Best Buy Corporate Building D (4)
Richfield, MN

Technical Assignment II

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Executive Summary:

This report is an analysis of possible alternate floor systems for Best Buy Corporate Building D found in Richfield, MN. After analyzing the existing system, feasible alternate systems were chosen and considered for the building's floor system. Advantages and disadvantages were derived and studied to determine if each system was worth further investigation.

Existing Floor System: Composite Steel Beam

Advantages of the system are: can be quickly erected, generally low cost, floor depth is comparatively, system is lightweight, smaller column sizes, smaller foundation.

Disadvantage of the system is: requires fireproofing to meet the 2 hour fire-rating necessary.

Floor System #1: One-Way Concrete Slab with Beams

Advantages of the system are: overall depth is decreased by 3.75" from the original system, no spray on fireproofing required.

Disadvantages of the system are: take longer to construct, overall weight in this system is more, increase in column size, increase in foundation size.

Floor System #2: Pre-stressed Pre-cast Concrete Slab

Advantages of the system are: faster to erect, no fireproofing required, removal of one row of columns from the length of the building.

Disadvantages of the system are: overall weight in this system is, increase in column and foundation size, depth of the system is greatly increased, reduction in bay size along the length of the building.

Floor System #3: Post-tensioned Concrete Slab

Advantages of the system are: depth is greatly decreased by 8.75" from the original system, one less row of columns along the width, no fireproofing.

Disadvantages of the system are: more time to erect, overall weight in this system is more than the existing system, column size will increase, foundation size will increase.

General Information:

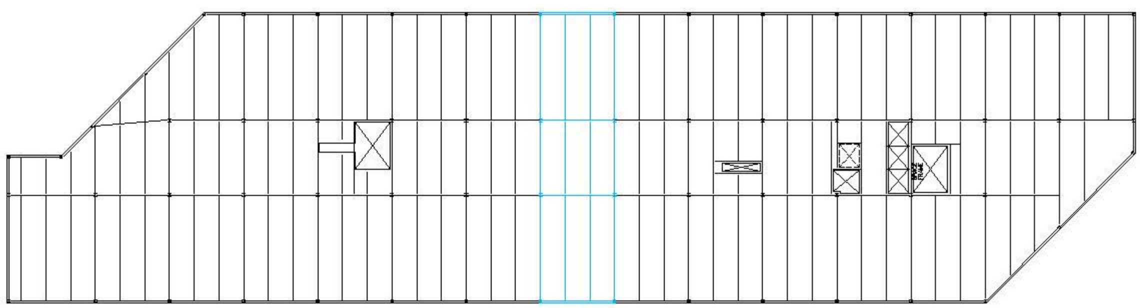
The Best Buy corporate campus consists of four buildings connected by a central hub. This report focuses on building number four, which is a six story braced frame, steel system. The 304,610 square foot building consists of slab on grade construction with wide flange steel columns supported on concrete piers. Lateral loads are supported by a braced frame system. The exterior of the building consists of an architectural precast curtain wall with integrated ribbon windows. Considering the large amounts of integrated technologies required by Best Buy, there are no other major dead or live loads other than those listed in the provided drawings. The occupancy of the building, as expected, is primarily for office use.

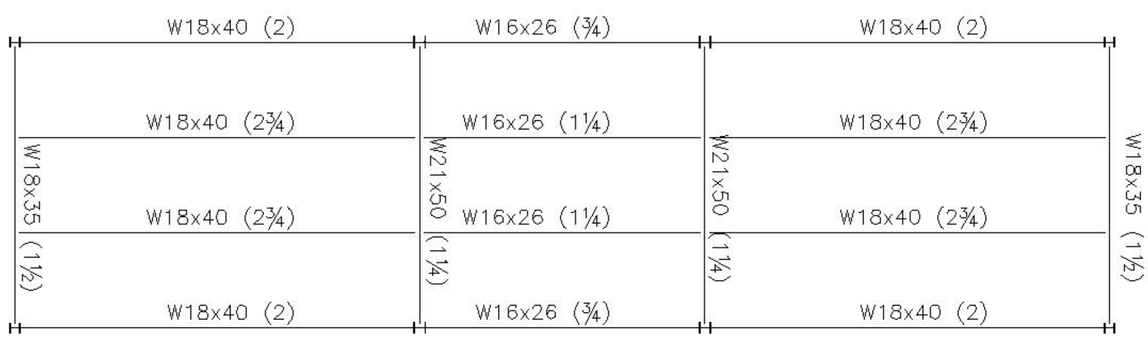
Dead Load:
Finishes: 25^{psf}

Live Load:
Main Floor: 100^{psf}

Existing System: Composite Steel Beam

The floor system Building D utilizes a composite beam floor framing system. The overall slab is 6¼" using 3" 20 gage composite deck and 3¼" lightweight concrete covering. The first floor uses #4 rebar at 18" on center for concrete reinforcing while the remaining floors use 6x6-W2.1xW2.1 welded wire frame. Each internal bay has a typical size of 30'x30' and external bays are typically 30'x42'8". The internal beams are typically W16*26 while the typical external beam is W18*40. Finally, the typical internal girder size is W21*50 and external is W18*35. Material strength is given as 3500 psi for the concrete and A992 50^{ksi} steel for the beams and girders. Spray on fireproofing was used to meet the fire rating required for the building. The floor framing system along with a typical interior bay (shown in blue and rotated 90 degrees) is shown below.



