APPENDICES

A. Existing Floor System

B. Hollow Core Slab System Selection

C. Composite Steel Deck/Concrete Slab Floor System Selection

D. Non-composite Steel Deck/Concrete Slab Floor System Selection

E. One-Way Concrete Joist System Selection

F. Two-Way Flat Plate with Drop Panels Selection

G. R.S. Means Assemblies Cost Data

H. List of Resources

APPENDIX A:

Existing Floor System

System self-weight

W_{slab} = (8" slab)*(147 pcf)*(1ft/12") = 98 psf

Total Self-Weight of Typical Bay = 98 psf

Please consult Technical Assignments #1 and #3 for analysis of existing floor system.

APPENDIX B:

Hollow Core Slab System Selection

- Superimposed Dead Load:
  - 7 psf for ceiling/mechanical (presumed)
  - 5 psf for collateral (listed on drawings)

- Worst Case Live Load (typical floor): 70 psf

- **Total Superimposed Load (unfactored)** = 70 psf + 7 psf + 5 psf = **82 psf**
- Total Superimposed Load (factored) = 1.2(12 psf) + 1.4(70psf) = 114.8 psf

- *From Nitterhouse Concrete Products (see following data chart):*

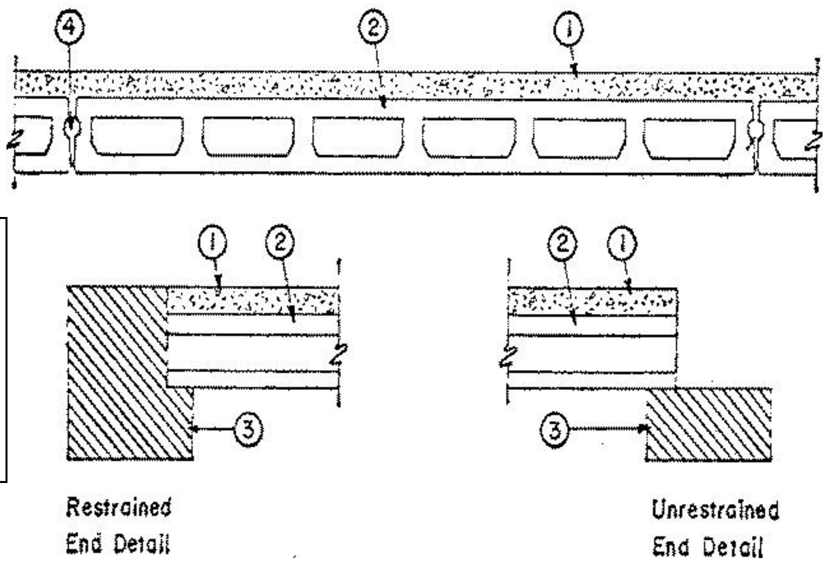
  - Span = 23'-2" → 24' (spanning in this direction allows for a thinner hollow core slab)

  - Choose **8" × 4' Prestressed Concrete SpanDeck with 2" topping (U.L. J917)**
    - f'_c = 5000 psi at 28 days, 3000 psi at release
    - Precast density = 150 pcf (top and webs), 115 pcf (soffit)
    - Allowable Superimposed Load for 24' span = 112 psf (flexure) > 82 psf req'd
    - (4) ½" diameter, 270 ksi Low-Relaxation Strands at 2" height
    - Precast System Weight = 330 plf = 82.5 psf

Fire Rating from Underwriters' Laboratories
- Restrained end: 2 in. concrete cover (1 in. gypsum board) required for 2 hour fire rating
- Unrestrained end: 1 ½ hour rating with same cover requirements

U.L. Assembly Diagram Key

1.) Floor Topping (concrete, gypsum, or floor mat material)
2.) Precast Plank
3.) Min. 1.5" End Bearing Detail
4.) Grout: 3500 psi



Courtesy Nitterhouse Concrete Products, Inc.:
http://www.nitterhouse.com/DrawingSpecs/DrawingsSpecs.html

Prestressed Concrete
8" x 4' SpanDeck – U.L. – J952
(2" C.I.P. TOPPING)

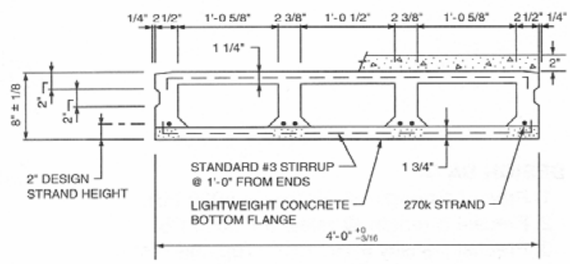
PHYSICAL PROPERTIES

Composite

$A' = 295 \text{ in.}^2$	$S'_b = 468 \text{ in.}^3$
$I' = 2624 \text{ in.}^4$	$S'_t = 1096 \text{ in.}^3$ (At Top of SpanDeck)
$Y_{b'} = 5.61$ in.	$S'_{tt} = 597 \text{ in.}^3$ (At Top of Topping)
$Y_t' = 2.39$ in. (To Top of SpanDeck)	Wt.' = 330 PLF
$Y_{tt}' = 4.39$ in. (To Top of Topping)	Wt.' = 82.5 PSF

DESIGN DATA

1. Precast Strength @ 28 days = 5000 PSI.
2. Precast Strength @ release = 3000 PSI.
3. Precast Density = 150 PCF (Top and Webs)
   = 115 PCF (Soffit)
4. Strand = 1/2"ø, 270K Lo-Relaxation.
5. Composite Strength = 3000 PSI.
6. Composite Density = 150 PCF.
7. Strand Height = 2.00 in.
8. Ultimate moment capacities (when fully developed) . . .
   4 – 1/2"ø, 270K = 88.3'K
   6 – 1/2"ø, 270K = 124.0'K
9. Maximum bottom tensile stress is $6\sqrt{f'c} = 424$ PSI.
10. All superimposed load is treated as live load in the strength analysis of flexure and shear.
11. Flexural strength capacity is based on stress/strain strand relationships.
12. Shear values are the maximum allowable before shear reinforcement is required.
13. Deflection limits were not considered when determining allowable loads in this table.
14. Load values to the left of the solid line are controlled by ultimate strength. Load values to the right are controlled by service stress.
15. All loads shown refer to allowable loads applied after topping has hardened.



