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Æ Structural
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THE hub on Chestnut

PHILADELPHIA, PA

Technical Assignment 2

October 27, 2006

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Structural Option
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The Hub on Chestnut
Philadelphia, PA
October 27, 2006

Executive Summary

Structural Technical Report 2

Within this report, are five (5) preliminary floor systems designed to functional as alternates for The HUB on Chestnut, located in Philadelphia, Pennsylvania. The original system is a post-tensioned two-way flat slab. The selected group consists of a hollow-core concrete slab, two-way flat plate, two-way flat plate with dropped panels, one-way concrete joist, and a composite steel beam. These options were selected to comply with the architectural and structure constraints of the designed building. With a repetitive design in levels 3 through 9, a critical bay was selected from the 7th level. This bay represents the largest spans and is nearly symmetrical in both directions. A few minor modification to the existing structural layout where incorporated to provide simplicity in the preliminary designs. Each alternate system was designed based on a 30' x 30' exterior bay. Several systems have been designed in accordance with applicable industry codes. Such codes include the 2002 CRSI Design Handbook, PCI Handbook 6th Edition, AISC 3rd Edition Manual, as well as manufacturers design manuals.

Many factors are considered in selecting a sustainable floor system. The system first and for most must provide a safe and adequate floor that can support all superimposed loading conditions. It is assumed the provided design aids have been incorporated to meet the requirements of deflection. Other criterion that affects the selection is constraints due to architectural aesthetics, fire rating, constructability, scheduling, and economical costs. The HUB is subjected to all of these features and each, along with others, will be incorporated into the selection process. Although five of the six systems are concrete structures, no bias opinions have been implemented towards either material. The application of a concrete design provides many alternatives that are suitable for the existing structure.

The alternative floor system will be selected using a points system. Each design will receive a point ranging from 1 to 6. The more efficient and desirable systems will be awarded a low value. The system which receives the lowest total point value will be considered to be the most applicable design. Each system can be evaluated and compared to other another based on their total tallied points.

Further research can involve several systems. Two feasible designs are the application of open-web joists and non-composite steel beams. Both designs are part of standard industry practice but were not incorporated for comparison. The composite steel beam was already considered. Although non-composite design may or may not be more economical, a lower floor depth will be controlled by composite design.

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Structural Technical Report 2

Study of Alternate Floor Systems

The objective of this study is to explore various flooring systems that can function as alternatives to the existing design. Within this report, the reader will be introduced to the five (5) systems that have been selected:

Hollow-Core Concrete Slab *One-Way Concrete Joists* *Two-Way Flat Slab*

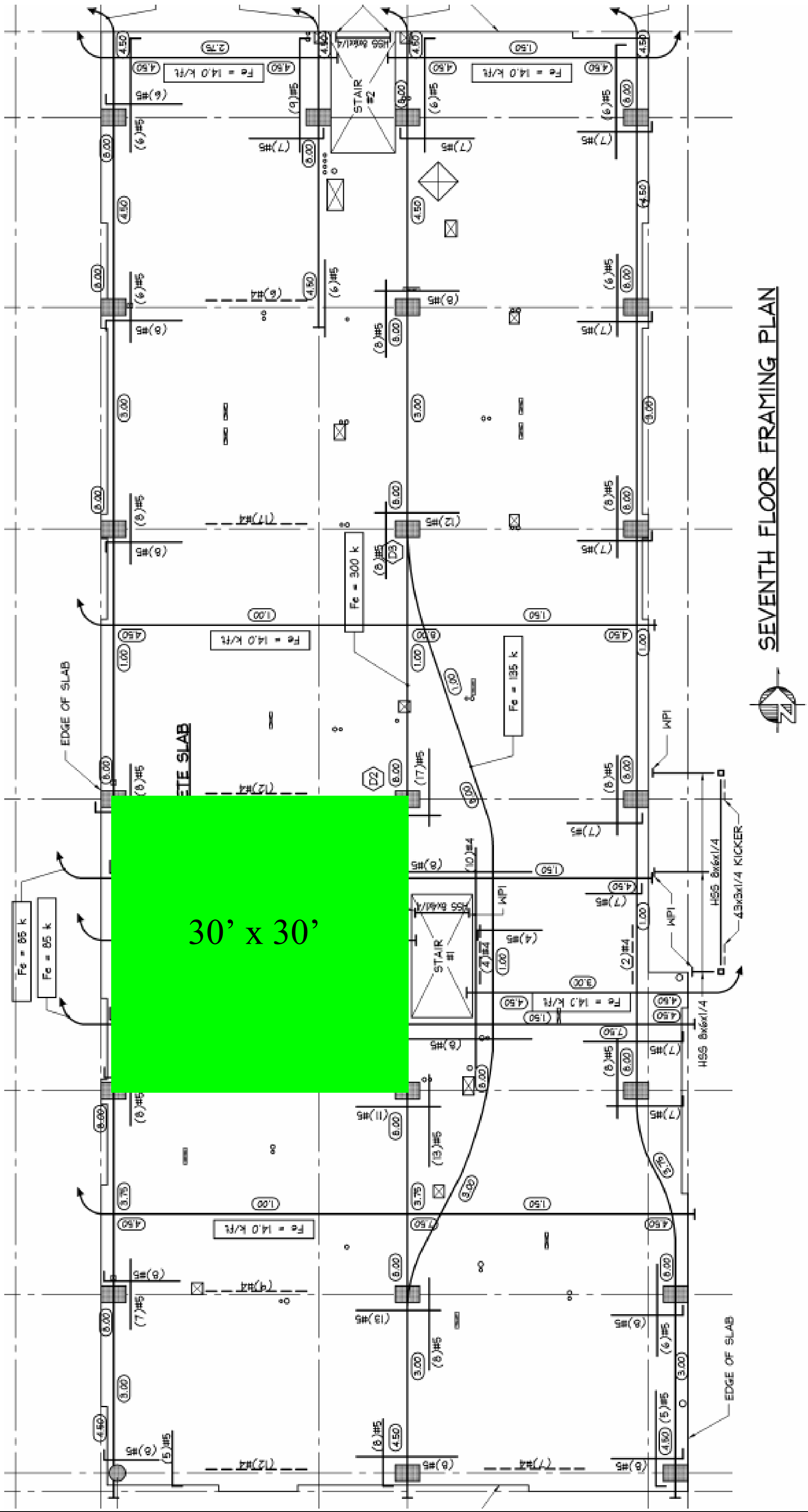
Two-Way Slab with Drop Panels *Composite Steel Beam*

Each flooring system provides both advantages and disadvantages when integrated with the admirations and requirements of the designers, as well as the owner. The systems will be compared among one another to provide a systematic selection process based on a 'points system'. The points system will provide a flooring system that will incorporate fundamental design criteria, construction restraints, architectural aesthetics, and economical costs.

For preliminary design purposes, the existing structural layout has been modified. The center column line has been shifted one-foot (12") in the East /West direction and the exterior columns have been transferred to the slab edge. No adjustments along each column line have implemented which will maintain their ambiguity within the partition walls. This slight revision will provide symmetry and simplicity in designing each system. In the illustration provided on the next page, the green area indicates the critical bay that will be analyzed in each flooring system.

The critical bay is located on the 7th level. This bay was selected for several reasons. The first reason is to account for the largest typical bay within the structure. Also, levels 3 through 9 provide the dominant common floor space. These seven levels serve as residential occupancy and have a redundancy in the architectural layout. The five flooring systems will be designed based on a typical 30' x 30' exterior bay required to support a superimposed dead and live load.

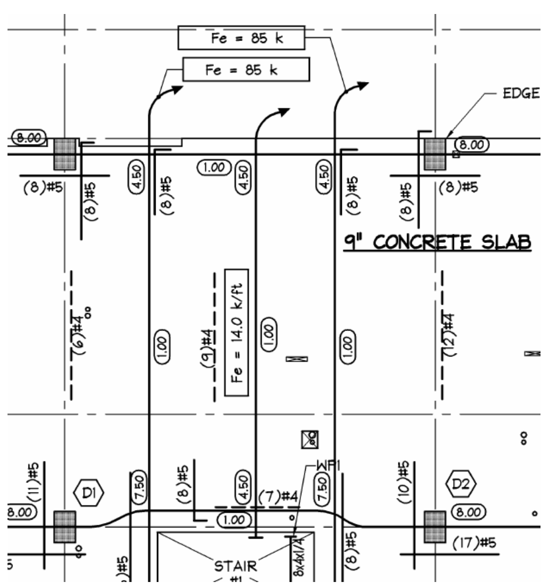
Dead Loads	Partitions	20	lb/ft²	*Live Loads*	Residential Use	
	MEP	5	lb/ft²			
	Collateral	5	lb/ft²		[ASCE7-02]	40 lb/ft²
		30	lb/ft²			


SEVENTH FLOOR FRAMING PLAN
30' x 30'

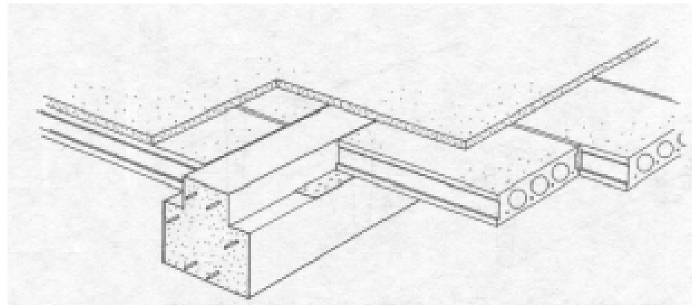
POST-TENSIONED TWO-WAY SLAB [EXISTING]

The HUB on Chestnut has been designed and constructed using a two-way post-tensioned floor system. The typical 9-inch slab, with 5,000 PSI high compressive strength concrete, is supported by three column lines oriented on each exterior edge and through the middle in the long geometry of the building. The column grid creates 12, nearly square bays, with #4 bars spaced continuously at 30" in each direction. Additional reinforcement (5 - #8 bars) is placed at the top and bottom in both directions where mild reinforcing is needed. As illustrated above, the post-tensioning strands are placed along each long column line and at intermediate bays. The typical tendon is a half-inch 270k seven-wire strand. The jacking forces range from 85k to 435k. The lower stressed tendons are spanned in the short direction.

