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Structural Option
Eight Tower Bridge
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Structural Technical Report #2
Pro/Con Study of Alternate Floor Systems

Executive Summary

This technical report deals specifically with the flooring system of Eight Tower Bridge located in Conshohocken, Pennsylvania. This sixteen story steel high-rise office tower currently employs a concrete slab poured over 2" metal deck in full composite action with wide flange steel beams. This report introduces five alternative flooring systems for the office tower. They include:

- Long span open web steel joists
- Short span open web steel joists
- Long span one-way concrete pan joists
- Short span one-way concrete pan joists
- Precast hollow core concrete deck

The five systems were evaluated on a number of different criteria including overall system weight, fire rating of the assembly and most importantly, and overall system depth.

Of the five alternative systems presented, both the long span open web steel joist system and precast hollow core concrete deck were deemed to have too deep of an overall system thickness, which cancelled out any possible benefits the system might have. The best alternative to further investigate was decided to be the short span, one-way concrete pan joist system.

Existing Floor System

Eight Tower Bridge is a sixteen story steel framed office tower with a rooftop mechanical penthouse. The entire structure is dedicated to office space with the exception of the ground floor which houses limited parking facilities, a small retail area and a three story main entrance lobby. The geometry of the building allows for repetition in the floor layout for each level of Eight Tower Bridge. Floors 3-15 have been designed with almost identical members, neglecting the columns. A typical floor of Eight Tower Bridge is approximately 21,800 sq. ft. with close to 19,450 sq. ft. of it being occupiable office space.

There are six different variations of flooring systems used in Eight Tower Bridge. The systems differ only in reinforcement and slab thickness, and have been designed to carry a range of loads found in different parts of the building (i.e. the mechanical room of each floor has a thickened slab). A deck slab schedule is included in Appendix E for comparison between different slabs. This floor system study will only deal with one of these slab decks.

The typical bay being studied in this report falls between column lines 1 and 4.1 and F and G. The existing floor system employed at this typical office bay consists of poured concrete on metal deck with full composite action between the wide flange steel beams. Full composite action is developed between the beams and the concrete deck slab through ¾" diameter, 4" long shear studs spaced evenly along the length of the beam. Beams span a typical 44'4" spaced at every 9'4" on center, and are sized to at W18x40. The deck has 2" flutes and has been specified to a minimum of 20 gauge A446 steel with 2" overlap. The deck supports 3-1/4" lightweight concrete reinforced with 6x6-W1.4xW1.4 welded wire fabric, bringing the total slab depth to 5-1/4". The total floor system has a depth of 23-1/4".

Development of Floor Loads

Floor loadings for a typical bay are listed below. The typical bay being designed for in this report has arbitrarily been chosen to be from the 6^{th} floor. Live load reductions corresponding to this location are applied. Other load cases are present in different parts of the building, but the loads below will be the only conditions applied to the bay being analyzed. The typical bay can be seen below in figure 2.1.

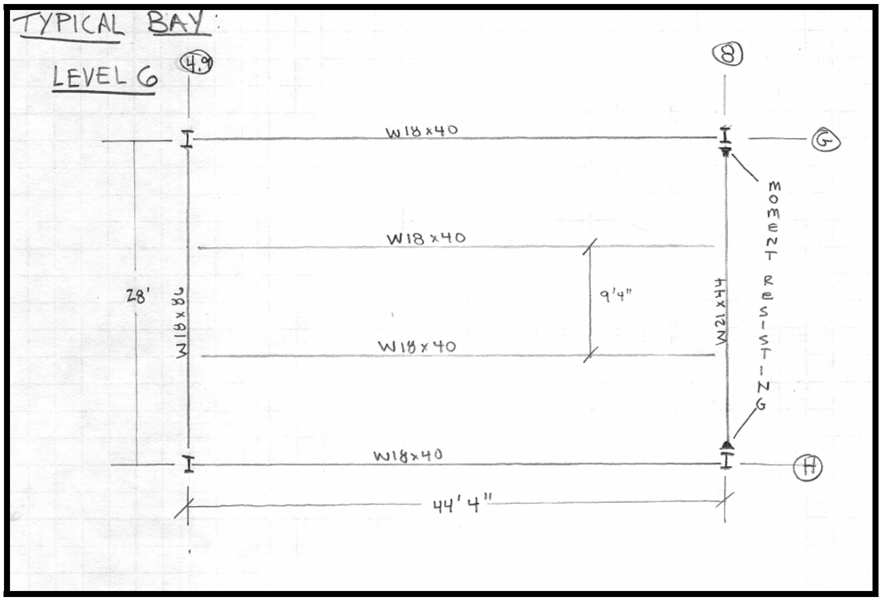


Figure 2.1- Typical Bay

<u>Loading</u>:

Live Load

Office Live Load: 50 psf
Partitions: <u>15 psf</u>
Total: 65 psf

Dead Load

Superimposed DL: 20 psf
CMEP: 5 psf
Carpet/misc.: <u>5 psf</u>
Total: 30 psf

Live			**Dead**		
Office	50	psf	CMEP	5	psf
Partitions	15	psf	Misc./Carpet	5	psf
			Slab	39	psf
Total	65	psf	Total	49	psf

Tributary Width (ft)	Tributary Area (ft^2)	AI (ft^2)	LL Reduction	Live Load (psf)	Dead Load (psf)	Total Load (psf)	Span (ft)	Max Moment (k-ft)
9.33	414	827	0.483	65	49	109	44.33	249.9

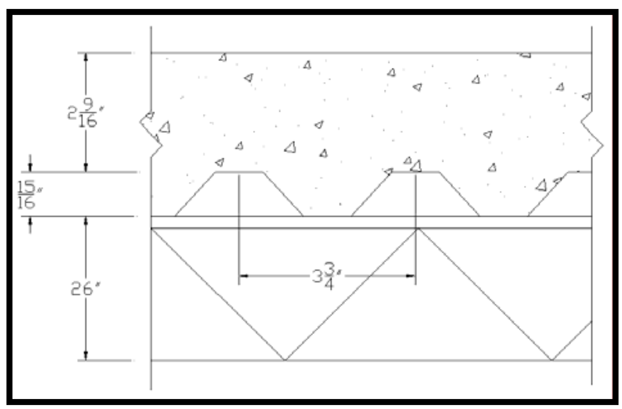
Table 2.1- Load development

Alternative Floor Systems

Open Web Steel Joist, Long Span

The first alternate flooring system being investigated is an open web steel joist system framing into non-composite steel girders spanning in the long direction. The system is comprised of 26K12 open web steel joists spaced at 3' on center. Joists span 44'4" and frame into non-composite 50 ksi W21x44 wide-flange girders. The joists were selected from New Columbia Joist Company catalog with loads based on a maximum tensile stress of 30 ksi. The girder designed for this system was an interior girder, so exterior wall loading was not taken into consideration. The joists support 4000psi light weight concrete poured over steel form metal deck with a total slab thickness 3-1/2", and reinforced with 6x6-W2.0xW2.0 wwf. The deck is 80 ksi Tensilform 75 deck manufactured by Wheeling and has been designated with a 2 hour fire rating by Underwriter Laboratories for the given assembly. The total depth of the system is 29-1/2", as seen below in figure 2.2. Relevant calculations can be found in Appendix A.

Figure 2.2- Section of alternate floor system 1



Open web steel joists are efficient engineered products. The relative light weight of each joist can reduce the size of beams and columns, reducing the overall building weight, thus lowering the overall cost of the project. The open webs of the joists permit passage for other systems through the member such as mechanical duct work, electrical conduit and plumbing systems. Additionally, construction with open web joists is relatively quick. Once each joist is erected, decking can be laid across them to form a working surface or to begin pouring the concrete slab.

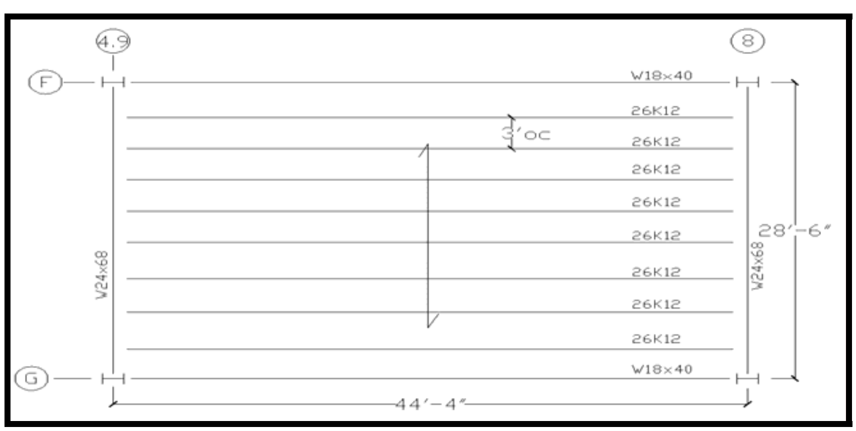


Figure 2.3- Open-Web Steel Joist, Long Direction

Open Web Steel Joist, Short Span (Alternate 2)

This alternative flooring system is comprised of the same decking and slab thickness, but contains open-web trussed spanning in the short direction of the bay. The joists selected are open-web 22k6 joists spaced at 4'0" on center, again from the New Columbia Steel Joist Company. The joists are framed into non-composite 50 ksi wide-flange steel girders sized at a W18x40 spanning 44'4". The total depth of the system is 25-1/2" and still retains a 2 hour fire rating designated by Underwriter Laboratories. Calculations for this system can be found in Appendix B.

