ELEMENTS OF ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 614
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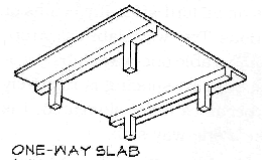
SPRING 2013

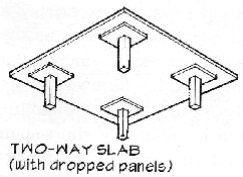
lecture
twenty two

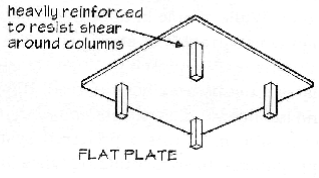
concrete construction:
T-beams & slabs

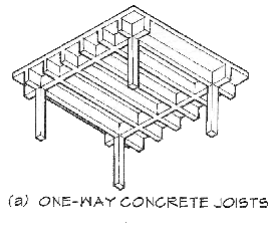
Systems

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



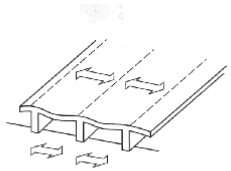


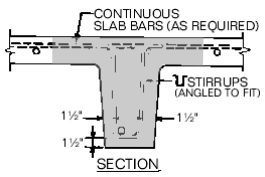


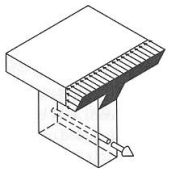


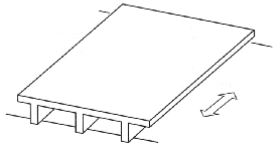
T sections

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







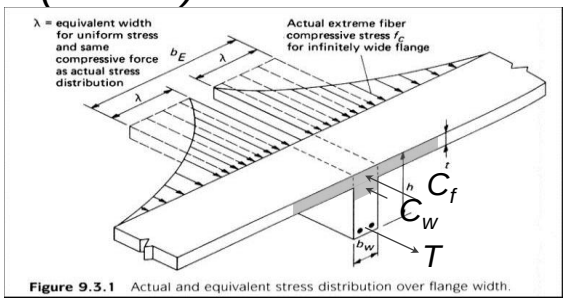


T sections

- negative bending: min A_s, larger of:

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

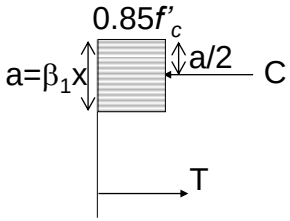
- effective width (interior)
  - L/4
  - b_w + 16t
  - center-to-center of beams



T sections

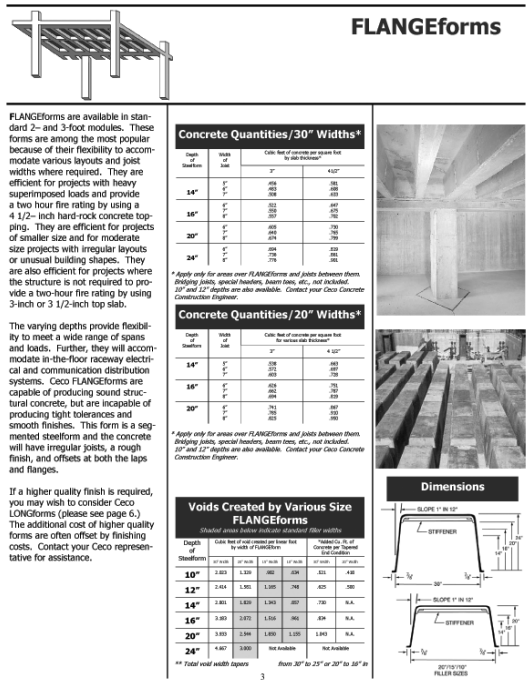
- *usual analysis steps*

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*



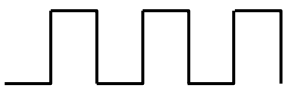
One-way

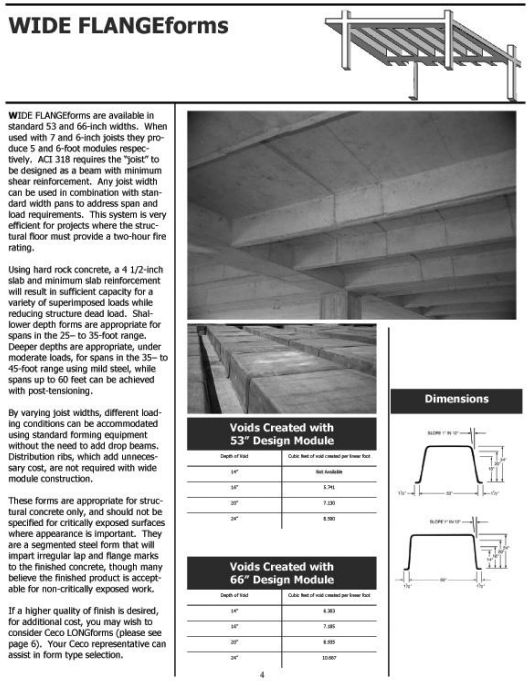
- *Joists*
  - *standard stems*
  - *2.5" to 4.5" slab*
  - *~30" widths*
  - *reusable forms*