8" SPANDECK CROSS SECTION
UL FIRE RATED J952

8" SPANDECK W/2" TOPPING	ALLOWABLE SUPERIMPOSED LOAD (PSF)																					
STRAND PATTERN	SPAN (FEET)																					
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Flexure 4 – 1/2"ø	750	675	611	546	462	394	338	291	252	218	191	167	146	128	112	98	85	74	63	51	41	31	
Shear 4 – 1/2"ø	527	469	421	382	348	317	294	272	252	235	219	197	176	157	140	129	122	110	98	88	78	70	
Flexure 6 – 1/2"ø	1098	900	898	794	676	580	502	437	382	336	296	262	233	207	185	165	147	132	116	101	87	74	63
Shear 6 – 1/2"ø	542	483	434	393	359	329	303	280	261	243	227	212	199	188	178	167	152	137	124	112	101	91	86

NITTERHOUSE
CONCRETE PRODUCTS

This table is for simple spans and uniform loads. Design data for any of these span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, flange or stem openings and narrow widths.

2655 Molly Pitcher Hwy. South, Box N
Chambersburg, PA 17201-0813
717-267-4505 • FAX: 717-267-4518

REVISED 12/93

APPENDIX C:

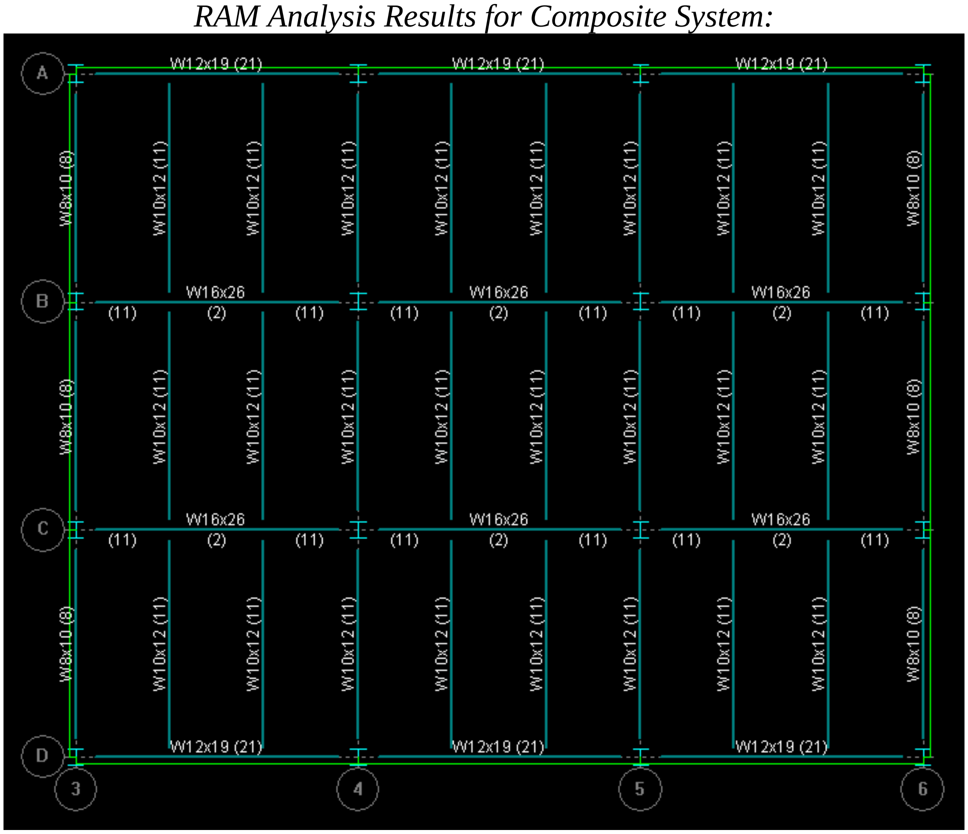
Composite Steel Deck/Concrete Slab System Selection

RAM Structural System software was used to determine the steel beam and girder sizing, based on the selection of 2" Lok-Floor steel decking from the United Steel Deck catalog. A 20 gage 2" Lok-Floor decking has a maximum three-span unshored distance of 9.59', which just clears the 9.5' dimension of the three even-spaced beams in a typical bay. Three inches of lightweight concrete (f'c = 3000 psi) lie above this decking, giving a total slab depth of 5".

Self-Weights for a Typical 23'× 28.5' Composite Bay

20 gage 2" Lok-Floor Deck	= 1.80 psf
3" Concrete Slab	= 38.0 psf
(2) W18×35 = 2(35 plf)/(23 ft)	= 3.04 psf
(4) W12×14 = 4(14 plf)/(28.5 ft)	= 1.96 psf
Total Self-Weight of Typical Bay	= <u>44.8 psf</u>

RAM Analysis Results for Composite System:



APPENDIX D:

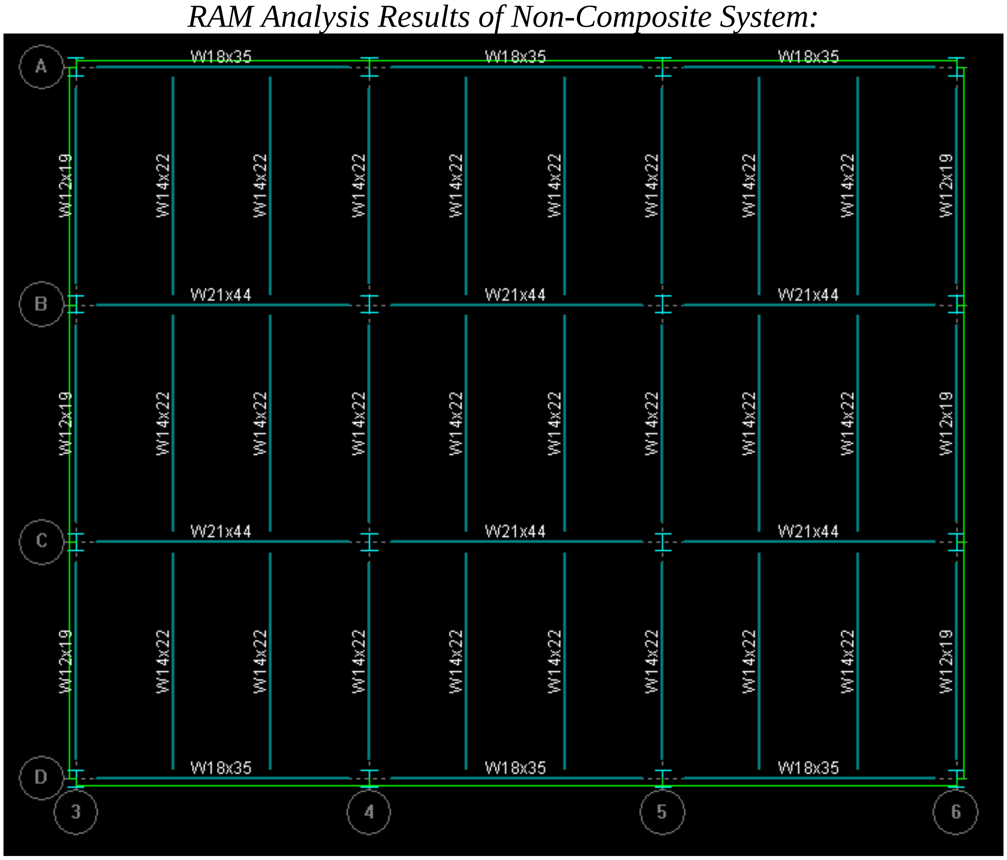
Non-Composite Steel Deck/Concrete Slab System Selection

RAM Structural System software was used to determine the steel beam and girder sizing, based on the selection of 2" Lok-Floor steel decking from the United Steel Deck catalog. A 20 gage 2" Lok-Floor decking has a maximum three-span unshored distance of 9.59', which just clears the required 9.5' dimension (3 equal spans in 28.5' bay) of the three even-spaced beams in a typical bay. Three inches of lightweight (f'c = 3000 psi) concrete lie above this decking, giving a total slab depth of 5".