A post-tensioned system is a welled designed system. The tensioning provides a strong concrete slab that can withstand a substantially higher loading than other conventional concrete slabs. A thinner slab thickness is one of the most popular attributes of post-tensioning. The tendons and anchors can be well hidden in the case of architectural examination. A creditable aspect is the elimination of fireproofing. Fireproofing is an additional cost and can be beneficial to the building budget if eliminated or reduced. Some disadvantages also come with this design. Post-tensioning can be less effective during construction. Each tendon must be carefully placed causing longer construction intervals. The tendons can not be stressed until the concrete has reached its setting strength which is detrimental to the schedule. Although this system is very effective, the cost is excessive compared to other systems. The tendons and high strength concrete are very costly along with the hiring of another subcontractor to provide the jacking. Please refer to Technical Report 1 for any concerns with the existing structure.

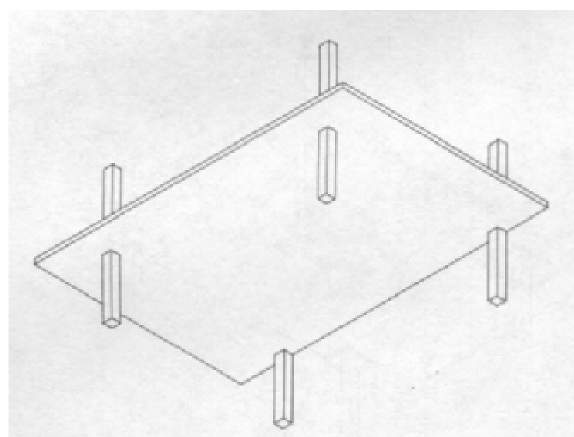


Hollow-Core Concrete Slab



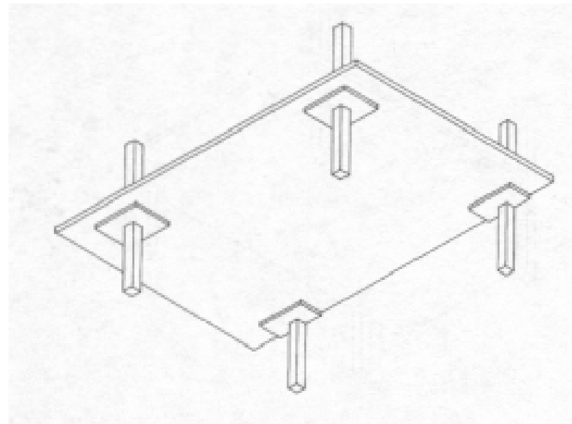
Precast concrete planks have several advantages. The most beneficial use of precast is the quick and steady installation. The product can arrive on-site and be put into place. No down time is required for concrete to be finished and set. The concrete planks, although hollow, can provide an adequate rigidity to resist lateral forces. Precast products provide the consumer with a quality product that is fabricated in a controlled working environment and can be installed in all weather conditions. The floor system devised will incorporate the use of precasted 8" x 4' hollow-core slabs spanning 30'. The planks will be reinforced using 6- ½ ø, 270k tendons within 5,000 PSI concrete. An additional 2" topping of concrete will be used to created an even finished floor which is an aspect desired by the design architect. The U.L. J917 is adequate for a 1-1½ hour fire rating. The entire supporting structure was not designed. The use of concrete ledger and inverted T beams will be needed. These beams can be integrated into the wall system which will allow for an exposed total depth of 10 inches. Please see Appendix II for loading, selection, and application.

Two-Way Flat Slab



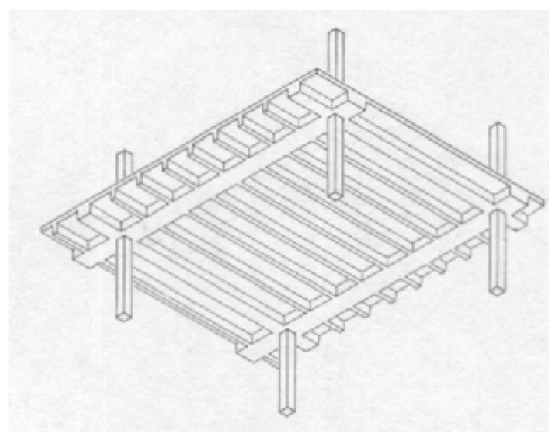
A two-way flat concrete slab provides the architect with a uniform floor system. There are no edge beams, dropped panels, and other obstructions to hinder his/her design. Both architects and engineers are subjected to using free column spacing and placement. This selection uses a 10" thick slab with 4,000 PSI compressive strength and 60 KSI reinforcing. The formwork is simple and uniform which allows for quick construction. Another advantage is the consistent and continuous reinforcing in each direction. This design does not include the use of shearheads. Some disadvantages come into play with flat monolithic slabs. The slab is very sustainable to punching shear. Usual design resists this action by creating large columns and thicker slabs. Again, the use of a thickness concrete slab eliminates the application of fireproofing and provides an adequate 2-hour rating. Please refer to Appendix III for loading, selection, and application.

TWO-WAY FLAT SLAB WITH DROPPED PANELS



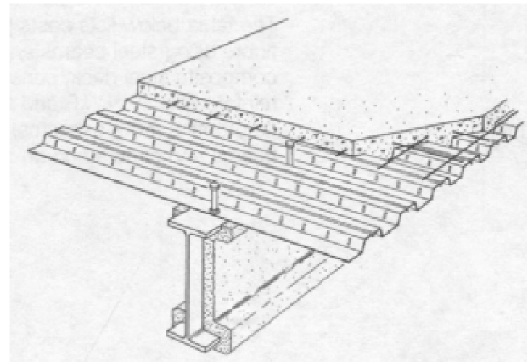
The two-way slab with dropped panels is an alternate to flat slabs and slabs with beams. The dropped panels provide the slab with the strength needed to eliminate obstructive deep supports. Also, the dropped panels can be incorporated for architectural aesthetics. This design will reduce the action of punching shear and can reduce the size of the support columns. Dropped panel systems will sustain higher loading than the flat plat system. The selected design indicates the use of 10' x 10' dropped panels 9" in depth. The concrete consist of 4,000 PSI compressive strength and 60 KSI reinforcing. A total depth of the system is 11.5". With the extra time to construct the formwork, the cost of this selection can be much higher than flat plate design. A dropped panel design can cause construction delays in placing the reinforcement. The discontinuity may hinder the schedule and quality of the finished product. Please refer to Appendix IV for loading, selection, and application

ONE-WAY CONCRETE JOISTS



One-way concrete joists are an alternate to steel joists. The cost is substantially less compared to the current high cost of steel. The monolithic slab and joist integration provides a much more rigid flooring system than the flat slab. A deep pan between joists can provide a cavity to mount and hide mechanical duct work. Several disadvantages are associated with one-way joists. The cumbersome formwork is not very economical but the finished product may be worth the extra time and cost. The selected system consists of 10" deep ribs with a width of 6" spaced 26" on center using 4,000 PSI. A monolithic 3" topping is applied to provide a stable uniform deck finish. All concrete is cast-in-place with 60 KSI integrated continuously at the top and bottom. A joist-band beam has also been designed for this application. The design requests a 24.5" x 24" doubly-reinforced member to act as an interior support. Please refer to Appendix V for loading, selection, and application.

COMPOSITE STEEL BEAM



A steel beam with a concrete slab-on-deck composite system is a very common floor design. This applied design consist two W10 x 26 joists spaced evenly at 10' on center within the 30' x 30' bay. The girder is sized as a W18 x 46. A 2" United Steel Deck metal decking, model UF2X, is in filled with 6.5" of 4,000 PSI normal weight concrete. The total depth above top steel flange is 6.6". A W4 x W4 welded wire mesh is placed in the slab system. The composite action is constructed of 12 shear studs attached to each joist beam and 15 studs attached to the girder. To avoid any design change with the stair opening, the joists are run parallel to the long geometry of the structure. This arrangement is also more economical because all the girders will be run in the long direction in each bay. The application of a steel joist with slab-on-deck system provides a quick and steady installation over concrete. No lead time is needed to allow for an acceptable strength to be acquired as there is in concrete construction. In today's economy, the price of steel is significantly higher than that of concrete. This type of system also includes an application of sprayed fiberous concrete fireproofing.

SYSTEM SELECTION

As previously stated in the introduction, a particular floor design will be selected based on a points system. The group of systems, including the existing, will be compared based on fundamental design criteria, construction restraints, architectural aesthetics, and economical costs. Each item will be scored in a particular section and issued a point value between 1 and 6. The most desirable design with be given a 1, the next feasible design will be issued a 2, and so on. Each system with be ranked in accordance by ascending order. No two systems can share a common value. After the numbers are tallied, the floor system with the least amount of points will be chosen as the paramount design.

