ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 331
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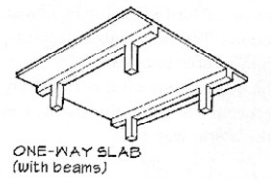
SUMMER 2014

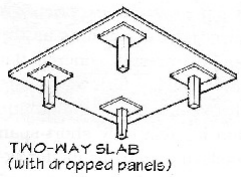
lecture
twenty

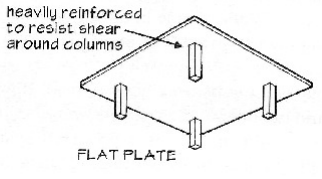
concrete construction:
T-beams & slabs

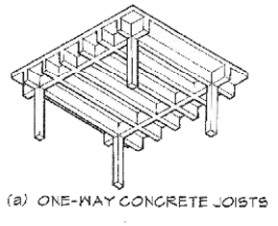
Systems

- beams separate from slab
- beams integral with slab
  - close spaced
- continuous beams
- no beams



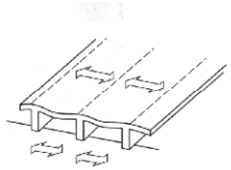


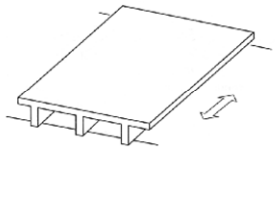


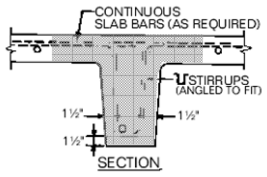


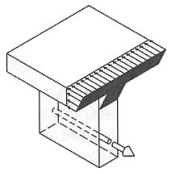
T sections

- two areas of compression in moment possible
- one-way joists
- effective flange width









T sections

- negative bending: min A_s, larger of:

$$A_s = \frac{6\sqrt{f'_c}}{f_y}(b_w d) \qquad A_s = \frac{3\sqrt{f'_c}}{f_y}(b_f d)$$

- effective width (interior)
  - L/4
  - b_w + 16t
  - center-to-center of beams

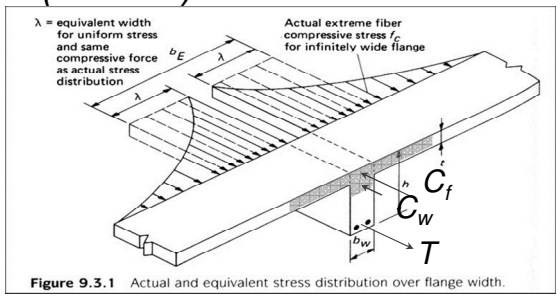
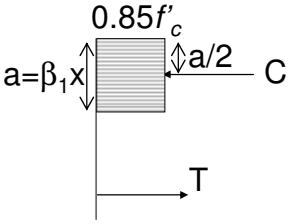


Figure 9.3.1 Actual and equivalent stress distribution over flange width.

T sections

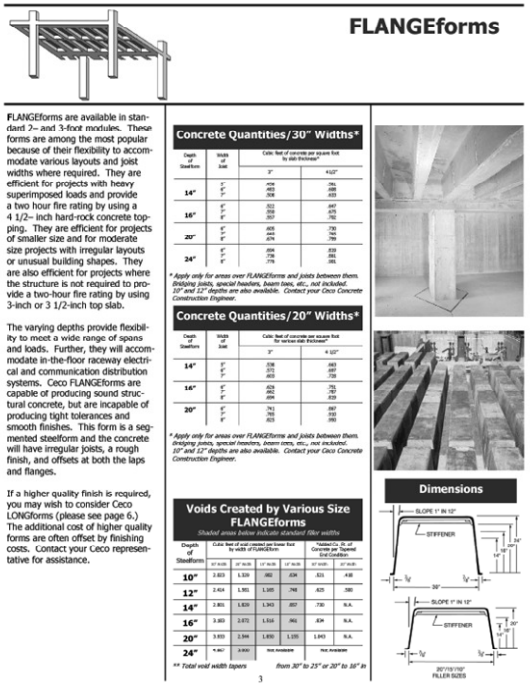
- *usual analysis steps*

1. *assume no compression in web*
2. *design like a rectangular beam*
3. *needs reinforcement in slab too*
4. *also analyze for negative moment, if any*