A joist with a smaller depth could be selected for this system due to the decrease in span from the system above, which decreases the load per linear foot on the truss. The joists were also allowed to be spaced an additional foot apart for this system. The Tensilform 75 steel deck is capable of spanning 4'0" for both systems, but became the limiting factor for the selection of a joist spanning the long direction. Orienting the joists in the short direction as shown below in Figure 2.4 resulted in a longer center to center spacing, in shallower system depth.

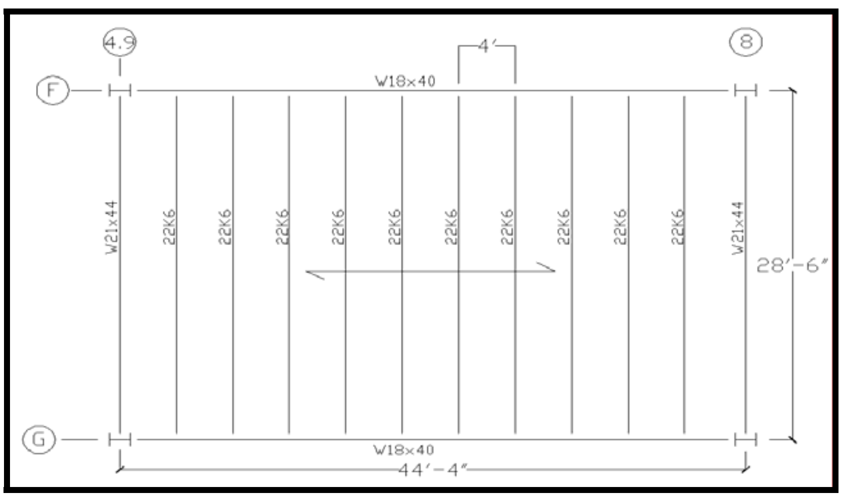


Figure 2.4- Open Web Steel Joist, Short Direction

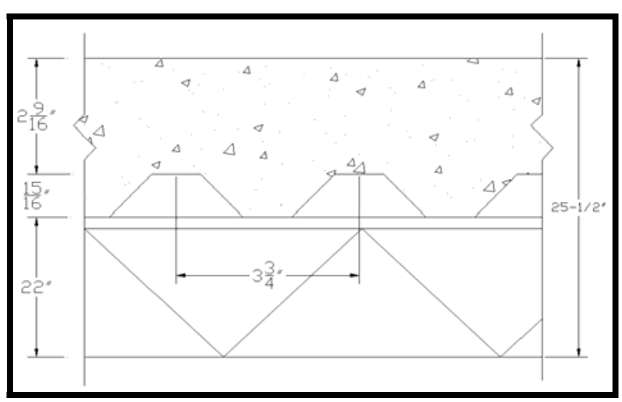
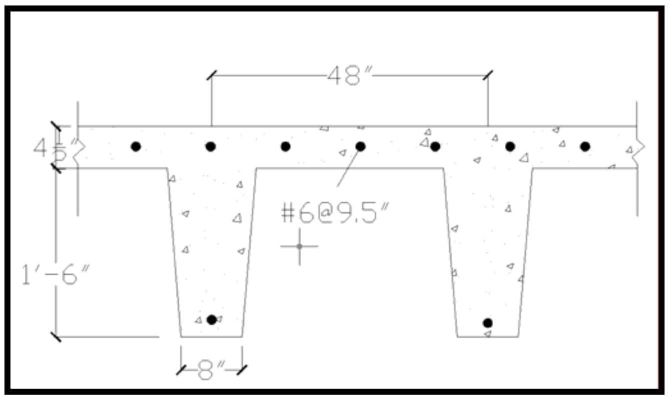


Figure 2.5- Section of alternate floor system 2

Concrete Pan Joist Girders, Long Span (Alternate 3)

The third alternate floor system being evaluated is a one-way concrete joist system in the long span direction. The CRSI 2002 design handbook was used as the guide to this design. The system uses 4000psi strength concrete and 60ksi strength reinforcing bars in design. The clear span was found to be 41'10", but designed as a 42' end span. The joist girder system selected from the CRSI handbook uses 40" forms with 10" ribs spaced at 48" center to center. The ribs are 18" deep with a top slab of 4.5", bringing the total depth of the system to 22.5". The maximum factored usable superimposed load for this system is 447 lb/ft^2, which is greater than the calculated 396 lb/ft^2. Top reinforcing consists of # 6 bars at 9.5" on center, while bottom reinforcing consists of a single #8 bar. The one-way concrete joist frames into a rectangular concrete girder found to be 36"x24.5". Both a cross section and typical bay layout for this system can be seen below in figures 2.6 and 2.7.

Figure 2.6- Typical cross section of one-way joist



The advantages of using a one way concrete pan joist system include the ability to span rather long distances and the overall relative lightweight of the system. The depth of the system can be minimized depending on the span condition.

Disadvantages of this system include costly formwork assembly and tear down, as well as concrete curing time. Both of these factors can result in increased labor costs and lost time on the project schedule.

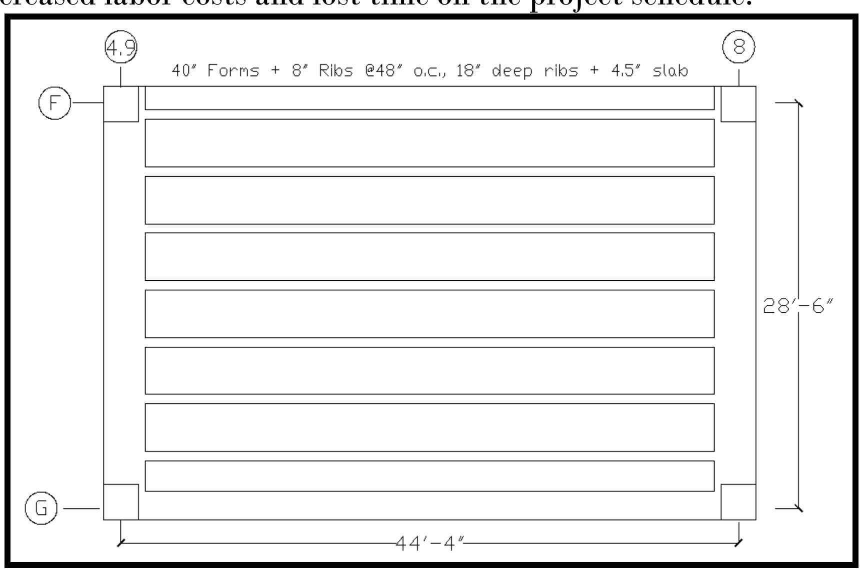


Figure 2.7- Typical bay layout for one-way concrete joist system, long span

Concrete Pan Joist Girders, Short Span (Alternate 4)

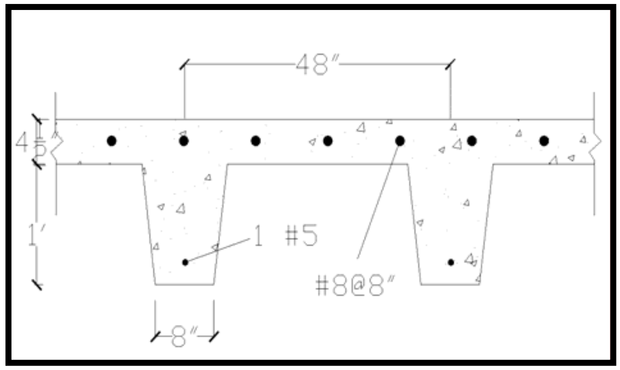


Figure 2.8- Cross section of concrete girder in short span

The forth alternative flooring system being evaluated is similar to alternative three, but spanning perpendicular to the original span. Similar to alternative 2, the floor system depth can be reduced when spanning in the short direction. The CRSI 2002 handbook was again used as the design aid for this system. Columns were assumed to be 30"x30" square, but were not checked for strength. The system was designed for a clear span of 26'0", which resulted in the selection of a joist system with 40" forms and 8" ribs spaced at 48" on center. The ribs are 12" deep with a top slab of 4.5", yielding a total system depth of only 16.5". The maximum usable load for this system is 686 lb/ft^2, greater than the calculated 396 lb/ft^2. Top reinforcing consists of #8 bars at 8", which bottom reinforcing consist of 1 #5 bar. A concrete girder was also selected from the CRSI 2002 handbook and sized at 30"x 42". The typical cross section of the concrete joist system is shown to the right in figure 2.8.