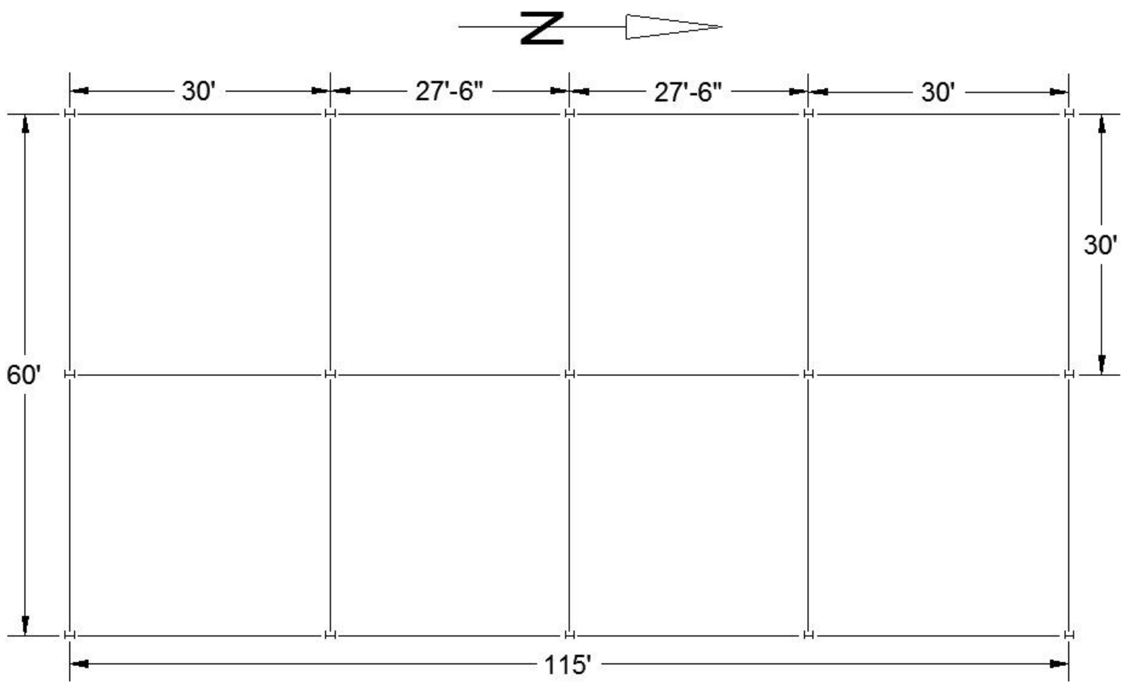


Some of the inherent advantages of the composite beam are that it can be quickly erected and at a generally low cost. Another advantage of the existing system is that the floor depth is comparatively shallow and can accommodate most building height restrictions. The structure for this system is lightweight, allowing smaller column sizes as well as a smaller foundation. One small disadvantage of the system is that it requires fireproofing to meet the 2 hour fire-rating necessary.

Alternate Systems:

System #1: One-Way Concrete Slab with Joists

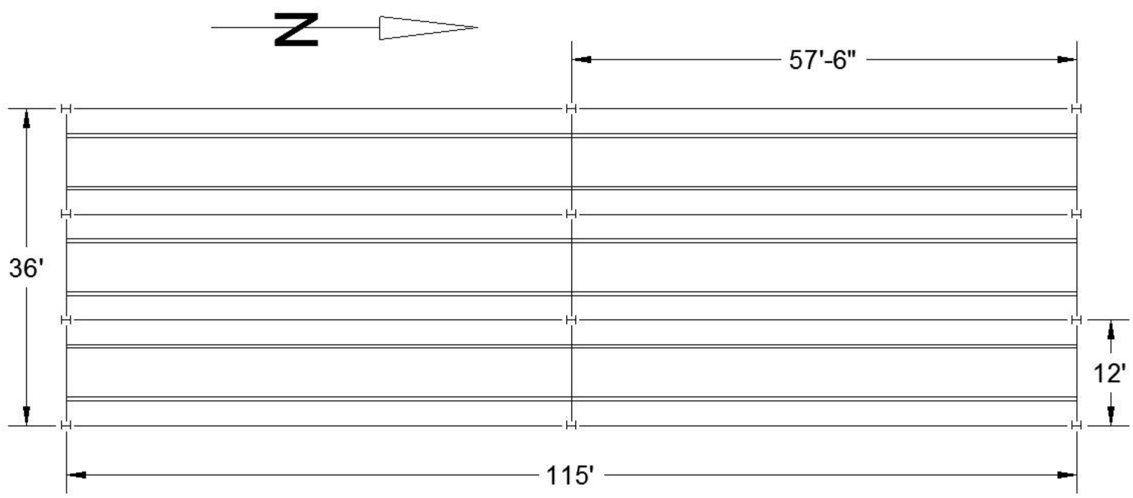
The first alternate system chosen to analyze was a one-way concrete slab with joists. The 2002 CRSI Handbook tables were used to size the joists. The total load calculated for the system was 190^{psf} over a span of 29'. Using page 8-30 from CRSI, a design of 16" deep ribs with a 4.5" top slab was used resulting in a total depth of 20.5". The system would contain 30" forms with 6" ribs at 36" center to center for the interior span. The reinforcement for the system was designed as $^{\#}$5 at 9" on center for the top bars and $^{\#}$6 and $^{\#}$7 bottom bars. The total weight of the system is calculated to be 87.3^{psf}. A typical bay is shown below.



One of the first advantages to this system is that the overall depth is decreased by 3.75" from the original system, so there would be more room for mechanical and electrical systems. There would also not be any spray on fireproofing required with this system. In terms of building time, this system would likely take longer than the existing system to construct. Another issue to consider is that the overall weight in this system is more than the existing system. This could cause an increase in column size as well as in the foundation, which must be considered.

System #2: Pre-stressed Pre-cast Concrete Slab

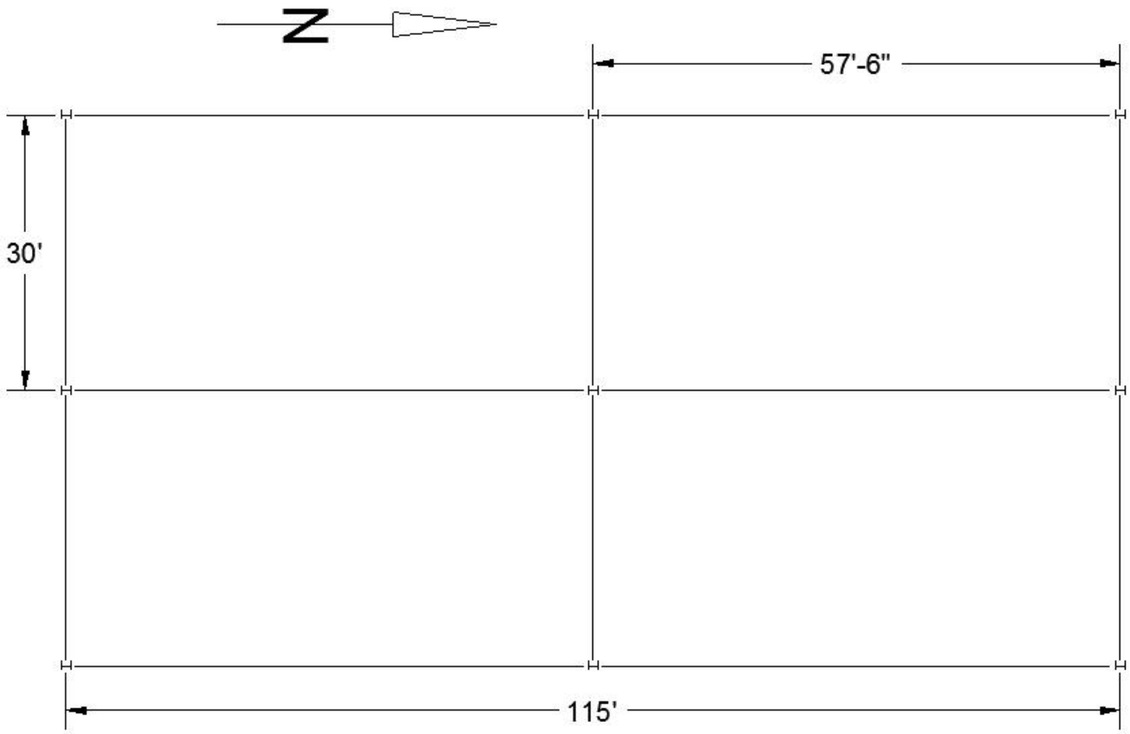
The second alternate system chosen to analyze was a pre-stressed pre-cast concrete slab. Charts from Nitterhouse Concrete Products were used to size the bays. The total load calculated for the system was 190^{psf} over a span of 57'6". Using these charts, a 34"x12' double tee was selected. The system requires 18 0.6" diameter strands draped through the section. A typical bay is shown below.



