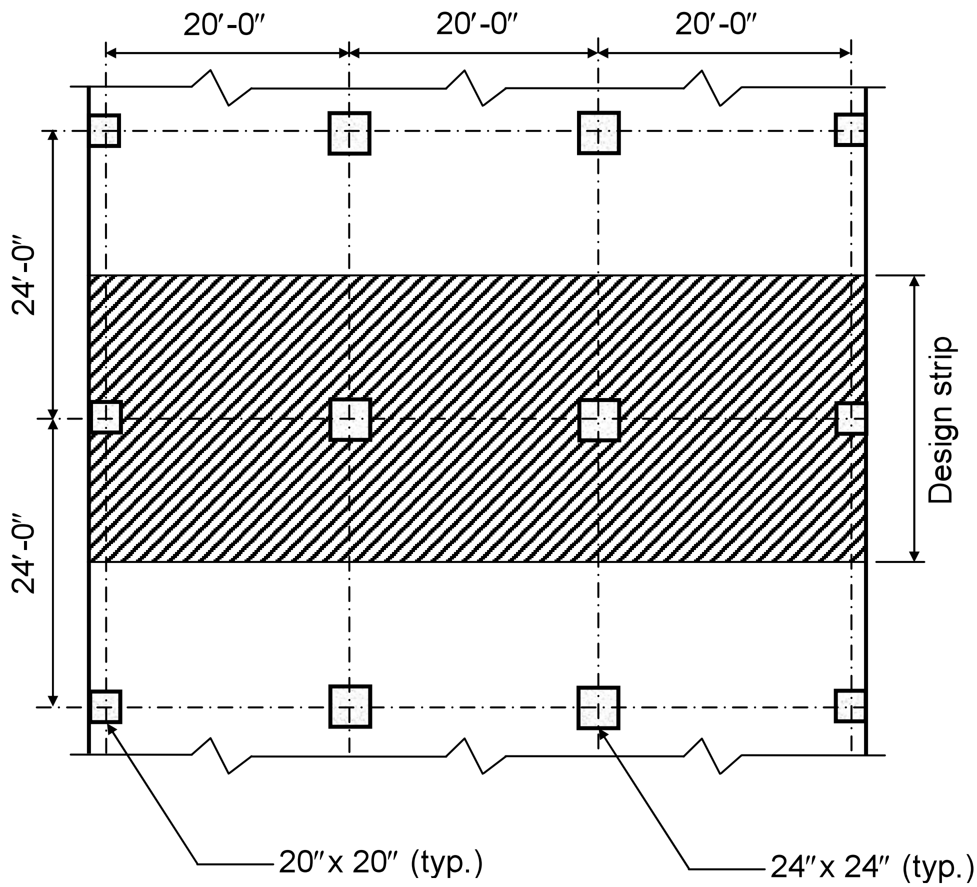
Two-Way Slabs

The following example illustrates the design methods presented in the PCA book "Simplified Design - Reinforced Concrete Buildings of Moderate Size and Height" third edition. Unless otherwise noted, all referenced table, figure, and equation numbers are from that book.

Example Building

Below is a partial plan of a typical floor in a cast-in-place reinforced concrete building. In this example, an interior strip of a flat plate floor system is designed and detailed for the effects of gravity loads according to ACI 318-05.



Design Data

Materials

- Concrete: normal weight (150 pcf), 3/4-in. maximum aggregate, f'_c = 4,000 psi
- Mild reinforcing steel: Grade 60 (f_y = 60,000 psi)

Loads

- Superimposed dead loads = 30 psf
- Live load = 50 psf

Minimum Slab Thickness

Longest clear span ℓ_n = 24 – (20/12) = 22.33 ft

From Fig. 4-3, minimum thickness h per ACI Table 9.5(c) = ℓ_n/30 = 8.9 in.

Use Fig. 1-8 to determine h based on shear requirements at interior column assuming a 9 in. slab:

q_u = 1.2(112.5 + 30) + 1.6(50) = 251.0 psf

A = 24 x 20 = 480 ft^2

A/c_1^2 = $480/2^2$ = 120

From Fig. 1-8, $d/c_1 \approx 0.22$

d = 0.22 x 24 = 5.3 in.

h = 5.3 + 1.25 = 6.55 in.

Try preliminary h = 9 in.

Design for Flexure

Use Fig. 4-4 to determine if the Direct Design Method of ACI Sect. 13.6 can be utilized to compute the bending moments due to the gravity loads:

- 3 continuous spans in one direction, more than 3 in the other O.K.
- Rectangular panels with long-to-short span ratio = 24/20 = 1.2 < 2 O.K.
- Successive span lengths in each direction are equal O.K.
- No offset columns O.K.
- L/D = 50/(112.5 + 30) = 0.35 < 2 O.K.
- Slab system has no beams N.A.

Since all requirements are satisfied, the Direct Design Method can be used.

Total panel moment M_o in end span:

$$M_o = \frac{q_u \ell_2 \ell_n^2}{8} = \frac{0.251 \times 24 \times 18.167^2}{8}$$

= 248.5 ft - kips

Total panel moment M_o in interior span:

$$M_o = \frac{q_u \ell_2 \ell_n^2}{8} = \frac{0.251 \times 24 \times 18.0^2}{8}$$

= 244 ft - kips

For simplicity, use M_o = 248.5 ft-kips for all spans.

Division of the total panel moment M_o into negative and positive moments, and then column and middle strip moments, involves the direct application of the moment coefficients in Table 4-2.

