American Eagle Outfitters
Quantum II Corporate Headquarters

Technical Report #2:
Pro-Con Structural Study
Of Alternative Floor System

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Structural Option

27 October 2006

Advisor: Dr. Memari

Executive Summary

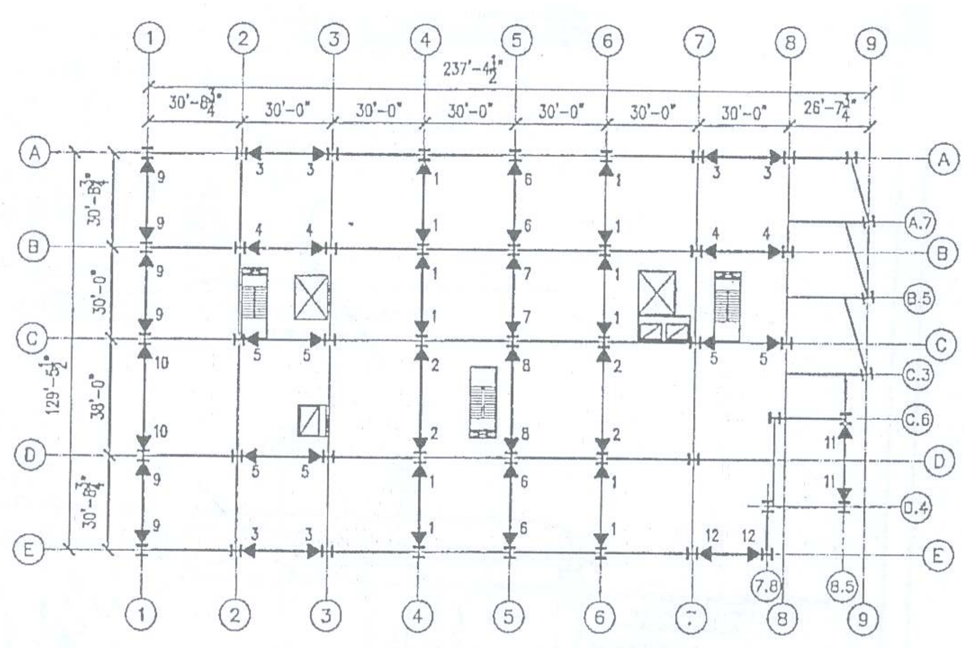
This report is a detailed analysis and comparison of various floor systems that could be utilized in the American Eagle Quantum II Corporate Headquarters. The first part of the report studies the existing design. Typical floor loads are defined per ASCE-7 02 and the buildings design. A typical framing bay is defined and analyzed, both manually and with RAM structural design software

The second and third sections of this report deal with alternative floor systems. The first investigates two more options in steel, non-composite beams and non-composite joists. The later section looks at the options provided by concrete floor systems. Hollow core planks and double tee beams are considered and designed with the use of manufacturer's charts. A design summary is presented for each of the four methods in the body of the report, while specific calculations are located in the appendix. Inherent strengths and weaknesses of each system are also discussed.

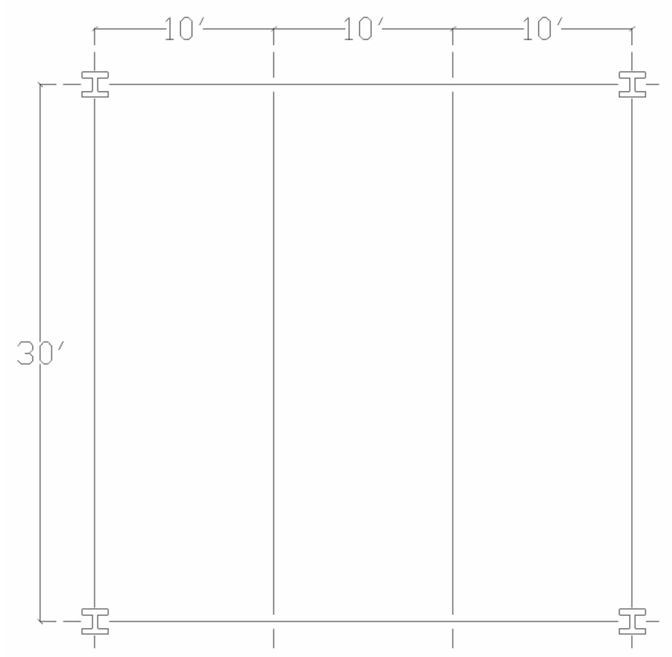
The final section is a comparison chart of all five floor systems. The ultimate aim of the report is to determine which system options are worthy of further consideration, and it is determined that the existing system of composite steel beams and the option of hollow core concrete planks are the most advantageous, and will be considered in further design work.