This system has the same advantages and disadvantages as alternate system number 4, but the advantage that is most obvious is the reduction in system depth. This system allows for the depth of the floor to be reduced nearly six inches. When dealing with a high-rise office tower like Eight Tower Bridge, 6 inches per floor correlates to height reduction of 8', close to a fully story height. This affects the overall building weight, seismic and wind calculations, an also building cladding costs. A designer may be particularly interested in such a reduction when facing height restrictions.

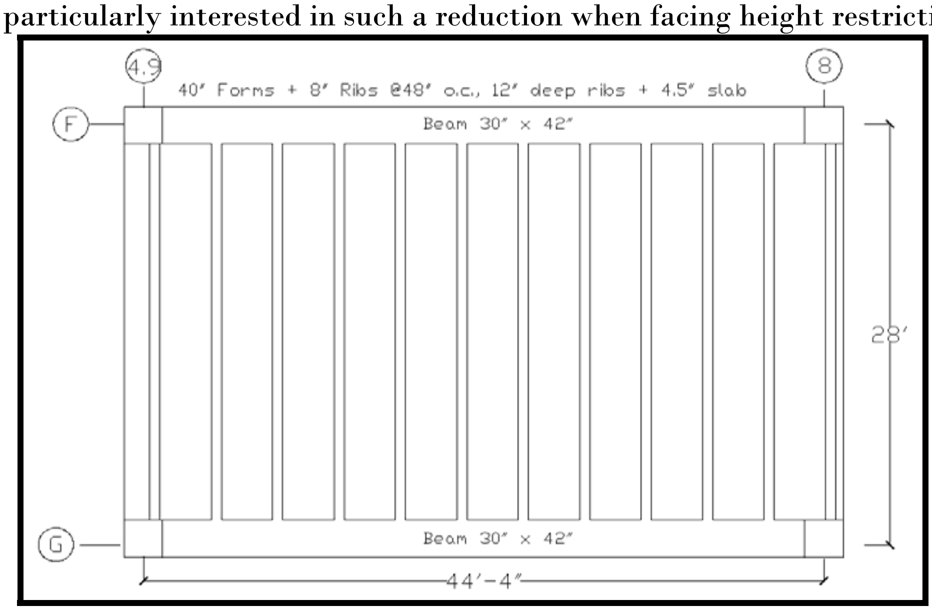


Figure 2.9- Typical bay layout for one-way concrete joist system, short span

Precast Concrete Hollow Core Deck (Alternate 5)

The final alternative flooring system developed is the use of precast concrete hollow core deck on wide flange beams. The Nitterhouse Precast Concrete Systems catalog was used as the design aid for this system. The planks were designed to span in the short direction of the typical bay. After developing an unfactored floor load of 95psf, it was determined that an 8"x4' prestressed span deck with 2" cast-in-place concrete toping. The allowable superimposed load in psf for this system is listed as 132 lb/ft^2. The 8 inch deep deck is cast from 5000psi concrete and reinforced with ½" diameter, 270k Lo-Relaxation prestessing tendons. The typical section of the precast spandeck is shown above in figure 2.10.

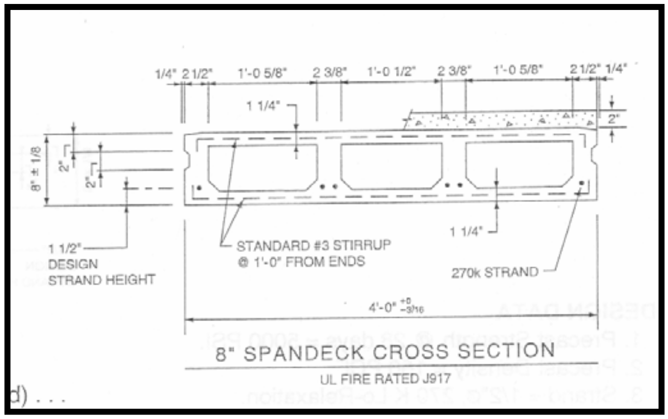


Figure 2.10- typical 8" spandeck cross section

The precast spandeck will sit on wide-flange steel girders that span 44'4". There were two girders sized from LRFD Manual of Steel Construction that meet the required moment capacity of 1645 k-ft for an interior girder. The most economical member was a W33x130 beam. However, to minimize the depth of the system, a shallower but heavier W27x146 was selected as this system's girder. The overall system depth is therefore 37". The two inch topping was necessary in order to ensure an even floor finish, as the girder would have to be cambered due to deflection.

Precast concrete members pose many advantages. They can be cast in a controlled area, ensuring quality in strength. Hollow core plank and deck systems are relatively light in weight due to their hollow cores, which also pose thermal and acoustical benefits.

Conclusion

Out of the five alternative systems proposed, the two systems that seem to pose no real advantage or improvement to the structure are the precast hollow core concrete deck and the open web steel joist spanning the long direction. While both of these systems are fairly light and do work for the required loadings, the increase in floor system depth is too much. Weight reduction is not an issue with this structure, as the bulk of the weight lies at the building core, and not at the perimeter where our typical bay lies. Choosing a system that may be lighter than the current system does not pose an advantage if the overall structure height is increased.

The remaining 3 alternative systems may have been viable options for the flooring system of Eight Tower Bridge. Most notably would be the one-way concrete pan joist system spanning in the short direction. The decrease in floor system depth of almost 6" could prove to be a very cost effective for the project. This system would also eliminate the need for long material lead time for steel members. However, the addition of form work assembly and disassembly, as well as concrete curing time may add time to the schedule. Additionally, the system requires a very large concrete girder, which may ruin all advantages of the system entirely. It may be worth while to investigate what shallow concrete framing members are available to span such a length. A summary table of the existing and alternative flooring systems is listed below.

Summary of Alternative flooring systems:

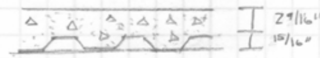
System	Overall Depth	System Weight (PSF)	Advantages	Disadvantages	Further Invesitgate?
Concrete on metal deck with full composite wide flange beams	23-1/4"	55	•Relatively quick construction •Easy construction •Light framing system	•Material lead time •Welding shear studs •Spray on fireproofing needed	Existing
Concrete on metal deck with open web steel joists in long direction	29-1/2"	42	•Light framing system •No shear stud welding •Quick construction	•Thicker floor system •Material lead time •Spray on fireproofing needed	No
Concrete on metal deck with open web steel joists in short direction	25-1/2"	33	•Light framing system •No shear stud welding •Quick construction	•Material lead time •Spray on fireproofing needed	Yes
One-way concrete pan joists spanning in long direction	24-1/2"	100	•No material lead time •Small floor depth	•Heavier system •Form work required •Curing concrete curing time	Yes
One-way concrete pan joists spanning in short direction	16-1/2"	95	•No material lead time •Small floor depth	•Heavier system •Form work required •Curing concrete curing time	Yes
Precast hollow core concrete deck on wide flange steel beams	37"	83	•Quality control in casting •Longer spans possible	•Material lead time •Thicker floor system •Taller building	No

Appendix A
Calculations for Alternative Floor System 1:

Open Web Steel Joist, Long Span

STEEL JOISTS, LONG SPAN

TOTAL SLAB THICKNESS: 3½"
→ DECK THICKNESS: 15/16"



LIVE LOAD: 65 psf (50 OFFICE + 15 PARTITION)
MEP: 5 psf
CARPET/MISC: 5 psf
SLAB WEIGHT: 31 psf [WHEELING DECK CATALOG pFD-9]

TOTAL: 106 psf

TENSILFORM 75 DECK → 3½" SLAB, LT WT. CONC. [2 HR. FIRE RATING]

USING 6x6 - W2.0 x W2.0 REINFORCING

ALLOWABLE UNIFORM LOAD: → 176 psf @ 3'6"

∴ SPACING IS 3'0"

→ JOISTS @ 3'0" O.C. [NEW COLUMBIA STEEL JOIST CATALOG]

TOTAL LIVE LOAD (PLF) → 65 psf (3'0") = 195 lb/ft

CLEAR SPAN = 44.33' → USE 45'