Slab Moments (ft-kips)	End Spans			Int. Span
	Ext. neg.	Positive	Int. neg.	Positive
Total Moment	64.6	129.2	173.9	87.0
Column Strip	64.6	77.0	131.7	52.2
Middle Strip	0	52.2	42.2	34.8

Note: All negative moments are at face of support.

Required slab reinforcement.

Span Location		M_u (ft-kips)	b* (in.)	d** (in.)	As† (in.^{2})	Min. As‡ (in.^{2})	Reinforcement+
End Span							
Column Strip	Ext. neg.	64.6	120	7.75	2.08	1.94	11-No. 4
	Positive	77.0	120	7.75	2.48	1.94	13-No. 4
	Int. Neg.	131.7	120	7.75	4.25	1.94	22-No. 4
Middle Strip	Ext. neg.	0.0	168	7.75	---	2.72	14-No. 4
	Positive	52.2	168	7.75	1.68	2.72	14-No. 4
	Int. Neg.	42.2	168	7.75	1.36	2.72	14-No. 4
Interior Span							
Column Strip	Positive	52.2	120	7.75	1.68	1.94	10-No. 4
Middle Strip	Positive	34.8	168	7.75	1.12	2.72	14-No. 4

*Column strip width b = (20 x 12)/2 = 120 in.
*Middle strip width b = (24 x 12) – 120 = 168 in.
**Use average d = 9 – 1.25 = 7.75 in.
†A_s = M_u /4d where M_u is in ft-kips and d is in inches
‡Min. A_s = 0.0018bh = 0.0162b; Max. s = 2h = 18 in. or 18 in. (Sect. 13.3.2)
+For maximum spacing:120/18 = 6.7 spaces, say 8 bars
168/18 = 9.3 spaces, say 11 bars

Design for Shear

Check slab shear and flexural strength at edge column due to direct shear and unbalanced moment transfer.

Check slab reinforcement at exterior column for moment transfer between slab and column.

Portion of total unbalanced moment transferred by flexure = $\gamma_f M_u$

b_1 = 20 + (7.75/2) = 23.875 in.

b_2 = 20 + 7.75 = 27.75 in.

b_1 /b_2 = 0.86

From Fig. 4-16, γ_f = 0.62*

*The provisions of Sect. 13.5.3.3 may be utilized; however, they are not in this example.

$\gamma_f M_u$ = 0.62 x 64.6 = 40 ft-kips

Required A_s = 40/(4 x 7.75) = 1.29 in.^{2}

Number of No. 4 bars = 1.29/0.2 = 6.5, say 7 bars

Must provide 7-No. 4 bars within an effective slab width = 3h + c_2 = (3 x 9) + 20 = 47 in.

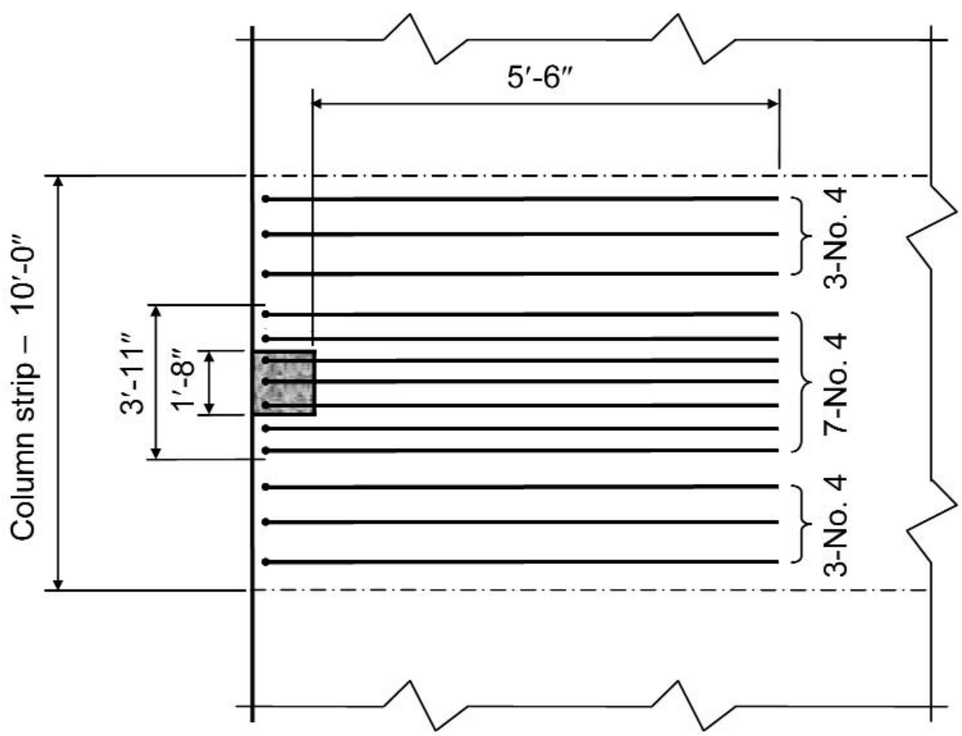
Provide the required 7-No. 4 bars by concentrating 7 of the column strip bars (11-No. 4) within the 47 in. slab width over the column.

Check bar spacing:

For 7-No. 4 within 47 in. width: 47/7 = 6.7 in. < 18 in. O.K.
For 4-No. 4 within 120 – 47 = 73 in. width: 73/4 = 18.25 in. > 18 in.

Add 1 additional bar on each side of the 47 in. strip; the spacing becomes 73/6 = 12.2 in. < 18 in. O.K.

Reinforcement details at this location are shown in the figure on the next page.



Check the combined shear stress at the inside face of the critical transfer section.