The largest advantage to this system is the speed at which it can be erected. Similar to the one-way slab, there would also not be any spray on fireproofing required with this system. This design also allowed for the removal of one row of columns from the length of the building. Again, the overall weight in this system is more than the existing system, and could cause an increase in column and foundation size. The overall depth of the system is greatly increased, therefore either reducing floor height or increasing building height. The biggest disadvantage is the reduction in bay size along the length of the building. This really makes the system unfeasible.

System #3: Post-tensioned Concrete Slab

The last alternate system selected was a post-tensioned concrete slab. This design allowed for a 15.5" slab spanning a bay size of 57'6"x30'. Using 35^k tensioning and a minimum 6.75" eccentricity, 68 strands are needed along the 30' span. This requires a minimum spacing of 5.3" between strands with is larger than the minimum 2" recommended. No post-tensioning was needed for the short span. A typical bay is shown below.



Some of the advantages to this system are that the overall depth is greatly decreased by 8.75" from the original system, and there is one less row of columns along the width. Even with this reduction of columns in the width, there is no sacrifice in the length as the column spacing stays the same. Once again, there would not be any spray on fireproofing required with this system. This system will however take more time to erect and the overall weight in this system is more than the existing system. Lateral bracing will also be affected as the braced frame is no longer usable. The column size as well as in the foundation size will also increase.

Conclusions:

Existing System: Composite Steel Beam

- Advantages:
  - Reduced time to erect
  - Large bay sizes
  - Relatively light weight system
  - Lower cost overall
  - Shallow floor
- Disadvantages:
  - Fireproofing required

System #1: One-Way Concrete Slab with Joists

- Advantages:
  - No fireproofing
  - Reduced floor depth
- Disadvantages:
  - Increased system weight
  - Smaller bays
  - Longer to construct
  - Increased column sizes

System #2: Pre-stressed Pre-cast Concrete Slab

- Advantages:
  - Much faster to erect
  - No fireproofing
  - Removal of a column row
- Disadvantages:
  - Heavier system
  - More expensive
  - Deeper floor system
  - More columns along length of building

System #3: Post-tensioned Concrete Slab

- Advantages:
  - No fireproofing
  - Removal of column row
  - Greatly decreased floor depth
- Disadvantages:
  - Heavier system
  - Increased time to erect
  - More expensive

Appendix

Existing Floor System: Composite Steel Beam

Metal Deck

Minimum as per code: 3” 20 gage

United Steel Deck Manual: Try 3” 20 gage

Maximum unshored span = 11.43’>10’

Slab depth = 6¼” Maximum load = 280^{psf}

Beam A: 30’ span

Dead Load = 70^{psf} Live Load = 100^{psf}

Load factors = 1.2(70)+1.6(100) = 244^{psf}

$P_u = 244^{psf}$ $w_u = 10(244) = 2.44^{klf}$

$F'_c = 4^{ksi}$ $f_y = 60^{ksi}$

$M_u = w_u l^2/8 = (2.44*30^2)/8 = 274.5^{ft\text{-}k}$

Assume a = 1” b_{eff} = min [(l_n=120”),(30*12/4=90”)]

y_2 = 6 - a/2 = 5.5”

Using LRFD table 3-19 use W14*38 -> $\phi Mp = 231^{ft\text{-}k}$

Assuming PNA = 7 (worst case) -> $\phi M_p = 339^{ft\text{-}k}$, $\sum Q_n = 140^k$

$\sum Q_n = .85f'_c ba$ -> $a = \sum Q_n/.85f'_c b$ = 140/.85*4*90 = .460

y_2 = 6 - .46/2 = 5.77” $\phi Mp = 341.5^{ft\text{-}k}$

$\sum Q_n$/shear stud = 140/9 = 15.56 -> 32 shear studs

Beam design: W14*38 with 32 shear studs

Beam B: 42'6" span

Dead Load = 70^{psf} Live Load = 100^{psf}

Load factors = 1.2(70)+1.6(100) = 244^{psf}

$P_u = 244^{psf}$ $w_u = 10(244) = 2.44^{klf}$

$F'_c = 4^{ksi}$ $f_y = 60^{ksi}$

$M_u = w_u l^2/8 = (2.44*42.5^2)/8 = 550.9^{ft\text{-}k}$

Assume a = 1" b_{eff} = min [(l_n=120"),(42.5*12/4=127")]

y_2 = 6 - a/2 = 5.5"

Using LRFD table 3-19 use W18*55 -> $\phi Mp = 420^{ft\text{-}k}$

Assuming PNA = 7 (worst case) -> $\phi M_p = 601^{ft\text{-}k}$, $\sum Q_n = 202^k$

$\sum Q_n = .85f'_c ba$ -> $a = \sum Q_n/.85f'_c b$ = 202/.85*4*120 = .495

y_2 = 6 - .495/2 = 5.75" $\phi Mp = 604.5^{ft\text{-}k}$

$\sum Q_n$/shear stud = 202/9 = 22.44 -> 46 shear studs

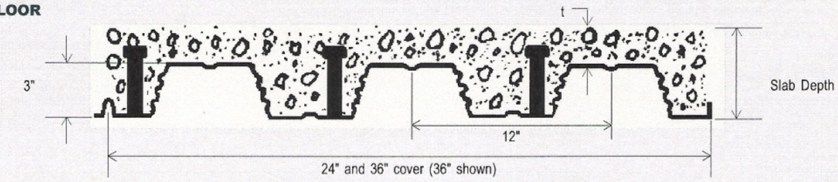
Beam design: W18*55 with 46 shear studs

3 x 12" DECK F_y = 33ksi f'_c = 3 ksi 115 pcf concrete

USD United Steel Deck, Inc.

LRFD

3" LOK-FLOOR



The **Deck Section Properties** are per foot of width. The **I** value is for positive bending (in.[4]); **t** is the gage thickness in inches; **w** is the weight in pounds per square foot; S_p and S_n are the section moduli for positive and negative bending (in.[3]); R_b and ϕV_n are the interior reaction and the shear in pounds (per foot of width); studs is the number of studs required per foot in order to obtain the full resisting moment, ϕM_{nf}.

