 x 46	254 x 254 x 132	40.40
7.5 x 7.5	3	2.50	356 x 127 x 33	533 x 210 x 82	24.13	203 x 203 x 52	254 x 254 x 167	43.07
7.5 x 9.0	3	2.50	356 x 171 x 45	533 x 210 x 92	28.22	203 x 203 x 86	305 x 305 x 158	51.96
7.5 x 12.0	3	2.50	457 x 152 x 67	610 x 229 x 113	36.22	254 x 254 x 132*	305 x 305 x 240	72.80
7.5 x 15.0	3	2.50	610 x 229 x 101	686 x 254 x 125	48.73	305 x 305 x 198*	305 x 305 x 283	98.07
7.5 x 18.0	3	2.50	686 x 254 x 140 *	762 x 267 x 147	64.17	356 x 406 x 287*	356 x 406 x 340	133.69
8.0 x 6.0	3	2.67	305 x 102 x 25	457 x 152 x 74	21.71	203 x 203 x 46	254 x 254 x 132	39.25
8.0 x 8.0	3	2.67	356 x 127 x 39	533 x 210 x 82	24.88	203 x 203 x 71	305 x 305 x 158	46.38
8.0 x 9.0	3	2.67	406 x 140 x 46	610 x 229 x 101	28.47	203 x 203 x 86	305 x 305 x 198	54.25
8.0 x 10.0	3	2.67	457 x 152 x 52	610 x 229 x 101	29.60	254 x 254 x 89	305 x 305 x 198	53.18
8.0 x 12.0	3	2.67	457 x 191 x 74	610 x 229 x 125	38.17	254 x 254 x 132*	305 x 305 x 240	69.50
8.0 x 15.0	3	2.67	610 x 229 x 101	762 x 267 x 147	47.68	305 x 305 x 198*	356 x 406 x 287	93.38
8.0 x 18.0	3	2.67	686 x 254 x 140 *	762 x 267 x 173	62.11	356 x 406 x 287*	356 x 406 x 393	129.46
9.0 x 6.0	3	3.00	305 x 102 x 28	533 x 210 x 82	23.00	203 x 203 x 46	254 x 254 x 167	43.17
9.0 x 7.2	3	3.00	356 x 127 x 39	610 x 229 x 101	27.03	203 x 203 x 60	305 x 305 x 198	47.50
9.0 x 7.5	3	3.00	356 x 127 x 39	610 x 229 x 101	26.47	203 x 203 x 71	305 x 305 x 198	50.07
9.0 x 8.0	3	3.00	406 x 140 x 39	610 x 229 x 101	25.63	203 x 203 x 86	305 x 305 x 198	53.42
9.0 x 9.0	3	3.00	457 x 152 x 52	610 x 229 x 113	29.89	254 x 254 x 89	305 x 305 x 240	56.33
9.0 x 10.0	3	3.00	457 x 152 x 60	610 x 229 x 125	32.50	254 x 254 x 107	305 x 305 x 240	59.67
9.0 x 12.0	3	3.00	533 x 210 x 82	686 x 254 x 140	39.00	254 x 254 x 167*	356 x 406 x 287	79.58
9.0 x 15.0	3	3.00	610 x 229 x 113 *	762 x 267 x 173	49.20	305 x 305 x 240*	356 x 406 x 393	106.20
9.0 x 18.0	3	3.00	762 x 267 x 147 *	838 x 292 x 194	59.78	356 x 406 x 340*	COLCORE x 477	139.83
10.0 x 6.0	4	2.50	305 x 102 x 25	610 x 229 x 101	26.83	203 x 203 x 46	305 x 305 x 198	51.40
10.0 x 8.0	4	2.50	356 x 127 x 39	686 x 254 x 140	33.10	203 x 203 x 71	356 x 406 x 287	64.28
10.0 x 9.0	4	2.50	356 x 171 x 45	762 x 267 x 147	34.33	203 x 203 x 86	356 x 406 x 287	66.29
10.0 x 10.0	4	2.50	457 x 152 x 52	762 x 267 x 147	35.50	254 x 254 x 89	356 x 406 x 340	69.60
10.0 x 12.0	4	2.50	457 x 152 x 67	838 x 292 x 176	41.47	254 x 254 x 132*	356 x 406 x 393	85.55
10.0 x 15.0	4	2.50	610 x 229 x 101	914 x 305 x 201	53.80	305 x 305 x 198*	356 x 406 x 551	115.93
10.0 x 18.0	4	2.50	686 x 254 x 140 *	914 x 305 x 253	70.06	356 x 406 x 287*	356 x 406 x 634	150.02
12.0 x 6.0	4	3.00	305 x 102 x 28	686 x 254 x 140	32.67	203 x 203 x 46	406 x 406 x 287	63.17
12.0 x 7.2	4	3.00	356 x 127 x 39	686 x 254 x 170	36.61	203 x 203 x 60	356 x 406 x 340	67.22
12.0 x 7.5	4	3.00	356 x 127 x 39	762 x 267 x 173	36.07	203 x 203 x 71	356 x 406 x 393	76.07