$v_u = \dfrac{V_u}{A_c} + \dfrac{\gamma_v M_u}{J/c}$

Factored shear force at edge column:

V_u = 0.251[(24 x 10.83) – (1.99 x 2.31)]

= 64.1 kips

When the end span moments are determined from the Direct Design Method, the fraction of unbalanced moment transferred by eccentricity of shear must be $0.3M_o$ = 0.3 x 248.5 = 74.6 ft-kips (Sect. 13.6.3.6).

$\gamma_v = 1 - \gamma_f = 1 - 0.62 = 0.38$

$c_2 / c_1 = 1.0$

$c_1 / d = 20/7.75 = 2.58$

From Table 4.9

$A_c = (2b_1 + b_2)\, d = 585.1 \text{ in.}^2$

$J_c = [2b_1 d(b_1 + 2b_2) + d^3(2b_1 + b_2)/b_1]/6 = 5{,}141 \text{ in.}^3$

$v_u = \dfrac{64{,}105}{585.1} + \dfrac{0.38 \times 64.6 \times 12{,}000}{5{,}141}$

$v_u = 109.6 + 57.6 = 167.2$ psi

Determine allowable shear stress ϕv_c from Fig. 4-13:

$b_o / d = (2b_1 + b_2)/d$

$b_o / d = [(2 \times 23.875) + 27.75]/7.75 = 9.74$

$\beta_c = 1$

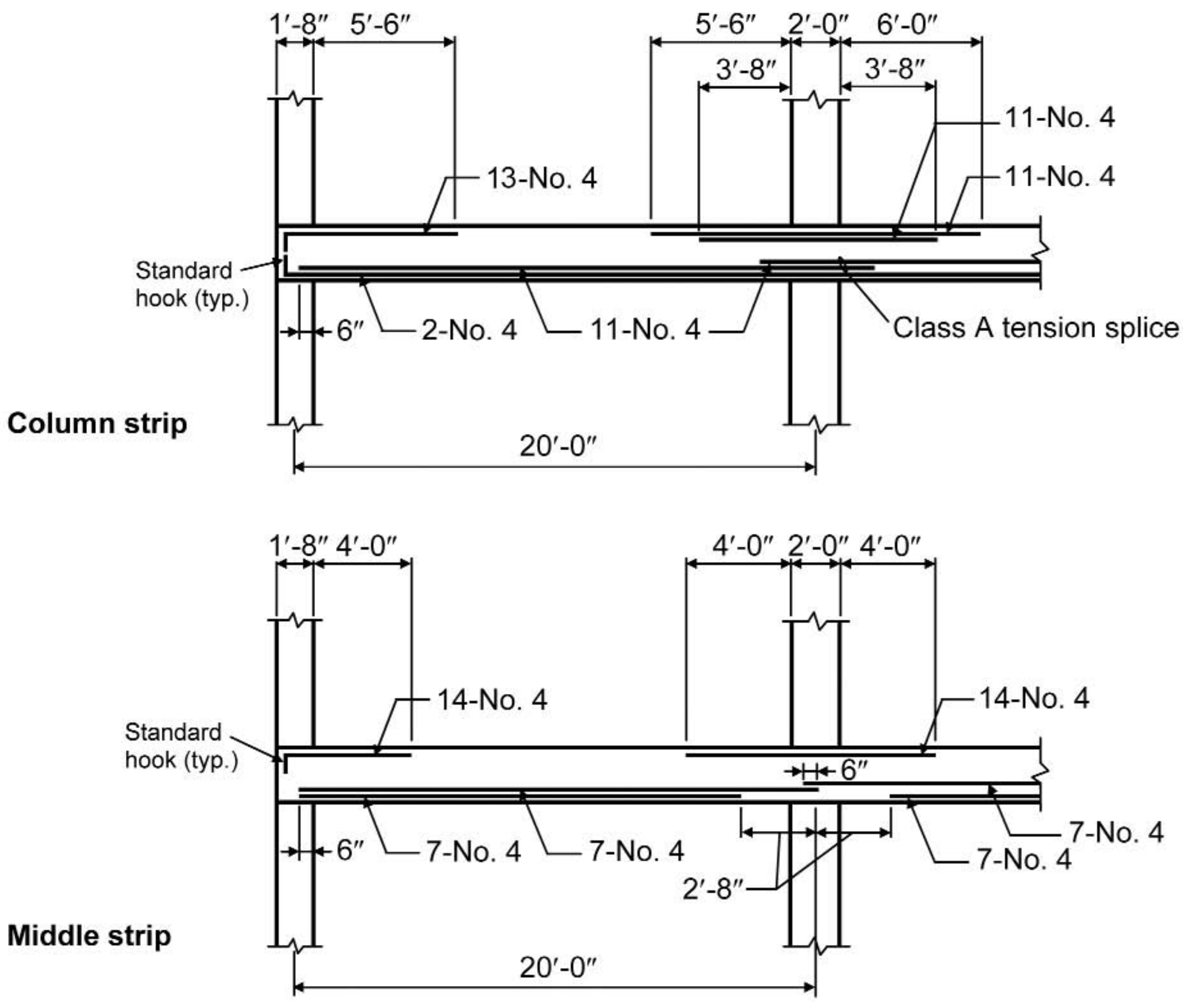
$\phi v_c = 189.7 \text{ psi} > v_u = 168.2$ psi OK