Self-Weights for a Typical 23'× 28.5' Non-composite Bay

20 gage 2" Lok-Floor Deck	= 1.8 psf
3" Concrete Slab	= 38 psf
(2) W18×60 = 2(60 plf)/(23 ft)	= 5.22 psf
(4) W14×22 = 4(22 plf)/(28.5 ft)	= 3.09 psf
Total Self-Weight of Typical Bay	= <u>48.11 psf</u>

RAM Analysis Results of Non-Composite System:



APPENDIX E:

One-Way Concrete Joist System Selection

LL = 70 psf (worst case for typical floor)
SDL = 2 psf (bridging)
12 psf (ceiling/mechanical/collateral)

Factored w_u = 1.4(14 psf) + 1.7(70 psf) = 138.6 psf (to keep consistent with 1996 values)

Largest clear span = 28.5' – 2*[(16"/2)*(1ft/12in)] = 27.167' → Use 28' span (conservative)

Referencing 1996 CRSI Handbook (see scan of table on next page):

Multiple span one-way joists: 10" Deep Rib + 3" Top Slab = 13.0" Total Depth
- End-span
  - Tabulated value: 164 psf > 138.6 psf (OK)
  - Top Bars: #6 @ 11.5"
  - Bottom Bars: (1) #5 and (1) #6
  - Steel: 1.52 psf

- Interior Span
  - Tabulated value: 164 psf > 138.6 psf (OK)
  - Top Bars: #5 @ 9"
  - Bottom Bars: (1) #4 and (1) #5
  - Steel: 1.39 psf

Concrete Self-Weight = 67 psf (Table 8-1 of CRSI Handbook)

STANDARD ONE-WAY JOISTS MULTIPLE SPANS	20" Forms — 5" rib @ 25" c.-c. FACTORED USABLE SUPERIMPOSED LOAD (PSF)(2)	f'_c = 4,000 psi f_y = 60,000 psi

Depth	10" Deep Rib + 3.0" Top Slab = 13.0" Total Depth											
TOP BARS Size #	# 4 10.5	# 4 8	# 5 10	# 6 11.5	# 6 9.5	End Span Defl. Coeff. (3)	# 4 10	# 5 12	# 5 9	# 6 10		Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 4 # 4	# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6		# 3 # 4	# 4 # 4	# 4 # 5	# 5 # 5		
Steel (psf)	.79	1.01	1.25	1.52	1.83		.82	1.08	1.39	1.78		
CLEAR SPAN	END SPAN						INTERIOR SPAN					
18'-0"	246 0	336 0	365 * 427	375 * 531	390 * 569 *	.878	291 0	401 0	419 * 532	428 * 639 *		.540
19'-0"	211 0	292 0	334 * 374	343 * 466	356 * 521 *	1.090	251 0	350 0	386 * 468	394 * 586		.671
20'-0"	182 0	254 0	307 * 328	315 * 412	326 * 479 *	1.338	217 0	307 0	358 * 413	364 * 520		.823
21'-0"	156 0	222 0	284 * 289	290 * 365	300 * 442	1.626	188 0	270 0	332 * 366	338 * 463		1.001
22'-0"	134 0	194 0	255 0	268 * 324	277 * 394	1.959	163 0	237 0	309 * 325	314 * 413		1.205
23'-0"	114 0	169 0	225 0	249 * 288	257 * 353	2.340	141 0	209 0	289 * 0	293 * 370		1.440
24'-0"	97 0	148 0	199 0	232 * 257	239 * 316	2.774	122 0	184 0	258 0	274 * 332		1.707
25'-0"	82 0	129 0	176 0	216 * 230	222 * 284	3.266	105 0	162 0	230 0	257 * 299		2.010
26'-0"	69 0	112 0	156 0	202 * 205	208 * 256	3.821	90 0	143 0	206 * 0	241 * 269		2.351
27'-0"	57 0	97 0	137 0	183 0	194 * 230	4.443	77 0	126 0	184 0	227 * 243		2.734
28'-0"	46 0	84 0	121 0	164 0	182 * 207	5.139	65 0	110 0	164 0	213 * 219		3.163
29'-0"		72 0	107 0	146 0	171 * 187	5.914	54 0	97 0	147 0	198 0		3.639
30'-0"		61 0	93 0	131 0	160 * 169	6.772	44 0	84 0	131 0	179 0		4.168
31'-0"		51 0	82 0	116 0	141** 152	7.722		73 0	117 0	161 0		4.752

(1) Gross section properties, Table 8-1.
(2) First load is for standard square end joists; second load is for special tapered end joists.
(3) Computation of deflection is not required above horizontal line (thickness $\geq \ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by capacity in shear.

PROPERTIES FOR DESIGN (CONCRETE .44 CF/SF) (4)

NEGATIVE BENDING												
STEEL AREA (SQ.IN.)	.48	.63	.77	.96	1.16		.50	.65	.86	1.10		
STEEL % (UNIFORM)	.68	.89	1.11	1.38	1.67		.71	.92	1.23	1.59		
(TAPERED)	.41	.53	.66	.83	1.00		.43	.55	.74	.95		
EFF. DEPTH, IN.	11.75	11.75	11.69	11.63	11.63		11.75	11.69	11.69	11.63		
-ICR/IGR	.182	.224	.259	.298	.340		.189	.227	.280	.328		
POSITIVE BENDING												
STEEL AREA (SQ.IN.)	.40	.51	.62	.75	.88		.31	.40	.51	.62		
STEEL %	.14	.17	.21	.26	.30		.11	.14	.17	.21		
EFF. DEPTH, IN.	11.75	11.69	11.69	11.63	11.63		11.75	11.75	11.69	11.69		
+ICR/IGR	.198	.244	.290	.339	.389		.157	.198	.244	.290		

APPENDIX F:

Two-Way Flat Plate with Drop Panels System Selection

Please see the following pages for hand calculations, assumptions, and justifications.