12.0 x 8.0	4	3.00	406 x 140 x 39	762 x 267 x 173	34.63	203 x 203 x 86	356 x 406 x 393	77.79
12.0 x 9.0	4	3.00	457 x 152 x 52	838 x 292 x 194	38.89	254 x 254 x 89	COLCORE x 477	82.67
12.0 x 10.0	4	3.00	457 x 152 x 60	914 x 305 x 201	40.10	254 x 254 x 107	356 x 406 x 467	82.37
12.0 x 12.0	4	3.00	533 x 210 x 82	914 x 305 x 224	46.00	254 x 254 x 167*	356 x 406 x 551	101.58
12.0 x 15.0	4	3.00	610 x 229 x 113 *	914 x 305 x 289	56.93	305 x 305 x 240*	914 x 419 x 343	102.87
12.0 x 18.0	4	3.00	762 x 267 x 147 *	914 x 419 x 388	70.56	356 x 406 x 340*	914 x 419 x 388	134.89
15.0 x 6.0	5	3.00	305 x 102 x 28	838 x 292 x 176	38.67	203 x 203 x 46	COLCORE x 477*	94.83
15.0 x 7.5	5	3.00	356 x 127 x 39	914 x 305 x 224	42.87	203 x 203 x 71	356 x 406 x 551	97.13
15.0 x 8.0	5	3.00	406 x 140 x 39	914 x 305 x 224	41.00	203 x 203 x 86	356 x 406 x 551	97.54
15.0 x 9.0	5	3.00	457 x 152 x 52	914 x 305 x 253	45.44	254 x 254 x 89	356 x 406 x 634*	100.11
15.0 x 10.0	5	3.00	457 x 152 x 60	914 x 305 x 289	48.90	254 x 254 x 107	914 x 305 x 289*	64.57
15.0 x 12.0	5	3.00	533 x 210 x 82	914 x 419 x 343 *	55.92	254 x 254 x 167*	914 x 419 x 388*	88.00
15.0 x 15.0	5	3.00	610 x 229 x 113 *	FAIL		305 x 305 x 240*	FAIL	
15.0 x 18.0	5	3.00	762 x 267 x 147 *	FAI L		356 x 406 x 340*	FAIL	
18.0 x 6.0	6	3.00	305 x 102 x 28	914 x 305 x 253 *	51.50	203 x 203 x 46	356 x 406 x 634*	121.00
18.0 x 7.2	6	3.00	356 x 127 x 39	914 x 419 x 343 *	60.64	203 x 203 x 60	914 x 419 x 343*	67.64
18.0 x 7.5	6	3.00	356 x 127 x 39	914 x 419 x 343 *	58.73	203 x 203 x 71	914 x 419 x 343*	69.40
18.0 x 8.0	6	3.00	406 x 140 x 39	914 x 419 x 343 *	55.88	203 x 203 x 86	914 x 419 x 388*	77.17
18.0 x 9.0	6	3.00	457 x 152 x 52	FAIL		254 x 254 x 89	FAIL	
18.0 x 10.0	6	3.00	457 x 152 x 60	FAIL		254 x 254 x 107	FAIL	
18.0 x 12.0	6	3.00	533 x 210 x 82	FAIL		254 x 254 x 167*	FAIL	
18.0 x 15.0	6	3.00	610 x 229 x 113 *	FAIL		305 x 305 x 240*	FAIL	
18.0 x 18.0	6	3.00	762 x 267 x 347 *	FAIL		356 x 406 x 340*	FAIL	

(\*) Natural frequency of the beam is less than 4.5Hz.





## 4.5 Composite Steel and Concrete (9/11)

### SAFE LOAD TABLES (2) GRADE 43 - LIGHTWEIGHT CONCRETE SLAB Imposed load = 4.0 + 1.0 kN/m<sup>2</sup>

Bay size (m x m)	No. sec. beams per grid	Spacing of sec. beams	Minimum Weight			Minimum Depth		
			Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )	Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )
6.0 x 6.0	2	3.00	305 x 102 x 25	406 x 140 x 46	16.00	203 x 203 x 46	203 x 203 x 86	29.67
6.0 x 7.2	2	3.00	356 x 127 x 33	457 x 152 x 52	18.22	203 x 203 x 52	254 x 254 x 89	29.69
6.0 x 7.5	2	3.00	305 x 102 x 37	457 x 152 x 52	19.27	203 x 203 x 60	254 x 254 x 107	34.27
6.0 x 8.0	2	3.00	356 x 127 x 39	457 x 152 x 60	20.50	203 x 203 x 71	254 x 254 x 107	37.04
6.0 x 9.0	2	3.00	406 x 140 x 46	457 x 152 x 67	22.78	203 x 203 x 86	254 x 254 x 132	43.33