9" slab is OK

Reinforcement Details

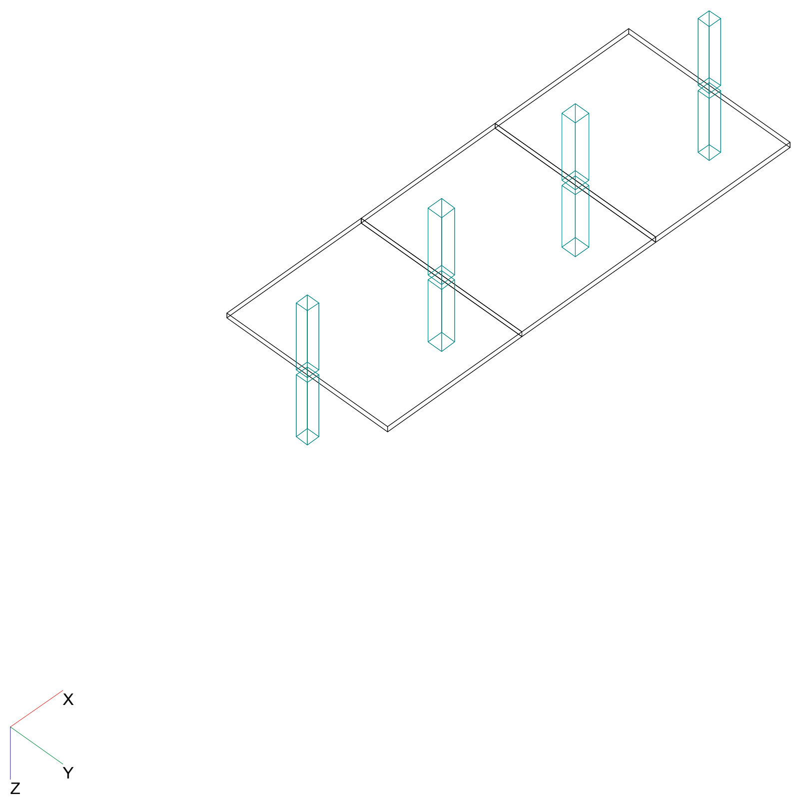
The figures below show the reinforcement details for the column and middle strips. The bar lengths are determined from Fig. 13.3.8 of ACI 318-05.

Two-Way Slabs



The PCA computer program pcaSlab can be used to expedite the design of different slab systems. The program covers wide range of two-way slab systems and can be used for more complex slab layouts. The output of the program for the slab in the example is shown in the following pages. Please note that the Equivalent Frame Method is used by the pcaSlab program.

Two-Way Slabs



pcaSlab v2.00. Licensed to: pcaStructurePoint. License ID: 12345-1234567-4-2D2DE-2C8D0

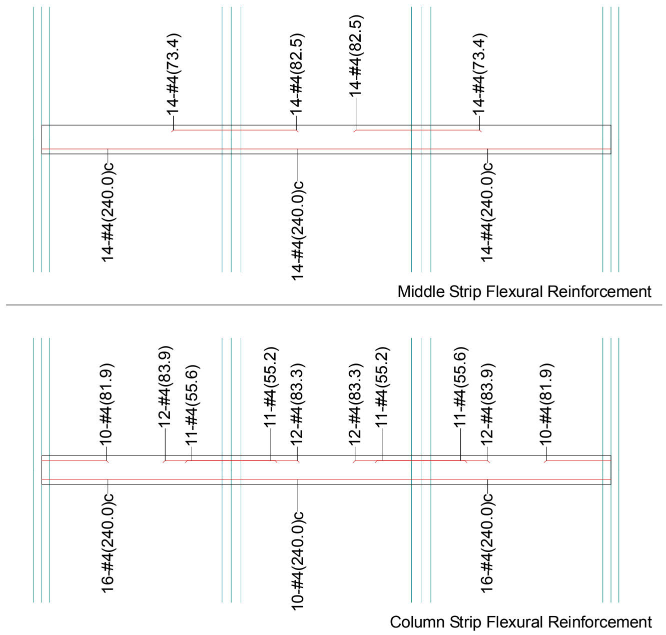
File: C:\Data\Time Saving Design Aid\Two-Way Slabs.slb

Project: Time Saving Design Aids

Frame: Two-Way Slab

Engineer: PCA

Two-Way Slabs



pcaSlab v2.00. Licensed to: pcaStructurePoint. License ID: 12345-1234567-4-2D2DE-2C8D0

File: C:\Data\Time Saving Design Aid\Two-Way Slabs.slb

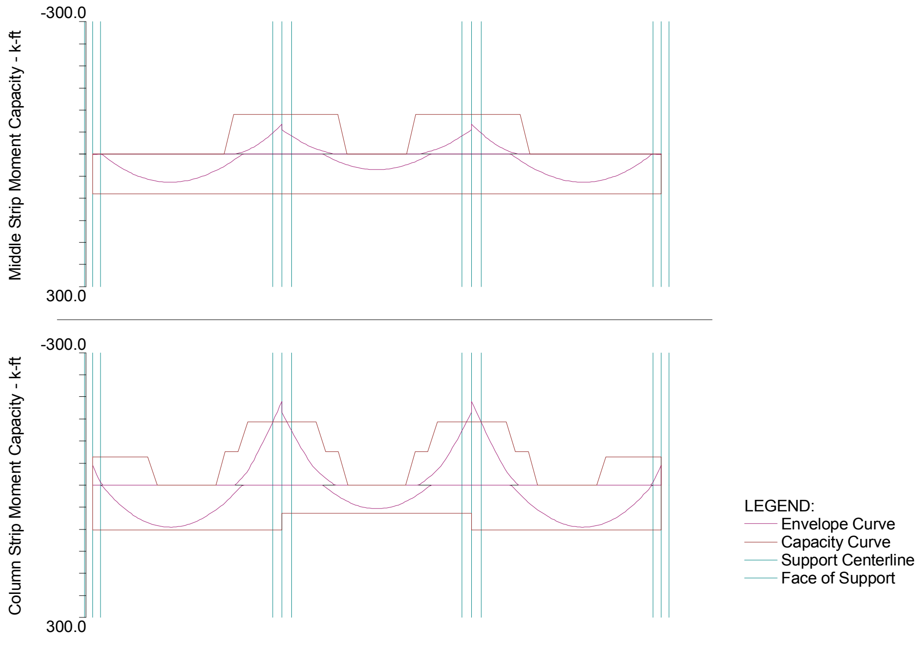
Project: Time Saving Design Aids

Frame: Two-Way Slab

Engineer: PCA

Portland Cement Association

Two-Way Slabs



pcaSlab v2.00. Licensed to: pcaStructurePoint. License ID: 12345-1234567-4-2D2DE-2C8D0