System Summary

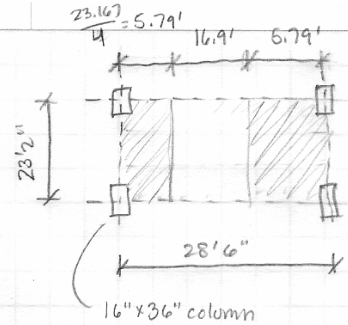
- 9.25” thick, 5000 psi concrete slab
- 7’ × 10’ drop panels at columns, 2.5” thick
- Short-span Reinforcement:
    - #4 @ 12” at top and bottom of middle strip
    - #4 @ 4” at top of column strip
    - #4 @ 10” at bottom of column strip
- Long-span Reinforcement:
    - #4 @ 8” for bottom reinforcement
    - #4 @ 6” for top of middle strip
    - #5 @ 4” for top of column strip

System Dead Weight

W_{slab} = (9.25” slab)*(147 pcf)*(1ft/12”) = 113.31 psf
(The drop panels and reinforcing steel contribute weight to the design, but were omitted due to relatively small tributary area and overall value.)

Total Self-Weight of Typical Bay = 113.31 psf

*(Shear reinforcement would also be required in this slab,
but was not designed in this preliminary analysis.)*



Flat Plate (2-Way) with Drop Panels

Min. thickness → ACI 9.5.3

Table 9.5(c)

f_y = 60 ksi , f'_c = 5 ksi

Interior panel → with drop panel

$$t = \frac{\ell_n}{36} = \frac{(28.5'(12''/ft) - 16'')}{36} = 9.056'' \rightarrow \text{Use } 9.25'' \text{ slab}$$

13.3.7.1 → Drop panel thickness $\geq \frac{1}{4} t_{slab} = \frac{1}{4}(9.25'') = 2.31'' \sim 2.5''$

Drop panel extends $\geq \frac{1}{6}$ (span length)

Long span: $\frac{1}{6}\left(28.5'\left(\frac{12in}{ft}\right) - 16''\right) = 54.33'' = 4.52'$

Short span: $\frac{1}{6}\left(23.167'(12in/ft) - 36''\right) = 40.33'' = 3.36'$

∴ Use 7' by 10' drop panel

13.3.7.3: Check distance from edge of drop panel to edge of column

$$\left(\frac{10'}{2}\right)(12in/ft) - \frac{16''}{2} = 52in$$

$\frac{1}{4}(52in) = 13in > 2.5''$ thickness ✓

Loading

Self-weight = $(147\,pcf)(9.25'')\left(\frac{1ft}{12''}\right) = 113.31$ psf

(Drop panel area is much smaller than total bay, omit its self-weight)

SDL = 12 psf (ceiling/mech./collateral)

LL = 70 psf (taken from ratio of public/private spaces)

Design $w_u = 1.2(113.31 + 12\,psf) + 1.6(70\,psf) = \underline{262.372\text{ psf}}$

Min. Reinforcement (unit strip method)

$A_s = 0.0018 A_g = 0.0018(9.25'')(12in/ft) = 0.1998\ in^2$

Max. spacing = | $2t = 18.5''$ | 18''

∴ Use #4 @ 12'' min. reinf top and bottom

Static Moment

Shortspan $$M_o = \frac{w_u \ell_2 \ell_n^2}{8} = \frac{(262.372psf)(28.5')(23.167' - 36''/12''/ft)^2}{8} = \underline{380.12\text{ kip}\cdot\text{ft}}$$

		Total Mu	Width	Moment/width
Interior support (M−) 65% M_o	C.S. 75%	185.31 kip·ft	11.58'	16.0 ft·kip/ft
	M.S. 25%	61.77 kip·ft	16.9'	3.66 ft·kip/ft
Midspan (M+) 35% M_o	C.S. 60%	79.83 kip·ft	11.58'	6.89 ft·kip/ft
	M.S. 40%	53.22 kip·ft	16.9'	3.15 kip·ft/ft

Verify #4 @ 12" works

$A_{s\,\#4} = 0.2\ in^2/ft$

$d = 9.25" - 0.75" \text{ cover} - 0.5" \text{ bar} - \frac{0.5"}{2} = 7.75"$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(0.2 in^2)(60\ ksi)}{0.85(5\ ksi)(12\ in/ft)} = 0.235"$

$\Phi M_n = \Phi A_s f_y (d - a/2) = 0.9(0.2\ \frac{in^2}{ft})(60\ ksi)(7.75" - \frac{0.235"}{2})$

$\Phi M_n = 82.43\ in{\cdot}kip/ft = 6.87\ ft{\cdot}kip/ft$ $\therefore$ good for both top and bottom of middle strips ($> 3.66\ kip{\cdot}ft/ft$)

Try #4 @ 10" for bottom of C.S. (midspan)

$A_s = 0.2 in^2/10" \left(\frac{12 in}{ft}\right) = 0.24 in^2/ft$, $d = 7.75"$ still

$a = \frac{(0.24\ in^2/ft)(60\ ksi)}{0.85(5\ ksi)(10\ in/ft)} = 0.381"$

$\Phi M_n = (0.9)(0.24\ \frac{in^2}{ft})(60\ ksi)(7.75" - \frac{0.381"}{2}) = 97.96\ \frac{kip{\cdot}in}{ft} = 8.16\ \frac{kip{\cdot}ft}{ft}$

$8.16\ kip{\cdot}ft/ft > 6.89\ kip{\cdot}ft/ft$ $\therefore$ Use for bottom of C.S. (midspan)

Try #4 @ 6" for top reinf. of C.S.

$A_s = \frac{0.2 in^2}{(6")}(12 in/ft) = 0.4\ in^2/ft$, $d = 7.75"$ still

$a = \frac{(0.4\ in^2/ft)(60\ ksi)}{0.85(5\ ksi)(6"/ft)} = 0.941"$

$\Phi M_n = (0.9)(0.4 in^2/ft)(60\ ksi)(7.75" - \frac{0.941"}{2}) = 157.24\ \frac{kip{\cdot}in}{ft} = 13.1\ \frac{kip{\cdot}ft}{ft}$

Decrease spacing $\rightarrow$ Try #4 @ 4"

$A_s = \frac{0.2 in^2}{4"}\left(\frac{12 in}{ft}\right) = 0.6 in^2/ft$, $d = 7.75"$

$a = \frac{(0.6\ in^2/ft)(60\ ksi)}{0.85(5\ ksi)(4"/ft)} = 2.11"$

$\Phi M_n = (0.9)(0.6\ \frac{in^2}{ft})(60\ ksi)(7.75" - \frac{2.11"}{2}) = 216.92\ \frac{kip\ in}{ft} = 18.08\ \frac{kip{\cdot}ft}{ft}$

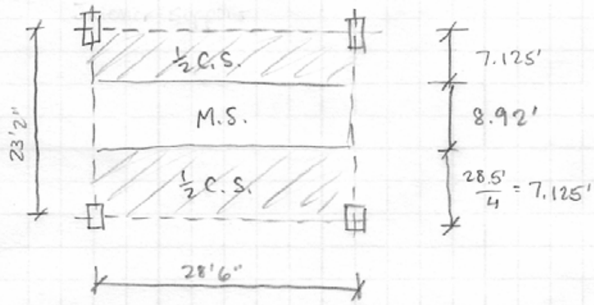
$18.07\ kip{\cdot}ft/ft > 16\ kip{\cdot}ft/ft$ $\therefore$ OK for top reinf. of C.S.