Table Key		
	I	Post-Tensioned Flat Slab
	II	Hollow-Core Concrete Slab
	III	Two-Way Flat Slab
	IV	Two-Way Flat Slab with Drop Panels
	V	One-Way Concrete Joists
	VI	Composite Steel Beam

Alternate Systems Evaluation Table

System	*I*	*II*	*III*	*IV*	*V*	*VI*
Economic Cost	5	1	2	4	5	6
Floor Depth	1	3	2	4	5	6
Loading Capacities	2	4	6	5	3	1
Fire Proofing (Rating)	4	3	2	1	5	6
Design Flexibility	2	6	1	4	5	3
Mechinical Placement	3	1	2	5	4	6
Constructability	5	1	2	3	6	4
Installation	4	1	2	3	6	5
Time Elapse	5	1	3	4	6	2
Weather Conditions	5	1	3	4	6	2
Quality	4	1	3	5	6	2
Aesthetics	2	3	1	4	6	5
Maintenance	3	2	1	4	5	6
Total	45	28	30	50	68	54

CONCLUSION

In the above selections, six (6) floor systems have been devised to serve the gravity loading conditions for The HUB on Chestnut located in Philadelphia, Pennsylvania. In the group, five (5) systems are concrete support structures while the other is steel framing. No bias is directed towards any material. Concrete structures have several applicable systems that would be functional. Two other steel systems may be applicable with steel construction. One is the open-web steel joist, and the other is non-composite steel beam. A steel joist could be further researched but the non-composite should be denied due to depth constraints compared to the other systems.

Using the evaluation table, the hollow-core concrete slab is best suited to be an alternate system to the existing design. This floor system is most applicable in all areas of design. The next selection could be the two-way flat slab. The most undesirable system is the one-way concrete joists. The existing condition is a well designed floor system but is out ranked by the other options.

APPENDIX I

SOURCES
[WORKS CITED]

SOURCES

- Hollow-Core Concrete Slab

Nitterhouse Concrete Products

Precast and Prestressed Concrete Design Handbook [PCI 6th Edition]

- Two-Way Flat Slab

Concrete Reinforcing Steel Institute, 2002 [CRSI-02]
Design Handbook

- Two-Way Flat Slab with Drop Panels

Concrete Reinforcing Steel Institute, 2002 [CRSI-02]
Design Handbook

- One-Way Concrete Joists

Concrete Reinforcing Steel Institute, 2002 [CRSI-02]
Design Handbook

- Composite Steel Beam

American Institute of Steel Construction, 3rd Edition [AISC]

United Steel Deck, Inc. [USD]
Deck Design Manual

- Cost Analysis

Cost Works Database 2005

RS Means Assembly Costs 2006

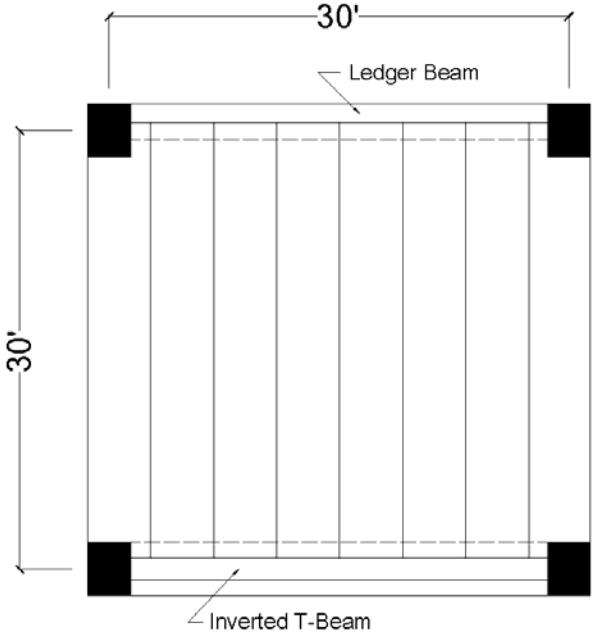
APPENDIX II

HOLLOW-CORE CONCRETE SLAB

HOLLOW-CORE CONCRETE SLAB

[In accordance with Nitterhouse Concrete]

Loading Conditions



Dead Loads

Partitions	20	lb/ft^2
MEP	5	lb/ft^2
Collateral	5	lb/ft^2
	30	lb/ft^2

Live Loads

Level 7 → Residential

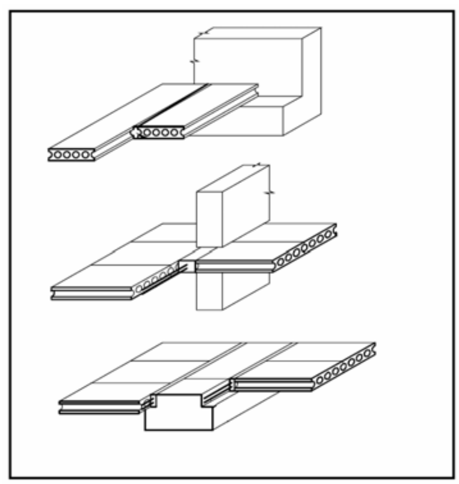
40 lb/ft^2

Superimposed Service Load

w_u = $D_L + L_L$
= 30 lb/ft^2 + 40 lb/ft^2
= 70 PSF

Factored Load

w_u = $1.2D_L + 1.6L_L$
= 1.2(30 lb/ft^2) + 1.6(40 lb/ft^2)
= 100 PSF

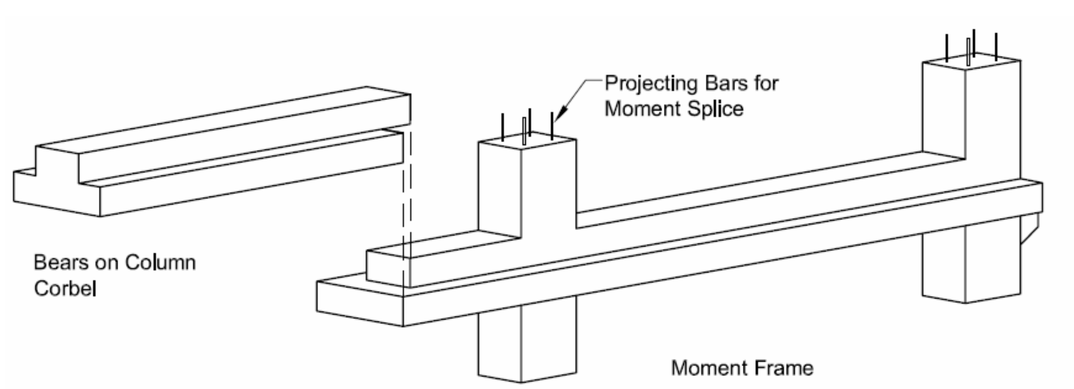


NITTERHOUSE Design Aid

Select 8” x 4’ Span Deck® U.L. - J917
2” CIP Topping
(6) Strand - ½ Φ, 270K

103 PSF > 70 PSF

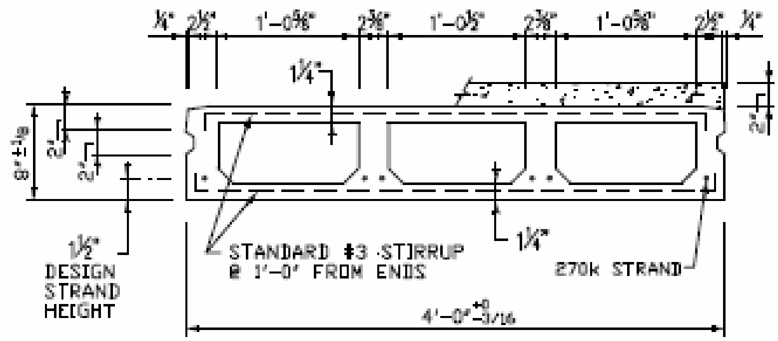
**Load value is controlled by service stress*



Prestressed Concrete
8"x4' 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, 270 K 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 determing allowable loads in this table.
14. All loads shown refer to allowable loads applied after the topping has hardened.

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	795	718	650	590	500	426	366	317	275	240	210	184	162	142	125	110	96	84	73	60	49	39	X
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	X
Flexure	6	–	1/2"ø	1156	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.

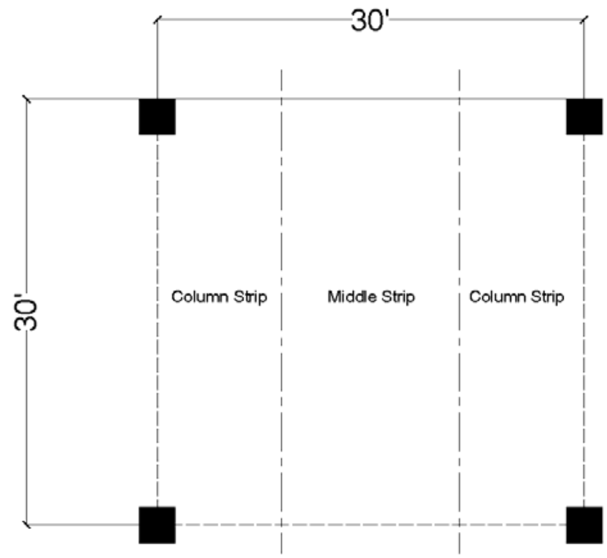
APPENDIX III

TWO-WAY FLAT SLAB

TWO-WAY SOLID FLAT SLAB

[In accordance with CSRI 2002]

Loading Conditions



Dead Loads

Partitions	20	lb/ft²
MEP	5	lb/ft²
Collateral	5	lb/ft²
	30	lb/ft²

Live Loads

Level 7 → Residential

40 lb/ft²

Factored Superimposed Load

w_u = 1.4DL + 1.7LL
= 1.4(30 lb/ft²) + 1.7(40 lb/ft²)
= 110 PSF

CRSI Design Aid (9-30)

f'_c = 4,000 PSI
Grade 60 KSI

Select Square Edge Panel
Without Shearheads

$\ell_1 = \ell_2$ = 30' **150 PSF > 110 PSF** Total Slab Thickness - 10"
Depth

Exterior Columns – 39" x 39" minimum
Interior Columns – 33" x 33" minimum

Reinforcement (E.W.)