File: C:\Data\Time Saving Design Aid\Two-Way Slabs.slb

Project: Time Saving Design Aids

Frame: Two-Way Slab

Engineer: PCA

Two-Way Slabs

```
pcaSlab v2.00 © Portland Cement Association                                                       05-03-2007, 11:27:26 AM
Licensed to: pcaStructurePoint, License ID: 12345-1234567-4-2D2DE-2C8D0
c:\Work\Time Saving Design Aids\318-05\Rev 2\Data\Two-Way Slabs.slb                                                Page 1


                         ooooooo      oooooo      ooooo
                         oooooooo    oooooooo    ooooooo
                         oo    oo    oo    oo    oo   oo
                         oo    oo    oo          oo   oo
                         oooooooo    oo          ooooooo   ooooo
                         ooooooo     oo    oo    ooooooo   ooooo
                         oo          oo    oo    oo   oo
                         oo          oooooooo    oo   oo
                         oo           oooooo     oo   oo


                       oooooo      o                    o
                      oooooooo    oo        ooooo      oo
                      oo          oo       o    oo     oo
                      oooo        oo       o    oo     oo
                       oooooo     oo        oooooo     oooooo
                          oooo    oo       oo   oo     oo   oo
                            oo    oo       oo   oo     oo   oo
                      oooooooo    oo  o    oo   oo     oo   oo
                       oooooo      ooo      ooooo o     ooooo

      =============================================================================
                                  pcaSlab v2.00 (TM)
               A Computer Program for Analysis, Design, and Investigation of
                Reinforced Concrete Beams, One-way and Two-way Slab Systems
      =============================================================================
                  Copyright © 2003-2006, Portland Cement Association
                                  All rights reserved

             Licensee stated above acknowledges that Portland Cement Association
         (PCA) is not and  cannot  be  responsible for  either the  accuracy  or
         adequacy of  the material supplied  as input  for  processing   by  the
         pcaSlab  computer program.  Furthermore, PCA neither makes any warranty
         expressed nor implied with respect  to  the  correctness of the  output
         prepared by the  pcaSlab   program.  Although  PCA  has  endeavored  to
         produce pcaSlab  error free the  program is not and cannot be certified
         infallible.  The final and only responsibility for analysis, design and
         engineering documents is the licensees. Accordingly, PCA disclaims  all
         responsibility in contract, negligence or other tort for any  analysis,
         design  or engineering documents prepared in connection with the use of
         the pcaSlab  program.

=============================================================================================
[1] INPUT ECHO
=============================================================================================

General Information:
====================
   File name: c:\Work\Time Saving Design Aids\318-05\Rev 2\Data\Two-Way Slabs.slb
   Project: Time Saving Design Aids
   Frame: Two-Way Slab
   Engineer: PCA
   Code: ACI 318-02
   Reinforcement Database: ASTM A615
   Mode: Design
   Number of supports = 4
   Floor System: Two-Way

   Live load pattern ratio = 75%
   Minimum free edge for punching shear = 10 times slab thickness
   Deflections are based on cracked section properties.
   In negative moment regions, Ig and Mcr DO NOT include flange/slab contribution (if available)
   Long-term deflections are calculated for load duration of 60 months.
   0% of live load is sustained.
   Compression reinforcement calculations NOT selected.

Material Properties:
====================
            Slabs|Beams       Columns
           ------------   ------------
   wc    =          150            150 lb/ft3
   f'c   =            4              4 ksi
   Ec    =       3834.3         3834.3 ksi
   fr    =      0.47434        0.47434 ksi

   fy    =           60 ksi, Bars are not epoxy-coated
   fyv   =           60 ksi
   Es    =        29000 ksi

Reinforcement Database:
===============
   Units: Db (in), Ab (in^2), Wb (lb/ft)
   Size       Db      Ab        Wb    Size       Db      Ab        Wb
   ---- -------- -------- --------    ---- -------- -------- --------
```

#3	0.38	0.11	0.38	#4	0.50	0.20	0.67
#5	0.63	0.31	1.04	#6	0.75	0.44	1.50
#7	0.88	0.60	2.04	#8	1.00	0.79	2.67
#9	1.13	1.00	3.40	#10	1.27	1.27	4.30
#11	1.41	1.56	5.31	#14	1.69	2.25	7.65
#18	2.26	4.00	13.60				

Span Data:
==========

Slabs: L1, wL, wR (ft); t, Hmin (in)

Span	Loc	L1	t	wL	wR	Hmin
1	Int	20.000	9.00	12.000	12.000	7.27
2	Int	20.000	9.00	12.000	12.000	6.55
3	Int	20.000	9.00	12.000	12.000	7.27

Support Data:
=============

Columns: c1a, c2a, c1b, c2b (in); Ha, Hb (ft)