6.0 x 10.0	2	3.00	457 x 152 x 52	457 x 191 x 74	24.73	254 x 254 x 107	254 x 254 x 132	48.87
6.0 x 12.0	2	3.00	457 x 191 x 74	533 x 210 x 82	31.50	254 x 254 x 167	254 x 254 x 167	69.58
6.0 x 15.0	2	3.00	610 x 229 x 101	610 x 229 x 101	40.40	305 x 305 x 198*	305 x 305 x 198	79.20
6.0 x 18.0	2	3.00	686 x 254 x 140*	610 x 229 x 113	52.94	356 x 406 x 340*	305 x 305 x 240	126.67
7.2 x 6.0	3	2.40	254 x 102 x 22	457 x 152 x 52	17.83	152 x 152 x 37	254 x 254 x 107	33.25
7.2 x 7.2	3	2.40	305 x 102 x 28	457 x 152 x 67	20.97	203 x 203 x 46	254 x 254 x 132	37.50
7.2 x 9.0	3	2.40	356 x 127 x 39	533 x 210 x 82	25.36	203 x 203 x 71	254 x 254 x 167	48.14
7.2 x 12.0	3	2.40	457 x 152 x 60	610 x 229 x 101	33.42	254 x 254 x 107	305 x 305 x 198	61.08
7.2 x 18.0	3	2.40	610 x 229 x 125*	686 x 254 x 140	59.86	356 x 406 x 287*	305 x 305 x 287	135.53
7.5 x 6.0	3	2.50	305 x 102 x 25	457 x 152 x 60	20.00	152 x 152 x 37	254 x 254 x 107	32.63
7.5 x 7.5	3	2.50	305 x 102 x 33	457 x 191 x 74	23.07	203 x 203 x 46	254 x 254 x 132	36.00
7.5 x 9.0	3	2.50	406 x 140 x 39	533 x 210 x 82	24.71	203 x 203 x 71	254 x 254 x 167	46.96
7.5 x 12.0	3	2.50	457 x 152 x 60	610 x 229 x 101	32.42	254 x 254 x 132	305 x 305 x 198	69.30
7.5 x 15.0	3	2.50	533 x 210 x 92	610 x 229 x 125	45.13	305 x 305 x 198*	305 x 305 x 283	98.07
7.5 x 18.0	3	2.50	610 x 229 x 125*	762 x 267 x 147	58.17	356 x 406 x 287*	356 x 406 x 287	130.74
8.0 x 6.0	3	2.67	305 x 102 x 25	457 x 152 x 67	20.54	152 x 152 x 37	254 x 254 x 132	35.88
8.0 x 8.0	3	2.67	356 x 127 x 39	533 x 210 x 82	24.88	203 x 203 x 60	254 x 254 x 167	43.38
8.0 x 9.0	3	2.67	406 x 140 x 39	533 x 210 x 92	24.85	203 x 203 x 86	305 x 305 x 158	49.81
8.0 x 10.0	3	2.67	457 x 152 x 52	610 x 229 x 101	29.60	254 x 254 x 89	305 x 305 x 198	53.18
8.0 x 12.0	3	2.67	457 x 152 x 67	610 x 229 x 113	34.54	254 x 254 x 132	305 x 305 x 240	69.50
8.0 x 15.0	3	2.67	610 x 229 x 101	686 x 254 x 140	47.21	305 x 305 x 198*	356 x 406 x 287	93.38
8.0 x 18.0	3	2.67	686 x 254 x 125*	686 x 254 x 170	56.32	356 x 406 x 287*	356 x 406 x 340	126.51
9.0 x 6.0	3	3.00	305 x 102 x 25	533 x 210 x 82	22.00	203 x 203 x 46	254 x 254 x 167	43.17
9.0 x 7.2	3	3.00	356 x 127 x 33	533 x 210 x 92	23.78	203 x 203 x 52	305 x 305 x 158	39.28
9.0 x 7.5	3	3.00	305 x 102 x 37	533 x 210 x 92	24.60	203 x 203 x 60	305 x 305 x 198	46.40
9.0 x 8.0	3	3.00	356 x 127 x 39	610 x 229 x 101	25.63	203 x 203 x 71	305 x 305 x 198	48.42
9.0 x 9.0	3	3.00	406 x 140 x 46	610 x 229 x 101	26.56	203 x 203 x 86	305 x 305 x 198	50.67
9.0 x 10.0	3	3.00	457 x 152 x 52	610 x 229 x 125	29.83	254 x 254 x 107	305 x 305 x 240	59.67
9.0 x 12.0	3	3.00	457 x 191 x 74	686 x 254 x 140	36.33	254 x 254 x 167	356 x 406 x 287	79.58
9.0 x 15.0	3	3.00	610 x 229 x 101	686 x 254 x 170	45.00	305 x 305 x 198*	356 x 406 x 340	88.67
9.0 x 18.0	3	3.00	686 x 254 x 140*	838 x 292 x 176	56.44	356 x 406 x 340*	COLCORE x 477	139.83
10.0 x 6.0	4	2.50	305 x 102 x 25	610 x 229 x 101	26.83	152 x 152 x 37	305 x 305 x 198	47.80