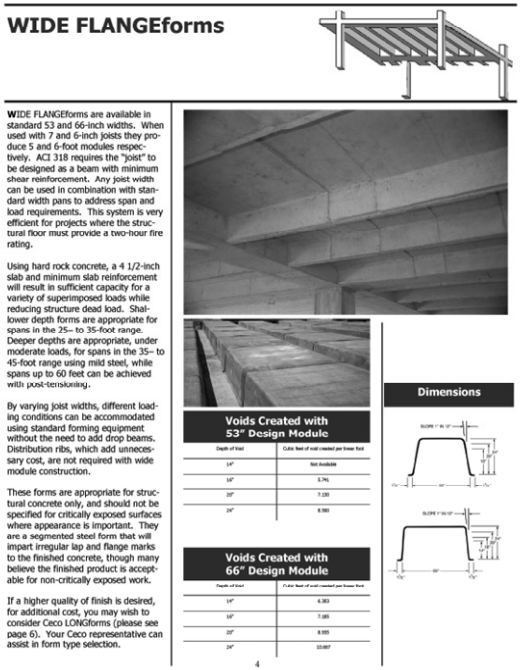
One-Way

- *Joists*
  - *standard stems*
  - *2.5" to 4.5" slab*
  - *~30" widths*
  - *reusable forms*



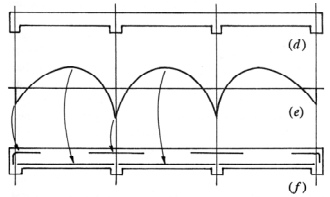
One-Way

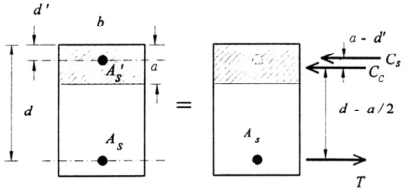
- *Joists*
  - *wide pans*
  - *5', 6' up*
  - *light loads & long spans*
  - *one-leg stirrups*



Compression Reinforcement

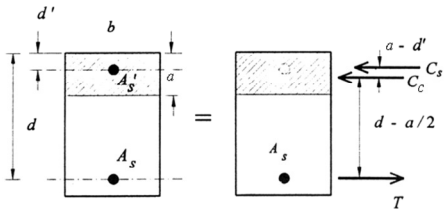
- *doubly reinforced*
- *negative bending*
- *two compression forces*
- *bigger M_n*
- *control deflection*
- *increase ductility*
- *needs ties because of buckling*





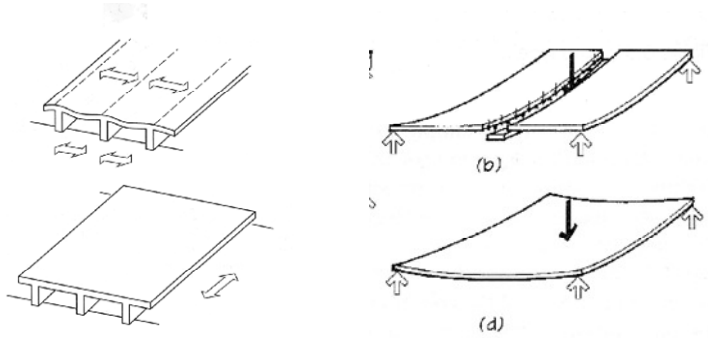
Compression Reinforcement

- *analysis*
  - A_s & A_s'
  - $T = C_c + C_s$
  - $T = A_s f_y$
  - $C_s = A_s'(f'_s - 0.85f'_c)$
  - $C_c = 0.85f'_c ba$ with $a = \beta_1 x$
  - f_s' not known, so solve for x (n.a.)
  - $f_s' < f_y$?
  - $M_n = T(d-a/2)+C_s(d-d')$