Supp	c1a	c2a	Ha	c1b	c2b	Hb	Red%
1	20.00	20.00	10.000	20.00	20.00	10.000	100
2	24.00	24.00	10.000	24.00	24.00	10.000	100
3	24.00	24.00	10.000	24.00	24.00	10.000	100
4	20.00	20.00	10.000	20.00	20.00	10.000	100

Boundary Conditions: Kz (kip/in); Kry (kip-in/rad)

Supp	Spring Kz	Spring Kry	Far End A	Far End B
1	0	0	Fixed	Fixed
2	0	0	Fixed	Fixed
3	0	0	Fixed	Fixed
4	0	0	Fixed	Fixed

Load Data:
==========

Load Cases and Combinations:

Case	SELF	Dead	Live
Type	DEAD	DEAD	LIVE
U1	1.400	1.400	0.000
U2	1.200	1.200	1.600
U3	1.200	1.200	1.600
U4	1.200	1.200	1.600
U5	1.200	1.200	1.000
U6	1.200	1.200	1.000
U7	0.900	0.900	0.000
U8	0.900	0.900	0.000
U9	1.200	1.200	1.000
U10	1.200	1.200	1.000
U11	0.900	0.900	0.000
U12	0.900	0.900	0.000

Span Loads:

Span	Case	Wa
Area Loads - Wa (lb/ft2):		
1	Dead	30
2	Dead	30
3	Dead	30
1	Live	50
2	Live	50
3	Live	50

Support Loads - Fz (kip), My (k-ft):

Supp	Case	Fz	My
1	SELF	0	0
2	SELF	0	0
3	SELF	0	0
4	SELF	0	0
1	Live	0	0
2	Live	0	0
3	Live	0	0
4	Live	0	0

Support Displacements - D (in), R (rad):

Supp	Case	D	R
1	SELF	0	0
2	SELF	0	0
3	SELF	0	0
4	SELF	0	0
1	Live	0	0
2	Live	0	0
3	Live	0	0
4	Live	0	0

pcaSlab v2.00 © Portland Cement Association 05-03-2007, 11:27:26 AM
Licensed to: pcaStructurePoint, License ID: 12345-1234567-4-2D2DE-2C8D0
c:\Work\Time Saving Design Aids\318-05\Rev 2\Data\Two-Way Slabs.slb Page 3

Reinforcement Criteria:

	Top bars Min	Top bars Max	Bottom bars Min	Bottom bars Max	Stirrups Min	Stirrups Max	
Slabs and Ribs:							
Bar Size	#4	#8	#4	#8			
Bar spacing	1.00	18.00	1.00	18.00			in
Reinf ratio	0.14	5.00	0.14	5.00			%
Cover	1.50		1.50				in
Beams:							
Bar Size	#5	#8	#5	#8	#3	#5	
Bar spacing	1.00	18.00	1.00	18.00	6.00	18.00	in
Reinf ratio	0.14	5.00	0.14	5.00			%
Cover	1.50		1.50				in
Side cover	1.50		1.50				in
Layer dist.	1.00		1.00				in
No. of legs					2	6	

[2] DESIGN RESULTS*

*Unless otherwise noted, all results are in the direction of analysis only. Another analysis in the perpendicular direction has to be carried out for two-way slab systems.

Top Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Zone	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	Left	10.00	6.22	0.833	1.944	15.714	12.000	0.191	10-#4
		Middle	10.00	0.00	9.917	0.000	15.714	0.000	0.000	---
		Right	10.00	142.72	19.000	1.944	15.714	5.217	4.588	23-#4
	Middle	Left	14.00	-0.00	0.833	0.000	22.000	0.000	0.000	---
		Middle	14.00	0.00	9.917	0.000	22.000	0.000	0.000	---
		Right	14.00	47.58	19.000	2.722	22.000	12.000	1.474	14-#4
2	Column	Left	10.00	122.98	1.000	1.944	15.714	5.217	3.926	23-#4
		Middle	10.00	0.00	10.000	0.000	15.714	0.000	0.000	---
		Right	10.00	122.98	19.000	1.944	15.714	5.217	3.926	23-#4
	Middle	Left	14.00	40.99	1.000	2.722	22.000	12.000	1.268	14-#4
		Middle	14.00	0.00	10.000	0.000	22.000	0.000	0.000	---
		Right	14.00	40.99	19.000	2.722	22.000	12.000	1.268	14-#4
3	Column	Left	10.00	142.72	1.000	1.944	15.714	5.217	4.588	23-#4
		Middle	10.00	0.00	10.083	0.000	15.714	0.000	0.000	---
		Right	10.00	6.22	19.167	1.944	15.714	12.000	0.191	10-#4
	Middle	Left	14.00	47.58	1.000	2.722	22.000	12.000	1.474	14-#4
		Middle	14.00	0.00	10.083	0.000	22.000	0.000	0.000	---
		Right	14.00	-0.00	19.167	0.000	22.000	0.000	0.000	---

Top Bar Details:

Units: Length (ft)

		Left				Continuous		Right			
Span	Strip	Bars	Length	Bars	Length	Bars	Length	Bars	Length	Bars	Length
1	Column	10-#4	6.83	---		---		12-#4	7.00	11-#4	4.63
	Middle	---		---		---		14-#4	6.12	---	
2	Column	12-#4	6.94	11-#4	4.60	---		12-#4	6.94	11-#4	4.60
	Middle	14-#4	6.87	---		---		14-#4	6.87	---	
3	Column	12-#4	7.00	11-#4	4.63	---		10-#4	6.83	---	
	Middle	14-#4	6.12	---		---		---		---	