DECK PROPERTIES									
Gage	t	w	As	I	S_p	S_n	R_b	ϕV_n	studs
22	0.0295	1.7	0.505	0.797	0.454	0.500	718	2190	0.49
20	0.0358	2.1	0.610	0.993	0.583	0.620	1020	3220	0.59
19	0.0418	2.4	0.710	1.158	0.708	0.726	1350	4310	0.69
18	0.0474	2.8	0.810	1.324	0.832	0.832	1720	4880	0.79
16	0.0598	3.5	1.020	1.666	1.045	1.045	2540	6130	0.99

The **Composite Properties** are a list of values for the composite slab. The **slab depth** is the distance from the bottom of the steel deck to the top of the slab in inches as shown on the sketch. U.L. ratings generally refer to the cover over the top of the deck so it is important to be aware of the difference in names. ϕM_{nf} is the factored resisting moment provided by the composite slab when the "full" number of studs as shown in the upper table are in place; inch kips (per foot of width). A_c is the area of concrete available to resist shear, in.[2] per foot of width. **Vol.** is the volume of concrete in ft.[3] per ft.[2] needed to make up the slab; no allowance for frame or deck deflection is included. **W** is the concrete weight in pounds per ft.[2]. S_c is the section modulus of the "cracked" concrete composite slab; in.[3] per foot of width. I_{av} is the average of the "cracked" and "uncracked" moments of inertia of the transformed composite slab; in.[4] per foot of width. The I_{av} transformed section analysis is based on steel; therefore, to calculate deflections the appropriate modulus of elasticity to use is 29.5 x 10^6 psi. ϕM_{no} is the factored resisting moment of the composite slab if there are no studs on the beams (the deck is attached to the beams or walls on which it is resting) inch kips (per foot of width). ϕV_{nt} is the factored vertical shear resistance of the composite system; it is the sum of the shear resistances of the steel deck and the concrete but is not allowed to exceed $\phi 4(f'_c)^{1/2} A_c$; pounds (per foot of width). The next three columns list the **maximum unshored spans** in feet; these values are obtained by using the construction loading requirements of the SDI; combined bending and shear, deflection, and interior reactions are considered in calculating these values. A_{wwf} is the minimum area of welded wire fabric recommended for temperature reinforcing in the composite slab; square inches per foot.

	COMPOSITE PROPERTIES									Max. unshored spans, ft.			
	Slab Depth	ϕM_{nf} in.k	A_c in²	Vol. ft³/ft²	W psf	S_c in³	I_{av} in³	ϕM_{no} in.k	ϕV_{nt} lbs.	1span	2span	3span	A_{wwf}
22 gage	5.50	52.80	37.6	0.333	38	1.27	7.6	35.57	4810	8.06	10.49	10.83	0.023
	6.00	59.89	42.0	0.375	43	1.46	9.7	40.92	5120	7.70	10.06	10.39	0.027
	6.25	63.43	44.3	0.396	46	1.56	10.9	43.68	5280	7.54	9.86	10.18	0.029
	6.50	66.97	46.6	0.417	48	1.66	12.1	46.49	5440	7.39	9.67	9.99	0.032
	7.00	74.05	51.3	0.458	53	1.86	15.0	52.24	5770	7.11	9.33	9.63	0.036
	7.25	77.59	53.8	0.479	55	1.97	16.6	55.17	5950	6.99	9.17	9.47	0.038
	7.50	81.13	56.3	0.500	58	2.07	18.3	58.14	6120	6.87	9.02	9.31	0.041
	8.00	88.22	61.3	0.542	62	2.29	22.0	64.15	6470	6.68	8.73	9.02	0.045
	8.25	91.76	63.9	0.563	65	2.40	24.1	67.20	6660	6.61	8.60	8.88	0.047
	8.50	95.30	66.6	0.583	67	2.50	26.3	70.27	6840	6.54	8.47	8.75	0.050
20 gage	5.50	62.81	37.6	0.333	38	1.51	8.1	42.29	5250	9.35	11.75	12.14	0.023
	6.00	71.37	42.0	0.375	43	1.73	10.4	48.61	5870	8.92	11.27	11.65	0.027
	6.25	75.65	44.3	0.396	46	1.85	11.7	51.89	6180	8.73	11.06	11.43	0.029
	6.50	79.92	46.6	0.417	48	1.97	13.0	55.23	6470	8.55	10.85	11.21	0.032
	7.00	88.48	51.3	0.458	53	2.21	16.1	62.07	6800	8.23	10.48	10.82	0.036
	7.25	92.76	53.8	0.479	55	2.34	17.8	65.57	6980	8.08	10.30	10.64	0.038
	7.50	97.03	56.3	0.500	58	2.46	19.6	69.10	7150	7.94	10.13	10.47	0.041
	8.00	105.59	61.3	0.542	62	2.72	23.6	76.28	7500	7.72	9.82	10.15	0.045
	8.25	109.87	63.9	0.563	65	2.85	25.7	79.92	7690	7.64	9.67	9.99	0.047
	8.50	114.15	66.6	0.583	67	2.98	28.0	83.59	7870	7.56	9.53	9.85	0.050
19gage	5.50	72.04	37.6	0.333	38	1.72	8.7	48.35	5250	10.47	12.73	13.16	0.023
	6.00	82.00	42.0	0.375	43	1.98	11.0	55.60	5870	9.98	12.23	12.64	0.027
	6.25	86.97	44.3	0.396	46	2.12	12.4	59.36	6180	9.77	11.99	12.40	0.029
	6.50	91.95	46.6	0.417	48	2.25	13.8	63.20	6510	9.56	11.78	12.17	0.032
	7.00	101.91	51.3	0.458	53	2.53	17.0	71.08	7170	9.19	11.37	11.75	0.036
	7.25	106.89	53.8	0.479	55	2.68	18.8	75.10	7510	9.02	11.18	11.56	0.038
	7.50	111.87	56.3	0.500	58	2.82	20.7	79.17	7860	8.87	11.00	11.37	0.041
	8.00	121.83	61.3	0.542	62	3.12	24.9	87.46	8570	8.62	10.67	11.02	0.045
	8.25	126.81	63.9	0.563	65	3.27	27.2	91.65	8780	8.52	10.51	10.86	0.047
	8.50	131.78	66.6	0.583	67	3.42	29.6	95.89	8960	8.43	10.36	10.71	0.050
18 gage	5.50	80.96	37.6	0.333	38	1.94	9.1	54.28	5250	11.48	13.61	14.07	0.023
	6.00	92.32	42.0	0.375	43	2.23	11.6	62.43	5870	10.94	13.07	13.51	0.027
	6.25	98.00	44.3	0.396	46	2.38	13.0	66.67	6180	10.70	12.83	13.26	0.029
	6.50	103.68	46.6	0.417	48	2.53	14.5	70.99	6510	10.48	12.59	13.01	0.032
	7.00	115.04	51.3	0.458	53	2.85	17.9	79.88	7170	10.07	12.16	12.57	0.036
	7.25	120.72	53.8	0.479	55	3.01	19.8	84.42	7510	9.88	11.96	12.36	0.038
	7.50	126.40	56.3	0.500	58	3.17	21.8	89.03	7860	9.71	11.77	12.16	0.041
	8.00	137.76	61.3	0.542	62	3.51	26.2	98.39	8570	9.43	11.42	11.80	0.045
	8.25	143.44	63.9	0.563	65	3.68	28.6	103.15	8930	9.33	11.25	11.62	0.047
	8.50	149.12	66.6	0.583	67	3.85	31.1	107.94	9300	9.23	11.09	11.46	0.050
16 gage	5.50	80.96	37.6	0.333	38	2.36	10.1	54.28	5250	13.04	15.20	15.71	0.023
	6.00	92.32	42.0	0.375	43	2.72	12.8	62.43	5870	12.43	14.61	15.10	0.027
	6.25	98.00	44.3	0.396	46	2.90	14.3	66.67	6180	12.15	14.34	14.82	0.029
	6.50	103.68	46.6	0.417	48	3.09	16.0	70.99	6510	11.89	14.08	14.55	0.032
	7.00	115.04	51.3	0.458	53	3.48	19.7	79.88	7170	11.42	13.60	14.06	0.036
	7.25	120.72	53.8	0.479	55	3.68	21.7	84.42	7510	11.21	13.38	13.83	0.038
	7.50	126.40	56.3	0.500	58	3.89	23.9	89.03	7860	11.01	13.17	13.61	0.041
	8.00	137.76	61.3	0.542	62	4.30	28.7	98.39	8570	10.69	12.78	13.20	0.045
	8.25	143.44	63.9	0.563	65	4.51	31.3	103.15	8930	10.57	12.59	13.01	0.047
	8.50	149.12	66.6	0.583	67	4.72	34.1	107.94	9300	10.46	12.41	12.83	0.050