SELECT 2 K12 JOIST: MAX LIVE LOAD: 212 lb/ft > 195 lb/ft
MAX TOTAL LOAD 389 lb/ft

[NCSJ CATALOG, P 25]

TOTAL SYSTEM DEPTH: 26" + 3½" = 29½"

Maximum Allowable Unshored Construction Clear Spans

Slab Depth	Type	145 pcf Normal Weight Concrete: Slab Wt. - psf	Single Span	Double Span	Triple Span	115 pcf Lightweight Concrete: Slab Wt. - psf	Single Span	Double Span	Triple Span
2-1/2"	26	26	3'-7"	4'-8"	4'-8"	21	3'-9"	4'-10"	4'-11"
	25	26	4'-1"	5'-4"	5'-5"	21	4'-4"	5'-7"	5'-8"
	24	26	4'-10"	6'-4"	6'-5"	21	5'-1"	6'-9"	6'-10"
	22	26	5'-7"	7'-5"	7'-3"	21	5'-11"	7'-10"	7'-10"
3"	26	32	3'-5"	4'-5"	4'-6"	26	3'-7"	4'-8"	4'-9"
	25	32	3'-10"	5'-1"	5'-1"	26	4'-1"	5'-4"	5'-5"
	24	32	4'-6"	6'-0"	6'-1"	26	4'-10"	6'-5"	6'-6"
	22	32	5'-3"	6'-11"	6'-9"	26	5'-7"	7'-5"	7'-3"
3-1/2"	26	38	3'-3"	4'-3"	4'-4"	31	3'-5"	4'-6"	4'-6"
	25	38	3'-8"	4'-10"	4'-11"	31	3'-11"	5'-1"	5'-2"
	24	38	4'-4"	5'-9"	5'-10"	31	4'-7"	6'-1"	6'-2"
	22	38	4'-11"	6'-7"	6'-5"	31	5'-4"	7'-1"	6'-10"
4"	26	44	3'-1"	4'-1"	4'-2"	35	3'-4"	4'-4"	4'-5"
	25	44	3'-6"	4'-8"	4'-8"	35	3'-9"	4'-11"	5'-0"
	24	44	4'-1"	5'-6"	5'-7"	35	4'-5"	5'-10"	5'-11"
	22	44	4'-8"	6'-4"	6'-1"	35	5'-1"	6'-9"	6'-7"
4-1/2"	26	50	3'-0"	3'-11"	4'-0"	40	3'-2"	4'-2"	4'-3"
	25	50	3'-4"	4'-6"	4'-6"	40	3'-7"	4'-9"	4'-10"
	24	50	4'-0"	5'-4"	5'-4"	40	4'-3"	5'-8"	5'-9"
	22	50	4'-6"	6'-1"	5'-10"	40	4'-11"	6'-6"	6'-3"
5"	26	56	2'-10"	3'-10"	3'-10"	45	3'-1"	4'-1"	4'-1"
	25	56	3'-3"	4'-4"	4'-4"	45	3'-6"	4'-7"	4'-8"
	24	56	3'-10"	5'-1"	5'-2"	45	4'-1"	5'-5"	5'-6"
	22	56	4'-4"	5'-10"	5'-7"	45	4'-8"	6'-3"	6'-1"

Allowable Uniform Superimposed Loads for Reinforced Concrete Slabs - psf

Slab Depth	Reinforcement: W.W.R.	A_s (in²/ft)	Three Span Condition - Center to Center: 3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"
2-1/2"	6x6-W1.4xW1.4	0.028*	78	52	34				
	6x6-W2.0xW2.0	0.040*	118	81	57	41			
	6x6-W2.9xW2.9	0.058*	176	124	90	66	50	37	
3"	6x6-W1.4xW1.4	0.028*	106	71	48	32			
	6x6-W2.0xW2.0	0.040*	160	111	79	57	41		
	6x6-W2.9xW2.9	0.058	240	169	123	92	69	53	40
3-1/2"	6x6-W2.0xW2.0	0.040*	203	176	127	94	70	53	39
	6x6-W2.9xW2.9	0.058*	303	260	192	145	111	87	68
	6x6-W4.0xW4.0	0.080	400	356	265	203	158	125	100
4"	6x6-W2.9xW2.9	0.058*	362	330	244	185	143	112	88
	6x6-W4.0xW4.0	0.080	400	400	339	261	204	162	131
	4x4-W2.9xW2.9	0.087	400	400	380	292	230	184	149
4-1/2"	6x6-W4.0xW4.0	0.080*	400	400	400	318	250	200	161
	4x4-W2.9xW2.9	0.087	400	400	400	356	280	224	182
	4x4-W4.0xW4.0	0.120	400	400	400	400	390	315	258
5"	6x6-W4.0xW4.0	0.080*	400	400	400	376	296	237	191
	4x4-W2.9xW2.9	0.087*	400	400	400	400	331	265	215
	4x4-W4.0xW4.0	0.120	400	400	400	400	400	373	306

*A_s does not meet A.C.I. criteria for temperature and shrinkage reinforcement (0.0018Ac)

STANDARD LOAD TABLE/OPEN WEB STEEL JOISTS, K-SERIES
Based on a Maximum Allowable Tensile Stress of 30 ksi

Joist Designation	24K4	24K5	24K6	24K7	24K8	24K9	24K10	24K12	26K5	26K6	26K7	26K8	26K9	26K10	26K12
Depth (In.)	24	24	24	24	24	24	24	24	26	26	26	26	26	26	26
Approx. Wt. (lbs./ft.)	8.4	9.3	9.7	10.1	11.5	12.0	13.1	16.0	9.8	10.6	10.9	12.1	12.2	13.8	16.6
Span (ft.) ↓															
24	520 516	550 544	550 544	550 544	550 544	550 544	550 544	550 544							
25	479 456	540 511	550 520	550 520	550 520	550 520	550 520	550 520							
26	442 405	499 453	543 493	550 499	550 499	550 499	550 499	550 499	542 535	550 541	550 541	550 541	550 541	550 541	550 541
27	410 361	462 404	503 439	550 479	550 479	550 479	550 479	550 479	502 477	547 519	550 522	550 522	550 522	550 522	550 522
28	381 323	429 362	467 393	521 436	550 456	550 456	550 456	550 456	466 427	508 464	550 501	550 501	550 501	550 501	550 501
29	354 290	400 325	435 354	485 392	536 429	550 436	550 436	550 436	434 384	473 417	527 463	550 479	550 479	550 479	550 479
30	331 262	373 293	406 319	453 353	500 387	544 419	550 422	550 422	405 346	441 377	492 417	544 457	550 459	550 459	550 459
31	310 237	349 266	380 289	424 320	468 350	510 379	550 410	550 410	379 314	413 341	460 378	509 413	550 444	550 444	550 444
32	290 215	327 241	357 262	397 290	439 318	478 344	549 393	549 393	356 285	387 309	432 343	477 375	519 407	549 431	549 431
33	273 196	308 220	335 239	373 265	413 289	449 313	532 368	532 368	334 259	364 282	406 312	448 342	488 370	532 404	532 404
34	257 179	290 201	315 218	351 242	388 264	423 286	502 337	516 344	315 237	343 257	382 285	422 312	459 338	516 378	516 378
35	242 164	273 184	297 200	331 221	366 242	399 262	473 308	501 324	297 217	323 236	360 261	398 286	433 310	501 356	501 356
36	229 150	258 169	281 183	313 203	346 222	377 241	447 283	487 306	280 199	305 216	340 240	376 263	409 284	486 334	487 334
37	216 138	244 155	266 169	296 187	327 205	356 222	423 260	474 290	265 183	289 199	322 221	356 242	387 262	460 308	474 315
38	205 128	231 143	252 156	281 172	310 189	338 204	401 240	461 275	251 169	274 184	305 204	337 223	367 241	436 284	461 299
39	195 118	219 132	239 144	266 159	294 174	320 189	380 222	449 261	238 156	260 170	289 188	320 206	348 223	413 262	449 283
40	185 109	208 122	227 133	253 148	280 161	304 175	361 206	438 247	227 145	247 157	275 174	304 191	331 207	393 243	438 269
41	176 101	198 114	216 124	241 137	266 150	290 162	344 191	427 235	215 134	235 146	262 162	289 177	315 192	374 225	427 256
42	168 94	189 106	206 115	229 127	253 139	276 151	327 177	417 224	205 125	224 136	249 150	275 164	300 178	356 210	417 244
43	160 88	180 98	196 107	219 118	242 130	263 140	312 165	406 213	196 116	213 126	238 140	263 153	286 166	339 195	407 232
44	153 82	172 92	187 100	209 110	231 121	251 131	298 154	387 199	187 108	204 118	227 131	251 143	273 155	324 182	398 222
45	146 76	164 86	179 93	199 103	220 113	240 122	285 144	370 185	179 101	194 110	217 122	240 133	261 145	310 170	389 212
46	139 71	157 80	171 87	191 97	211 106	230 114	272 135	354 174	171 95	186 103	207 114	229 125	250 135	296 159	380 203
47	133 67	150 75	164 82	183 90	202 99	220 107	261 126	339 163	164 89	178 96	199 107	219 117	239 127	284 149	369 192
48	128 63	144 70	157 77	175 85	194 93	211 101	250 118	325 153	157 83	171 90	190 100	210 110	229 119	272 140	353 180
49									150 78	164 85	183 94	202 103	220 112	261 131	339 169
50									144 73	157 80	175 89	194 97	211 105	250 124	325 159
51									139 69	151 75	168 83	186 91	203 99	241 116	313 150
52									133 65	145 71	162 79	179 86	195 93	231 110	301 142