10.0 x 8.0	4	2.50	356 x 127 x 33	610 x 229 x 125	28.83	203 x 203 x 60	305 x 305 x 283	59.38
10.0 x 9.0	4	2.50	406 x 140 x 39	686 x 254 x 140	31.16	203 x 203 x 71	356 x 406 x 287	60.29
10.0 x 10.0	4	2.50	406 x 140 x 46	762 x 267 x 147	33.10	203 x 203 x 86	356 x 406 x 287	63.10
10.0 x 12.0	4	2.50	457 x 152 x 60	762 x 267 x 173	38.42	254 x 254 x 132	356 x 406 x 393	85.55
10.0 x 15.0	4	2.50	533 x 210 x 92	914 x 305 x 201	50.20	305 x 305 x 198*	356 x 406 x 467	110.33
10.0 x 18.0	4	2.50	610 x 229 x 125*	914 x 305 x 253	64.06	356 x 406 x 287*	356 x 406 x 634	150.02
12.0 x 6.0	4	3.00	305 x 102 x 25	686 x 254 x 125	29.17	203 x 203 x 46	305 x 305 x 283	62.50
12.0 x 7.2	4	3.00	356 x 127 x 33	762 x 267 x 147	31.42	203 x 203 x 52	356 x 406 x 287	57.19
12.0 x 7.5	4	3.00	305 x 102 x 37	762 x 267 x 147	31.93	203 x 203 x 60	356 x 406 x 340	65.33
12.0 x 8.0	4	3.00	356 x 127 x 39	762 x 267 x 173	34.63	203 x 203 x 71	356 x 406 x 340	66.17
12.0 x 9.0	4	3.00	406 x 140 x 46	838 x 292 x 176	34.89	203 x 203 x 86	356 x 406 x 393	72.33
12.0 x 10.0	4	3.00	457 x 152 x 52	838 x 292 x 194	36.73	254 x 254 x 107	COLCORE x 477	83.37
12.0 x 12.0	4	3.00	457 x 191 x 74	914 x 305 x 224	43.33	254 x 254 x 167	356 x 406 x 511	98.25
12.0 x 15.0	4	3.00	610 x 229 x 101	914 x 305 x 289	52.93	305 x 305 x 198*	356 x 406 x 634	108.27
12.0 x 18.0	4	3.00	686 x 254 x 140*	914 x 419 x 343	65.72	356 x 406 x 340*	914 x 419 x 388	134.89
15.0 x 6.0	5	3.00	305 x 102 x 25	762 x 267 x 173	37.37	203 x 203 x 46	356 x 406 x 393*	80.83
15.0 x 7.5	5	3.00	305 x 102 x 37	914 x 305 x 201	39.13	203 x 203 x 60	356 x 406 x 551	93.47
15.0 x 8.0	5	3.00	356 x 127 x 39	934 x 305 x 224	41.00	203 x 203 x 71	356 x 406 x 551	92.54
15.0 x 9.0	5	3.00	406 x 140 x 46	914 x 305 x 253	43.44	203 x 203 x 86	356 x 406 x 634*	99.11
15.0 x 10.0	5	3.00	457 x 152 x 52	914 x 305 x 289	46.23	254 x 254 x 107	356 x 406 x 634*	99.07
15.0 x 12.0	5	3.00	457 x 191 x 74	914 x 419 x 343	53.25	254 x 254 x 167	914 x 419 x 343	84.25
15.0 x 15.0	5	3.00	610 x 229 x 101	FAIL		305 x 305 x 198*	FAIL	
15.0 x 18.0	5	3.00	686 x 254 x 140*	FAIL		356 x 406 x 340*	FAIL	
18.0 x 6.0	6	3.00	305 x 102 x 25	914 x 305 x 253 *	50.50	203 x 203 x 46	356 x 406 x 634*	121.00
18.0 x 7.2	6	3.00	356 x 127 x 33	914 x 305 x 289 *	51.14	203 x 203 x 52	914 x 305 x 289*	57.47
18.0 x 7.5	6	3.00	305 x 102 x 37	914 x 419 x 343 *	58.07	203 x 203 x 60	914 x 419 x 343*	65.73
18.0 x 8.0	6	3.00	356 x 127 x 39	914 x 419 x 343*	55.88	203 x 203 x 71	914 x 419 x 34 *	66.54
18.0 x 9.0	6	3.00	406 x 140 x 46	914 x 419 x 388*	58.44	203 x 203 x 86	914 x 419 x 388*	71.78
18.0 x 10.0	6	3.00	457 x 152 x 52	FAIL		254 x 254 x 107	FAIL	
18.0 x 12.0	6	3.00	457 x 191 x 74	FAIL		254 x 254 x 167	FAIL	
18.0 x 15.0	6	3.00	610 x 229 x 101	FAIL		305 x 305 x 198*	FAIL	
18.0 x 18.0	6	3.00	686 x 254 x 140*	FAIL		356 x 406 x 340*	FAIL	

(\*) Natural frequency of the beam is less than 4.5Hz.