Existing System

The structure consists of 6 floors. Each level is approximately 31,000 square feet and consists mostly of office space, with a large cafeteria on the top floor. Each deck is made of a composite steel system, where 3" of 4 ksi strength concrete lays on top of a 3" 20 gauge steel deck. Steel studs ¾" in diameter and 4 ½" long are used to create composite action between the beams and the deck. A copy of a standard floor framing plan is shown below.



The plan is dominated by three rows of bays measuring 30’ x 30’and one row measuring 30’ x 38’. All bays contain two beams spaced 10’ apart spanning parallel to the 38’ long side of the larger bays. For the purpose of the analyses herein the 30’ x 30’ bay, shown below, was considered being that it dominated the vast majority of the floor plan.



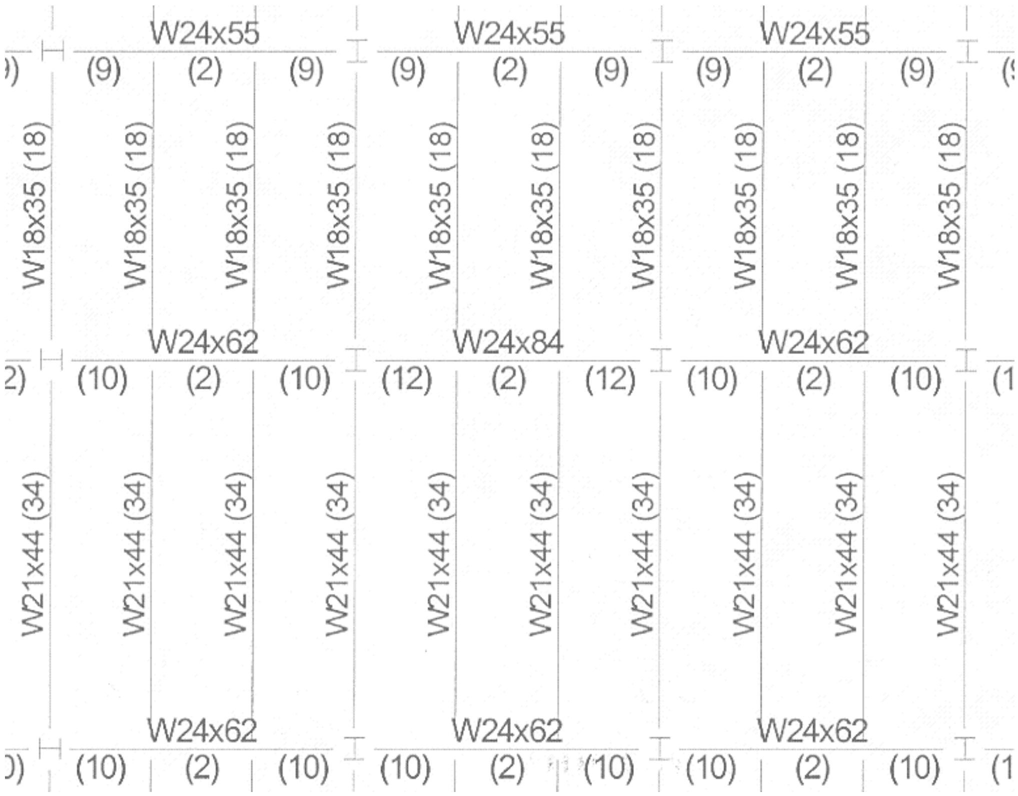
Floor Loads

The structure was designed without a known tenant or floor plan. To prepare for various fit-outs the following loads are applied to the entire floor to ensure a conservative design.