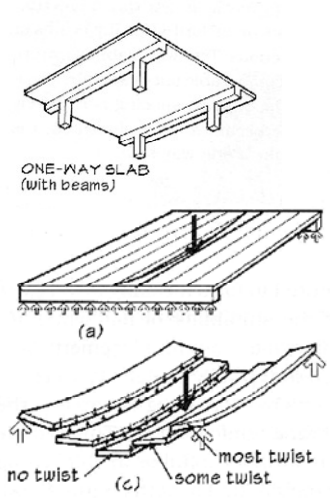
Slabs

- *one way behavior – like beams*
- *two way behavior – more complex*



Slab Design

- *one unit wide "strip"*
- *with uniform loads*
  - *like "wide" beams*
  - *moment / unit width*
  - *uniform curvature*
- *with point loads*
  - *resisted by stiffness of adjacent strips*
  - *more curvature in middle*



Slab Design

- *min thickness by code*
- *reinforcement*
  - *bars, welded wire mesh*
  - *cover*
  - *minimum by steel grade*
    - *40-50:* $\rho = \frac{A_s}{bt} = 0.002$
    - *60:* $\rho = \frac{A_s}{bt} = 0.0018$

TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE COMPUTED

	Minimum thickness, *h*			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
Solid one-way slabs	$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$
Beams or ribbed one-way slabs	$\ell/16$	$\ell/18.5$	$\ell/21$	$\ell/8$

Notes:
Values given shall be used directly for members with normalweight concrete and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
a) For lightweight concrete having equilibrium density, w_c, in the range of 90 to 115 lb/ft^3, the values shall be multiplied by $(1.65 - 0.005w_c)$ but not less than 1.09.
b) For f_y other than 60,000 psi, the values shall be multiplied by $(0.4 + f_y/100{,}000)$.

One-Way Slabs

- A_s tables
- max spacing
  - $\leq 3(t)$ and 18”
  - $\leq 5(t)$ and 18” – temp & shrinkage steel
- no room for stirrups

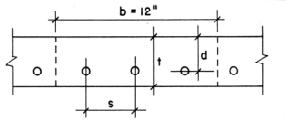
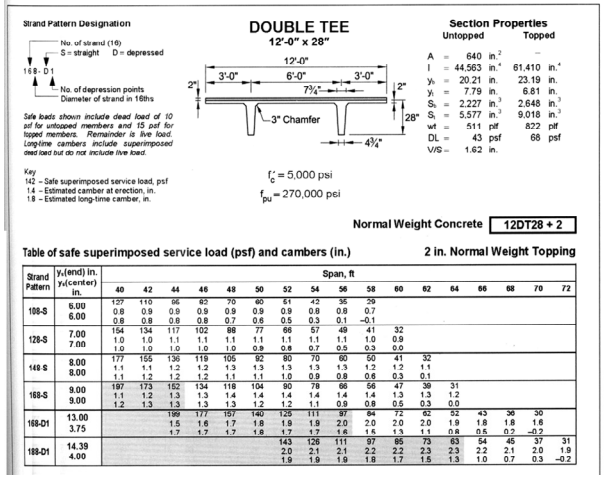


Table 3-7 Areas of Bars per Foot Width of Slab—A_s (in.^{2}/ft)