GIRDER W/ STEEL JOIST; LONG SPAN:

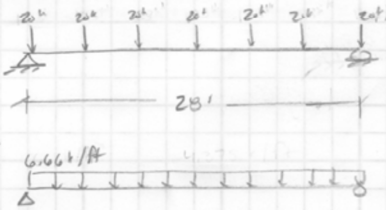
LOAD: $(1.6(65) + 1.2(41))3' = 460$ lb/ft

SELF WT: 16.6 lb/ft → $(16.6$ lb/ft$)(22.165') = 368$ PLF $(1.2) = 442$ PLF

460 lb/ft $+ 442$ lb/ft $= 902$ lb/ft $(\frac{44.3'}{2}) = 19992$ lb

SIMPLE BEAM:

EQUIVALENT



$M_{MAX} = \frac{w l^2}{8} = \frac{(6.6 k/ft)(28')^2}{8} = 646.8$ k.ft

$Z_{REQD} = \frac{(646.8 k \cdot ft)(12 in)}{.9(50 ksi)}$ 172.48 IN³

(LRFD TABLE 5-3, p 5-47)   W24 x 68   Z = 177

$\phi M_p = 664$ k.ft > 646.8 k ft

Appendix B
Calculations for Alternative Floor System 2:

Open Web Steel Joist, Short Span

STEEL JOIST, SHORT SPAN

SLAB THICKNESS: 3½"
DECK THICKNESS: 15/16"

LIVE LOAD: 65 psf DEAD LOAD: 41 psf

USING 6×6 – W2.0×W2.0 WWF → TENSILFORM 75 @ 4'0" [WHEELING DECK CATALOG]

SPACING @ 4'0" w/ TENSILFORM 75 DECK [2 hr. FIRE RATING]

TOTAL LIVE LOAD (PLF) = (65 psf)(4') = 260 PLF

SPAN @ 28'

SELECT 22K6 JOIST: MAX LIVE LOAD: 328 lb/ft > 260 lb/ft
MAX TOTAL LOAD: 427 lb/ft > 424 lb/ft

[NCSJ CATALOG, P-33]

TOTAL SYSTEM DEPTH: 22" + 3½" = 25½"

GIRDER DESIGN

LIVE LOAD: 65 psf (1.6) = 104 psf
DEAD LOAD: 41 PSF (1.2) = 49.2 PSF
SELF WT: 258 lb/ft (1.2) = 309.6 PLF

TOTAL JOIST LOAD @ GIRDER:

$((104 + 49.2)\ 28' + 309.6\ lb/ft) = 4.6^k$

$M_u = \frac{(1.15k/ft)\ 44.33^2}{8} = 282.5\ k\cdot ft$ $Z_{REQ'D} = \frac{(282.5\ k\cdot ft)(12\ in)}{.9(50\ ksi)} = 75.33\ in^3$

TRY W18×40 $\phi M_p = 294\ k\cdot ft > 282.5\ k\cdot ft$ [LRFD P 5-47]

$Z = 78.4\ in^3 > 75.3\ in^3$

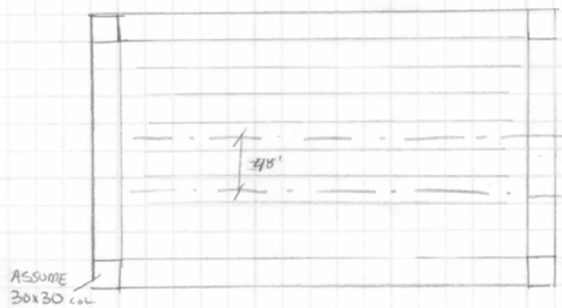
Joist Designation	14K6	18K5	22K4	16K6	20K5	24K4	18K6	16K7	22K5	20K6	18K7	↓ 22K6	20K7	24K5	22K7	24K6
Depth (In).	14	18	22	16	20	24	18	16	22	20	18	22	20	24	22	24
Approx. Wt. (lbs./ft)	7.7	7.7	8.0	8.1	8.2	8.4	8.5	8.6	8.8	8.9	9.0	9.2	9.3	9.3	9.7	9.7
Span (ft)																
14	550 550															
15	550 507															
16	550 467			550 550				550 550								
17	550 443			550 526				550 526								
18	550 408	550 550		550 490			550 550	550 490			550 550					
19	550 383	550 523		550 455			550 523	550 455			550 523					
20	525 347	550 490		550 426	550 550		550 490	550 426		550 550	550 490		550 550			
21	475 299	550 460		548 405	550 520		550 460	550 406		550 520	550 460		550 520			
22	432 259	518 414	550 548	498 351	550 490		550 438	550 385	550 548	550 490	550 438	550 548	550 490		550 548	
23	395 226	473 362	518 491	455 307	529 451		516 393	507 339	550 518	550 468	550 418	550 518	550 468		550 518	
24	362 199	434 318	475 431	418 269	485 396	520 516	473 345	465 298	536 483	528 430	526 382	550 495	550 448	550 544	550 495	550 544
25	334 175	400 281	438 381	384 238	446 350	479 456	435 305	428 263	493 427	486 380	485 337	537 464	541 421	540 511	550 474	550 520
26	308 156	369 249	404 338	355 211	412 310	442 405	402 271	395 233	455 379	449 337	448 299	496 411	500 373	499 453	550 454	543 493
27	285 139	342 222	374 301	329 188	382 277	410 361	372 241	366 208	422 337	416 301	415 267	459 367	463 333	462 404	512 406	503 439
28	265 124	318 199	348 270	306 168	355 248	381 323	346 216	340 186	392 302	386 269	385 239	427 328	430 298	429 362	475 364	467 393
29		296 179	324 242	285 151	330 223	354 290	322 194	317 167	365 272	360 242	359 215	398 295	401 268	400 325	443 327	435 354
30		276 161	302 219	266 137	308 201	331 262	301 175	296 151	341 245	336 218	335 194	371 266	374 242	373 293	413 295	406 319
31		258 146	283 198	249 124	289 182	310 237	281 158	277 137	319 222	314 198	313 175	347 241	350 219	349 266	387 267	380 289
32		242 132	265 180	233 112	271 165	290 215	264 144	259 124	299 201	295 179	294 159	326 219	328 199	327 241	363 242	357 262
33		228 121	249 164		254 150	273 196	248 131		281 183	277 163	276 145	306 199	309 181	308 220	341 221	335 239
34		214 110	235 149		239 137	257 179	233 120		265 167	261 149	260 [illegible]	288 [illegible]	290 165	290 204	321 [illegible]	315 [illegible]

Appendix C
Calculations for Alternative Floor System 3:

Concrete Pan Joist Girders, Long Span

ONE-WAY CONC PAN JOIST

LONG SPAN DIRECTION



LIVE LOAD:

OFFICE	50 PSF
PARTITIONS	15 PSF
	65 PSF

DEAD LOAD:

SUPERIMPOSED	20 PSF
CMEP	5 PSF
CARPET / MISC	5 PSF
	30 PSF

LIVE LOAD REDUCTION:
→ .606

$1.6(65 \times .606) + 1.2(30) = 99$ PSF

CLEAR SPAN:
44'4" − (15"+15") = 41'10" ∴ USE 42' AS CLEAR SPAN

TRY 40" FORMS + 8" RIBS @ 48" C-C, END SPAN

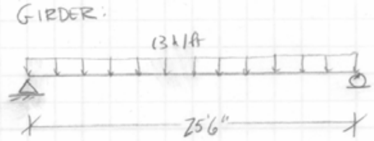
(99 PSF)(48"/12) = 396 PLF

18" DEEP RIB + 4.5" TOP SLAB = 22.5" TOTAL DEPTH

MAX FACTORED LOAD, PLF: 447 PLF > 396 PLF

REINFORCEMENT: TOP: #6 @ 9.5"
BOTTOM: 1 #8
STIRRUPS: #3-163 [CRSI 2002, P 8-62]