One-way

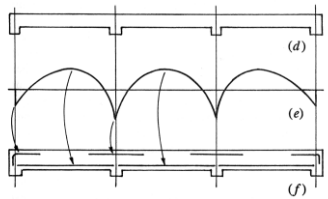
- *Joists*
  - *wide pans*
  - *5', 6' up*
  - *light loads & long spans*
  - *one-leg stirrups*



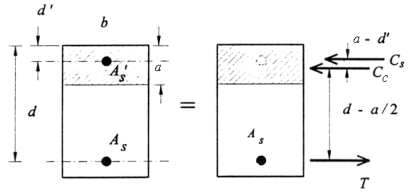


Compression Reinforcement

- *doubly reinforced*
- *negative bending*
- *two compression forces*



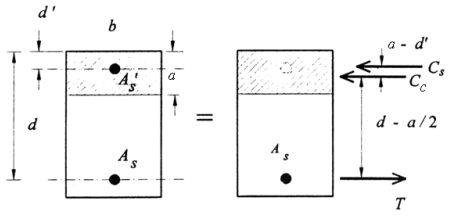
- $T = C_c + C_s$
- $T = A_s f_y$
- $C_s = A_s' f_y$
- $M_n = T(d-a/2)+C_s(d-d')$



Compression Reinforcement

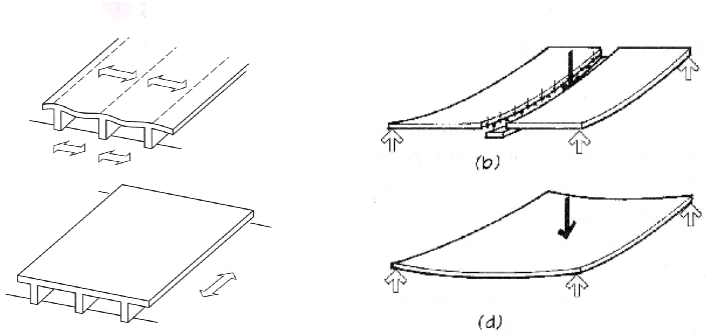
- needs ties because of buckling
- simplified method in text assumes
  - $A_s' = 0.3A_s$
  - $M_n > M_u/\phi$
  - $f'_s = \frac{1}{2} f_y$
  - $a = 2d'$
  - so

$$A_s = \frac{M_u/\phi}{f_y(d - d')}$$



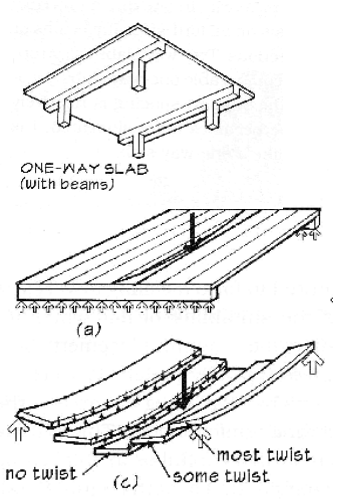
Slabs

- 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:
1) Span length ℓ is in inches.
2) Values given shall be used directly for members with normalweight concrete (w_c = 145 lb/ft³) and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
a) For structural lightweight concrete having unit weight in the range 90-120 lb/ft³, the values shall be multiplied by $(1.65 - 0.005w_c)$ but not less than 1.09, where w_c is the unit weight in lb/ft³.
b) For f_y other than 60,000 psi, the values shall be multiplied by $(0.4 + f_y/100{,}000)$.

One-way Slabs

**not in note set*

- *A_s tables*
- *max spacing**
  - *$\leq 3(t)$ and18”*
  - *$\leq 5(t)$ and18” – temp & shrinkage steel*
- *no room for stirrups*

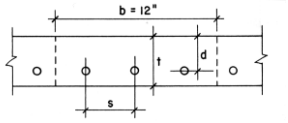


Table 3-7 Areas of Bars per Foot Width of Slab—A_s (in.^{2}/ft)

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