3" LOK-FLOOR
40

3 x 12" DECK F_y = 33ksi f'_c = 3 ksi 115 pcf concrete

LRFD

	Slab Depth	φMn in.k	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00
			L, Uniform Live Loads, psf *												
22 gage	5.50	52.80	240	215	190	170	150	135	125	110	100	90	80	75	70
	6.00	59.89	275	245	215	195	175	155	140	125	115	105	95	85	75
	6.25	63.43	290	255	230	205	185	165	150	135	120	110	100	90	80
	6.50	66.97	305	270	240	215	195	175	155	140	130	115	105	95	85
	7.00	74.05	340	300	270	240	215	190	175	155	140	130	115	105	95
	7.25	77.59	355	315	280	250	225	200	180	165	150	135	120	110	100
	7.50	81.13	375	330	295	260	235	210	190	170	155	140	130	115	105
	8.00	88.22	400	360	320	285	255	230	205	185	170	155	140	125	115
20 gage	5.50	62.81	295	260	230	205	185	170	150	135	125	115	105	95	85
	6.00	71.37	335	295	265	235	210	190	175	155	140	130	120	110	100
	6.25	75.65	355	315	280	250	225	205	185	165	150	135	125	115	105
	6.50	79.92	375	330	295	265	240	215	195	175	160	145	130	120	110
	7.00	88.48	400	365	330	295	265	240	215	195	175	160	145	135	125
	7.25	92.76	400	385	345	310	275	250	225	205	185	170	155	140	130
	7.50	97.03	400	400	360	320	290	260	235	215	195	175	160	150	135
	8.00	105.59	400	400	390	350	315	285	255	235	210	195	175	160	145
19 gage	5.50	72.04	340	300	270	240	220	195	180	160	145	135	125	110	105
	6.00	82.00	390	345	305	275	250	225	205	185	170	155	140	130	120
	6.25	86.97	400	365	325	295	265	240	215	195	180	165	150	135	125
	6.50	91.95	400	385	345	310	280	250	230	205	190	170	160	145	135
	7.00	101.91	400	400	385	345	310	280	255	230	210	190	175	160	145
	7.25	106.89	400	400	400	360	325	295	265	240	220	200	185	170	155
	7.50	111.87	400	400	400	380	340	310	280	255	230	210	195	175	160
	8.00	121.83	400	400	400	400	370	335	305	275	250	230	210	195	175
18 gage	5.50	80.96	385	345	305	275	250	225	205	185	170	155	140	130	120
	6.00	92.32	400	390	350	315	285	255	235	210	195	175	160	150	135
	6.25	98.00	400	400	370	335	300	275	245	225	205	190	170	160	145
	6.50	103.68	400	400	395	355	320	290	260	240	220	200	180	165	155
	7.00	115.04	400	400	400	395	355	320	290	265	240	220	205	185	170
	7.25	120.72	400	400	400	400	370	335	305	280	255	235	215	195	180
	7.50	126.40	400	400	400	400	390	355	320	290	265	245	225	205	190
	8.00	137.76	400	400	400	400	400	385	350	320	290	265	245	225	205
16 gage	5.50	80.96	385	345	305	275	250	225	205	185	170	155	140	130	120
	6.00	92.32	400	390	350	315	285	255	235	210	195	175	160	150	135
	6.25	98.00	400	400	370	335	300	275	245	225	205	190	170	160	145
	6.50	103.68	400	400	395	355	320	290	260	240	220	200	180	165	155
	7.00	115.04	400	400	400	395	355	320	290	265	240	220	205	185	170
	7.25	120.72	400	400	400	400	370	335	305	280	255	235	215	195	180
	7.50	126.40	400	400	400	400	390	355	320	290	265	245	225	205	190
	8.00	137.76	400	400	400	400	400	385	350	320	290	265	245	225	205
22 gage	5.50	35.57	155	135	120	105	90	80	75	65	60	50	45	40	35
	6.00	40.92	175	155	135	120	105	95	85	75	65	60	55	45	40
	6.25	43.68	190	165	145	130	115	100	90	80	70	65	55	50	45
	6.50	46.49	200	175	155	140	125	110	95	85	75	70	60	55	50
	7.00	52.24	230	200	175	155	140	125	110	100	90	80	70	65	55
	7.25	55.17	240	210	185	165	145	130	115	105	95	85	75	65	60
	7.50	58.14	255	225	200	175	155	140	125	110	100	90	80	70	65
	8.00	64.15	280	250	220	195	175	155	140	125	110	100	90	80	70
20 gage	5.50	42.29	185	165	145	130	115	105	90	80	75	65	60	55	50
	6.00	48.61	215	190	170	150	135	120	105	95	85	75	70	60	55
	6.25	51.89	230	205	180	160	145	130	115	105	90	85	75	65	60
	6.50	55.23	245	215	195	170	155	135	120	110	100	90	80	70	65
	7.00	62.07	280	245	220	195	175	155	140	125	110	100	90	80	75
	7.25	65.57	295	260	230	205	185	165	145	130	120	105	95	85	80
	7.50	69.10	310	275	245	215	195	175	155	140	125	115	100	90	85
	8.00	76.28	345	305	270	240	215	190	170	155	140	125	115	105	95
19 gage	5.50	48.35	220	195	170	150	135	120	110	100	90	80	70	65	60
	6.00	55.60	250	225	200	175	155	140	125	115	105	95	85	75	70
	6.25	59.36	270	240	210	190	170	150	135	120	110	100	90	80	75
	6.50	63.20	285	255	225	200	180	160	145	130	120	105	95	90	80
	7.00	71.08	325	285	255	225	205	185	165	150	135	120	110	100	90
	7.25	75.10	345	305	270	240	215	195	175	155	140	130	115	105	95
	7.50	79.17	360	320	285	255	230	205	185	165	150	135	125	110	100
	8.00	87.46	400	355	315	280	255	225	205	185	165	150	135	125	115
18 gage	5.50	54.28	250	220	195	175	155	140	125	115	105	95	85	75	70
	6.00	62.43	285	255	225	200	180	160	145	130	120	110	100	90	80
	6.25	66.67	305	270	240	215	195	175	155	140	130	115	105	95	85
	6.50	70.99	325	290	260	230	205	185	165	150	135	125	115	105	95
	7.00	79.88	370	325	290	260	235	210	190	170	155	140	130	115	105
	7.25	84.42	390	345	310	275	245	225	200	180	165	150	135	125	115
	7.50	89.03	400	365	325	290	260	235	210	190	175	160	145	130	120
	8.00	98.39	400	400	360	325	290	260	235	215	195	175	160	145	135
16 gage	5.50	54.28	250	220	195	175	155	140	125	115	105	95	85	75	70
	6.00	62.43	285	255	225	200	180	160	145	130	120	110	100	90	80
	6.25	66.67	305	270	240	215	195	175	155	140	130	115	105	95	85
	6.50	70.99	325	290	260	230	205	185	165	150	135	125	115	105	95
	7.00	79.88	370	325	290	260	235	210	190	170	155	140	130	115	105
	7.25	84.42	390	345	310	275	245	225	200	180	165	150	135	125	115
	7.50	89.03	400	365	325	290	260	235	210	190	175	160	145	130	120
	8.00	98.39	400	400	360	325	290	260	235	215	195	175	160	145	135