Column Strip → 20 - #5 Bars [Exterior Top]
→ 10 - #8 Bars [Bottom]
→ 18 - #8 Bars [Interior Top]

Middle Strip → 16 - #5 Bars [Bottom]
→ 10 - #6 Bars [Interior Top]

Total Steel → 4.21 PSF [Edge]
→ 4.26 PSF [Edge-Corner]
→ 4.41 PSF [Corner]

FLAT PLATE SYSTEM
(WITHOUT SHEARHEADS)

SQUARE EDGE PANEL

SPAN c.-c. Cols. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	(1) Min. Square Column (in.)	γ_f	Total Panel Moments −M Ext. (ft-kip)	+M Int. (ft-kip)	−M 1st. int. (ft-kip)	Reinforcing Bars, Each Column Strip: Top Ext. +	Bottom	Top Int.	Each Middle Strip: Bottom	Top Int.	End Panel Steel (psf), Location of Panel: E	EC	C
10 in. = TOTAL THICKNESS OF SLAB														**0.833 c.f./s.f.**
26	50	20	0.762	115	230	309	12-# 5 4	12-# 5	15-# 6	10-# 5	10-# 5	2.72	2.74	2.74
26	100	24	0.724	136	272	367	12-# 5 5	14-# 5	13-# 7	10-# 5	10-# 5	2.96	2.98	2.96
26	150	28	0.685	157	313	421	14-# 5 4	9-# 7	12-# 8	11-# 5	10-# 5	3.33	3.37	3.42
26	200	32	0.677	175	350	471	16-# 5 5	10-# 7	13-# 8	12-# 5	10-# 5	3.70	3.73	3.83
26	250	36	0.612	192	384	517	12-# 6 2	20-# 5	15-# 8	10-# 6	11-# 5	4.11	4.14	4.29
26	300	41	0.613	205	411	553	13-# 6 3	9-# 8	16-# 8	11-# 6	12-# 5	4.47	4.52	4.71
26	350	47	0.610	216	431	580	19-# 5 3	10-# 8	17-# 8	11-# 6	9-# 6	4.72	4.77	4.96
27	50	22	0.741	128	256	345	12-# 5 5	10-# 6	12-# 7	10-# 5	10-# 5	2.80	2.80	2.74
27	100	26	0.708	151	303	407	13-# 5 5	16-# 5	12-# 8	11-# 5	10-# 5	3.11	3.16	3.17
27	150	31	0.675	173	346	466	15-# 5 6	10-# 7	13-# 8	12-# 5	10-# 5	3.50	3.54	3.66
27	200	35	0.652	194	387	521	12-# 6 4	11-# 7	15-# 8	10-# 6	12-# 5	4.02	4.05	4.20
27	250	40	0.611	211	422	568	19-# 5 3	12-# 7	16-# 8	11-# 6	9-# 6	4.41	4.42	4.65
27	300	46	0.610	224	447	602	14-# 6 3	10-# 8	17-# 8	11-# 6	13-# 5	4.61	4.67	4.95
27	350	53	0.609	233	466	628	15-# 6 2	9-# 9	18-# 8	9-# 7	10-# 6	5.13	5.18	5.32
28	50	24	0.706	142	283	381	13-# 5 4	11-# 6	14-# 7	10-# 5	10-# 5	2.86	2.89	2.95
28	100	28	0.722	168	335	451	15-# 5 6	10-# 7	13-# 8	12-# 5	10-# 5	3.33	3.36	3.50
28	150	33	0.665	192	383	516	17-# 5 5	20-# 5	15-# 8	10-# 6	11-# 5	3.80	3.81	3.94
28	200	37	0.668	214	428	576	19-# 5 6	12-# 7	16-# 8	11-# 6	13-# 5	4.24	4.26	4.50
28	250	44	0.616	230	460	619	20-# 5 5	10-# 8	18-# 8	16-# 5	10-# 6	4.49	4.56	4.82
28	300	52	0.609	241	483	650	15-# 6 3	11-# 8	19-# 8	12-# 6	10-# 6	4.90	4.97	5.18
28	350	59	0.608	252	504	678	16-# 6 2	11-# 8	20-# 8	10-# 7	11-# 6	5.25	5.32	5.46
29	50	26	0.730	156	312	420	14-# 5 7	12-# 6	15-# 7	11-# 5	11-# 5	3.03	3.05	3.07
29	100	31	0.665	184	369	496	16-# 5 5	14-# 6	14-# 8	13-# 5	11-# 5	3.49	3.53	3.69
29	150	36	0.644	210	421	566	13-# 6 4	12-# 7	16-# 8	11-# 6	13-# 5	4.03	4.08	4.14
29	200	42	0.611	233	466	627	15-# 6 2	10-# 8	18-# 8	16-# 5	10-# 6	4.39	4.45	4.69
29	250	50	0.609	248	496	667	16-# 6 2	11-# 8	19-# 8	10-# 7	11-# 6	4.91	4.97	5.11
29	300	57	0.608	261	521	702	23-# 5 4	10-# 9	20-# 8	10-# 7	11-# 6	5.22	5.29	5.59
29	350	65	0.607	270	541	728	17-# 6 2	10-# 9	21-# 8	10-# 7	16-# 5	5.43	5.50	5.88
30	50	28	0.699	171	343	462	15-# 5 6	10-# 7	17-# 7	12-# 5	11-# 5	3.21	3.23	3.26
30	100	33	0.692	203	406	546	18-# 5 7	12-# 7	15-# 8	10-# 6	12-# 5	3.77	3.78	3.86
30	150	39	0.642	231	462	622	20-# 5 6	10-# 8	18-# 8	16-# 5	10-# 6	4.21	4.26	4.41
30	200	47	0.616	251	502	676	16-# 6 4	11-# 8	19-# 8	10-# 7	11-# 6	4.74	4.79	4.95
30	250	55	0.608	267	534	718	17-# 6 2	10-# 9	21-# 8	10-# 7	11-# 6	5.14	5.20	5.46
30	300	63	0.607	280	560	754	18-# 6 1	10-# 9	22-# 8	14-# 6	12-# 6	5.35	5.42	5.77
30	350	71	0.607	290	579	780	19-# 6 0	13-# 8	23-# 8	20-# 5	12-# 6	5.58	5.68	6.00
31	50	30	0.707	188	376	506	17-# 5 7	14-# 6	14-# 8	13-# 5	11-# 5	3.28	3.33	3.46
31	100	35	0.705	222	444	597	14-# 6 6	13-# 7	17-# 8	11-# 6	13-# 5	3.92	3.97	4.16
31	150	43	0.655	250	500	673	16-# 6 5	11-# 8	19-# 8	13-# 6	11-# 6	4.53	4.58	4.75
31	200	52	0.609	270	541	728	17-# 6 4	12-# 8	21-# 8	14-# 6	16-# 5	4.93	4.99	5.14
31	250	61	0.608	287	573	772	18-# 6 3	13-# 8	22-# 8	20-# 5	12-# 6	5.19	5.26	5.62
31	300	69	0.607	300	600	808	19-# 6 1	17-# 7	23-# 8	15-# 6	13-# 6	5.50	5.58	5.88
31	350	78	0.606	310	620	835	20-# 6 0	11-# 9	24-# 8	12-# 7	13-# 6	5.89	5.95	6.34

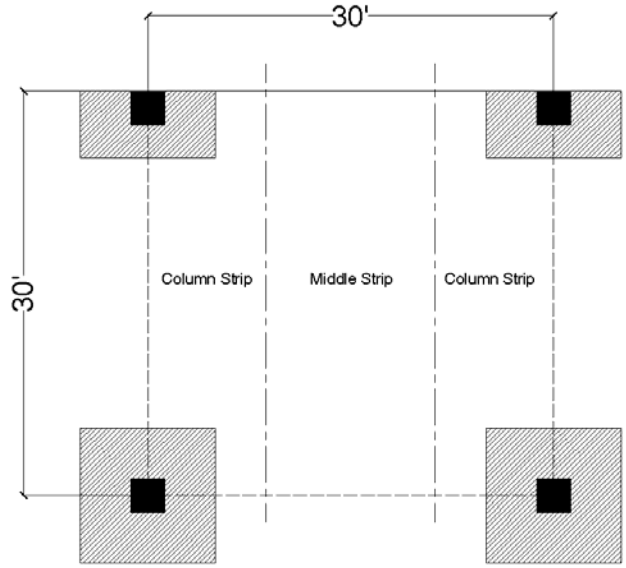
Appendix IV

TWO-WAY FLAT SLAB WITH DROP PANELS

TWO-WAY FLAT SLAB WITH DROP PANELS

[In accordance with CSRI 2002]

Loading Conditions



Dead Loads

Partitions	20	lb/ft²
MEP	5	lb/ft²
Collateral	5	lb/ft²
	30	lb/ft²

Live Loads

Level 7 → Residential

	40	lb/ft²

Factored Superimposed Load

w_u = 1.4DL + 1.7LL
= 1.4(30 lb/ft²) + 1.7(40 lb/ft²)
= 110 PSF

CRSI Design Aid (10-29)

f'_c = 4,000 PSI
Grade 60 KSI

Select Square Edge Panel
With Drop Panels
No Beams

$\ell_1 = \ell_2$ = 30' **200 PSF > 110 PSF**

Drop Panels → 10' x 10'
9" Depth

Total Slab Depth between Drop Panels – 11.5"
Exterior Columns – 16" x 16" minimum
Interior Columns – 19" x 19" minimum

Reinforcement (E.W.)
Column Strip → 14 - #5 Bars [Exterior Top]
→ 12 - #8 Bars [Bottom]
→ 18 - #6 Bars [Interior Top]

Middle Strip → 14 - #6 Bars [Bottom]
→ 16 - #5 Bars [Interior Top]