GIRDER:



JOIST WT: 145((48 × 4.5) + (18 × 8))/144)
= 407 PSF
FACTORED LOAD: 99 PSF

TOTAL LINEAR LOAD: 99 PSF + 1.2(407 PSF) = 587.4 (22'2") = 13k/ft

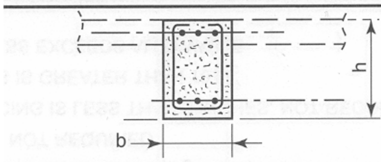
$M_{MAX} = \frac{wl^2}{8} = \frac{(13k/ft)(25.5')}{8} = 1056.6 \text{ k·ft}/.9 = 1174$ k·ft

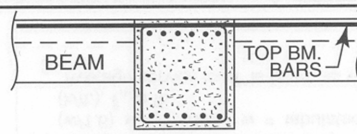
SPAN 26' → b = 36", h = 24.5" $\phi M_p = 1261$ ft k

REINFORCING: TOP: 7 #14, BOTTOM: 14 #6 IN 2 ROWS [CRSI 2002 p 12-90]

WIDE MODULE (1) ONE-WAY JOISTS MULTIPLE SPANS	40″ Forms + 8″ Ribs @ 48″ c.-c. 18″ Deep Rib + 4.5″ Top Slab = 22.5″ Total Depth FACTORED USABLE SUPERIMPOSED LOAD (PLF)											f'_c = 4,000 psi f_y = 60,000 psi
TOP BARS NO	# 4	# 5	# 5	# 6	# 6	End Span Defl. Coeff. (2)	# 4	# 4	# 5	# 6	# 6	Int. Span Defl. Coeff. (2)
AT	11.5	10.5	9.5	11.0	9.5		8.5	5.0	7.0	8.0	7.0	
BOTTOM BARS NO	2# 4	1# 5	2# 6	1# 8	1# 8		2# 4	1# 5	2# 6	1# 8	1# 8	
BARS NO	1# 5	2# 6	1# 6	1# 8	1# 9		1# 5	2# 6	1# 6	1# 8	1# 9	
STEEL (PSF)	.72	1.18	1.33	1.66	1.87		.64	.64	.64	.64	.64	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
32′-0″ (3)	142	610	736	979	1177	4.000	463	1144	1327	1680	1969	2.461
STIR	#3- 38	#3-111	#3-122	#3-138	#3-134		#3- 66	#3-117	#3-124	#3-137	#4-144	
33′-0″	100	540	658	887	1073	4.523	402	1042	1214	1546	1818	2.784
STIR	3- 33	#3-111	#3-123	#3-140	#3-142		#3- 64	#3-118	#3-126	#3-140	#3-147	
34′-0″	61	476	587	802	978	5.097	346	949	1111	1424	1680	3.137
STIR	#3- 28	#3-111	#3-123	#3-141	#3-151		#3- 62	#3-119	#3-128	#3-142	#3-149	
35′-0″		417	522	725	892	5.724	294	864	1016	1312	1554	3.522
STIR		#3-110	#3-123	#3-142	#3-154		S#3- 60	#3-120	#3-129	#3-124	#3-152	
36′-0″		363	463	655	812	6.407	247	785	930	1209	1437	3.942
STIR		#3-110	#3-123	#3-143	#3-156		#3- 57	#3-121	#3-130	#3-131	#3-155	
37′-0″		314	408	590	738	7.149	204	713	850	1114	1331	4.399
STIR		#3-109	#3-123	#3-144	#3-157		#3- 54	#3-121	#3-131	#3-139	#3-157	
38′-0″		268	357	530	671	7.953	164	647	777	1027	1232	4.894
STIR		#3-108	#3-123	#3-145	#3-159		#3- 51	#3-122	#3-132	#3-146	#3-159	
39′-0″		226	311	474	608	8.824	127	586	709	947	1141	5.430
STIR		#3-106	#3-122	#3-146	#3-160		#3- 47	#3-122	#3-133	#3-150	#3-162	
40′-0″		187	267	423	550	9.765	93	529	646	872	1057	6.009
STIR		#3-105	#3-121	#3-146	#3-161		#3- 43	#3-122	#3-134	#3-151	#3-144	
41′-0″		151	227	375	496	10.778	61	476	587	803	979	6.633
STIR		#3-103	#3-120	#3-146	#3-162		#3- 39	#3-122	#3-134	#3-153	#3-151	
→ 42′-0″		117	190	331	447	11.869	32	427	533	738	906	7.304
STIR		#3-101	#3-119	#3-147	#3-163		#3- 35	#3-122	#3-135	#3-154	#3-158	
43′-0″		86	155	290	400	13.040		381	483	679	839	8.025
STIR		#3- 98	#3-118	#3-147	#3-164			#3-121	#3-135	#3-155	#3-166	
44′-0″		57	123	252	357	14.296		339	436	623	776	8.798
STIR		#3- 96	#3-116	#3-146	#3-164			#3-121	#3-135	#3-156	#3-169	
PROPERTIES FOR DESIGN (CONCRETE .67 CF/SF)												
NEGATIVE MOMENT												
STEEL AREA (SQ. IN.)	.83	1.42	1.57	1.92	2.22		1.13	1.92	2.13	2.64	3.02	
ACTUAL STEEL %	.414	.704	.779	.958	1.109		.559	.951	1.057	1.317	1.505	
EFF. DEPTH, IN.	20.75	20.69	20.69	20.63	20.63		20.75	20.75	20.69	20.63	20.63	
– ICR/IGR	.119	.181	.196	.227	.253		.152	.230	.247	.287	.315	
POSITIVE MOMENT												
STEEL AREA (SQ. IN.)	.71	1.19	1.32	1.58	1.79		.71	1.19	1.32	1.58	1.79	
ACTUAL STEEL %	.342	.575	.638	.768	.871		.342	.575	.638	.768	.871	
EFF. DEPTH, IN.	20.72	20.64	20.63	20.50	20.46		20.72	20.64	20.63	20.50	20.46	
+ICR/IGR	.125	.200	.220	.255	.284		.125	.200	.220	.255	.284	
SINGLE LEG STIRRUP AT 10 IN. CONSTANT SPACING-DISTANCE (IN.)												

(1) For gross section properties, see Table 8-3.
(2) Computation of deflection is not required above horizontal line (thickness ≥ ℓ_n/18.5 for end spans, ℓ_n/21 for interior spans).
(3) Single leg stirrup size space at X in. c.-c. Distance over which stirrups must extend from face of support at each end (in.).





APACITY $U = 1.4D + 1.7L^{(3)}$

(cut off)	… ft STEEL WGT lb.	SPAN, ℓ_n = 24 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN, ℓ_n = 26 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	$+\phi M_n$ $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\times 10^{-9}$ in.
-	595	6.4	133H	18	-	645	5.4	133H	18	-	685	350	353
9	932		155H	74	1.9	1041		165H	73	1.9	1115	368	
-	721	6.7	133H	18	-	779	5.7	133H	18	-	828	350	312
9	1058		155H	74	1.9	1175		165H	73	1.9	1258	547	
-	1194	10.7	154H	18	-	1306	9.1	164H	18	-	1401	560	257
9	1620		215E	73	1.9	1766		225E	72	1.8	1878	742	
-	1663	13.1	155H	18	-	1728	11.2	165H	18	-	1853	685	222
9	2109		245D	73	1.9	2140		225E	72	1.8	2170	886	
-	818	9.0	123H	33	-	875	7.7	133H	33	-	942	471	231
8	1438		155H	133	2.8	1341		523A	131	2.7	1465	580	
-	1126	11.1	133H	33	-	1082	9.4	143H	33	-	1163	580	222
8	1621		215E	133	2.8	1770		225E	131	2.7	1881	697	
-	1735	16.6	155H	33	-	1904	14.2	165H	33	-	2042	885	177
8	2359		245D	133	2.8	2391		265D	131	2.7	2578	956	
-	2244	19.3	165EeH	33	-	2375	16.4	175EcH	33	-	2546	1010	153
8	3466		295C	132	2.7	3026		315C	131	2.7	3245	1261	
-	1081	12.2	123H	49	-	1159	10.4	133H	49	-	1248	701	175
7	1665		294C	197	3.7	1826		**	195	0.0	1110	701	
-	1298	13.4	133H	49	-	1277	11.4	133H	49	-	1362	701	172
7	1882		294C	197	3.7	1933		314C	195	3.6	2074	845	
-	2365	23.1	165EeH	49	-	2549	19.7	175EdH	49	-	2734	1213	129
7	3320		365B	197	3.7	3603		395B	195	3.6	3886	1329	
-	3139	25.6	185DiH	49	-	3065	21.8	185EgH	48	-	3250	1339	116
7	4218		365B	196	3.6	4054		395B	194	3.6	4369	1633	

open stirrups, secondline is for closed ties. See Fig. 12-4. At
nterior Spans". For b > 24 in., provide 4 legs (two stirrups) of
nomenclature, see page 12-13.