Light Weight

☐ 1 STUD/FT.

☐ NO STUDS

* The **Uniform Live Loads** are based on the LRFD equation $\phi M_n = (1.6L + 1.2D)l^2/8$. Although there are other load combinations that may require investigation, this will control most of the time. The equation assumes there is no negative bending reinforcement over the beams and therefore each composite slab is a single span. Two sets of values are shown; ϕM_{nf} is used to calculate the uniform load when the full required number of studs is present; ϕM_{no} is used to calculate the load when no studs are present. A straight line interpolation can be done if the average number of studs is between zero and the required number needed to develop the "full" factored moment. The tabulated loads are checked for shear controlling (it seldom does), and also limited to a live load deflection of 1/360 of the span.

An upper limit of 400 psf has been applied to the tabulated loads. This has been done to guard against equating large concentrated to uniform loads. Concentrated loads may require special analysis and design to take care of servicibility requirements not covered by simply using a uniform load value. On the other hand, for any load combination the values provided by the composite properties can be used in the calculations.

Welded wire fabric in the required amount is assumed for the table values. If welded wire fabric is not present, deduct 10% from the listed loads.

Refer to the example problems for the use of the tables.

3" LOK-FLOOR

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Floor System #1: One-Way Concrete Slab with Joists

Beam A (exterior): 30' span

Dead Load = 25^{psf} Live Load = 100^{psf}

$w_u = 1.2(25)+1.6(100) = 190^{psf}$

From CRSI joist supporting 190^{psf} spanning 30'
- 30" forms
- 6" ribs
- 16" rib depth
- 36" center to center distance
- 4.5" slab depth
- Reinforcement:
  - Top = #5 @ 9"
  - Bottom = #6, #7

This will hold 222^{psf} Total Weight = 30*30*97 = 87.3^{k}

Beam B (interior): 27'6" span

Dead Load = 25^{psf} Live Load = 100^{psf}

$w_u = 1.2(25)+1.6(100) = 190^{psf}$

From CRSI joist supporting 190^{psf} spanning 28'
- 30" forms
- 6" ribs
- 16" rib depth
- 36" center to center distance
- 4.5" slab depth
- Reinforcement:
  - Top = #5 @ 11"
  - Bottom = (2) #7

This will hold 225^{psf} Total Weight = 30*27.5*97 = 80.0^{k}

Girders: 30' span

Using weight of exterior beams to size girders for uniformity.

$w_u = 1.2(87.3+25)+1.6(100) = 294.76^{psf}$

$W_u = 294.76*30 = 8.84^{klf}$

$M_u = (8.84*302)/8 = 994.5^{ft\text{-}k}$

$F'_c = 4^{ksi}$ $f_y = 60^{ksi}$ $\rho = .0124$ $d = 20.5–2.5 = 18”$

$Mu \leq \phi M_n = [\phi\rho bd^2f_y(1-.59\ \rho(f_y/f'_c))](1/12)$

$994.5*12 = .9*.0124*bd^2*60*(1-.59*.0124*(60/4)$

$bd^2 = 20019.5$ $d = 18”$ $b = 61.78” \text{->} 66”$

$W_{uGIRDER} = (1.2*66*30*150)/144 = 2.48^{klf}$

$M_{uGIRDER} = 994.5 + (2.48*30^2)/8 = 1273.5^{ft\text{-}k}$

Steel Design:

$Mu = \phi A_sdf_y(1-.59\ \rho(f_y/f'_c)$

$1273.5 = [.9*A_s*18*60*(1-.59*.0124*(60/4))]/12$

$A_s = 17.86$ Use: (8) #18

Deflection:

$I = bh^3/12 = (66*18^3)/12 = 32076\ in^4$

$w_u = ((8.84+2.48)/12)*1000 = 943.33^{lb/in}$

$\Delta \leq (30*12)/240 = 1.5”$

$\Delta = (5w_ul^4)/(384EI) = (5*943.33*30^4)/(384*3.6E6*32076) = .000087”$

$.000087” \leq 1.5”$

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS — **30" Forms + 6" Rib @ 36" c.-c. (2)** — **FACTORED USABLE SUPERIMPOSED LOAD (PSF)** — $f'_c = 4{,}000$ psi, $f_y = 60{,}000$ psi