Total Steel → 3.79 PSF

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM
SQUARE EDGE PANEL — With Drop Panels
No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	Square Drop Panel Depth (in.)	Square Drop Panel Width (ft)	(3) Square Column Size (in.)	γ_f	REINFORCING BARS (E. W.) Column Strip (1) Top Ext.	+	Column Strip Bottom	Column Strip Top Int.	Middle Strip Bottom	Middle Strip Top Int.	Total Steel (psf)	MOMENTS Edge (−) (ft-k)	Bot. (+) (ft-k)	Int. (−) (ft-k)
h = 11.5 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS															
29	100	7.00	9.67	12	0.786	13-#5	3	11-#7	14-#6	10-#6	12-#5	2.94	225.5	451.0	607.1
29	200	9.00	9.67	16	0.673	13-#5	3	11-#8	16-#6	10-#7	15-#5	3.61	290.2	580.4	781.3
29	300	9.00	9.67	19	0.717	14-#5	4	11-#9	15-#7	12-#7	10-#7	4.50	355.0	710.0	955.8
29	400	11.00	9.67	21	0.640	15-#5	3	13-#9	16-#7	18-#6	15-#6	5.11	420.6	841.2	1132.4
29	500	11.00	11.60	23	0.707	17-#5	3	15-#9	14-#8	12-#8	10-#8	5.87	485.4	970.8	1306.9
30	100	9.00	10.00	12	0.698	14-#5	1	12-#7	14-#6	15-#5	13-#5	2.99	251.2	502.3	676.2
30	200	9.00	10.00	16	0.721	14-#5	3	12-#8	18-#6	14-#6	16-#5	3.79	322.4	644.9	868.1
30	300	11.00	10.00	19	0.636	14-#5	3	12-#9	15-#7	10-#8	20-#5	4.61	395.5	791.0	1064.8
30	400	11.00	10.00	21	0.698	17-#5	3	18-#8	14-#8	12-#8	10-#8	5.55	467.8	935.7	1259.6
30	500	11.00	12.00	25	0.757	19-#5	6	17-#9	16-#8	11-#9	12-#8	6.52	536.9	1073.9	1445.6
31	100	9.00	10.33	12	0.740	14-#5	2	18-#6	16-#6	12-#6	14-#5	3.16	277.8	555.5	747.8
31	200	9.00	10.33	16	0.777	14-#5	5	11-#9	15-#7	12-#7	13-#6	4.17	357.0	713.9	961.1
31	300	11.00	10.33	19	0.678	16-#5	3	17-#8	22-#6	11-#8	12-#7	5.01	438.1	876.2	1179.5
31	400	11.00	12.40	23	0.749	18-#5	6	16-#9	15-#8	13-#8	11-#8	5.89	517.8	1035.7	1394.2
31	500	11.00	12.40	28	0.746	15-#6	4	19-#9	14-#9	12-#9	16-#7	6.92	588.5	1176.9	1584.3
32	100	9.00	10.67	12	0.803	15-#5	5	15-#7	17-#6	13-#6	11-#6	3.36	306.2	612.4	824.3
32	200	11.00	10.67	16	0.651	15-#5	2	12-#9	15-#7	13-#7	14-#6	4.31	394.9	789.8	1063.2
32	300	11.00	10.67	19	0.781	17-#5	7	15-#9	18-#7	12-#8	13-#7	5.30	483.7	967.4	1302.3
32	400	11.00	12.80	26	0.718	20-#5	5	18-#9	17-#8	12-#9	12-#8	6.49	567.2	1134.4	1527.1
32	500	11.00	12.80	31	0.692	16-#6	3	21-#9	15-#9	13-#9	11-#9	7.31	639.5	1278.9	1721.6
33	100	11.00	11.00	12	0.710	15-#5	2	22-#6	17-#6	20-#5	12-#6	3.48	337.7	675.5	909.3
33	200	11.00	11.00	16	0.754	15-#5	5	17-#8	16-#7	11-#8	12-#7	4.63	434.4	868.8	1169.5
33	300	11.00	11.00	22	0.734	19-#5	5	17-#9	15-#8	13-#8	11-#8	5.84	528.0	1056.0	1421.5
33	400	11.00	13.20	29	0.711	22-#5	6	20-#9	18-#8	13-#9	13-#8	6.83	616.2	1232.4	1659.0
34	100	11.00	11.33	12	0.762	16-#5	4	14-#8	26-#5	12-#7	19-#5	3.77	370.1	740.2	996.4
34	200	11.00	11.33	18	0.752	17-#5	6	18-#8	18-#7	12-#8	13-#7	4.84	473.9	947.8	1275.9
34	300	11.00	11.33	24	0.757	20-#5	8	18-#9	17-#8	12-#9	12-#8	6.19	576.4	1152.8	1551.9
34	400	11.00	13.60	31	0.689	17-#6	3	21-#9	16-#9	14-#9	14-#8	7.18	667.9	1335.8	1798.2

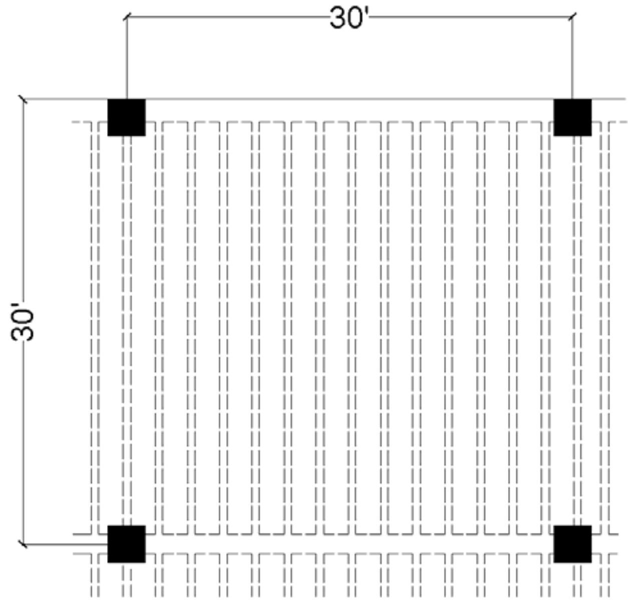
APPENDIX V

ONE-WAY CONCRETE JOISTS

ONE-WAY CONCRETE JOIST

[In accordance with CSRI 2002]

Loading Conditions



f'_c = 4,000 PSI
Grade 60 KSI

Dead Loads

Partitions	20	lb/ft²
MEP	5	lb/ft²
Collateral	5	lb/ft²
	30	lb/ft²

Live Loads

Level 7 → Residential

40 lb/ft²

Superimposed Service Load

$$w_u = 1.4DL + 1.7LL$$
$$= 1.4(30\ lb/ft^2) + 1.7(40\ lb/ft^2)$$
$$= 110\ PSF$$

CRSI Design Aid (8-15)

Select Clear Span – 30'-0"
End Span Condition
20" Form + 6" Ribs @ 26" c.-c.

Factored Load → **118 PSF > 110 PSF**

Joist System → 10" Deep Rib + 3" Top Slab → Total Depth – 13"

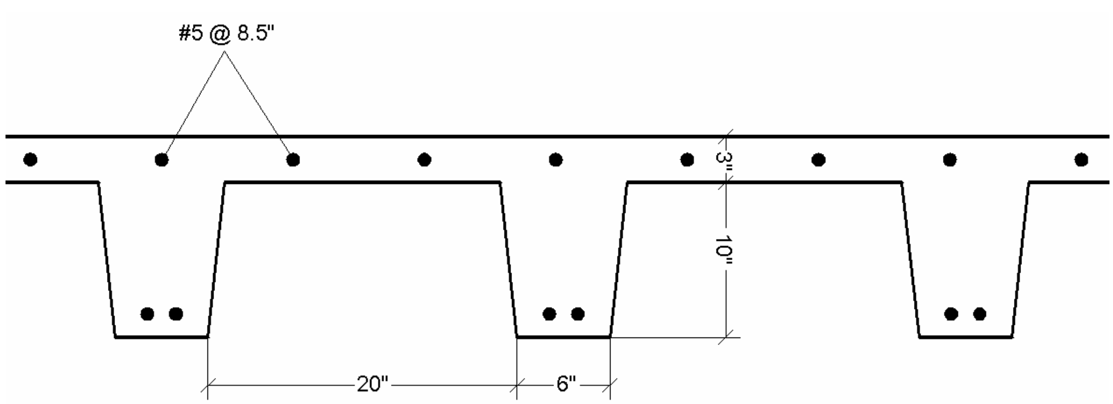
Reinforcement (E.W.)

Top Bars → #5 @ 8.5" o.c.

Bottom Bars → (1) #5, (1) #6 per rib

Self Weight → 70 PSF (8-13)

Total Steel → 1.46 PSF



STANDARD ONE-WAY JOISTS (1) MULTIPLE SPANS		20" Forms + 6" Rib @ 26" c.-c. (2) FACTORED USABLE SUPERIMPOSED LOAD (PSF)										f'_c = 4,000 psi f_y = 60,000 psi
10" Deep Rib + 3.0" Top Slab 13.0" Total Depth												
TOP BARS	Size (in)	# 4 11	# 4 8.5	# 4 7	# 5 8.5	# 6 10.5	End Span Defl. Coeff. (3)	# 4 10	# 4 8	# 5 9.5	# 6 11	# 6 9	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	# 5 # 6	
Steel (psf)		.76	.97	1.19	1.46	1.73		.81	1.04	1.33	1.66	2.00	
CLEAR SPAN		END SPAN						INTERIOR SPAN					
18'-0"		229	316	403	420*	427*	.913	272	378	470*	476*	487*	.562
		0	0	0	503	601*		0	0	504	631	691*	
19'-0"		196	273	352	385*	391*	1.133	234	329	434*	439*	449*	.697
		0	0	0	441	532		0	0	442	557	640*	
20'-0"		167	237	308	355*	359*	1.391	201	287	389	407*	416*	.856
		0	0	0	389	471		0	0	0	493	596*	
21'-0"		142	206	270	328*	332*	1.691	174	252	344	378*	386*	1.041
		0	0	0	343	418		0	0	0	438	544	
22'-0"		121	179	237	304	308*	2.037	149	220	305	352*	360*	1.254
		0	0	0	0	372		0	0	0	390	487	
23'-0"		102	155	209	270	266*	2.433	128	193	270	329*	336*	1.497
		0	0	0	0	332		0	0	0	349	437	
24'-0"		86	134	184	240	268*	2.885	110	170	240	309*	315*	1.775
		0	0	0	0	297		0	0	0	312	393	
25'-0"		71	116	162	213	249*	3.397	93	149	214	280	295*	2.090
		0	0	0	0	266		0	0	0	0	355	
26'-0"		59	100	142	190	233*	3.974	79	130	190	251	278*	2.445
		0	0	0	0	238		0	0	0	0	321	
27'-0"		47	86	125	169	214	4.621	66	113	169	226	261*	2.844
		0	0	0	0	0		0	0	0	0	290	
28'-0"			73	109	150	192	5.345	55	98	150	203	247*	3.289
			0	0	0	0		0	0	0	0	263	
29'-0"			61	95	133	172	6.150	44	85	134	183	233*	3.785
			0	0	0	0		0	0	0	0	238	
30'-0"			51	82	118	155	7.043		73	118	164	216	4.334
			0	0	0	0			0	0	0	0	
31'-0"			41	71	104	138	8.030		62	105	148	196	4.942
			0	0	0	0			0	0	0	0	