- Live Load = 100 psf
- Metal Deck + Conc. Slab = 57 psf
- Miscellaneous Deal Load = 20 psf
  (ceilings, mechanical, etc.)

Analysis

The existing floor system was analyzed by manual calculation and also with RAM structural design software. Both verified the structures design as adequate. The manual calculations are located in appendix B, while the Ram design, of both long and short bays, is shown below.



<u>**Alternative Steel Systems**</u>

Composite Decking – Noncomposite Beams

Often times steel framing is used without composite beams. This method can save time and money because the materials and manpower to attach the two systems is eliminated. In this example the same decking as in the existing system was utilized. The new system was modeled and analyzed using RAM, the design is shown below. As expected without utilizing composite action between the beams and deck the beam sizes must be larger to resist the load. This must be weighed against installation cost when deciding on a floor system.

Composite Decking – Steel Joists

Another way to utilize steel is with a steel joist system. Steels joists are very light weight and east to install. Not as strong as conventional steel beams, joists must be placed closer together to decrease the tributary are they support and therefore their load. Steel Joists are also deeper then beams and are more expensive to fireproof. The same decking as used in the existing design was used here. Again, RAM was utilized to perform an analysis of this design method, a layout of the results are shown below.

Steel Cost

The following breaks down the cost of spanning members for one bay of a steel system. Costs were taken from RS Means and are shown in appendix E with calculations.

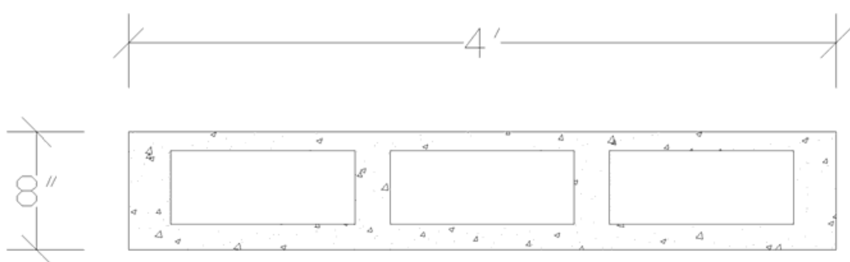
Existing System = $2,850
Non-composite Beam = $3,450
Steel Joist = $3,525

Alternative Concrete Systems

Concrete provides many options for spanning bays. Various self supporting floor slabs are available that can rest on steel members and span farther and hold more load than steel deck due to their utilization of pre-stressing. These slab systems come prefabricated and are easy to install. Also, bring made off site higher concrete strengths can be obtained. Finally, these systems save money on fireproofing due to the fire resistant nature of concrete.

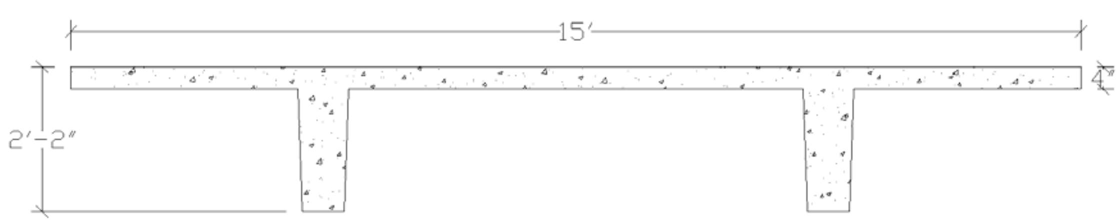
Hollow Core Concrete Planks

The first concrete system considered is hollow core planks. Apart from advantages brought with concrete hollow core planks often have shallow depths. In order for this system to feasibly carry the load the span must be decreased. One girder must run vertically in the middle of the bay. The planks will rest on the steel girders and span the two 15' spans horizontally across the bays. Design tables obtained from Nitterhouse Concrete Products, Inc. were utilized to select the proper size. The 8" x 4' – U.L. – J952, with no topping, and strand pattern 4 – ½" was selected. This system has a concrete strength specified as 5 ksi, and a self weight of 57.5 psf, which is very comparable to the composite deck used in the steel systems.