16" Deep Rib + 4.5" Top Slab = 20.5" Total Depth

TOP BARS Size @	# 4 10	# 4 8	# 5 10.5	# 5 9	# 6 10.5	End Span Defl. Coeff. (3)	# 4 9	# 5 11	# 5 9	# 6 11	# 6 9	Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	# 7 # 7		# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	
Steel (psf)	.85	1.04	1.24	1.44	1.71		.93	1.18	1.42	1.70	2.01	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
27'-0"	131 0	185 0	240 0	305* 306	314* 373	6.398	184 0	252 0	331 0	359* 412	368* 454*	3.938
28'-0"	112 0	163 0	214 0	275 0	293* 338	7.400	161 0	225 0	299 0	338* 373	346* 423*	4.554
29'-0"	95 0	142 0	190 0	247 0	274* 306	8.516	141 0	201 0	269 0	318* 339	325* 395*	5.240
30'-0"	80 0	124 0	169 0	222 0	256* 277	9.752	123 0	178 0	243 0	300* 307	306* 370*	6.001
31'-0"	66 0	108 0	149 0	200 0	240* 250	11.119	106 0	158 0	218 0	279 0	289* 347*	6.842
32'-0"	54 0	93 0	132 0	179 0	226* 227	12.625	92 0	140 0	197 0	254 0	273* 322	7.769
33'-0"	43 0	78 0	116 0	160 0	205 0	14.278	78 0	124 0	177 0	230 0	258* 295	8.767
34'-0"		66 0	101 0	143 0	185 0	16.089	66 0	109 0	159 0	209 0	244* 270	9.901
35'-0"		55 0	88 0	127 0	167 0	18.067	54 0	95 0	142 0	190 0	231* 247	11.118
36'-0"		45 0	76 0	113 0	150 0	20.222	44 0	82 0	127 0	172 0	219* 226	12.445
37'-0"			64 0	99 0	135 0	22.565		71 0	113 0	155 0	207 0	13.886
38'-0"			54 0	87 0	121 0	25.105		60 0	100 0	140 0	189 0	15.449
39'-0"			44 0	76 0	108 0	27.853		50 0	88 0	126 0	172 0	17.141
40'-0"				65 0	96 0	30.822		41 0	77 0	113 0	157 0	18.967

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .65 CF/SF) (4)

NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.72	.90	1.06	1.24	1.51		.80	1.01	1.24	1.44	1.76	
STEEL % (UNIFORM)	.49	.61	.73	.85	1.04		.55	.70	.85	.99	1.21	
(TAPERED)	.30	.37	.44	.51	.63		.33	.42	.51	.60	.73	
EFF. DEPTH, IN.	19.3	19.3	19.2	19.2	19.1		19.3	19.2	19.2	19.1	19.1	
-ICR/IGR	.154	.184	.208	.234	.269		.168	.201	.234	.260	.300	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.62	.75	.88	1.04	1.20		.51	.62	.75	.88	1.04	
STEEL %	.09	.11	.13	.15	.17		.07	.09	.11	.13	.15	
EFF. DEPTH, IN.	19.2	19.1	19.1	19.1	19.1		19.2	19.2	19.1	19.1	19.1	
+ICR/IGR	.168	.199	.230	.265	.302		.140	.168	.199	.230	.265	

STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS — **30" Forms + 7" Rib @ 37" c.-c. (2)** — **FACTORED USABLE SUPERIMPOSED LOAD (PSF)** — $f'_c = 4{,}000$ psi, $f_y = 60{,}000$ psi

16" Deep Rib + 4.5" Top Slab = 20.5" Total Depth

TOP BARS Size @	# 4 10	# 4 8.5	# 5 11	# 5 9	# 5 8	End Span Defl. Coeff. (3)	# 4 9	# 5 11	# 5 9.5	# 5 8	# 6 9.5	Int. Span Defl. Coeff. (3)
BOTTOM BARS # #	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	# 7 # 7		# 4 # 5	# 5 # 5	# 5 # 6	# 6 # 6	# 6 # 7	
Steel (psf)	.83	1.00	1.20	1.41	1.63		.92	1.16	1.36	1.63	1.93	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
27'-0"	118 0	171 0	225 0	289 0	346* 354	6.576	170 0	236 0	313 0	391 0	406* 485	4.047
28'-0"	100 0	149 0	199 0	259 0	319 0	7.606	148 0	210 0	281 0	354 0	382* 441	4.681
29'-0"	83 0	129 0	176 0	232 0	288 0	8.752	128 0	186 0	253 0	320 0	360* 401	5.386
30'-0"	69 0	112 0	155 0	207 0	260 0	10.023	110 0	164 0	227 0	290 0	340* 386	6.168
31'-0"	55 0	95 0	136 0	185 0	235 0	11.428	94 0	145 0	203 0	263 0	321* 334	7.033
32'-0"	43 0	81 0	119 0	165 0	211 0	12.975	80 0	127 0	182 0	238 0	304* 0	7.985
33'-0"		68 0	103 0	147 0	190 0	14.675	67 0	111 0	163 0	215 0	278 0	9.031
34'-0"		55 0	89 0	130 0	171 0	16.536	55 0	97 0	145 0	194 0	253 0	10.176
35'-0"		44 0	76 0	115 0	153 0	18.569	43 0	83 0	129 0	175 0	231 0	11.427
36'-0"			64 0	100 0	137 0	20.784		71 0	114 0	158 0	211 0	12.790
37'-0"			53 0	88 0	122 0	23.191		59 0	100 0	142 0	192 0	14.272
38'-0"			43 0	76 0	109 0	25.802		49 0	88 0	127 0	175 0	15.878
39'-0"				65 0	96 0	28.627			76 0	114 0	159 0	17.617
40'-0"				54 0	84 0	31.678			65 0	101 0	144 0	19.494

(1) For gross section properties, see Table 8-1.
(2) First load is for standard square joist ends; second load is for special tapered joist ends.
(3) Computation of deflection is not required above horizonal line (thickness ≥ $\ell_n/18.5$ for end spans, $\ell_n/21$ for interior spans).
(4) Exclusive of bridging joists and tapered ends.
*Controlled by shear capacity. +Capacity at elastic deflection = $\ell_n/360$.

