

concrete construction: T-beams & slabs

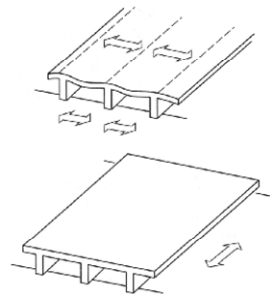
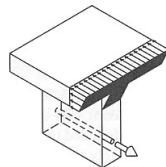
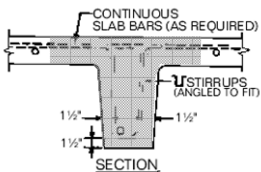
Concrete Slabs 1
Lecture 20

Architectural Structures
ARCH 331

F2009abn

T sections

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



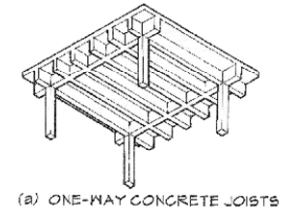
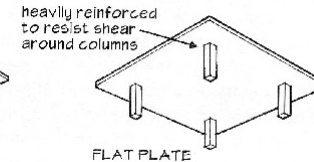
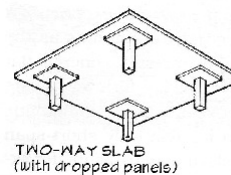
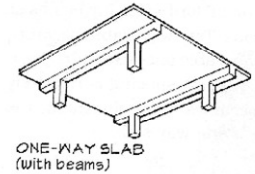
Concrete Slabs 3
Lecture 23

Foundations Structures
ARCH 331

F2008abn

Systems

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



Concrete Slabs 2
Lecture 23

Foundations Structures
ARCH 331

F2008abn

T sections

- negative bending: min A_s , larger of:

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

- effective width (interior)

- $L/4$
- $b_w + 16t$
- center-to-center of beams

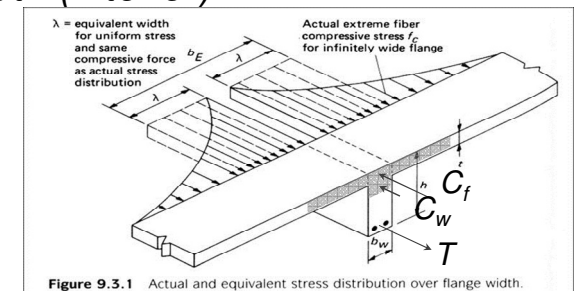


Figure 9.3.1 Actual and equivalent stress distribution over flange width.

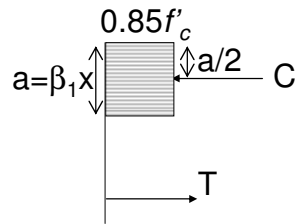
Concrete Slabs 4
Lecture 23

Foundations Structures
ARCH 331

F2008abn

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



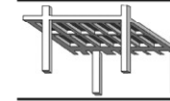
Concrete Slabs 5
Lecture 23

Foundations Structures
ARCH 331

F2008abn

One-Way

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



FLANGEforms

FLANGEforms are available in standard 2- and 3-foot modules. These forms are among the most popular because of their flexibility to accommodate various layouts and joist widths where required. They are efficient for projects with heavy superimposed loads and provide a two hour fire rating by using a 4 1/2-inch hard-rock concrete topping. They are efficient for projects of smaller size and for moderate size projects with irregular layouts or unusual building shapes. They are also efficient for projects where the structure is not required to provide a two-hour fire rating by using 3-inch or 3 1/2-inch top slab.

The varying depths provide flexibility to meet a wide range of spans and loads. Further, they will accommodate in-floor raceway electrical and communication distribution systems. Ceco FLANGEforms are capable of producing sound structural concrete, but are incapable of producing tight tolerances and smooth finishes. This form is a segmented steelform and the concrete will have irregular joints, a rough finish, and offsets at both the laps and flanges.

If a higher quality finish is required, you may wish to consider Ceco LONGforms (please see page 6). The additional cost of higher quality forms are often offset by finishing costs. Contact your Ceco representative for assistance.