## 4.5 Composite Steel and Concrete (10/11)

### SAFE LOAD TABLES (3) GRADE 50 - DENSE CONCRETE SLAB Imposed load = 4.0 + 1.0 kN/m<sup>2</sup>

Bay size (m x m)	No. sec. beams per grid	Spacing of sec. beams	Minimum Weight			Minimum Depth		
			Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )	Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )
6.0 x 6.0	2	3.00	305 x 102 x 25	406 x 140 x 39	14.83	152 x 152 x 37	203 x 203 x 86	26.67
6.0 x 7.2	2	3.00	305 x 102 x 33	406 x 140 x 46	17.39	203 x 203 x 46	254 x 254 x 89	27.69
6.0 x 7.5	2	3.00	305 x 102 x 33	457 x 152 x 52	17.93	203 x 203 x 52	254 x 254 x 89	29.20
6.0 x 8.0	2	3.00	356 x 127 x 33	457 x 152 x 52	17.50	203 x 203 x 60	254 x 254 x 89	31.13
6.0 x 9.0	2	3.00	406 x 140 x 39	457 x 152 x 60	19.67	203 x 203 x 86	254 x 254 x 107	40.56
6.0 x 10.0	2	3.00	457 x 152 x 52	457 x 152 x 67	24.03	254 x 254 x 89	254 x 254 x 132	42.87
6.0 x 12.0	2	3.00	457 x 191 x 67	533 x 210 x 82	29.17	254 x 254 x 132*	254 x 254 x 167	57.92
6.0 x 15.0	2	3.00	533 x 210 x 92	533 x 210 x 92	36.80	305 x 305 x 198*	305 x 305 x 158	76.53
6.0 x 18.0	2	3.00	686 x 254 x 125	610 x 229 x 101	47.28	356 x 406 x 340*	305 x 305 x 198	124.33
7.2 x 6.0	3	2.40	254 x 102 x 22	457 x 152 x 52	17.83	152 x 152 x 30	254 x 254 x 89	27.33
7.2 x 7.2	3	2.40	305 x 102 x 25	457 x 152 x 60	18.75	203 x 203 x 46	254 x 254 x 107	34.03
7.2 x 9.0	3	2.40	305 x 127 x 37	457 x 152 x 74	23.64	203 x 203 x 60	254 x 254 x 132	39.67
7.2 x 12.0	3	2.40	457 x 152 x 52	533 x 210 x 92	29.33	254 x 254 x 107*	254 x 254 x 167	58.50
7.2 x 18.0	3	2.40	610 x 229 x 101	610 x 229 x 125	49.03	356 x 406 x 287*	305 x 305 x 283	135.31
7.5 x 6.0	3	2.50	254 x 102 x 22	457 x 152 x 52	17.47	152 x 152 x 30	254 x 254 x 89	26.83
7.5 x 7.5	3	2.50	305 x 102 x 28	457 x 152 x 67	20.13	203 x 203 x 46	254 x 254 x 132	36.00
7.5 x 9.0	3	2.50	356 x 127 x 39	457 x 152 x 74	23.82	203 x 203 x 60	254 x 254 x 167	42.56
7.5 x 12.0	3	2.50	457 x 152 x 52	533 x 210 x 92	28.47	254 x 254 x 107*	305 x 305 x 198	59.30
7.5 x 15.0	3	2.50	533 x 210 x 82	610 x 229 x 113	40.33	305 x 305 x 198*	305 x 305 x 240	95.20
7.5 x 18.0	3	2.50	610 x 229 x 113 *	686 x 254 x 125	52.14	356 x 406 x 287*	305 x 305 x 283	130.52
8.0 x 6.0	3	2.67	254 x 102 x 22	457 x 152 x 60	18.25	152 x 152 x 37	254 x 254 x 107	31.71
8.0 x 8.0	3	2.67	305 x 102 x 33	457 x 152 x 74	21.63	203 x 203 x 52	254 x 254 x 167	40.38
8.0 x 9.0	3	2.67	356 x 127 x 39	533 x 210 x 82	23.74	203 x 203 x 71	254 x 254 x 167	45.18
8.0 x 10.0	3	2.67	406 x 140 x 46	533 x 210 x 92	26.45	203 x 203 x 86	305 x 305 x 158	48.05
8.0 x 12.0	3	2.67	457 x 152 x 60	610 x 229 x 101	30.92	254 x 254 x 132*	305 x 305 x 198	66.00
8.0 x 15.0	3	2.67	533 x 210 x 82	610 x 229 x 125	39.08	305 x 305 x 198*	305 x 305 x 240	90.25
8.0 x 18.0	3	2.67	610 x 229 x 125*	762 x 267 x 147	55.04	356 x 406 x 287*	356 x 406 x 287	123.57
9.0 x 6.0	3	3.00	305 x 102 x 25	457 x 191 x 74	20.67	152 x 152 x 37	254 x 254 x 132	34.33
9.0 x 7.2	3	3.00	305 x 102 x 33	533 x 210 x 82	22.39	203 x 203 x 46	254 x 254 x 167	38.53
9.0 x 7.5	3	3.00	305 x 102 x 33	533 x 210 x 82	21.93	203 x 203 x 52	254 x 254 x 167*	39.60
9.0 x 8.0	3	3.00	356 x 127 x 33	533 x 210 x 92	22.50	203 x 203 x 60	305 x 305 x 158	39.75
9.0 x 9.0	3	3.00	406 x 140 x 39	610 x 229 x 101	24.22	203 x 203 x 86	305 x 305 x 198	50.67
9.0 x 10.0	3	3.00	457 x 152 x 52	610 x 229 x 101	27.43	254 x 254 x 89	305 x 305 x 198	49.47
