4.3 PRESTRESSED CONCRETE

4.3.1 RULES OF THUMB

Advantages of using prestressed concrete

- Increased clear spans
- Thinner slabs
- Lighter structures
- Reduced cracking and deflections
- Reduced storey height
- Rapid construction
- Water tightness

Note: use of prestressed concrete does not significantly affect the ultimate limit state (except by virtue of the use of a higher grade of steel).

Maximum length of slab

50m, bonded or unbonded, stressed from both ends.
25m, bonded, stressed from one end only.

Mean prestress

Typically: P/A ≈ 1 to 2 N/mm²

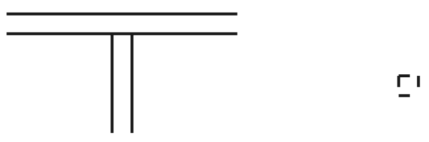
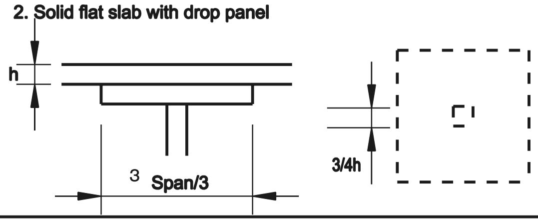
Cover

Take minimum cover to be 25mm.
Allow sufficient cover for (at least) nominal bending reinforcement over the columns, in both directions (typically T16 bars in each direction).

Effect of restraint to floor shortening

Post-tensioned floors must be able to shorten to enable the prestress to be applied to the floor.

Typical span/total depth ratios for a variety of section types of multi-span prestressed floors[2]

Section type	Total imposed loading kpa	Span/ depth ratio 6m – 13m	Additional requirement
1. Solid flat slab 	2.5 5.0 10.0	40 36 30	A
2. Solid flat slab with drop panel 	2.5 5.0 10.0	44 40 34	A

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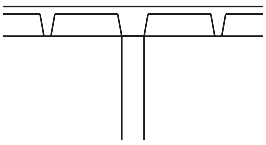
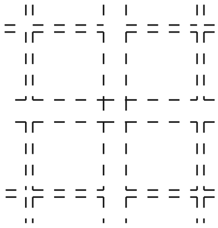
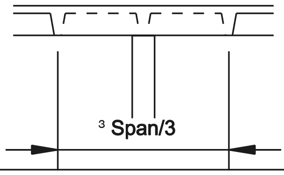
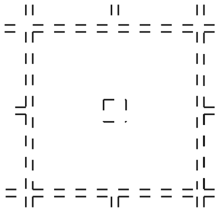
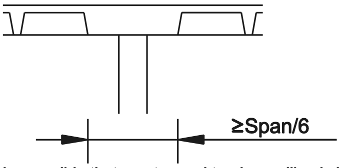
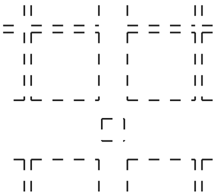
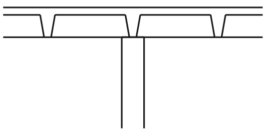
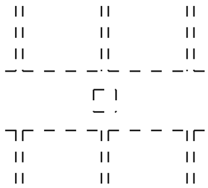
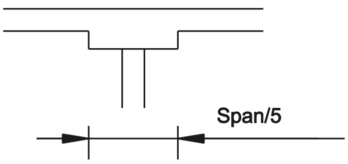
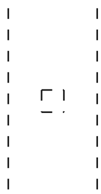
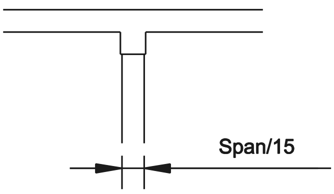
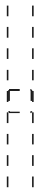
[Typical span/total depth ratios for <u>multi-span</u> prestressed floors (cont.)]