PROPERTIES FOR DESIGN (CONCRETE .68 CF/SF) (4)

NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.74	.87	1.04	1.27	1.43		.82	1.04	1.21	1.43	1.71	
STEEL % (UNIFORM)	.45	.53	.63	.77	.87		.50	.63	.73	.87	1.04	
(TAPERED)	.28	.33	.40	.49	.55		.31	.40	.46	.55	.66	
EFF. DEPTH, IN.	19.3	19.3	19.2	19.2	19.2		19.3	19.2	19.2	19.2	19.1	
-ICR/IGR	.146	.166	.191	.223	.244		.159	.191	.214	.244	.277	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.62	.75	.88	1.04	1.20		.51	.62	.75	.88	1.04	
STEEL %	.09	.11	.12	.15	.17		.07	.09	.11	.12	.15	
EFF. DEPTH, IN.	19.2	19.1	19.1	19.1	19.1		19.2	19.2	19.1	19.1	19.1	
+ICR/IGR	.152	.180	.208	.240	.273		.127	.152	.180	.208	.240	

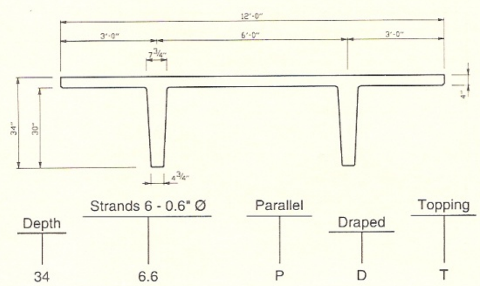
Floor System #2: Pre-stressed Pre-cast Concrete Slab

Dead Load = 25^{psf} Live Load = 100^{psf} $w_u = 1.2(25)+1.6(100) = 190^{psf}$

Prestressed Concrete
34" × 12' Double Tee
(PRETOPPED)

PHYSICAL PROPERTIES
Precast

A = 951 in.²	S_b = 3300 in.³
I = 85,053 in.⁴	S_t = 10,335 in.³
Y_b = 25.77 in.	Wt. = 991 PLF
Y_t = 8.23 in.	Wt. = 83 PSF



DESIGN DATA

1. Precast strength @ RELEASE = 3000 PSI (min.)
2. Precast strength @ 28 days = 6000 PSI
3. Precast Density = 150 PCF
4. Strand = 0.6" Ø 270k LO-relaxation
5. Maximum bottom tensile stress is $12\sqrt{f'c}$ = 930 PSI.
6. All superimposed load is treated as live load in the flexural strength analysis.
7. Flexural capacity is based on stress/strain strand relationships.
8. Maximum moment capacity is critical at midspan for parallel stands and is critical near 0.4 span for draped strands.

Table of Safe Superimposed Loads (lbs. per sq. ft.)

Section	Ø M_n (in. Kips)	Span in Feet																				
		52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92
34 - 6.6 P	9,405	46	37	30																		
34 - 8.6 P	12,117	78	67	58	49	42	35															
34 - 10.6 P	14,586	108	95	83	73	64	56	48	41	35												
34 - 12.6 P	16,796	134	120	106	95	84	74	66	58	50	44	38	32									
34 - 14.6 D	21,450	191	173	156	141	127	114	103	93	84	75	67	60	53	47	42	36	31				
34 - 16.6 D	24,293	225	204	185	168	152	138	126	114	104	94	85	77	69	62	56	50	44	39	34	30	
34 - 18.6 D	26,938			212	193	176	160	146	134	122	111	101	92	83	75	67	60	55	51	45	40	36

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.

NITTERHOUSE
CONCRETE PRODUCTS

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

Floor System #3: Post-tensioned Concrete Slab

$F'_c = 4^{ksi}$ 2'x2' columns

Column strip = ½ short span = 30/2 = 15'

Thickness of slab = span/depth ratio = 45

57.5(12)/45 = 15.33 = 15.5" slab

Dead Load = 150*(15.5/12) = 218.75^{psf} Live Load = 100^{psf}

N-S:

$l_1 = 57.5'$ $l_2 = 30'$ $l_n = 55.5'$ $w_o = 318.75^{psf}$

$M_o = w_o l_2 l_n^2/8 = (.318*30*55.5^2)/8 = 3681.75^{ft-k}$

End Span	Moment
Ext. Neg.	$.65Mo = 2393.2^{ft-k}$
Positive	$.35Mo = 1288.7^{ft-k}$
Int. Neg.	$.65Mo = 2393.2^{ft-k}$

$S = bd^2/6 = (12*15.52)/6 = 480.5in^3$

$f_{tmax} = 7.5*sqrt(f'_c) = .474^{ksi}$

$A = 15.5(12) = 186in^2$

$f_c = .6f'_c = 2.4^{ksi}$

$e_{min} = (15.5/2)-1 = 6.75"$

Support:

$f_{tmax} = M_o/S – P_e/A – P_e e/S$ $f_c = -M_o/S – P_e/A + P_e e/S$

$.474 = (2393.2(12))/(480.5*28.75) – P_e/(186*28.75) – (P_e*6.75)/(480.5*28.75)$

$P_e = 2375.67^k$

$-2.4 = -(2393.2(12))/13814.4 – P_e/5347.5 + (P_e*6.75)/13814.4$

$P_e = -1063.3^k$

Mid-span:

$f_{tmax} = M_o/S – P_e/A – P_e e/S$ $f_c = -M_o/S – P_e/A + P_e e/S$

$.474 = (1288.7(12))/13814.4 – P_e/5347.5 – (P_e*6.75)/13814.4$

$P_e = 955^k$

$-2.4 = -(1288.7(12))/13814.4 – P_e/5347.5 + (P_e*6.75)/13814.4$

$P_e = -4240.3^k$

Post-tension:

$P_{emin} = 2375.7^k$ $P_{ei} = 35^k$

P_e/P_{ei} = strands Strands = 2375.7/35 = 67.9

68 strands for post-tension $P_e = 68*35 = 2380^k$ -> ok

(30’(12))/68 = 5.3 spacing

E-W:

$l_1 = 30’$ $l_2 = 57.5’$ $l_n = 28’$ $w_o = 318.75^{psf}$

$M_o = w_o l_2 l_n^2/8 = (.318*57.5*28^2)/8 = 1791.9^{ft-k}$

Int. Support
65% C.S.(75%) = 873.6^{ft-k}
1164.8^{ft-k} M.S.(25%) = 291.2^{ft-k}
Mid-span
35% C.S.(60%) = 376.3^{ft-k}
627.2^{ft-k} M.S.(40%) = 250.8^{ft-k}

$S = bd^2/6 = (12*15.52)/6 = 480.5in^3$

$f_{tmax} = 7.5*sqrt(f’_c) = .474^{ksi}$

$A = 15.5(12) = 186in^2$

$f_c = .6f’_c = 2.4^{ksi}$

$e_{min} = (15.5/2)-1 = 6.75”$

Support:

$f_{tmax} = M_o/S - P_e/A - P_e e/S$ $f_c = -M_o/S - P_e/A + P_e e/S$

$.474 = (873.6(12))/13814.4 - P_e/5347.5 - (P_e*6.75)/13814.4$

$P_e = -79.9^k$

$-2.4 = -(873.6(12))/13814.4 - P_e/5347.5 + (P_e*6.75)/13814.4$

$P_e = -13398^k$

Mid-span:

$f_{tmax} = M_o/S - P_e/A - P_e e/S$ $f_c = -M_o/S - P_e/A + P_e e/S$

$.474 = (376.3(12))/13814.4 - P_e/5347.5 - (P_e*6.75)/13814.4$

$P_e = -919.3^k$

$-2.4 = -(376.3(12))/13814.4 - P_e/5347.5 + (P_e*6.75)/13814.4$

$P_e = -14830.4^k$

No post-tensioning needed.