9.0 x 12.0	3	3.00	457 x 152 x 67	610 x 229 x 125	32.75	254 x 254 x 132*	305 x 305 x 240*	64.00
9.0 x 15.0	3	3.00	533 x 210 x 92	762 x 267 x 147	40.47	305 x 305 x 198*	305 x 305 x 287*	85.13
9.0 x 18.0	3	3.00	686 x 254 x 125*	762 x 267 x 173	51.28	356 x 406 x 340*	356 x 406 x 340*	132.22
10.0 x 6.0	4	2.50	254 x 102 x 22	533 x 210 x 92	24.13	152 x 152 x 30	305 x 305 x 158*	38.33
10.0 x 8.0	4	2.50	305 x 102 x 33	610 x 229 x 113	27.33	203 x 203 x 52	305 x 305 x 240*	50.80
10.0 x 9.0	4	2.50	356 x 127 x 39	610 x 229 x 125	29.49	203 x 203 x 60	305 x 305 x 240*	50.67
10.0 x 10.0	4	2.50	406 x 140 x 39	686 x 254 x 140	29.60	203 x 203 x 86	305 x 305 x 283*	62.70
10.0 x 12.0	4	2.50	457 x 152 x 52	762 x 267 x 147	33.05	254 x 254 x 107*	3% x 406 x 340*	71.13
10.0 x 15.0	4	2.50	533 x 210 x 82	838 x 292 x 176	44.53	305 x 305 x 198*	356 x 406 x 393*	105.40
10.0 x 18.0	4	2.50	610 x 229 x 113	914 x 305 x 201	56.37	356 x 406 x 287*	COLCORE x 477*	141.30
12.0 x 6.0	4	3.00	305 x 102 x 25	610 x 229 x 125	29.17	152 x 152 x 37	305 x 305 x 240*	52.33
12.0 x 7.2	4	3.00	305 x 102 x 33	686 x 254 x 140	30.44	203 x 203 x 46	305 x 305 x 283*	54.64
12.0 x 7.5	4	3.00	305 x 102 x 33	686 x 254 x 140	29.67	203 x 203 x 52	305 x 305 x 283	55.07
12.0 x 8.0	4	3.00	356 x 127 x 33	762 x 267 x 147	29.38	203 x 203 x 60	356 x 406 x 287*	55.88
12.0 x 9.0	4	3.00	406 x 140 x 39	686 x 254 x 170	31.89	203 x 203 x 86	356 x 406 x 340*	66.44
12.0 x 10.0	4	3.00	457 x 152 x 52	762 x 267 x 173	34.63	254 x 254 x 89	356 x 406 x 340*	63.67
12.0 x 12.0	4	3.00	457 x 152 x 67	838 x 292 x 194	38.50	254 x 254 x 332*	COLCORE x 477*	83.75
12.0 x 15.0	4	3.00	533 x 210 x 92	914 x 305 x 253	47.53	305 x 305 x 198*	356 x 406 x 551	102.73
12.0 x 18.0	4	3.00	686 x 254 x 125	914 x 305 x 289	57.72	356 x 406 x 340*	914 x 419 x 343	132.39
15.0 x 6.0	5	3.00	305 x 102 x 25	762 x 267 x 147 *	32.83	152 x 152 x 37	356 x 406 x 393*	77.83
15.0 x 7.5	5	3.00	305 x 102 x 33	838 x 292 x 176 *	34.47	203 x 203 x 52	COLCORE x 477*	80.93
15.0 x 8.0	5	3.00	356 x 127 x 33	838 x 292 x 194 *	35.25	203 x 203 x 60	356 x 406 x 467*	78.38
15.0 x 9.0	5	3.00	406 x 140 x 39	914 x 305 x 201 *	35.33	203 x 203 x 86	356 x 406 x 551	89.89
15.0 x 10.0	5	3.00	457 x 152 x 52	914 x 305 x 224 *	39.73	254 x 254 x 89	356 x 406 x 634*	93.07
15.0 x 12.0	5	3.00	457 x 152 x 67	914 x 305 x 289 *	46.42	254 x 254 x 132*	914 x 305 x 289*	68.08
15.0 x 15.0	5	3.00	533 x 210 x 92	914 x 419 x 343 *	53.53	305 x 305 x 198*	914 x 419 x 343*	88.87
15.0 x 18.0	5	3.00	686 x 254 x 125	FAIL		356 x 406 x 340*	FAIL	
18.0 x 6.0	6	3.00	305 x 102 x 25	914 x 305 x 201 *	41.83	152 x 152 x 37	356 x 406 x 634 *	118.00
18.0 x 7.2	6	3.00	305 x 102 x 33	914 x 305 x 253 *	46.14	203 x 203 x 46	914 x 305 x 253*	50.47
18.0 x 7.5	6	3.00	305 x 102 x 33	914 x 305 x 253 *	44.73	203 x 203 x 52	914 x 305 x 253*	51.07
18.0 x 8.0	6	3.00	356 x 127 x 33	914 x 305 x 289 *	47.13	203 x 203 x 60	914 x 305 x 289*	56.13
18.0 x 9.0	6	3.00	406 x 140 x 39	914 x 419 x 343 *	51.11	203 x 203 x 86	914 x 419 x 343*	66.78
18.0 x 10.0	6	3.00	457 x 152 x 52	914 x 419 x 343 *	51.63	254 x 254 x 89	914 x 419 x 343*	63.97
18.0 x 12.0	6	3.00	457 x 152 x 67	FAIL		254 x 254 x 132*	FAIL	
18.0 x 15.0	6	3.00	533 x 210 x 92	FAIL		305 x 305 x 198*	FAIL	
18.0 x 18.0	6	3.00	686 x 254 x 125	FAIL		356 x 406 x 340*	FAIL	

(\*) Natural frequency of the beam is less than 4.5Hz.