Section type	Total imposed loading kpa	Span/ depth ratio 6m≤ l ≤13m	Additional requirement
3. Coffered flat slab (not meeting the requirement of types 4 or 5) 	2.5 5.0 10.0	25 23 20	B
4. Coffered flat slab with solid panels 	2.5 5.0 10.0	28 26 23	B
5. Coffered flat slab with band beams  Note : It may be possible that prestressed tendons will only be required in the banded section and that untensioned reinforcement will surface in the nos. or vice versa	2.5 5.0 10.0	28 26 23	B
6. Ribbed slab  Note : The values of span/depth ratio can vary according to the width of the beam	2.5 5.0 10.0	30 27 24	B
7. one way slab with broad beam 	2.5 5.0 10.0	SLAB BEAM 45 25 40 22 35 18	A
8. One way slab with narrow beam 	2.5 5.0 10.0	SLAB BEAM 42 18 38 16 34 13	A

*Additional requirements if no vibration check to be carried out for normal office conditions

A ≥4 panels and ≥250mm thick slab or ≥8 panels and ≥200mm thick slab
B ≥4 panels and ≥400mm thick overall or ≥8 panels and ≥300mm thick overall

Note
1. All panels assumed to be square
2. Span/depth ratios not affected by column head

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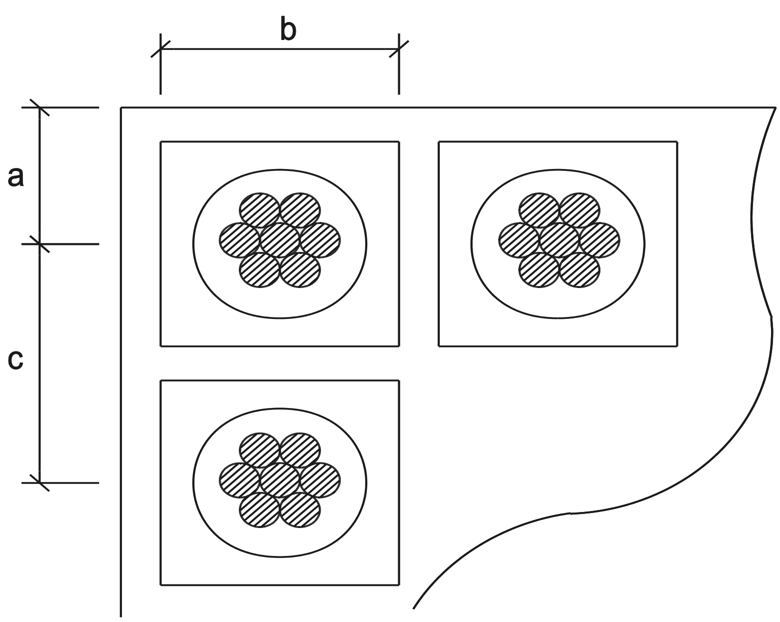
4.3.2 COMMON STRANDS[4]

	Nominal diameter (mm)	Steel area (mm^2)	Mass (kg/m)	Nominal tensile strength (N/mm^2)	Characteristic breaking load (kN)	Modulus of elasticity (kN/mm^2 or GPa)
Standard	15.2 12.5 11.0 9.3	139 93 71 52	1.090 0.730 0.557 0.408	1670 1770 1770 1770	232 164 125 92	195 ± 10 195 ± 10 195 ± 10 195 ± 10
Super	15.7 12.9 11.3 9.6 8.0	150 100 75 55 38	1.180 0.785 0.590 0.432 0.298	1770 1860 1860 1860 1860	265* 186 139 102 70	195 ± 10 195 ± 10 195 ± 10 195 ± 10 195 ± 10
Compact/ Dyform	18.0 15.2 12.7	223 165 112	1.750 1.295 0.890	1700 1820 1860	380 300 209	195 ± 10 195 ± 10 195 ± 10

* 279 also available, details not yet published

4.3.3 COMMON TENDONS[1]

No. strands per duct for 15.7mm "super" strand	70% UTS (kN)	Internal sheath (mm)	Anchor sizes			Jack		
			a	b	c	Length (mm)	ϕ (mm)	Stroke (mm)
1	186	25						
7	1299	65	175	210	270	630	350	150
12	2226	75	200	245	300	750	390	250
15	2783	85				750	390	250
19	3525	95	250	315	375	900	510	250
27	5009	110	300	365	450	950	610	250
37	6864	130	375	450	525	1000	720	250