Bar size	Bar spacing (in.)												
	6	7	8	9	10	11	12	13	14	15	16	17	18
#3	0.22	0.19	0.17	0.15	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07
#4	0.40	0.34	0.30	0.27	0.24	0.22	0.20	0.18	0.17	0.16	0.15	0.14	0.13
#5	0.62	0.53	0.46	0.41	0.37	0.34	0.31	0.29	0.27	0.25	0.23	0.22	0.21
#6	0.88	0.75	0.66	0.59	0.53	0.48	0.44	0.41	0.38	0.35	0.33	0.31	0.29
#7	1.20	1.03	0.90	0.80	0.72	0.65	0.60	0.55	0.51	0.48	0.45	0.42	0.40
#8	1.58	1.35	1.18	1.05	0.95	0.86	0.79	0.73	0.68	0.63	0.59	0.56	0.53
#9	2.00	1.71	1.50	1.33	1.20	1.09	1.00	0.92	0.86	0.80	0.75	0.71	0.67
#10	2.54	2.18	1.91	1.69	1.52	1.39	1.27	1.17	1.09	1.02	0.95	0.90	0.85
#11	3.12	2.67	2.34	2.08	1.87	1.70	1.56	1.44	1.34	1.25	1.17	1.10	1.04

Precast

- *prestressed*
  - *PCI Design Handbook*
  - *double T’s*
  - *hollow core*
  - *L’s*
- *topping*
- *load tables*



Strand Pattern Designation

No. of strand (16)
S = straight D = depressed
168 - D1
No. of depression points
Diameter of strand in 16ths

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Key
142 – Safe superimposed service load, psf
1.4 – Estimated camber at erection, in.
1.8 – Estimated long-time camber, in.

DOUBLE TEE
12'-0" x 28"

f'_c = 5,000 psi
f_{pu} = 270,000 psi

Section Properties

	Untopped	Topped
A =	640 in.^{2}	–
I =	44,563 in.^{4}	61,410 in.^{4}
y_b =	20.21 in.	23.19 in.
y_t =	7.79 in.	6.81 in.
S_b =	2,227 in.^{3}	2,648 in.^{3}
S_t =	5,577 in.^{3}	9,018 in.^{3}
wt =	511 plf	822 plf
DL =	43 psf	68 psf
V/S =	1.62 in.	

Normal Weight Concrete **12DT28 + 2**

Table of safe superimposed service load (psf) and cambers (in.) — 2 in. Normal Weight Topping

Strand Pattern	y_t(end) in. y_t(center) in.	Span, ft															
		40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72
108-S	6.00 / 6.00	127 0.8 0.8	110 0.9 0.8	96 0.9 0.8	82 0.9 0.8	70 0.9 0.7	60 0.9 0.6	51 0.9 0.5	42 0.8 0.3	35 0.8 0.1	29 0.7 –0.1							
128-S	7.00 / 7.00	154 1.0 1.0	134 1.0 1.0	117 1.1 1.0	102 1.1 1.0	88 1.1 0.9	77 1.1 0.8	66 1.1 0.7	57 1.1 0.5	49 1.1 0.3	41 1.0 0.0	32 0.9 0.0						
148-S	8.00 / 8.00	177 1.1 1.1	155 1.1 1.2	136 1.2 1.2	119 1.2 1.2	105 1.3 1.1	92 1.3 1.1	80 1.3 1.0	70 1.3 0.9	60 1.3 0.8	50 1.2 0.6	41 1.2 0.3	32 1.1 0.1					
168-S	9.00 / 9.00	197 1.1 1.2	173 1.2 1.3	152 1.3 1.3	134 1.3 1.3	118 1.4 1.3	104 1.4 1.2	90 1.4 1.2	78 1.4 1.1	68 1.4 0.9	56 1.4 0.8	47 1.3 0.5	39 1.3 0.3	31 1.2 0.0				
168-D1	13.00 / 3.75			199 1.5 1.7	177 1.6 1.7	157 1.7 1.7	140 1.8 1.8	125 1.9 1.7	111 1.9 1.7	97 2.0 1.6	84 2.0 1.5	72 2.0 1.3	62 2.0 1.1	52 1.9 0.8	43 1.8 0.5	36 1.8 0.2	30 1.6 –0.2	
188-D1	14.39 / 4.00							143 2.0 1.9	126 2.1 1.9	111 2.1 1.9	97 2.2 1.8	85 2.2 1.7	73 2.3 1.5	63 2.3 1.3	54 2.2 1.0	45 2.1 0.7	37 2.0 0.3	31 1.9 –0.2