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**SAFE LOAD TABLES (4)**  
**GRADE 50 - LIGHTWEIGHT CONCRETE SLAB**  
 Imposed load = 4.0 + 1.0 kN/m<sup>2</sup>

Bay size (m x m)	No. sec. beams per grid	Spacing of sec. beams	Minimum Weight			Minimum Depth		
			Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )	Secondary Beams	Primary Beams	Weight (kg/m <sup>2</sup> )
6.0 x 6.0	2	3.00	254 x 102 x 22	356 x 127 x 39	13.83	152 x 152 x 37	203 x 203 x 71	24.17
6.0 x 7.2	2	3.00	305 x 102 x 28	406 x 140 x 46	15.72	203 x 203 x 46	203 x 203 x 86	27.28
6.0 x 7.5	2	3.00	305 x 102 x 28	406 x 140 x 46	15.47	203 x 203 x 46	254 x 254 x 73	25.07
6.0 x 8.0	2	3.00	305 x 102 x 33	457 x 152 x 52	17.50	203 x 203 x 52	254 x 254 x 89	28.46
6.0 x 9.0	2	3.00	356 x 127 x 39	457 x 152 x 52	18.78	203 x 203 x 71	254 x 254 x 107	35.56
6.0 x 10.0	2	3.00	406 x 140 x 46	457 x 191 x 60	21.33	254 x 254 x 73	254 x 254 x 107	35.03
6.0 x 12.0	2	3.00	457 x 191 x 60	457 x 191 x 74	26.17	254 x 254 x 132*	254 x 254 x 132	55.00
6.0 x 15.0	2	3.00	533 x 210 x 82	533 x 210 x 82	32.80	305 x 305 x 198*	254 x 254 x 167	77.13
6.0 x 18.0	2	3.00	610 x 229 x 125*	610 x 229 x 101	47.28	356 x 406 x 340*	305 x 305 x 198	124.33
7.2 x 6.0	3	2.40	254 x 102 x 22	406 x 140 x 46	16.83	152 x 152 x 30	254 x 254 x 73	24.67
7.2 x 7.2	3	2.40	305 x 102 x 25	457 x 152 x 52	17.64	152 x 152 x 37	254 x 254 x 107	30.28
7.2 x 9.0	3	2.40	305 x 102 x 33	457 x 152 x 67	21.19	203 x 203 x 52	254 x 254 x 132	36.33
7.2 x 12.0	3	2.40	457 x 152 x 52	533 x 210 x 82	28.50	254 x 254 x 107*	254 x 254 x 167	58.50
7.2 x 18.0	3	2.40	610 x 229 x 101	610 x 229 x 125	49.03	356 x 406 x 287*	305 x 305 x 240	132.92
7.5 x 6.0	3	2.50	254 x 102 x 22	457 x 152 x 52	17.47	152 x 152 x 30	254 x 254 x 89	26.83
7.5 x 7.5	3	2.50	305 x 102 x 25	457 x 152 x 60	18.00	203 x 203 x 46	254 x 254 x 107	32.67
7.5 x 9.0	3	2.50	356 x 127 x 33	457 x 152 x 74	21.42	203 x 203 x 60	254 x 254 x 132	38.67
7.5 x 12.0	3	2.50	457 x 152 x 52	533 x 210 x 92	28.47	254 x 254 x 132*	305 x 305 x 158	65.97
7.5 x 15.0	3	2.50	533 x 210 x 82	610 x 229 x 101	39.53	305 x 305 x 198*	305 x 305 x 198	92.40
7.5 x 18.0	3	2.50	610 x 229 x 101	610 x 229 x 125	47.34	356 x 406 x 287*	305 x 305 x 283	130.52
8.0 x 6.0	3	2.67	254 x 102 x 22	457 x 152 x 52	16.92	152 x 152 x 30	254 x 254 x 107	29.08
8.0 x 8.0	3	2.67	305 x 102 x 33	457 x 152 x 74	21.63	203 x 203 x 46	254 x 254 x 132	33.75
8.0 x 9.0	3	2.67	356 x 127 x 33	533 x 210 x 82	21.49	203 x 203 x 60	254 x 254 x 167	41.06
8.0 x 10.0	3	2.67	406 x 140 x 39	533 x 210 x 82	22.83	203 x 203 x 86	254 x 254 x 167	48.95
8.0 x 12.0	3	2.67	457 x 152 x 52*	610 x 229 x 101	27.92	254 x 254 x 132*	305 x 305 x 198	66.00
8.0 x 15.0	3	2.67	533 x 210 x 82*	610 x 229 x 125	39.08	305 x 305 x 198*	305 x 305 x 240	90.25
8.0 x 18.0	3	2.67	610 x 229 x 101*	686 x 254 x 140	45.65	356 x 406 x 287*	305 x 305 x 283	132.35
9.0 x 6.0	3	3.00	254 x 102 x 22	457 x 191 x 67	18.50	152 x 152 x 37	254 x 254 x 132	34.33
9.0 x 7.2	3	3.00	305 x 102 x 28	533 x 210 x 82	20.72	203 x 203 x 46	254 x 254 x 167	38.53
9.0 x 7.5	3	3.00	305 x 102 x 28	533 x 210 x 82	20.27	203 x 203 x 46	254 x 254 x 167	37.60
9.0 x 8.0	3	3.00	305 x 102 x 33	533 x 210 x 82	21.25	203 x 203 x 52	254 x 254 x 167	38.21
9.0 x 9.0	3	3.00	356 x 127 x 39	533 x 210 x 92	23.22	203 x 203 x 71	305 x 305 x 158	41.22
9.0 x 10.0	3	3.00	406 x 140 x 46	610 x 229 x 101	25.43	254 x 254 x 73	305 x 305 x 198	44.13