Bottom Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	10.00	95.59	8.299	1.944	15.714	7.500	3.023	16-#4
	Middle	14.00	63.73	8.299	2.722	22.000	12.000	1.982	14-#4
2	Column	10.00	52.89	10.000	1.944	15.714	12.000	1.649	10-#4
	Middle	14.00	35.26	10.000	2.722	22.000	12.000	1.089	14-#4
3	Column	10.00	95.59	11.701	1.944	15.714	7.500	3.023	16-#4
	Middle	14.00	63.73	11.701	2.722	22.000	12.000	1.982	14-#4

Bottom Bar Details:

```
pcaSlab v2.00 © Portland Cement Association                                                  05-03-2007, 11:27:27 AM
Licensed to: pcaStructurePoint, License ID: 12345-1234567-4-2D2DE-2C8D0
c:\Work\Time Saving Design Aids\318-05\Rev 2\Data\Two-Way Slabs.slb                                         Page 4

   Units: Start (ft), Length (ft)
                _______Long Bars_______ ______Short Bars_______
   Span Strip      Bars   Start  Length    Bars   Start  Length
   ---- ------- ------- ------- ------- ------- ------- -------
      1 Column    16-#4    0.00   20.00     ---
        Middle    14-#4    0.00   20.00     ---

      2 Column    10-#4    0.00   20.00     ---
        Middle    14-#4    0.00   20.00     ---

      3 Column    16-#4    0.00   20.00     ---
        Middle    14-#4    0.00   20.00     ---

Flexural Capacity:
==================
   Units: x (ft), As (in^2), PhiMn (k-ft)
   Span Strip          x AsTop AsBot       PhiMn-       PhiMn+
   ---- ------ --------- ----- ----- ------------ ------------
      1 Column     0.000  2.00  3.20       -63.93       101.01
                   0.833  2.00  3.20       -63.93       101.01
                   5.829  2.00  3.20       -63.93       101.01
                   6.829  0.00  3.20         0.00       101.01
                   7.192  0.00  3.20         0.00       101.01
                  10.000  0.00  3.20         0.00       101.01
                  12.642  0.00  3.20         0.00       101.01
                  13.005  0.00  3.20         0.00       101.01
                  14.005  2.40  3.20       -76.39       101.01
                  15.366  2.40  3.20       -76.39       101.01
                  16.366  4.60  3.20      -143.07       101.01
                  19.000  4.60  3.20      -143.07       101.01
                  20.000  4.60  3.20      -143.07       101.01
        Middle     0.000  0.00  2.80         0.00        89.50
                   0.833  0.00  2.80         0.00        89.50
                   7.192  0.00  2.80         0.00        89.50
                  10.000  0.00  2.80         0.00        89.50
                  12.642  0.00  2.80         0.00        89.50
                  13.883  0.00  2.80         0.00        89.50
                  14.883  2.80  2.80       -89.50        89.50
                  19.000  2.80  2.80       -89.50        89.50
                  20.000  2.80  2.80       -89.50        89.50

      2 Column     0.000  4.60  2.00      -143.07        63.93
                   1.000  4.60  2.00      -143.07        63.93
                   3.601  4.60  2.00      -143.07        63.93
                   4.601  2.40  2.00       -76.39        63.93
                   5.940  2.40  2.00       -76.39        63.93
                   6.940  0.00  2.00         0.00        63.93
                   7.300  0.00  2.00         0.00        63.93
                  10.000  0.00  2.00         0.00        63.93
                  12.700  0.00  2.00         0.00        63.93
                  13.060  0.00  2.00         0.00        63.93
                  14.060  2.40  2.00       -76.39        63.93
                  15.399  2.40  2.00       -76.39        63.93
                  16.399  4.60  2.00      -143.07        63.93
                  19.000  4.60  2.00      -143.07        63.93
                  20.000  4.60  2.00      -143.07        63.93
        Middle     0.000  2.80  2.80       -89.50        89.50
                   1.000  2.80  2.80       -89.50        89.50
                   5.875  2.80  2.80       -89.50        89.50
                   6.875  0.00  2.80         0.00        89.50
                   7.300  0.00  2.80         0.00        89.50
                  10.000  0.00  2.80         0.00        89.50
                  12.700  0.00  2.80         0.00        89.50
                  13.125  0.00  2.80         0.00        89.50
                  14.125  2.80  2.80       -89.50        89.50
                  19.000  2.80  2.80       -89.50        89.50
                  20.000  2.80  2.80       -89.50        89.50

      3 Column     0.000  4.60  3.20      -143.07       101.01
                   1.000  4.60  3.20      -143.07       101.01
                   3.634  4.60  3.20      -143.07       101.01
                   4.634  2.40  3.20       -76.39       101.01
                   5.995  2.40  3.20       -76.39       101.01
                   6.995  0.00  3.20         0.00       101.01
                   7.358  0.00  3.20         0.00       101.01
                  10.000  0.00  3.20         0.00       101.01
                  12.808  0.00  3.20         0.00       101.01
                  13.171  0.00  3.20         0.00       101.01
                  14.171  2.00  3.20       -63.93       101.01
                  19.167  2.00  3.20       -63.93       101.01
                  20.000  2.00  3.20       -63.93       101.01
        Middle     0.000  2.80  2.80       -89.50        89.50
                   1.000  2.80  2.80       -89.50        89.50
                   5.117  2.80  2.80       -89.50        89.50
                   6.117  0.00  2.80         0.00        89.50
                   7.358  0.00  2.80         0.00        89.50
                  10.000  0.00  2.80         0.00        89.50
```

```
pcaSlab v2.00 © Portland Cement Association                                                      05-03-2007, 11:27:27 AM