Concrete Quantities/30" Widths*

Depth Height	Width	Cubic Yds. of concrete per square foot of slab surface	
		1"	4 1/2"
14"	1/2"	0.00	0.00
14"	1"	0.00	0.00
14"	1 1/2"	0.00	0.00
14"	2"	0.00	0.00
14"	2 1/2"	0.00	0.00
14"	3"	0.00	0.00
14"	3 1/2"	0.00	0.00
14"	4"	0.00	0.00
14"	4 1/2"	0.00	0.00

* Apply only for areas over FLANGEforms and joists between them. Shoring posts, wench handles, beam ties, etc., not included. 1/2" and 1 1/2" depths are also available. Contact your local Ceco Concrete Construction Engineer.

Concrete Quantities/20" Widths*

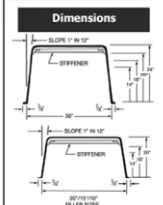
Depth Height	Width	Cubic Yds. of concrete per square foot of slab surface	
		1"	4 1/2"
14"	1/2"	0.00	0.00
14"	1"	0.00	0.00
14"	1 1/2"	0.00	0.00
14"	2"	0.00	0.00
14"	2 1/2"	0.00	0.00
14"	3"	0.00	0.00
14"	3 1/2"	0.00	0.00
14"	4"	0.00	0.00
14"	4 1/2"	0.00	0.00

* Apply only for areas over FLANGEforms and joists between them. Shoring posts, wench handles, beam ties, etc., not included. 1/2" and 1 1/2" depths are also available. Contact your local Ceco Concrete Construction Engineer.

Voids Created by Various Size FLANGEforms

Depth Height	Cubic Yds. of concrete per square foot of slab surface		Cubic Yds. of concrete for Joists
	1"	4 1/2"	
10"	0.00	0.00	0.00
12"	0.00	0.00	0.00
14"	0.00	0.00	0.00
16"	0.00	0.00	0.00
20"	0.00	0.00	0.00
24"	0.00	0.00	0.00

** Total void width spans from 30" to 25" or 20" to 18" or 16"



One-Way

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

WIDE FLANGEforms



WIDE FLANGEforms are available in standard 53 and 66-inch widths. When used with 7 and 6-inch joists they produce 5 and 6-foot modules respectively. ACI 318 requires the "joist" to be designed as a beam with minimum shear reinforcement. Any joist width can be used in combination with standard width pans to address span and load requirements. This system is very efficient for projects where the structural floor must provide a two-hour fire rating.

Using hard rock concrete, a 4 1/2-inch slab and minimum slab reinforcement will result in sufficient capacity for a variety of superimposed loads while reducing structure dead load. Shallower depth forms are appropriate for spans in the 25- to 35-foot range. Deeper depths are appropriate, under moderate loads, for spans in the 35- to 45-foot range using mild steel, while spans up to 60 feet can be achieved with post-tensioning.

By varying joist widths, different loading conditions can be accommodated using standard forming equipment without the need to add drop beams. Distribution ribs, which add unnecessary cost, are not required with wide module construction.

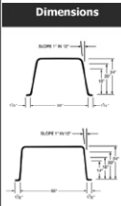
These forms are appropriate for structural concrete only, and should not be specified for critically exposed surfaces where appearance is important. They are a segmented steel form that will impart irregular lap and flange marks to the finished concrete, though many believe the finished product is acceptable for non-critically exposed work.

If a higher quality of finish is desired, for additional cost, you may wish to consider Ceco LONGforms (please see page 6). Your Ceco representative can assist in form type selection.



Voids Created with 53" Design Module	
Depth of Void	Cubic Yds. of concrete per square foot
14"	0.00
16"	0.00
20"	0.00
24"	0.00

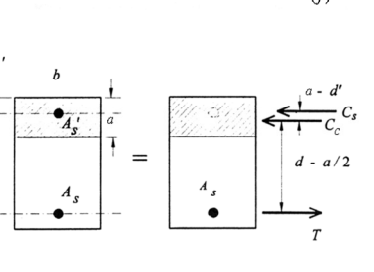
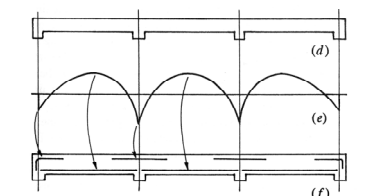
Voids Created with 66" Design Module	
Depth of Void	Cubic Yds. of concrete per square foot
14"	0.00
16"	0.00
20"	0.00
24"	0.00