(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 .47 CF/SF) (4)											
NEGATIVE MOMENT											
STEEL AREA (SQ. IN.)	.47	.61	.74	.95	1.09		.52	.65	.85	1.04	1.27
STEEL % (UNIFORM)	.58	.75	.91	1.16	1.34		.63	.79	1.04	1.28	1.57
(TAPERED)	.37	.47	.58	.74	.85		.40	.50	.66	.82	1.00
EFF. DEPTH, IN.	11.8	11.8	11.8	11.7	11.6		11.8	11.8	11.7	11.6	11.6
ICR/IGR	.165	.203	.235	.278	.304		.178	.212	.256	.294	.338
POSITIVE MOMENT											
STEEL AREA (SQ. IN.)	.40	.51	.62	.75	.88		.31	.40	.51	.62	.75
STEEL %	.13	.17	.20	.25	.29		.10	.13	.17	.20	.25
EFF. DEPTH, IN.	11.8	11.7	11.7	11.6	11.6		11.8	11.8	11.7	11.7	11.6
ICR/IGR	.176	.216	.257	.301	.345		.139	.176	.216	.257	.301

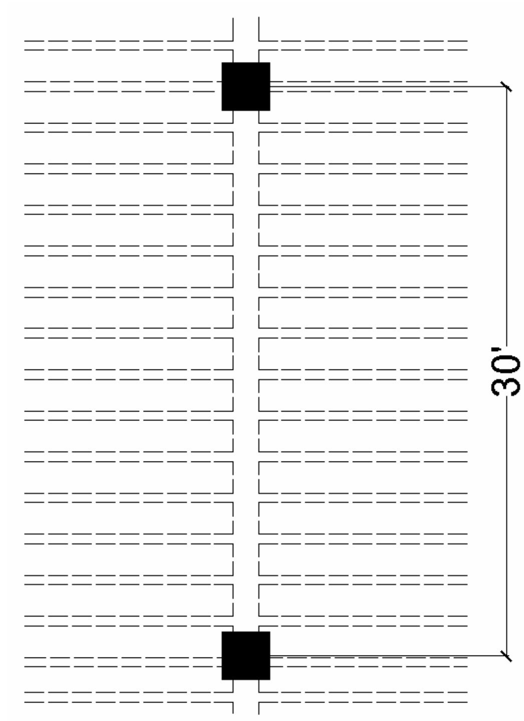
TABLE 8-1 CROSS SECTION PROPERTIES — STANDARD JOIST CONSTRUCTION (1)

Joist (2)	3-Inch Top Slab Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)	4.5-Inch Top Slab Gross Area(3) (in.²)	Wt.(4) (psf)	Y_{cg}(3) (in.)	I_g(3) (in.⁴)	$+M_{cr}$ (ft-k)	$-M_{cr}$(3) (ft-k)
8 – 5 – 20	120.3	60	7.49	1,104	5.8	12.4	157.8	79	8.50	1,630	7.6	16.1
	152.3		6.75	1,582		14.7	189.8		7.74	2,340		19.4
8 + 6 – 20	131.3	63	7.32	1,254	6.8	13.5	170.3	82	8.33	1,852	8.8	17.6
	163.3		6.67	1,709		15.6	202.3		7.65	2,528		20.6
10 + 5 – 20	133.3	67	8.76	1,826	8.2	17.0	170.8	85	9.86	2,561	10.3	21.8
	173.3		7.89	2,594		20.1	210.8		8.93	3,659		26.0
10 – 6 + 20	146.3	70	8.56	2,069	9.6	18.4	185.3	89	9.65	2,906	11.9	23.7
	186.3		7.80	2,801		21.3	225.3		8.83	3,951		27.5
12 – 5 + 20	147.0	74	9.99	2,799	11.1	22.1	184.5	92	11.16	3,797	13.4	28.1
	195.0		9.01	3,951		26.1	232.5		10.10	5,388		33.3
12 – 6 + 20	162.0	78	9.76	3,165	12.8	23.9	201.0	97	10.92	4,300	15.6	30.5
	210.0		8.90	4,264		27.6	249.0		9.97	5,815		35.2
8 – 5 – 30	150.3	54	7.89	1,223	6.1	15.5	202.8	72	8.89	1,813	8.1	19.8
	190.3		7.07	1,914		19.3	242.8		8.08	2,825		25.3
8 – 6 + 30	161.3	56	7.73	1,393	7.1	16.8	215.3	75	8.74	2,058	9.3	21.6
	201.3		6.99	2,051		20.2	255.3		7.99	3,028		26.6
10 + 5 – 30	163.3	58	9.26	2,032	8.7	21.5	215.8	77	10.35	2,841	10.8	27.1
	213.3		8.26	3,145		26.2	265.8		9.35	4,422		33.9
10 – 6 – 30	176.3	61	9.06	2,307	10.1	23.1	230.3	80	10.16	3,227	12.6	29.4
	226.3		8.16	3,366		27.5	280.3		9.24	4,737		35.6
12 – 5 + 30	177.0	63	10.58	3,128	11.7	28.0	229.5	82	11.77	4,219	14.2	35.2
	237.0		9.42	4,790		34.0	289.5		10.57	6,520		43.5
12 + 6 – 30	192.0	67	10.34	3,541	13.5	30.1	246.0	85	11.53	4,783	16.4	38.0
	252.0		9.31	5,124		35.6	306.0		10.45	6,979		45.6
14 – 5 – 30	191.3	68	11.86	4,549	15.2	35.0	243.8	87	13.13	5,986	18.0	44.1
	261.3		10.56	6,905		42.4	313.8		11.76	9,174		53.8
14 – 6 + 30	208.3	72	11.59	5,135	17.5	37.5	262.3	91	12.86	6,773	20.8	47.4
	278.3		10.44	7,382		44.4	332.3		11.62	9,812		56.4
16 – 6 + 30	225.3	78	12.81	7,127	22.0	45.5	279.3	97	14.15	9,238	25.8	57.5
	305.3		11.55	10,197		54.1	359.3		12.78	13,295		68.1
16 – 7 – 30	244.3	83	12.55	7,890	24.9	48.3	299.8	101	13.88	10,246	29.2	61.2
	324.3		11.43	10,844		56.6	379.8		12.64	14,137		71.1
20 – 6 – 30	261.3	91	15.18	12,469	32.5	63.0	315.3	109	16.65	15,768	37.4	79.4
	361.3		13.74	17,741		75.8	415.3		15.05	22,454		93.9
20 – 7 + 30	284.3	96	14.88	13,769	36.6	67.0	339.8	115	16.33	17,433	42.2	84.3
	384.3		13.61	18,864		79.4	439.8		14.89	23,861		98.1

JOIST-BAND BEAM

[In accordance with CSRI 2002]

Loading Conditions



Dead Loads

Partitions	20	lb/ft^2
MEP	5	lb/ft^2
Collateral	5	lb/ft^2
Joists	70	lb/ft^2
	100	lb/ft^2

Live Loads

Level 7 → Residential

40 lb/ft^2

Superimposed Service Load

w_u = 1.4DL + 1.7LL
= 1.4(100 lb/ft^2) + 1.7(40 lb/ft^2)
= 208 PSF

Loading per Foot → (30 ft)(208 lb/ft^2) = 6240 lb/ft

CRSI Design Aid (12-105)

f'_c = 4,000 PSI
Grade 60 KSI

Select Clear Span – 30'-0"
24.5" Depth
24" Width

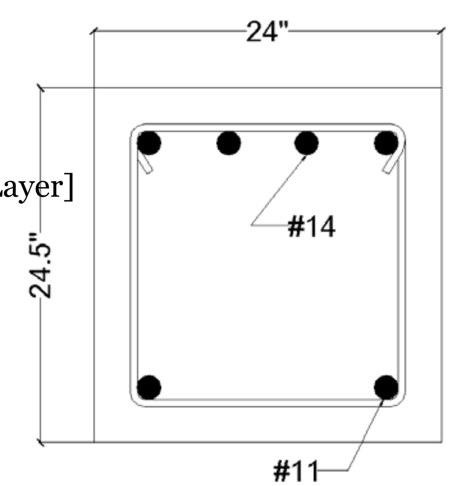
L_1 = 30' **9.10 > 6.24** Self-Weight → 1.4(150 lb/ft^3)(24.5/12)(24/12)
858 lb/ft

Check: **9.10 > 7.10**

Reinforcement (E.W.)