Licensed to: pcaStructurePoint, License ID: 12345-1234567-4-2D2DE-2C8D0
c:\Work\Time Saving Design Aids\318-05\Rev 2\Data\Two-Way Slabs.slb                                                Page 5

                  12.808  0.00  2.80         0.00        89.50
                  19.167  0.00  2.80         0.00        89.50
                  20.000  0.00  2.80         0.00        89.50

Slab Shear Capacity:
====================
   Units: b, d (in), Xu (ft), PhiVc, Vu(kip)
   Span        b        d   Vratio        PhiVc           Vu           Xu
   ---- -------- -------- -------- ------------ ------------ ------------
      1   288.00     7.25    1.000       198.09        61.26        18.40
      2   288.00     7.25    1.000       198.09        50.58        18.40
      3   288.00     7.25    1.000       198.09        61.26         1.60

Flexural Transfer of Negative Unbalanced Moment at Supports:
============================================================
   Units: Width (in), Munb (k-ft), As (in^2)
   Supp    Width  GammaF*Munb Comb Pat     AsReq   AsProv Additional Bars
   ---- -------- ------------ ---- ---- -------- -------- ---------------
      1    47.00        30.23 U2   All     0.950    0.783     1-#4
      2    51.00        33.44 U2   Odd     1.051    1.955      ---
      3    51.00        33.44 U2   Odd     1.051    1.955      ---
      4    47.00        30.23 U2   All     0.950    0.783     1-#4

Punching Shear Around Columns:
==============================
   Units: Vu (kip), Munb (k-ft), vu (psi), Phi*vc (psi)
   Supp           Vu       vu         Munb Comb Pat  GammaV       vu   Phi*vc
   ---- ------------ -------- ------------ ---- ---- ------ -------- --------
      1        48.92    129.4         3.20 U2   All   0.320    134.6    189.7
      2       129.49    149.2       -37.01 U2   All   0.400    168.7    189.7
      3       129.49    149.2        37.01 U2   All   0.400    168.7    189.7
      4        48.92    129.4        -3.20 U2   All   0.320    134.6    189.7

Deflections:
============
   Section properties
   ------------------
   Units: Ig, Icr, Ie (in^4), Mcr, Mmax (k-ft)                               ________________Load Level_______________
        _________Ie,avg_________                                             _________Dead_______  ______Dead+Live_____
   Span        Dead   Dead+Live Zone            Ig         Icr      Mcr     Mmax          Ie     Mmax          Ie
   ---- ----------- ----------- ------ ----------- ----------- -------- -------- ----------- -------- -----------
      1       17496       16272 Middle       17496        1816   153.69    90.45       17496   122.19       17496
                                Right        17496        2174   153.69  -146.59       17496  -198.03        9336
      2       17496       16317 Left         17496        2174   153.69  -125.58       17496  -169.64       13567
                                Middle       17496        1494   153.69    45.42       17496    61.36       17496
                                Right        17496        2174   153.69  -125.58       17496  -169.64       13567
      3       17496       16272 Left         17496        2174   153.69  -146.59       17496  -198.03        9336
                                Middle       17496        1816   153.69    90.45       17496   122.19       17496

   Maximum Instantaneous Deflections - Direction of Analysis
   ---------------------------------------------------------
   Units:  D (in), Ig (in^4)
        ___________Frame__________ ____________________________Strips___________________________
   Span    Ddead    Dlive   Dtotal Strip               Ig    LDF  Ratio    Ddead    Dlive   Dtotal
   ---- -------- -------- -------- ------ ------------ ------ ------ -------- -------- --------
      1    0.074    0.032    0.106 Column         7290  0.738  1.770    0.132    0.056    0.188
                                   Middle        10206  0.262  0.450    0.034    0.014    0.048
      2    0.022    0.009    0.031 Column         7290  0.675  1.620    0.036    0.015    0.051
                                   Middle        10206  0.325  0.557    0.012    0.005    0.017
      3    0.074    0.032    0.106 Column         7290  0.738  1.770    0.132    0.056    0.188
                                   Middle        10206  0.262  0.450    0.034    0.014    0.048

   Maximum Long-term Deflections - Direction of Analysis
   -----------------------------------------------------
   Time dependant factor for sustained loads = 2.000
   Units:  D (in)
        ___________________Column Strip____________________ ____________________Middle Strip___________________
   Span    Dsust Lambda      Dcs   Dcs+lu    Dcs+l   Dtotal    Dsust Lambda      Dcs   Dcs+lu    Dcs+l   Dtotal
   ---- -------- ------ -------- -------- -------- -------- -------- ------ -------- -------- -------- --------
      1    0.132  2.000    0.264    0.320    0.320    0.451    0.034  2.000    0.067    0.081    0.081    0.115
      2    0.036  2.000    0.071    0.086    0.086    0.122    0.012  2.000    0.024    0.030    0.030    0.042
      3    0.132  2.000    0.264    0.320    0.320    0.451    0.034  2.000    0.067    0.081    0.081    0.115

Material Takeoff:
=================
   Reinforcement in the Direction of Analysis
   ------------------------------------------
   Top Bars:       693.4 lb   <=>  11.56 lb/ft   <=>  0.481 lb/ft^2
   Bottom Bars:   1122.2 lb   <=>  18.70 lb/ft   <=>  0.779 lb/ft^2
   Stirrups:         0.0 lb   <=>   0.00 lb/ft   <=>  0.000 lb/ft^2
   Total Steel:   1815.6 lb   <=>  30.26 lb/ft   <=>  1.261 lb/ft^2
   Concrete:      1080.0 ft^3 <=>  18.00 ft^3/ft <=>  0.750 ft^3/ft^2
```