E NOT REQUIRED

ACING IS LESS THAN 3 INCHES. NOT RECOMMENDED

SS IS GREATER THAN $10\sqrt{f'_c}$

ESS EXCEEDS ALLOWABLE

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.

(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft. "Average service load" is taken as w/1.6.

Appendix D
Calculations for Alternative Floor System 4:

Concrete Pan Joist Girders, Short Span

ONE WAY CONC. PAN JOIST

SHORT SPAN DIRECTION: (28'0")

FACTORED LOAD: 99 PSF

CLEAR SPAN, ℓ_n = 28' - (30") = 25'6", USE 26'0"

40" FORMS + 8" RIBS @ 48" O.C., INTERIOR SPAN

(99 PSF)(4'0") = 396 PLF

→ 12" DEEP RIB + 4.5" TOP SLAB = 16.5" TOTAL DEPTH

MAX FACTORED LOAD: 686 PLF > 396 PLF [CRSI 2002, P8-58]

REINFORCING: TOP: #8 @ 8"
BOTTOM: 1 #5
STIRRUPS: #3-93

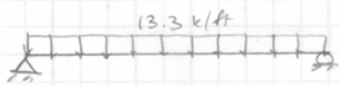
GIRDER: (44'4")

CLEAR SPAN: 41'10"

SELF WT. JST:
145 PCF ((12" × 8") + (48" × 4.5")/144)

FACTORED LOAD: 99 PSF → 314 PSF

99 PSF + 1.2(314 PSF) = 476 PSF (28') = 13.3 k/ft



$M_{max} = \frac{13.3(41'10")^2}{8} = 2909$ k·ft

SPAN → USE 42' DESIGN, INTERIOR

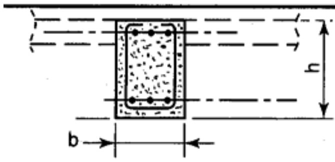
USE 30" × 42" RECT BEAM, ϕM_n = 3122 ft·k

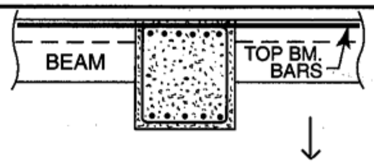
REINFORCING: TOP: 10 #14
BOTTOM: 3 #14 IN 2 LAYERS

[CRSI 2002 P 12-76]

WIDE MODULE (1) ONE-WAY JOISTS MULTIPLE SPANS	40″ Forms + 8″ Ribs @ 48″ c.-c. 12″ Deep Rib + 4.5″ Top Slab = 16.5″ Total Depth FACTORED USABLE SUPERIMPOSED LOAD (PLF)											f'_c = 4,000 psi f_y = 60,000 psi
TOP BARS NO	# 4	# 4	# 4	# 5	# 5	End Span Defl. Coeff. (2)	# 4	# 4	# 5	# 6	# 6	Int. Span Defl. Coeff. (2)
AT	12.0	11.0	9.0	11.5	10.0		12.0	8.0	10.5	11.5	10.5	
BOTTOM BARS NO	1# 4	1# 5	1# 6	1# 6	1# 5		1# 4	1# 5	1# 6	1# 6	1# 5	
BARS NO	1# 5	1# 6	1# 6	1# 7	2# 6		1# 5	1# 6	1# 6	1# 7	2# 6	
STEEL (PSF)	.56	.76	.92	1.09	1.20		.39	.39	.39	.39	.39	
CLEAR SPAN	END SPAN						INTERIOR SPAN					
24′-0″ (3)	168	462	621	814	1002	1.265	459	888	1118	1399	1672	0.779
STIR	#3- 30	#3- 73	#3- 86	#3- 99	#3-107		#3- 51	#3- 80	#3- 90	#3-100	#3-107	
25′-0″	117	389	535	713	886	1.490	386	781	993	1252	1504	0.917
STIR	#3- 25	#3- 72	#3- 86	#3-100	#3-109		#3- 49	#3- 81	#3- 91	#3- 91	#3-109	
→ 26′-0″	73	324	459	623	784	1.743	321	686	883	1122	1355	1.073
STIR	#3- 20	#3- 70	#3- 86	#3-101	#3-111		#3- 46	#3- 81	#3- 93	#3- 99	#3-111	
27′-0″	33	266	391	544	692	2.027	263	602	784	1006	1222	1.247
STIR		#3- 69	#3- 86	#3-101	#3-112		#3- 44	#3- 81	#3- 94	#3-104	#3-114	
28′-0″		214	331	472	611	2.344	212	527	696	902	1103	1.443
STIR		#3- 66	#3- 85	#3-102	#3-114		#3- 41	#3- 81	#3- 94	#3-106	#3-116	
29′-0″		168	276	408	537	2.698	165	459	617	809	996	1.660
STIR		#3- 64	#3- 84	#3-102	#3-115		#3- 37	#3- 81	#3- 95	#3-107	#3-107	
30′-0″		126	227	351	471	3.090	123	398	545	725	900	1.901
STIR		#3- 61	#3- 83	#3-102	#3-115		#3- 34	#3- 80	#3- 95	#3-108	#3-114	
31′-0″		88	183	298	411	3.523	86	343	481	649	813	2.168
STIR		#3- 58	#3- 81	#3-102	#3-116		#3- 30	#3- 79	#3- 95	#3-110	#3-119	
32′-0″		53	142	251	357	4.000	51	292	422	580	734	2.461
STIR		#3- 55	#3- 79	#3-101	#3-117		#3- 26	#3- 78	#3- 95	#3-110	#3-121	
33′-0″			106	208	307	4.523		247	368	517	662	2.784
STIR			#3- 77	#3-100	#3-117			#3- 77	#3- 95	#3-111	#3-122	
34′-0″			72	168	262	5.097		205	320	460	596	3.137
STIR			#3- 75	#3- 99	#3-117			#3- 76	#3- 95	#3-112	#3-124	
35′-0″			41	132	221	5.724		167	275	407	536	3.522
STIR			#3- 72	#3- 98	#3-117			#3- 74	#3-94	#3-112	#3-125	
36′-0″				99	183	6.407		132	234	359	480	3.942
STIR				#3- 97	#3-116			#3- 72	#3- 93	#3-112	#3-126	
PROPERTIES FOR DESIGN (CONCRETE .56 CF/SF)												
NEGATIVE MOMENT STEEL AREA (SQ. IN.)	.80	.87	1.07	1.29	1.49		.80	1.20	1.42	1.84	2.01	
ACTUAL STEEL %	.588	.641	.784	.955	1.098		.588	.882	1.046	1.362	1.492	
EFF. DEPTH, IN.	14.75	14.75	14.75	14.69	14.69		14.75	14.75	14.69	14.63	14.63	
– ICR/IGR	.139	.149	.174	.200	.222		.139	.191	.214	.256	.273	
POSITIVE MOMENT STEEL AREA (SQ. IN.)	.51	.75	.88	1.04	1.19		.51	.75	.88	1.04	1.19	
ACTUAL STEEL %	.364	.537	.631	.748	.853		.364	.537	.631	.748	.853	
EFF. DEPTH, IN.	14.71	14.65	14.63	14.59	14.64		14.71	14.65	14.63	14.59	14.64	
+ICR/IGR	.116	.164	.189	.218	.248		.116	.164	.189	.218	.248	
SINGLE LEG STIRRUP AT 7 IN. CONSTANT SPACING-DISTANCE (IN.)												

(1) For gross section properties, see Table 8-3.
(2) Computation of deflection is not required above horizontal line (thickness ≥ ℓ_n/18.5 for end spans, ℓ_n/21 for interior spans).
(3) Single leg stirrup size space at X in. c.-c. Distance over which stirrups must extend from face of support at each end (in.).