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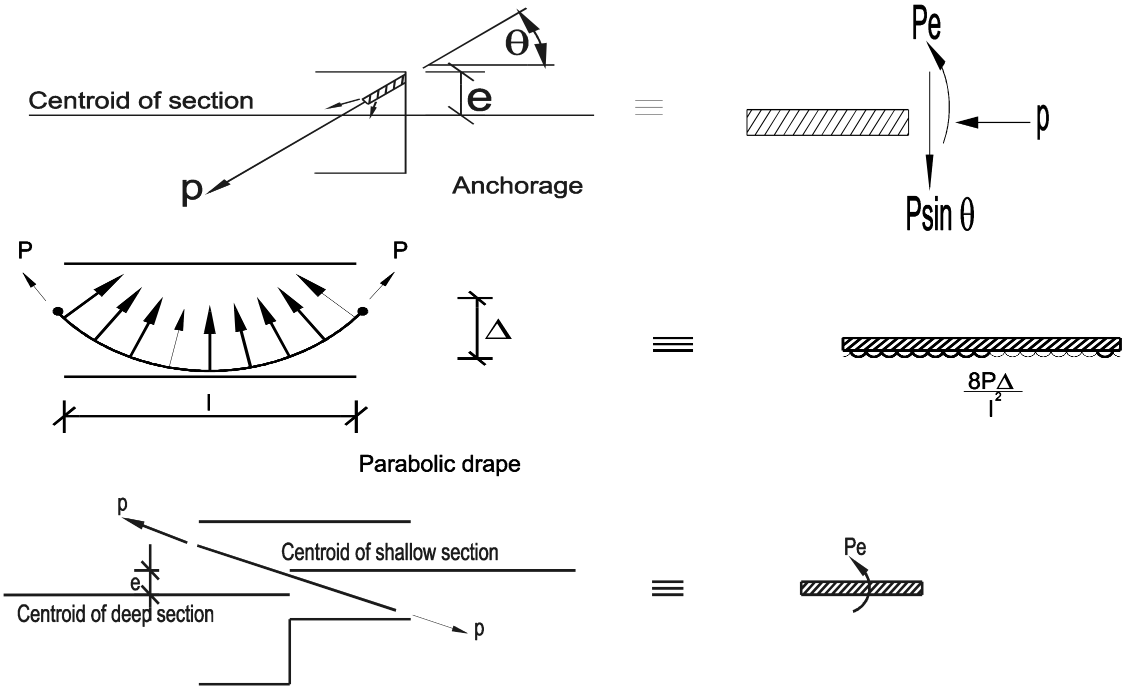
4.3.4 EQUIVALENT LOADS[6]

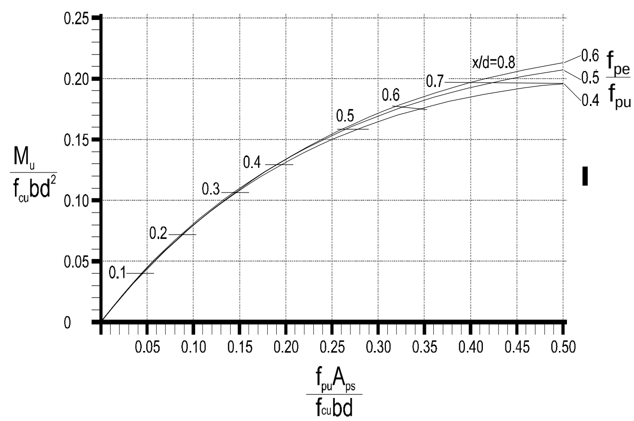


4.3.5 ALLOWABLE STRESSES AT SERVICE LOADS

	In service	At transfer
Compression	beams: $0.33f_{cu}$ ($0.4f_{cu}$ at supports for indeterminate beams) columns: $0.25f_{cu}$	bending: $0.5f_{ci}$ compression: $0.4f_{ci}$
Tension	Class 1: No tension Class 2: 2N/mm² post-tensioned 3N/mm² pre-tensioned Class 3: See BS 8110	1.0 N/mm² $0.45\sqrt{(f_{ci})}$ $0.36\sqrt{(f_{ci})}$