Longspan direction

$l_n = 28.5' - 16"/12"/ft = 27.167'$

$l_2 = 23.167'$

$M_0 = \frac{w_u l_2 l_n^2}{8} = \frac{(262.372 psf)(23.167')(27.167')^2}{8} = 560.76\ kip{\cdot}ft$



Long span
$M_0 = 560.76$ kip·ft

		Total Mu	Width	Moment/width
Int. Support ($65\% M_0$)	C.S. (75%)	273.37 kip·ft	14.25'	19.18 kip·ft/ft
	M.S (25%)	91.124 kip·ft	8.92'	10.22 kip·ft/ft
Midspan ($35\% M_0$)	C.S. (60%)	117.76 kip·ft	14.25'	8.26 kip·ft/ft
	M.S. (40%)	78.5 kip·ft	8.92'	8.8 kip·ft/ft

From shortspan calculations, #4 @ 6" could apply (13.1 kip·ft/ft)
but let's check #4 @ 8":

$$A_s = \frac{0.2\,in^2}{8"}\left(12in/ft\right) = 0.3\,in^2/ft,\quad d = 7.75"$$

$$a = \frac{(0.3\,in^2/ft)(60\,ksi)}{0.85(5\,ksi)(8"/ft)} = 0.529"$$

$$\Phi M_n = (0.9)(0.3\,in^2/ft)(60\,ksi)\left(7.75" - \frac{0.529"}{2}\right) = 121.27\ \text{kip·in/ft} = 10.11\ \text{kip·ft/ft}$$

∴ Use #4 @ 8" for bottom reinforcement
∴ Use #4 @ 6" for top reinf. for M.S.

Try #5 @ 10" for top (C.S.) reinf.

For #5 ⟶ $d = 9.25" - 0.75" - 5/8" - \frac{5/8"}{2} = 7.5625"$

$$A_s = 0.31\,in^2/10"\left(\frac{12in}{ft}\right) = 0.372\,in^2/ft$$

$$a = \frac{(0.372\,in^2/ft)(60\,ksi)}{0.85(5\,ksi)(10"/ft)} = 0.525"$$

$$\Phi M_n = (0.9)(0.372\,in^2/ft)(60\,ksi)\left(7.5625" - \frac{0.525"}{2}\right) = 146.64\ \frac{\text{kip·in}}{ft} = 12.22\ \text{kip·ft/ft}$$

Try #5 @ 6"

$$d = 7.5625",\quad A_s = \frac{0.31\,in^2}{6"}\left(\frac{12in}{ft}\right) = 0.62\,in^2/ft$$

$$a = \frac{(0.62)(60)}{0.85(5)(6")} = 1.46"$$

$$\Phi M_n = (0.9)(0.62\,in^2/ft)(60\,ksi)\left(7.5625" - \frac{1.46"}{2}\right) = 228.75\ \frac{\text{kip·in}}{ft} = 19.06\ \frac{\text{kip·ft}}{ft}$$

Try #5 @ 4"

$$d = 7.5625",\quad A_s = 0.31\,in^2/ft\,(12in/ft)\left(\frac{1}{4"}\right) = 0.93\,in^2/ft$$

$$a = \frac{(0.93)(60)}{0.85(5)(4)} = 3.28"$$

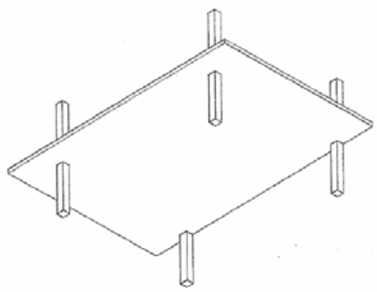
$$\Phi M_n = (0.9)(0.93\,in^2/ft)(60\,ksi)\left(7.563" - \frac{3.28"}{2}\right) = 297.48\ \frac{\text{kip·in}}{ft} = 24.79\ \frac{\text{kip·ft}}{ft}$$

∴ OK for top reinf. of C.S.

APPENDIX G:

R.S. Means Assemblies Cost Data (2005)

Existing System: *Two-Way Flat Plate Concrete Slab*



General: Flat Plates: Solid uniform depth concrete two-way slab without drops or interior beams. Primary design limit is shear at columns.

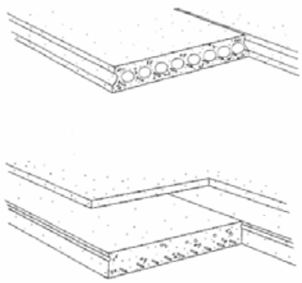
Design and Pricing Assumptions:
Concrete f'c to 4 KSI, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 223 2000					
15'X15' BAY 40 PSF S. LOAD, 12" MIN. COL.					
Forms in place, flat plate to 15' high, 4 uses	.992	S.F.	1.42	4.41	5.83
Edge forms to 6" high on elevated slab, 4 uses	.065	L.F.	.01	.21	.22
Reinforcing in place, elevated slabs #4 to #7	1.706	Lb.	.78	.60	1.38
Concrete ready mix, regular weight, 3000 psi	.459	C.F.	1.51		1.51
Place and vibrate concrete, elevated slab less than 6", pump	.459	C.F.		.57	.57
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.70	.70
Cure with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
TOTAL			3.78	6.56	10.34

B1010 223	Cast in Place Flat Plate							
	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
2000	15 x 15	40	12	5-1/2	109	3.78	6.60	10.38
2200	RB1010 -010	75	14	5-1/2	144	3.81	6.60	10.41
2400		125	20	5-1/2	194	3.95	6.65	10.60
2600		175	22	5-1/2	244	4.04	6.70	10.74
3000	15 x 20	40	14	7	127	4.35	6.65	11
3400	RB1010 -100	75	16	7-1/2	169	4.62	6.80	11.42
3600		125	22	8-1/2	231	5.05	6.95	12
3800		175	24	8-1/2	281	5.10	6.95	12.05
4200	20 x 20	40	16	7	127	4.36	6.65	11.01
4400		75	20	7-1/2	175	4.67	6.80	11.47
4600		125	24	8-1/2	231	5.10	6.95	12.05
5000		175	24	8-1/2	281	5.10	7	12.10
5600	20 x 25	40	18	8-1/2	146	5.05	6.95	12
6000		75	20	9	188	5.20	7.05	12.25
6400		125	26	9-1/2	244	5.60	7.25	12.85
6600		175	30	10	300	5.85	7.35	13.20
7000	25 x 25	40	20	9	152	5.20	7.05	12.25
7400		75	24	9-1/2	194	5.50	7.20	12.70
7600		125	30	10	250	5.85	7.35	13.20
8000								

From linear interpolation: Total Cost/S.F. = $12.33

Alternate System #1: *Hollow Core Concrete Slab*



General: Units priced here are for plant produced prestressed members, transported to site and erected.