9.0 x 12.0	3	3.00	457 x 152 x 60	610 x 229 x 113	29.42	254 x 254 x 132*	305 x 305 x 240	64.00
9.0 x 15.0	3	3.00	533 x 210 x 82	686 x 254 x 140	36.67	305 x 305 x 198*	305 x 305 x 283	84.87
9.0 x 18.0	3	3.00	610 x 229 x 125	686 x 254 x 170	51.11	356 x 406 x 340*	356 x 406 x 340	132.22
10.0 x 6.0	4	2.50	254 x 102 x 22	533 x 210 x 82	22.47	152 x 152 x 30	254 x 254 x 167*	39.83
10.0 x 8.0	4	2.50	305 x 102 x 28	610 x 229 x 101	23.83	203 x 203 x 46	305 x 305 x 198*	43.15
10.0 x 9.0	4	2.50	356 x 127 x 33	610 x 229 x 125	27.09	203 x 203 x 60	305 x 305 x 240	50.67
10.0 x 10.0	4	2.50	356 x 127 x 39	686 x 254 x 125	28.10	203 x 203 x 86	305 x 305 x 283	62.70
10.0 x 12.0	4	2.50	457 x 152 x 52	762 x 267 x 147	33.05	254 x 254 x 107*	356 x 406 x 287*	66.72
10.0 x 15.0	4	2.50	533 x 210 x 82	762 x 267 x 173	44.33	305 x 305 x 198*	356 x 406 x 393	105.40
10.0 x 18.0	4	2.50	610 x 229 x 101	838 x 292 x 194	51.18	356 x 406 x 287*	COLCORE x 477*	141.30
12.0 x 6.0	4	3.00	254 x 102 x 22	610 x 229 x 101	24.17	152 x 152 x 37	305 x 305 x 240*	52.33
12.0 x 7.2	4	3.00	305 x 102 x 28	686 x 254 x 125	26.69	203 x 203 x 46	305 x 305 x 283*	54.64
12.0 x 7.5	4	3.00	305 x 102 x 28	686 x 254 x 125	26.00	203 x 203 x 46	305 x 305 x 283*	53.07
12.0 x 8.0	4	3.00	305 x 102 x 33	686 x 254 x 140	28.50	203 x 203 x 52	356 x 406 x 287*	53.21
12.0 x 9.0	4	3.00	356 x 127 x 39	762 x 267 x 147	29.33	203 x 203 x 71	356 x 406 x 287	55.56
12.0 x 10.0	4	3.00	406 x 140 x 46	686 x 254 x 170	32.33	254 x 254 x 73	356 x 406 x 340*	58.33
12.0 x 12.0	4	3.00	457 x 152 x 60	838 x 292 x 176	34.67	254 x 254 x 132*	356 x 406 x 393*	76.75
12.0 x 15.0	4	3.00	533 x 210 x 92	914 x 305 x 224	45.60	305 x 305 x 198*	356 x 406 x 551	102.73
12.0 x 18.0	4	3.00	610 x 229 x 125	914 x 305 x 289	57.72	356 x 406 x 340*	356 x 406 x 634*	148.56
15.0 x 6.0	5	3.00	254 x 102 x 22	762 x 267 x 147*	31.83	152 x 152 x 37	356 x 406 x 393*	77.83
15.0 x 7.5	5	3.00	305 x 102 x 28	762 x 267 x 173*	32.40	203 x 203 x 46	COLCORE x 477*	78.93
15.0 x 8.0	5	3.00	305 x 102 x 33	838 x 292 x 176*	33.00	203 x 203 x 52	356 x 406 x 467*	75.71
15.0 x 9.0	5	3.00	356 x 127 x 39	838 x 292 x 194*	34.56	203 x 203 x 71	356 x 406 x 551	84.89
15.0 x 10.0	5	3.00	406 x 140 x 46	914 x 305 x 224*	37.73	254 x 254 x 73	356 x 406 x 634*	87.73
15.0 x 12.0	5	3.00	457 x 152 x 60	914 x 305 x 253*	41.08	254 x 254 x 132*	914 x 305 x 289	68.08
15.0 x 15.0	5	3.00	533 x 210 x 82*	914 x 419 x 343*	50.20	305 x 305 x 198*	914 x 419 x 343*	88.87
15.0 x 18.0	5	3.00	610 x 229 x 125*	914 x 419 x 388*	63.22	356 x 406 x 340*	914 x 419 x 388*	134.89
18.0 x 6.0	6	3.00	254 x 102 x 22	838 x 292 x 194*	39.67	152 x 152 x 37	356 x 406 x 634*	118.00
18.0 x 7.2	6	3.00	305 x 102 x 28	914 x 305 x 224*	40.44	203 x 203 x 46	914 x 305 x 224*	46.44
18.0 x 7.5	6	3.00	305 x 102 x 28	914 x 305 x 253*	43.07	203 x 203 x 46	914 x 305 x 253*	49.07
18.0 x 8.0	6	3.00	305 x 102 x 33	914 x 305 x 253*	42.63	203 x 203 x 52	914 x 305 x 253*	48.96
18.0 x 9.0	6	3.00	356 x 127 x 39	914 x 305 x 289*	45.11	203 x 203 x 71	914 x 305 x 289*	55.78
18.0 x 10.0	6	3.00	406 x 340 x 46	914 x 419 x 343*	49.63	254 x 254 x 73	914 x 419 x 343*	58.63
18.0 x 12.0	6	3.00	457 x 152 x 60	914 x 419 x 388*	52.33	254 x 254 x 132*	914 x 419 x 388*	76.33
18.0 x 15.0	6	3.00	533 x 210 x 82	FAIL		305 x 305 x 198*	FAIL	
18.0 x 18.0	6	3.00	610 x 229 x 125	FAIL		356 x 406 x 340*	FAIL	

(\*) Natural frequency of the beam is less than 4.5Hz.