4.3.6 ULTIMATE BENDING STRENGTH[6]

For rectangular beams or T beams with neutral axis in flange:



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4.3.7 SHEAR

Require that $v_u < 0.8 \sqrt{(f_{cu})}$ and $5N/mm^2$

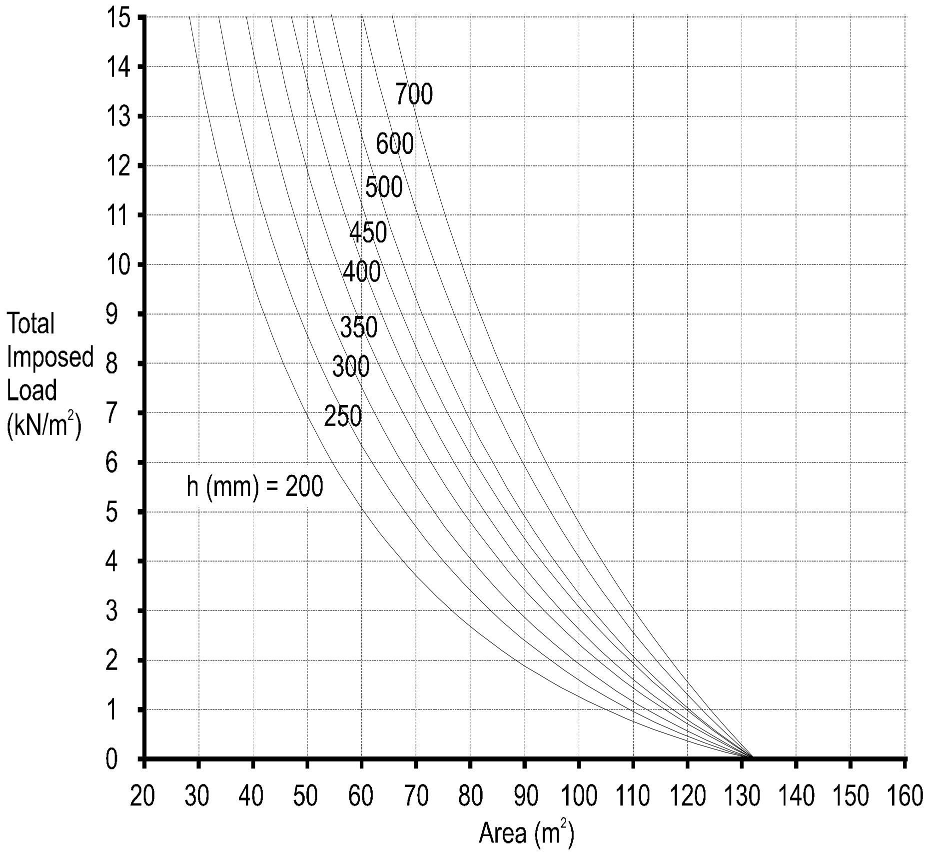
<u>Except</u> that inclined tendons may contribute to a reduced effective shear force on the concrete provided the shear zone is not cracked in bending at M_{ult}.