CITY $U = 1.4D + 1.7L^{(3)}$

TEEL WGT lb.	SPAN, ℓ_n = 40 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN, ℓ_n = 42 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	$+\phi M_n$ $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\times 10^{-9}$ in.
1347	7.6	104R	30	-	1334	6.9	114R	30	-	1407	784	45
1913		305F	122	2.8	2000		285G	121	2.7	2007	1098	
1347	7.6	104R	30	-	1334	6.9	114R	30	-	1407	784	45
1913		305F	122	2.8	2000		285G	121	2.7	2007	1098	
2575	13.2	185GIR	30	-	2670	11.9	195GIR	30	-	2805	1424	34
3411		485C	122	2.8	3579		505C	121	2.7	3746	1913	
3227	15.0	235EqR	30	-	3288	13.6	235EqR	30	-	3428	1730	30
4194		605B	122	2.8	4413		635B	121	2.7	4633	2179	
1222	7.1	103R	41	-	1292	6.5	103R	41	-	1350	791	35
2302		275G	165	3.3	2406		285G	163	3.2	2509	1038	
1862	10.0	114R	41	-	1945	9.1	114R	41	-	2028	1113	36
2926		305F	165	3.3	3055		285G	163	3.2	3046	1451	
2857	14.5	125OcR	41	-	2982	13.2	135OcR	41	-	3145	1451	30
4140		405D	165	3.3	4357		365E	163	3.2	4298	2261	
3427	17.2	145KfR	41	-	3577	15.6	145MfR	41	-	3728	1772	27
5001		405D	165	3.3	4875		425D	163	3.2	5117	2498	
1749	10.2	104R	59	-	1827	9.2	104R	59	-	1905	1051	30
2899		305F	236	4.0	3025		285G	234	4.0	3006	1478	
2445	12.5	114R	59	-	2389	11.3	114R	58	-	2493	1478	28
3602		345E	236	4.0	3755		365E	234	4.0	3957	1814	
3406	18.1	145KfR	59	-	3597	16.5	145MeR	58	-	3747	1814	24
5112		485C	236	4.0	5360		425D	234	4.0	5219	2742	
4511	21.5	175HjR	59	-	4669	19.5	165IiR	58	-	4826	2446	21
6016		485C	236	4.0	6311		505C	234	4.0	6606	3122 ←	
1926	10.6	094R	79	-	2014	9.6	104R	78	-	2129	1060	22
3367		345E	314	4.8	3506		365E	311	4.7	3696	1842	
2654	15.0	115R	78	-	2769	13.6	115R	78	-	2884	1496	25
4131		405D	314	4.8	4348		365E	311	4.7	4259	2177	
4155	21.8	155IhR	78	-	4295	19.8	155JgR	78	-	4478	2177	20
5830		485C	314	4.8	6114		505C	311	4.7	6398	3234	
5226	25.8	205FnR	78	-	5455	23.4	195GIR	78	-	5643	2814	18
7294		605B	314	4.8	7677		635B	311	4.7	8059	3747	

tirrups, secondline is for closed ties. See Fig. 12-4. At Spans". For b > 24 in., provide 4 legs (two stirrups) of nclature, see page 12-13.

REQUIRED

IS LESS THAN 3 INCHES. NOT RECOMMENDED

EATER THAN 10 [illegible]

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.

(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft.
"Average service load" is taken as w/1.6.

Appendix E
Calculations for Alternative Floor System 5:

Precast Hollow Core Concrete Deck

HOLLOW CORE PLANK

LOADS:

LIVE: 65 PSF
DEAD: 30 PSF

TOTAL 95 PSF

NITTERHOUSE PRESTRESSED HOLLOW CORE PLANK CATALOG

8" x 4' SPAN DECK w/ 2" C.I.P. CONCRETE TOPPING

@ 28' SPAN, ALLOWABLE LOAD → 132 PSF > 95 PSF

REINFORCING: 6 - 1/2" ϕ 270K LO-RELAXATION STRANDS

GIRDER SELECTION:

LIVE: 65 PSF
DEAD: 30 PSF
SELF WT: 82.5 PSF

$1.6(65) + 1.2(30+82.5) = 239$ PSF

$239 \text{ PSF}(28') = 6.7 \text{ k/ft}$

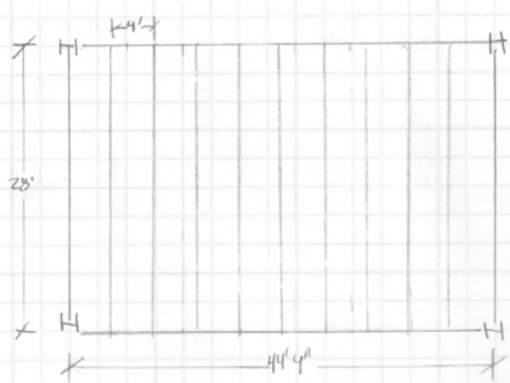
$$M_{u_{MAX}} = \frac{(6.7 \text{ k/ft})(44.33^2)}{8}$$

$$M_{u_{MAX}} = 1645 \text{ k-ft}$$

$$Z_{REQ'D} = \frac{1645(12 \text{ in})}{.9(50)} = 439 \text{ in}^3$$

TABLE 5-3 IN LRFD: MOST ECONOMICAL → W33x130, $\phi M_p = 1750$

SHALLOWEST: W 27 x 146, $\phi M_p = 1740$

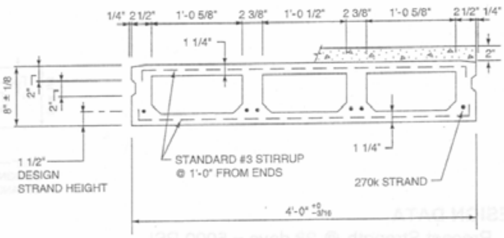


Prestressed Concrete
8" x 4' SpanDeck – U.L. – J917
(2" C.I.P. TOPPING)

PHYSICAL PROPERTIES

Composite

$A' = 254$ in.^{2}	$S'_b = 547$ in.^{3}
$I' = 2944$ in.^{4}	$S'_t = 1124$ in.^{3} (At Top of SpanDeck)
$Y_{b'} = 5.38$ in.	$S'_{tt} = 637$ in.^{3} (At Top of Topping)
$Y_t' = 2.62$ in. (To Top of SpanDeck)	Wt.' = 330 PLF
$Y'_{tt} = 4.62$ in. (To Top of Topping)	Wt.' = 82.5 PSF



8" SPANDECK CROSS SECTION

UL FIRE RATED J917

DESIGN DATA

1. Precast Strength @ 28 days = 5000 PSI.
2. Precast Density = 150 PCF.
3. Strand = 1/2"ø, 270K Lo-Relaxation.
4. Composite Strength = 3000 PSI.
5. Composite Density = 150 PCF.
6. Strand Height = 1.5 in.
7. Ultimate moment capacities (when fully developed) . . .
   4 – 1/2"ø, 270K = 94.6'K
   6 – 1/2"ø, 270K = 133.3'K
8. Maximum bottom tensile stress is $6\sqrt{f'c}$ = 424 PSI.
9. All superimposed load is treated as live load in the strength analysis of flexure and shear.
10. Flexural strength capacity is based on stress/strain strand relationships.
11. Load values to the left of the solid line are controlled by ultimate strength. Load values to the right are controlled by service stress.
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. All loads shown refer to allowable loads applied after topping has hardened.

8" SPANDECK W/2" TOPPING	ALLOWABLE SUPERIMPOSED LOAD (PSF)																						
	SPAN (FEET)																						
STRAND PATTERN	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	795	718	650	590	500	426	366	317	275	240	210	184	162	142	125	110	96	84	73	60	49	39	
Shear 4 – 1/2"ø	571	509	458	415	378	347	320	296	275	257	240	222	199	178	160	145	133	126	115	103	93	84	
→ Flexure 6 – 1/2"ø	1155	1040	945	859	732	629	544	474	416	366	324	287	256	228	204	183	164	147	132	118	103	90	77
Shear 6 – 1/2"ø	589	525	472	428	391	360	331	308	286	266	249	235	220	207	195	184	175	160	145	132	120	110	100

↑

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 F

Slab Schedule for Eight Tower Bridge

Reinforced Metal Deck Slab Schedule							f'c=4000psi
Deck Thickness (in)	Slab Thickness (in)	Superimposed Load (PSF)		Main Reinforcement		Wt. Conc (PCF)	Location
		Live	Dead	Top	Bottom		
2	6	125	8	#5 @ 12"	#4 @ 18"	145	Mech. Fan Room, Elev. Mach. Room
3	6	200	10	#4 @ 12"	#4 @ 18"	145	Mech. Penthouse

Composite Metal Deck Slab Schedule						f'c=4000psi
Deck Thickness	Slab Thickness	Superimposed Load		One Layer Reinforcing	Wt. Conc (PCF)	Location
		Live	Dead			
2	3-1/4	50	28	6x6-W1.4xW1.4	115	Typical Office
2	3-1/4	125	28	6x6-W1.4xW1.5	115	Mech. Level 2
2	3-1/4	30	75	6x6-W1.4xW1.6	115	Terrace Level 15
2	3-1/4	30	17	6x6-W1.4xW1.7	115	Penthouse Level