Concrete Slabs 7
Lecture 23

Compression Reinforcement

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



Concrete Slabs 8
Lecture 23

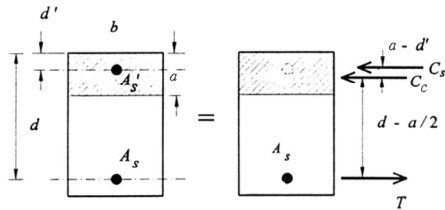
Foundations Structures
ARCH 331

F2008abn

Compression Reinforcement

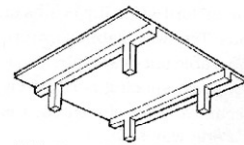
analysis

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

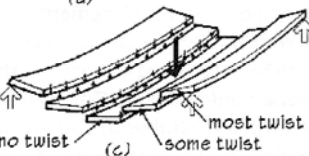
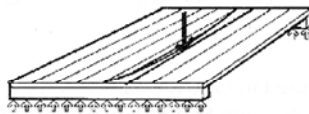


Slab Design

- 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

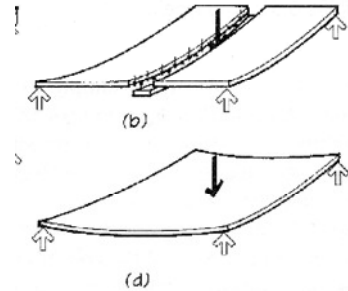
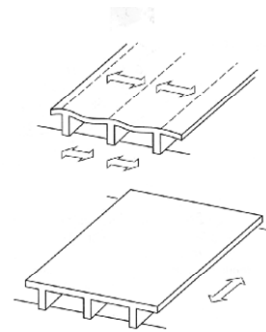


ONE-WAY SLAB (with beams)



Slabs

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



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

Member	Minimum thickness, h			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Solid one-way slabs	$l/20$	$l/24$	$l/28$	$l/10$
Beams or ribbed one-way slabs	$l/16$	$l/18.5$	$l/21$	$l/8$

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 lbm³, the values shall be multiplied by $(1.65 - 0.005w_c)$ but not less than 1.0.
 b) For f_c other than 60,000 psi, the values shall be multiplied by $(0.4 + f_c/100,000)$.



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

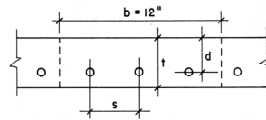


Table 3-7 Areas of Bars per Foot Width of Slab— A_s (in.²/ft)

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

Concrete Slabs 13
Lecture 23

Foundations Structures
ARCH 331

F2008abn

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

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. Longtime cambers include superimposed dead load but do not include live load.

Key
103 - Safe superimposed service load, psf
14 - Estimated camber at erection, in.
18 - Estimated long-time camber, in.

DOUBLE TEE
12'-0" x 28"

Section Properties
Untopped

A = 840 in.²
I = 44,563 in.⁴
y_t = 20.21 in.
S_t = 2,227 in.³
S_b = 5,577 in.³
wt = 511 pcf
DL = 43 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 _b (center) in.	Span, ft																
		40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72
100-S	6.00	127	110	96	82	70	60	51	42	36	29							
	6.00	0.8	0.9	0.9	0.8	0.8	0.7	0.6	0.5	0.3	0.1	-0.1						
120-S	7.00	154	134	117	102	88	77	68	57	48	41	32						
	7.00	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.0	0.9	0.8	0.7					
140-S	8.00	177	155	136	119	105	92	80	70	60	50	41	32					
	8.00	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.1				
160-S	9.00	197	175	152	134	118	104	90	79	68	56	47	38	31				
	9.00	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.2				
180-D1	13.00				189	177	167	140	128	111	97	84	72	62	52	43	36	30
	3.75				1.5	1.6	1.7	1.8	1.8	1.8	1.8	2.0	2.0	2.0	1.9	1.8	1.8	1.8
180-D1	14.38								143	126	111	97	85	73	63	54	46	37
	4.00								1.7	1.7	1.8	1.7	1.7	1.6	1.6	1.5	1.4	1.3

Concrete Slabs 14
Lecture 23

Foundations Structures
ARCH 331

F2008abn