Top Bars → 4 - #14 [One Layer]

Bottom Bars → 2 - #11 [One Layer]



f'_c = 4,000 psi
f_y = 60,000 psi

JOIST-BAND BEAMS, INTERIOR SPANS

TOTAL CAPACITY $U = 1.4D + 1.7L$[3]

STEM h (in.)	STEM b (in.)	BARS[1] BOTTOM ℓ_n + 12 in.	BARS BOTTOM 0.875 ℓ_n	Layers (2)	TOP	SPAN ℓ_n = 28 ft LOAD (4) k/ft	28 ft STIR. TIES (5)	28 ft ϕT_n ft-kips	28 ft $A\ell$ sq. in.	28 ft STEEL WGT lb.	SPAN ℓ_n = 30 ft LOAD (4) k/ft	30 ft STIR. TIES (5)	30 ft ϕT_n ft-kips	30 ft $A\ell$ sq. in.	30 ft STEEL WGT lb.	SPAN ℓ_n = 32 ft LOAD (4) k/ft	32 ft STIR. TIES (5)	32 ft ϕT_n ft-kips	32 ft $A\ell$ sq. in.	32 ft STEEL WGT lb.	SPAN ℓ_n = 34 ft LOAD (4) k/ft	34 ft STIR. TIES (5)	34 ft ϕT_n ft-kips	34 ft $A\ell$ sq. in.	34 ft STEEL WGT lb.	$+\phi M_n$ $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\times 10^{-6}$ in.
		2# 9	1# 9	1	4# 9	5.2	123H	18	-	626	4.5	123H	18	-	663	4.0	123H	18	-	700	3.5	123H	18	-	737	281	187
				1			175H	73	1.9	1099		185H	73	1.9	1169		195H	72	1.8	1240		215H	72	1.8	1345	368	
		2#10	1#10	1	4#11	7.2	133H	18	-	849	6.2	143H	18	-	910	5.5	143H	18	-	962	4.9	153H	18	-	1022	350	192
				1			175H	73	1.9	1313		185H	73	1.9	1399		195H	72	1.8	1485		215H	72	1.8	1604	547	
	24	2#11	2#11	1	4#14	10.4	154H	18	-	1354	9.1	164H	18	-	1448	8.0	164H	18	-	1526	7.1	174H	18	-	1621	547	157
				1			245E	73	1.9	1916		265E	73	1.8	2062		285E	72	1.8	2208		295E	72	1.8	2320	742	
		2#14	1#14	1	5#14	11.9	155H	18	-	1720	10.4	164H	18	-	1679	9.1	174H	18	-	1789	8.1	184H	18	-	1899	582	143
				1			245E	73	1.9	2132		265E	73	1.8	2293		285E	72	1.8	2454		295E	71	1.8	2581	886	
		2# 9	2# 9	1	5#10	7.7	113H	33	-	848	6.7	123H	33	-	910	5.9	123H	33	-	962	5.2	123H	32	-	1015	377	125
				1			563A	133	2.8	1440		603A	131	2.7	1542		643A	130	2.7	1645		683A	129	2.7	1747	580	
		2#11	2#11	1	5#11	9.8	133H	33	-	1153	8.5	133H	33	-	1225	7.5	143H	32	-	1308	6.6	143H	32	-	1380	569	128
				1			245E	132	2.7	1958		185H	131	2.7	1798		195H	130	2.7	1909		683A	129	2.7	2093	697	
24.5	36	2#14	2#14	1	6#14	15.6	155H	33	-	2065	13.6	165H	33	-	2209	12.0	164H	32	-	2149	10.6	174H	32	-	2282	787	106
				1			285D	132	2.7	2707		305D	131	2.7	2899		285E	130	2.7	2937		295E	129	2.7	3090	1114	
		3#14	2#14	1	7#14	17.7	155H	33	-	2430	15.4	165H	33	-	2600	13.5	175H	32	-	2769	12.0	185H	32	-	2939	956	94
				1			345C	132	2.7	3304		305D	131	2.7	3290		325D	130	2.7	3507		345D	129	2.7	3725	1261	
		3# 9	3# 9	1	6#11	11.5	123H	49	-	1233	10.0	133H	49	-	1322	8.8	133H	48	-	1400	7.8	133H	48	-	1478	562	99
				1			**	197	3.9	1105		**	195	3.8	1183		**	193	3.8	1261		**	192	3.7	1340	845	
		3#10	3#10	1	6#14	14.3	134H	49	-	1768	12.5	144H	49	-	1894	11.0	143H	48	-	1864	9.7	153H	48	-	1981	701	94
				1			245E	196	3.7	2549		364C	195	3.6	2595		384C	193	3.6	2756		414C	191	3.6	2945	1164	
	48	4#11	3#11	1	7#14	18.7	145H	49	-	2403	16.2	155H	49	-	2573	14.3	165H	48	-	2744	12.7	164H	48	-	2691	972	85
				1			425B	196	3.6	3783		455B	194	3.6	4052		485B	193	3.6	4321		295E	191	3.6	3629	1329	
		3#14	3#14	1	9#14	22.9	175EfH	49	-	2982	20.0	175EeH	49	-	3154	17.6	185EcH	48	-	3359	15.5	175H	48	-	3499	1164	74
				1			425B	196	3.6	4265		455B	194	3.6	4568		485B	193	3.6	4871		515B	191	3.6	5174	1633	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of ℓ_n/360 are designated thus: * —ℓ_n/360 < deflection < ℓ_n/240
X —ℓ_n/240 < deflection < ℓ_n/180
Y — deflection > ℓ_n/180

(5) For each beam design, first line is for open stirrups, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

Other notation: N/A — STIRRUPS ARE NOT REQUIRED
** — MAXIMUM SPACING IS LESS THAN 3 INCHES. NOT RECOMMENDED
*** — SHEAR STRESS IS GREATER THAN $10\sqrt{f'_c}$
**** — TORSION STRESS 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.

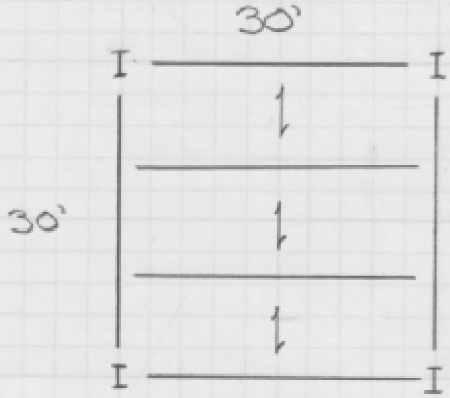
APPENDIX VI

COMPOSITE STEEL BEAM

COMPOSITE STEEL BEAM

[In accordance with AISC 3rd Edition]

~ Composite Steel Beam ~



Assumptions

United Steel Deck (USD)

2", 20 Gauge UF2X Deck

$f'c = 4000$ psi

$f_y = 50$ ksi

30' × 30' Bay
w/ 10' spacing Joist

Beam Check, Selection

Dead Load:

Partitions	20	PSF
MEP	5	↓
Collateral	5	
Fireproofing	2	
Decking	2	
Concrete	60 *	
	94 lb/ft²	

Live Load:

40 lb/ft²

Factored Load: 1.2D + 1.6L

$w_u = 1.2((94\ lb/ft^2)(10') + 30\ lb/ft) + 1.6(40\ lb/ft^2)(10\ lb/ft)$

$= 1804\ lb/ft$

$M_u = \frac{w_u l^2}{8} = \frac{(1804)(30')^2}{8} = 203^{'-k}$

$V_u = \frac{w_u l}{2} = \frac{(1804)(30')^2}{8} = 27^k$

$Y2 = 6.5 - a/2 \longrightarrow$ (assume $a = 1.0$)

$= 6.0"$

Select W10×26 → $217^{'k} > 203^{'k}$

$\Sigma Q = 190$

$\frac{b_{eff}}{2} \leq$ 1/8 span = 7.5'
1/2 spacing = 10'

$a_{req} = \Sigma Q_n / 0.85 f'_c b = 190 / 0.85(4)(7.5)(12"/')$
= 0.62 ≤ 1.0 (conservative)

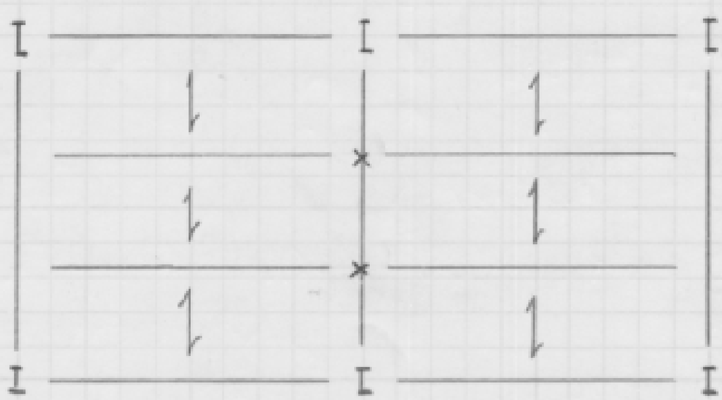
Perpendicular to Deck

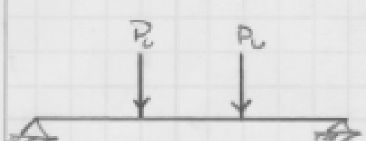
(1) Weak Stud Per Rib

Ø3/4 → Q_n = 17.2 → $190^k / 17.2'$ = 11.1 → 12

Select W10 × 26 [12]
2", 20G UF2X Deck
4½" Slab above deck

~ Composite Steel Girder ~





$P_u = 2V_u = 2(27^k) = 54^k$

$M_u = 1/3 P l = (1/3)(54)(30') = 540'^k$

Assume a = 1"

Y2 = 6.5 - 0.5 = 6.0"

$\frac{b_{eff}}{2} \leq$ 1/8 SPAN = 7.5' ∴ ✓
1/2 SPACE = 30'