Normal weight concrete is most frequently used. Lightweight concrete may be used to reduce dead weight.

Structural topping is sometimes used on floors: insulating concrete or rigid insulation on roofs.

Camber and deflection may limit use by depth considerations.

Prices are based upon 10,000 S.F. to 20,000 S.F. projects, and 50 mile to 100 mile transport.

Concrete is f'c = 5 KSI and Steel is fy = 250 or 300 KSI

Note: Deduct from prices 20% for Southern states. Add to prices 10% for Western states.

Description of Table: Enter table at span and load. Most economical sections will generally consist of normal weight concrete without topping. If acceptable, note this price, depth and weight. For topping and/or lightweight concrete, note appropriate data.

Generally used on masonry and concrete bearing or reinforced concrete and steel framed structures.

The solid 4" slabs are used for light loads and short spans. The 6" to 12" thick hollow core units are used for longer spans and heavier loads. Cores may carry utilities.

Topping is used structurally for loads or rigidity and architecturally to level or slope surface.

Camber and deflection and change in direction of spans must be considered (door openings, etc.), especially untopped.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 230 2000					
10' SPAN, 40 LBS S.F. WORKING LOAD, 2" TOPPING					
Precast prestressed concrete roof/floor slabs 4" thick, grouted	1.000	S.F.	4.42	2.60	7.02
Edge forms to 6" high on elevated slab, 4 uses	.100	L.F.	.02	.32	.34
Welded wire fabric 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf, 10% lap	.010	C.S.F.	.22	.29	.51
Concrete ready mix, regular weight, 3000 psi	.170	C.F.	.56		.56
Place and vibrate concrete, elevated slab less than 6", pumped	.170	C.F.		.21	.21
Finishing floor, monolithic steel trowel finish for resilient tile	1.000	S.F.		.64	.64
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
TOTAL			5.28	4.13	9.41

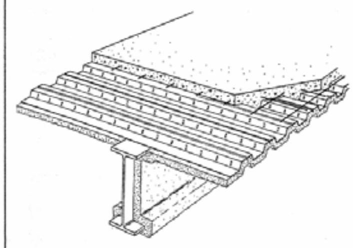
1700

B1010 230 — Precast Plank with 2" Concrete Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2000	10	40	6	75	115	5.30	4.13	9.43
2100		75	8	75	150	6.30	3.76	10.06
2200		100	8	75	175	6.30	3.76	10.06
2500	15	40	8	75	115	6.30	3.76	10.06
2600		75	8	75	150	6.30	3.76	10.06
2700		100	8	75	175	6.30	3.76	10.06
2800	20	40	8	75	115	6.30	3.76	10.06
2900		75	8	75	150	6.30	3.76	10.06
3000		100	8	75	175	6.30	3.76	10.06
3100	25	40	8	75	115	6.30	3.76	10.06
3200		75	8	75	150	6.30	3.76	10.06
3300		100	10	80	180	6.85	3.48	10.33
3400	30	40	10	80	120	6.85	3.48	10.33
3500		75	10	80	155	6.85	3.48	10.33
3600		100	10	80	180	6.85	3.48	10.33
3700	35	40	12	95	135	6.75	3.26	10.01
3800		75	12	95	170	6.75	3.26	10.01
3900		100	14	95	195	7.60	3.09	10.69
4000	40	40	12	95	135	6.75	3.26	10.01
4500		75	14	95	170	7.60	3.09	10.69
5000	45	40	14	95	135	7.60	3.09	10.69

From linear interpolation: Total Cost/S.F. = $10.14

Alternate System #2: *Composite Steel Framing System*



Description: Table below lists costs per S.F. for floors using steel beams and girders, composite steel deck, concrete slab reinforced with W.W.F. and sprayed fiber fireproofing (non-asbestos) on the steel beams and girders and on the steel deck.

Design and Pricing Assumptions:
Structural Steel is A36, high strength bolted.

Composite steel deck varies from 2″–20 gauge to 3″–16 gauge galvanized.
WWF 6 x 6 – W1.4 x W1.4 (10 x 10)
Concrete f'c = 3 KSI.
Steel trowel finish and cure.

Spandrels are assumed the same weight as interior beams and girders to allow for exterior wall loads and bracing or moment connections.

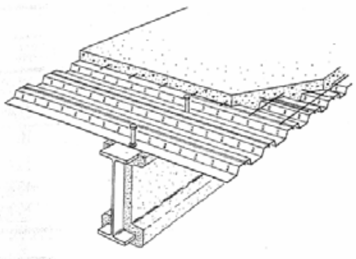
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 254 0540					
W SHAPE BEAMS & DECK, FIREPROOFED, 15'X20', 5" SLAB, 40 PSF LOAD					
Structural steel	4.470	Lb.	4.03	1.40	5.43
Metal decking, non-cellular composite, galv 3" deep, 20 gage	1.050	S.F.	1.97	.81	2.78
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.058	L.F.	.19	.10	.29
Welded wire fabric 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/CSF roll, 10% lap	1.000	S.F.	.22	.29	.51
Concrete ready mix, regular weight, 3000 psi	.011	C.Y.	.98		.98
Place and vibrate concrete, elevated slab less than 6", pumped	.011	C.Y.		.28	.28
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.70	.70
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
Sprayed mineral fiber/cement for fireproof, 1" thick on decks	1.000	S.F.	.68	.93	1.61
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.615	S.F.	.28	.48	.76
TOTAL			8.41	5.06	13.47