Ultimate shear check at column face

Column (inc. head) 300 x 300

Note: For column sizes other than 300 x 300, the slab depth should be multiplied by the factor (column perimeter/1200)

Explanation



Information to be used in conjunction with the graph:
1. f_{cu} = 40 N/mm²
2. Dead load factor = 1.4
3. Live load factor = 1.6
4. The value of d/h is assumed to be 0.85
5. The ratio of V_{eff}/V is assumed to be 1.15
6. These curves do not take account of elastic distribution effects
7. The maximum shear stress for f_{cu} = 40 N/mm² and more is 5 N/mm².
   For f_{cu} < 40 N/mm² the maximum shear stress is $0.8 \sqrt{f_{cu}}$
   For f_{cu} = 35 N/mm² increase slab depth by a factor of 1.06
   For f_{cu} = 30 N/mm² increase slab depth by a factor of 1.14

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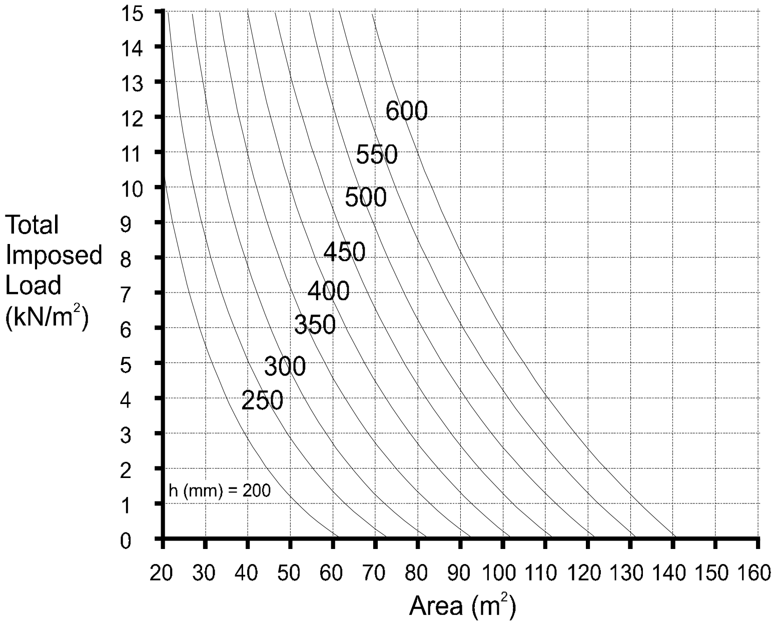
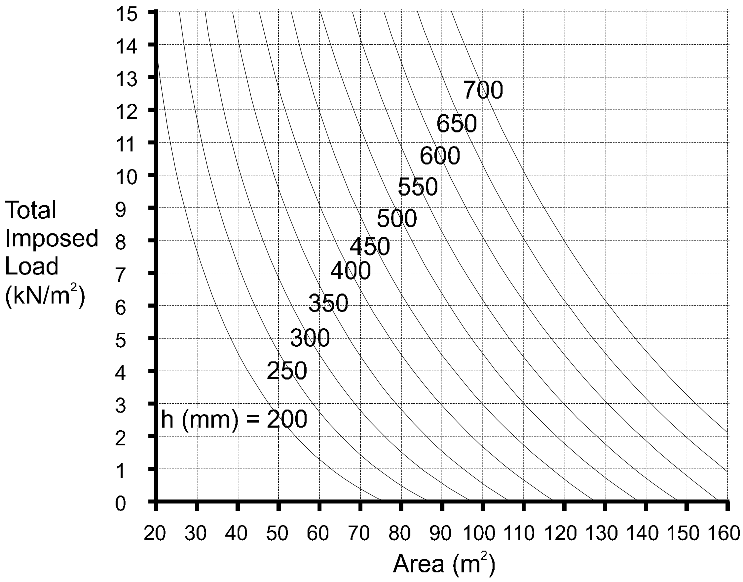
Column 300 x 300
Punching shear check for preliminary design (v_c = 0.75 N/mm²)



Column 500 x 500
Punching shear check for preliminary design (v_c = 0.75 N/mm²)



4.3.8 REFERENCES

1. PSC FREYSSINET, The 'K' Range
2. ARUP, Notes on Structures 29, June 1991
3. BRIDON ROPES, Ropes and Lifting Gear
4. BS 5896 : 1980, High tensile steel wire and strand for the prestressing of concrete
5. ARUP, Notes on Structures 18, June 1989
6. PALLADIAN PUBLICATIONS, Handbook to BS 8110 (1987)

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