Select W18 × 46

ΣQ_n = 308

$556'^k > 540'^k$ ∴ ✓ OK

$a_{required} = \Sigma Q_n / 0.85 f'_c b_{eff}$

$= 308 / 0.85(4)(7.5)(12"/') = 1.00"$

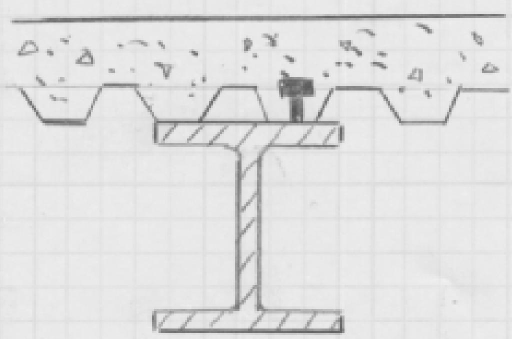
$1.00 \leq 1.00$ ∴ OK ✓

Parallel Deck

$w_r/h_r = 6/3 \geq 1.5 \rightarrow 3/4\phi \rightarrow Q_n = 21.5^k$

Studs $\Sigma Q_n / Q_n = 308/21.5 = 14.3 \rightarrow 15$

Use W18×46 [15]
20 Gauge UF2X Metal Deck
2" Deck Flute w/ 4½" slab above
Total Depth 6.5" slab
18"
24.5"



concrete slabs on UF2X form deck - UNIFORM LOADS, PSF

LRFD

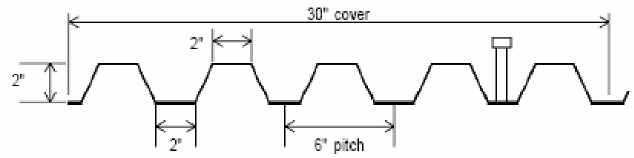
Slab	Mesh	+d	-d	+M	-M	Spans, feet 4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"
4.0"	66 - W2.0 x 2.0* 66 - W2.9 x 2.9*	1.919 1.904	3.007 2.962	4.060 5.785	6.326 8.921	157 224	127 181	105 150	88 126	75 107	65 93	57 81	50 71	44 63	56
4.5"	66 - W4.0 x 4.0 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.387 2.404 2.387	3.412 3.462 3.412	9.975 10.893 14.708	14.062 15.463 20.585	386 ### ###	313 342 ###	259 282 381	217 237 320	185 202 273	160 174 235	139 152 205	122 133 180	108 118 160	97 105 142
5.0"	66 - W4.0 x 4.0* 44 - W2.9 x 2.9 44 - W4.0 x 4.0	2.887 2.904 2.887	3.912 3.962 3.912	12.135 13.242 17.948	16.222 17.812 23.825	### ### ###	381 ### ###	315 343 ###	264 289 389	225 246 332	194 212 286	169 185 249	149 162 219	132 144 194	117 128 173
5.5"	44 - W2.9 x 2.9* 44 - W4.0 x 4.0	3.404 3.387	4.462 4.412	15.591 21.188	20.161 27.065	### ###	### ###	392 ###	329 ###	281 377	242 325	211 283	185 249	164 220	146 197
6.0"	44 - W4.0 x 4.0	3.887	4.912	24.428	30.305	###	###	###	###	###	364	317	279	247	220
6.5"	44 - W4.0 x 4.0	4.387	5.412	27.668	33.545	###	###	###	###	###	###	351	308	273	244
7.0"	44 - W4.0 x 4.0*	4.887	5.912	30.908	36.785	###	###	###	###	###	###	385	338	299	267
						24 gage	24 gage	24 gage	24 gage	24 gage	24 gage	22 gage	22 gage	20 gage	20 gage

FORM DECKS weights and volumes

Total Slab Depth		UFS C_v = .0234	UF1X C_v = .0417	UFX C_v = .0547	INV. B C_v = .0781	UF2X C_v = .0833
2.5"	Wt Vol.	27 0.185				
3.0"	Wt Vol.	33 0.226	30 0.208	28 0.195		
3.5"	Wt Vol.	39 0.268	36 0.250	34 0.237	36 0.245	
4.0"	Wt Vol.	45 0.310	42 0.292	40 0.279	41 0.286	36 0.250
4.5"	Wt Vol.	51 0.352	48 0.333	46 0.320	48 0.328	42 0.292
5.0"	Wt Vol.	57 0.393	54 0.375	52 0.362	54 0.370	48 0.333
5.5"	Wt Vol.	63 0.435	60 0.417	59 0.404	60 0.411	54 0.375
6.0"	Wt Vol.	69 0.476	66 0.458	65 0.445	66 0.453	60 0.417
6.5"	Wt Vol.	75 0.518	73 0.500	71 0.487	72 0.495	67 0.459
7.0"	Wt Vol.	81 0.560	79 0.542	77 0.528	78 0.536	73 0.500

SECTION PROPERTIES						ASD			LRFD		
Metal Thickness		Wt.	I_p	S_p	S_n	V	R_1	R_2	ϕV	ϕR_1	ϕR_2
Gage	Inches	(psf)	(in.^{4})	(in.^{3})	(in.3)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
24	0.0239	1.50	0.232	0.192	0.200	2360	360	836	3223	532	1156
22	0.0295	2.00	0.300	0.252	0.263	4205	528	1484	5477	736	1992
20	0.0358	2.00	0.379	0.325	0.339	6062	728	2224	8067	1004	3064
18	0.0474	3.00	0.523	0.468	0.485	8796	1204	3948	11182	1648	5388

UF2X



The bottom flange can accept a ¾" shear stud.

approx. scale: 1½" = 1'0"

UNIFORM TOTAL LOAD / Load that Produces l/180 Deflection, psf

	Gage	Span Condition	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"	9'6"	10'0"
ASD	24	Single	128 / 94	109 / 74	94 / 59	82 / 48	72 / 40	64 / 33	57 / 28	51 / 24	46 / 20
ASD	24	Double	130 / 226	111 / 178	96 / 143	84 / 116	74 / 96	66 / 80	59 / 67	53 / 57	48 / 49
ASD	24	Triple	162 / 177	138 / 139	120 / 112	105 / 91	92 / 75	82 / 62	73 / 52	66 / 45	59 / 38
ASD	22	Single	168 / 122	143 / 96	123 / 77	108 / 62	94 / 51	84 / 43	75 / 36	67 / 31	60 / 26
ASD	22	Double	173 / 293	148 / 230	128 / 184	111 / 150	98 / 123	87 / 103	78 / 87	70 / 74	63 / 63
ASD	22	Triple	215 / 229	184 / 180	159 / 144	139 / 117	122 / 97	108 / 81	97 / 68	87 / 58	78 / 49
ASD	20	Single	217 / 154	185 / 121	159 / 97	139 / 79	122 / 65	108 / 54	96 / 46	86 / 39	78 / 33
ASD	20	Double	224 / 370	191 / 291	165 / 233	144 / 189	126 / 156	112 / 130	100 / 110	90 / 93	81 / 80
ASD	20	Triple	279 / 289	238 / 228	205 / 182	179 / 148	158 / 122	140 / 102	125 / 86	112 / 73	101 / 63
ASD	18	Single	312 / 212	266 / 167	229 / 133	200 / 109	176 / 89	155 / 75	139 / 63	124 / 53	112 / 46
ASD	18	Double	320 / 510	273 / 401	236 / 321	206 / 261	181 / 215	160 / 179	143 / 151	128 / 129	116 / 110
ASD	18	Triple	399 / 399	340 / 314	294 / 252	256 / 204	226 / 168	200 / 140	179 / 118	160 / 101	145 / 86
LRFD	24	Single	177 / 94	164 / 74	149 / 59	130 / 48	114 / 40	101 / 33	90 / 28	81 / 24	73 / 20
LRFD	24	Double	154 / 226	142 / 178	132 / 143	123 / 116	116 / 96	104 / 80	93 / 67	83 / 57	75 / 49
LRFD	24	Triple	175 / 177	162 / 139	150 / 112	140 / 91	131 / 75	124 / 62	115 / 52	103 / 45	94 / 38
LRFD	22	Single	245 / 122	226 / 96	195 / 77	170 / 62	150 / 51	133 / 43	118 / 36	106 / 31	96 / 26
LRFD	22	Double	266 / 293	233 / 230	201 / 184	176 / 150	155 / 123	137 / 103	122 / 87	110 / 74	99 / 63
LRFD	22	Triple	302 / 229	279 / 180	250 / 144	218 / 117	192 / 97	171 / 81	152 / 68	137 / 58	124 / 49
LRFD	20	Single	335 / 154	292 / 121	252 / 97	220 / 79	193 / 65	171 / 54	152 / 46	137 / 39	124 / 33
LRFD	20	Double	353 / 370	301 / 291	260 / 233	227 / 189	200 / 156	177 / 130	158 / 110	142 / 93	128 / 80
LRFD	20	Triple	418 / 289	375 / 228	324 / 182	283 / 148	249 / 122	221 / 102	197 / 86	177 / 73	160 / 63
LRFD	18	Single	494 / 212	421 / 167	363 / 133	316 / 109	278 / 89	246 / 75	220 / 63	197 / 53	178 / 46
LRFD	18	Double	505 / 510	431 / 401	372 / 321	325 / 261	286 / 215	253 / 179	226 / 151	203 / 129	183 / 110
LRFD	18	Triple	627 / 399	536 / 314	463 / 252	404 / 204	356 / 168	316 / 140	282 / 118	253 / 101	229 / 86

APPENDIX VII

COST TABLE

	FLOOR SYSTEM	Unit	Area	Material	Install	Total
I	Post-Tensioning Two-Way Flat Slab	S.F.	900	$8.18	$8.94	$17.12
II	Hollow-Core Concrete Slab	S.F.	900	$6.85	$3.48	$10.33
III	Two-Way Flat Slab	S.F.	900	$5.85	$7.35	$13.20
IV	Two-Way Flat Slab with Drop Panels	S.F.	900	$7.50	$8.55	$16.05
V	One-Way Concrete Joist	S.F.	900	$7.10	$9.45	$16.55
VI	Composite Steel Beam	S.F.	900	$13.65	$6.25	$19.90