10 254 W Shape, Composite Deck, & Slab

BAY SIZE (FT.) BEAM X GIRD	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
25x30	40	5	2-5	91	10.35	5.80	16.15
	75	5	2-5	128	12.55	6.50	19.05
	125	5	2-8	180	14.15	7.20	21.35
	200	5	2-11	259	17.60	8.30	25.90
30x25	40	5	2-5	92	11	6.05	17.05
	75	5	2-5	129	12.85	6.70	19.55
	125	5	2-8	181	14.60	7.40	22
	200	5-1/2	2-11	200	17.70	8.55	26.25
30x30	40	5	2-2	92	11.45	6.20	17.65
	75	5	2-5	129	13.30	6.90	20.20
	125	5	2-11	182	15.70	7.75	23.45
	200	5	3-2	263	21	9.70	30.70
30x35	40	5	2-5	94	12.45	6.55	19
	75	5	2-11	131	14.45	7.20	21.65
	125	5	3-2	183	16.80	8.10	24.90
	200	5-1/2	3-5-1/2	268	20.50	9.35	29.85
35x30	40	5	2-5	93	12	6.40	18.40
	75	5	2-8	130	14.30	7.25	21.55
	125	5	2-11	183	16.85	8.20	25.05
	200	5	3-5	262	20.50	9.60	30.10
35x35	40	5	2-8	94	12.85	6.55	19.40
	75	5	2-11	131	14.80	7.25	22.05
	125	5	3-5	184	17.70	8.30	26
	200	5-1/2	3-5-1/2	270	22.50	9.85	32.35
35x40	40	5	2-11	94	13.30	6.90	20.20
	75	5	3-2	131	15.40	7.65	23.05
	125	5	3-5	184	18.10	8.65	26.75
	200	5	3-5-1/2	264	23	10.40	33.40

From linear interpolation: for 82 psf, Total Cost/S.F. = $19.37

<u>Alternate System #3:</u> *Non-Composite Steel Framing System*



Description: Table below lists costs ($/S.F.) for a floor system using composite steel beams with welded shear studs, composite steel deck, and light weight concrete slab reinforced with W.W.F. Price includes sprayed fiber fireproofing on steel beams.

Design and Pricing Assumptions:
Structural steel is A36, high strength bolted.
Composite steel deck varies from 22 gauge to 16 gauge, galvanized.
Shear Studs are 3/4".
W.W.F., 6 x 6 – W1.4 x W1.4 (10 x 10)
Concrete f'c = 3 KSI, lightweight.
Steel trowel finish and cure.
Fireproofing is sprayed fiber (non-asbestos).

Spandrels are assumed the same as interior beams and girders to allow for exterior wall loads and bracing or moment connections.

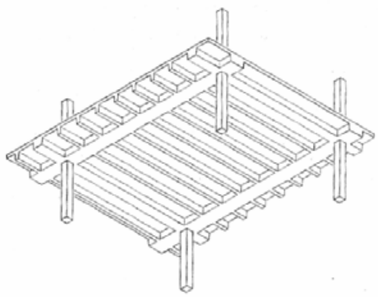
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 256 2400					
20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS					
Structural steel	4.320	Lb.	4.23	1.47	5.70
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.09	.25	.34
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	1.76	.75	2.51
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.045	L.F.	.15	.08	.23
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.22	.29	.51
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	2		2
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.41	.41
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.70	.70
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
Shores, erect and strip vertical to 10' high	.020	Ea.		.33	.33
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.22	.38	.60
TOTAL			8.73	4.73	13.46

B1010 256 — Composite Beams, Deck & Slab

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2400	20x25	40	5-1/2	1 - 5-1/2	80	8.75	4.73	13.48
2500	RB1010 -100	75	5-1/2	1 - 9-1/2	115	9.10	4.73	13.83
2750		125	5-1/2	1 - 9-1/2	167	11.05	5.55	16.60
2900		200	6-1/4	1 - 11-1/2	251	12.40	6	18.40
3000	25x25	40	5-1/2	1 - 9-1/2	82	8.65	4.49	13.14
3100		75	5-1/2	1 - 11-1/2	118	9.60	4.56	14.16
3200		125	5-1/2	2 - 2-1/2	169	10	4.94	14.94
3300		200	6-1/4	2 - 6-1/4	252	13.45	5.80	19.25
3400	25x30	40	5-1/2	1 - 11-1/2	83	8.85	4.47	13.32
3600		75	5-1/2	1 - 11-1/2	119	9.50	4.52	14.02
3900		125	5-1/2	1 - 11-1/2	170	10.95	5.10	16.05
4000		200	6-1/4	2 - 6-1/4	252	13.50	5.80	19.30
4200	30x30	40	5-1/2	1 - 11-1/2	81	8.80	4.61	13.41
4400		75	5-1/2	2 - 2-1/2	116	9.50	4.83	14.33
4500		125	5-1/2	2 - 5-1/2	168	11.45	5.40	16.85
4700		200	6-1/4	2 - 9-1/4	252	13.65	6.25	19.90
4900	30x35	40	5-1/2	2 - 2-1/2	82	9.20	4.78	13.98
5100		75	5-1/2	2 - 5-1/2	117	10	4.88	14.88
5300		125	5-1/2	2 - 5-1/2	169	11.75	5.55	17.30
5500		200	6-1/4	2 - 9-1/4	254	13.75	6.30	20.05
5750	35x35	40	5-1/2	2 - 5-1/2	84	9.85	4.79	14.64
6000		75	5-1/2	2 - 5-1/2	121	11.20	5.15	16.35

From linear interpolation: for 82 psf, Total Cost/S.F. = $14.30

Alternate System #4: *One-Way Concrete Joist System*



General: Combination of thin concrete slab and monolithic ribs at uniform spacing to reduce dead weight and increase rigidity. The ribs (or joists) are arranged parallel in one direction between supports.

Square end joists simplify forming. Tapered ends can increase span or provide for heavy load.

Costs for multiple span joists are provided in this section. Single span joist costs are not provided here.

Design and Pricing Assumptions:
Concrete f'c = 4 KSI, normal weight placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
4-1/2" slab.
30" pans, sq. ends (except for shear req.).
6" rib thickness.
Distribution ribs as required.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

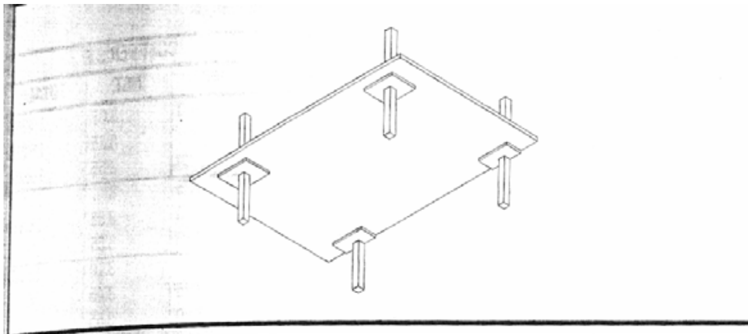
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 226 2000					
15'X15' BAY, 40 PSF, S. LOAD 12" MIN. COLUMN					
Forms in place, floor slab with 30" metal pans, 4 use	.905	S.F.	2.70	4.51	7.21
Forms in place, exterior spandrel, 12" wide, 4 uses	.170	SFCA	.21	1.37	1.58
Forms in place, interior beam. 12" wide, 4 uses	.095	SFCA	.13	.63	.76
Edge forms, 7"-12" high on elevated slab, 4 uses	.010	L.F.	.01	.05	.06
Reinforcing in place, elevated slabs #4 to #7	.628	Lb.	.29	.22	.51
Concrete ready mix, regular weight, 4000 psi	.555	C.F.	1.90		1.90
Place and vibrate concrete, elevated slab, 6" to 10" pump	.555	C.F.		.57	.57
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.70	.70
Cure with sprayed membrane curing compound	.010	S.F.	.06	.07	.13
TOTAL			5.30	8.12	13.42

B1010 226 Cast in Place Multispan Joist Slab

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	RIB DEPTH (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
5400	25 x 30	40	14	12	125	5.80	8.25	14.05
5600		75	16	12	160	6	8.50	14.50
5800		125	18	12	210	6.40	9.10	15.50
6000		200	20	14	291	6.90	9.55	16.45
6200	30 x 30	40	14	14	131	6.10	8.40	14.50
6400		75	18	14	166	6.25	8.65	14.90
6600		125	20	14	216	6.65	9.10	15.75
6700		200	24	16	297	7.10	9.45	16.55
6900	30 x 35	40	16	14	131	6.25	8.75	15
7000		75	18	14	166	6.40	8.80	15.20
7100		125	22	14	216	6.50	9.25	15.75
7200		200	26	16	297	7.20	9.75	16.95
7400	35 x 35	40	16	16	137	6.40	8.65	15.05
7500		75	20	16	172	6.75	8.95	15.70
7600		125	24	16	222	6.80	8.95	15.75
7700		200	26	20	309	7.40	9.60	17
8000	35 x 40	40	18	16	137	6.60	8.95	15.55
8100		75	22	16	172	6.90	9.30	16.20
8300		125	26	16	222	6.95	9.20	16.15
8400		200	30	20	309	7.60	9.65	17.25
8750	40 x 40	40	18	20	149	7.05	8.90	15.95
8800		75	24	20	184	7.25	9.15	16.40
8900		125	26	20	234	7.55	9.50	17.05
9100	40 x 45	40	20	20	149	7.35	9.25	16.60
9500		75	24	20	184	7.40	9.35	16.75
9800		125	28	20	234	7.65	9.65	17.30

Through linear interpolation: for 82 psf, Total Cost/S.F. = $14.64

<u>Alternate System #5:</u> *Two-Way Flat Plate System with Drop Panels*



General: Flat Slab: Solid uniform depth concrete two-way slabs with drop panels at columns and no column capitals.

Design and Pricing Assumptions:
Concrete f'c = 3 KSI, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 222 1700					
15'X15' BAY 40 PSF S. LOAD, 12" MIN. COL. 6" SLAB, 1-1/2" DROP, 117 PSF					
Forms in place, flat slab with drop panels, to 15' high, 4 uses	.993	S.F.	1.58	4.55	6.13
Forms in place, exterior spandrel, 12" wide, 4 uses	.034	SFCA	.04	.27	.31
Reinforcing in place, elevated slabs #4 to #7	1.588	Lb.	.73	.56	1.29
Concrete ready mix, regular weight, 3000 psi	.513	C.F.	1.69		1.69
Place and vibrate concrete, elevated slab, 6" to 10" pump	.513	C.F.		.53	.53
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.70	.70
Cure with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
TOTAL			4.10	6.68	10.78

B1010 222 Cast in Place Flat Slab with Drop Panels

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB & DROP (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1700	15 x 15	40	12	6 - 1-1/2	117	4.10	6.65	10.75
1720	RB1010 -010	75	12	6 - 2-1/2	153	4.19	6.75	10.94
1760		125	14	6 - 3-1/2	205	4.38	6.90	11.28
1780		200	16	6 - 4-1/2	281	4.61	7.05	11.66
1840	15 x 20	40	12	6-1/2 - 2	124	4.37	6.80	11.17
1860	RB1010 -100	75	14	6-1/2 - 4	162	4.56	6.95	11.51
1880		125	16	6-1/2 - 5	213	4.84	7.10	11.94
1900		200	18	6-1/2 - 6	293	4.97	7.20	12.17
1960	20 x 20	40	12	7 - 3	132	4.59	6.90	11.49
1980		75	16	7 - 4	168	4.86	7.05	11.91
2000		125	18	7 - 6	221	5.40	7.30	12.70
2100		200	20	8 - 6-1/2	309	5.50	7.40	12.90
2300	20 x 25	40	12	8 - 5	147	5.10	7.15	12.25
2400		75	18	8 - 6-1/2	184	5.50	7.45	12.95
2600		125	20	8 - 8	236	6	7.75	13.75
2800		200	22	8-1/2 - 8-1/2	323	6.20	7.90	14.10
3200	25 x 25	40	12	8-1/2 - 5-1/2	154	5.35	7.25	12.60
3400		75	18	8-1/2 - 7	191	5.65	7.50	13.15
4000		125	20	8-1/2 - 8-1/2	243	6.05	7.80	13.85
4400		200	24	9 - 8-1/2	329	6.35	7.95	14.30
5000	25 x 30	40	14	9-1/2 - 7	168	5.80	7.50	13.30
5200		75	18	9-1/2 - 7	203	6.20	7.80	14
5600		125	22	9-1/2 - 8	256	6.50	8	14.50
5800		200	24	10 - 10	342	6.90	8.25	15.15
6400	30 x 30	40	14	10-1/2 - 7-1/2	182	6.30	7.75	14.05

65

Through interpolation: for 82 psf, Total Cost/S.F. = $14.07

APPENDIX H:

List of Resources

Hollow Core Slab System

Precast/Prestressed Concrete Products and Building Systems. Nitterhouse Concrete Products, 2005. <http://www.nitterhouse.com>.

PCI Design Handbook: Precast and Prestressed Concrete. Fifth Edition. Precast/Prestressed Concrete Institute, 1999.

Girder-Slab Design Guide. Volume 1.2. Girder-Slab Technologies, LLC, 2005. <http://www.girder-slab.com/design/design.asp>.

Composite and Non-Composite Steel Deck/Concrete Slab Systems

United Steel Deck Design Manual and Catalog of Products. Catalog #303-16. United Steel Deck, Inc., 2002.

RAM Structural System. Computer software. Version 8.0. Ram International, Inc., 2002.

Manual of Steel Construction: Load and Resistance Factor Design. Third Edition. American Institute of Steel Construction, Inc., 2001.

One-Way Composite Joist System

CRSI Design Handbook 1996. Concrete Reinforcing Steel Institute, 1996.

Two-Way Flat Plate Concrete Slab System

ACI Building Code Requirements for Structural Concrete and Commentary. ACI Standard 318-02. American Concrete Institute Committee, 2002.

General Resources

R.S. Means Assemblies Cost Data. 30th Annual Edition. Reed Construction Data, 2005.

Underwriters Laboratories Online Certifications Directory. Underwriters Laboratories, 2005. <http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm>.