Concrete Double Tee Beams

Double tee beams are excellent at creating a floor slab that can span long distances. Unfortunately they are often very deep, increasing floor depth. Design charts obtained from High Concrete Structures, Inc. were used to select an appropriate size. The 15DT26 with strand pattern 128-S was chosen. This system has a concrete strength specified as 6 ksi, and a self weight of 75 psf, which is significantly greater then the composite deck used in the steel systems.



Comparison

The Following chart is designed to summarize and compare the pros and cons of each system, and states whether further consideration is planned.

System	Depth (in)	Weight (psf)	Installation 5 = hardest	Fireproofing 5 = hardest	Cost ($/sf)	Further Consideration
Existing	23.7	57	5	4	17.80	Yes
Non-Comp. Beams	26.7	57	4	4	24.75	No
Steel Joist	24	57	3	5	19.15	No
Hollow Core Plank	8	57	1	1	8.53	Yes
Double Tee Beam	22	75	2	1	9.30	No

Appendix A: References

High Concrete Structures, Inc.
Double Tee Beam Design Chart

LRFD
Manual of Steel Construction, Third Edition

Nitterhouse Concrete Products, Inc.
Hollow Core Plank Design Chart

RS Means
Assemblies and Cost Data, 2006 edition

Vulcraft
Steel Roof and Floor Deck, 2001 Edition

Appendix B: Existing System

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Loads

Slab: 57 psf (Vulcraft) pg. 30
Total additional Dead = 20 psf
Live = 100 psf

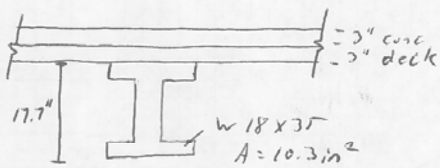
Factored load = $1.2(57+20)+1.6(100) = 252.4$ psf

Actual moment

10' Beam spacing, 30' span
$w = 252.4\,psf \cdot 10' = 2.524\ k/ft$
$M_u = \frac{wL^2}{8} = \frac{2.524\ k/ft\,(30')^2}{8} = 283.95\ 'k$

Allowable Moment

$f_y = 50$ ksi $f'c = 4$ ksi



$b_{eff} = \begin{cases} Spacing = 10' \cdot \frac{12''}{1'} = 120'' \\ Span/4 = 30' \cdot \frac{12''}{1'} \cdot \frac{1}{4} = 90'' \leftarrow \text{controls} \end{cases}$

$C_c = 0.85(4ksi)\,3'' \cdot 90'' = 918\ k$
$T_s = 50\ ksi \cdot 10.3\,in^2 = 515\ k$ ← Tension controlled

Assume fully composite

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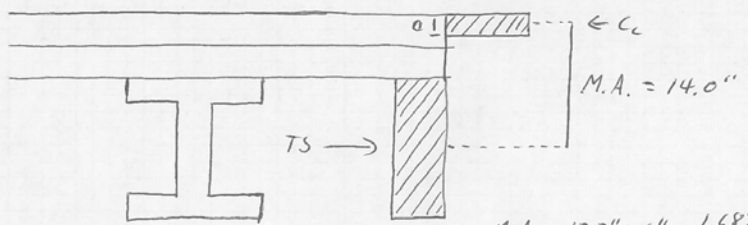
$515\,k = 0.85\,(4\,ksi)\,a \cdot 90'' \Rightarrow a = 1.683''$



$$M.A. = \frac{17.7''}{2} + 6'' - \frac{1.683''}{2} = 14.0''$$

Moment Capacity $= 515\,k \cdot 14'' = 7210''k = 600'k$

$\phi M_n = 0.85(600'k) = 510'k$

$510'k = \phi M_n > M_u = 284'k$

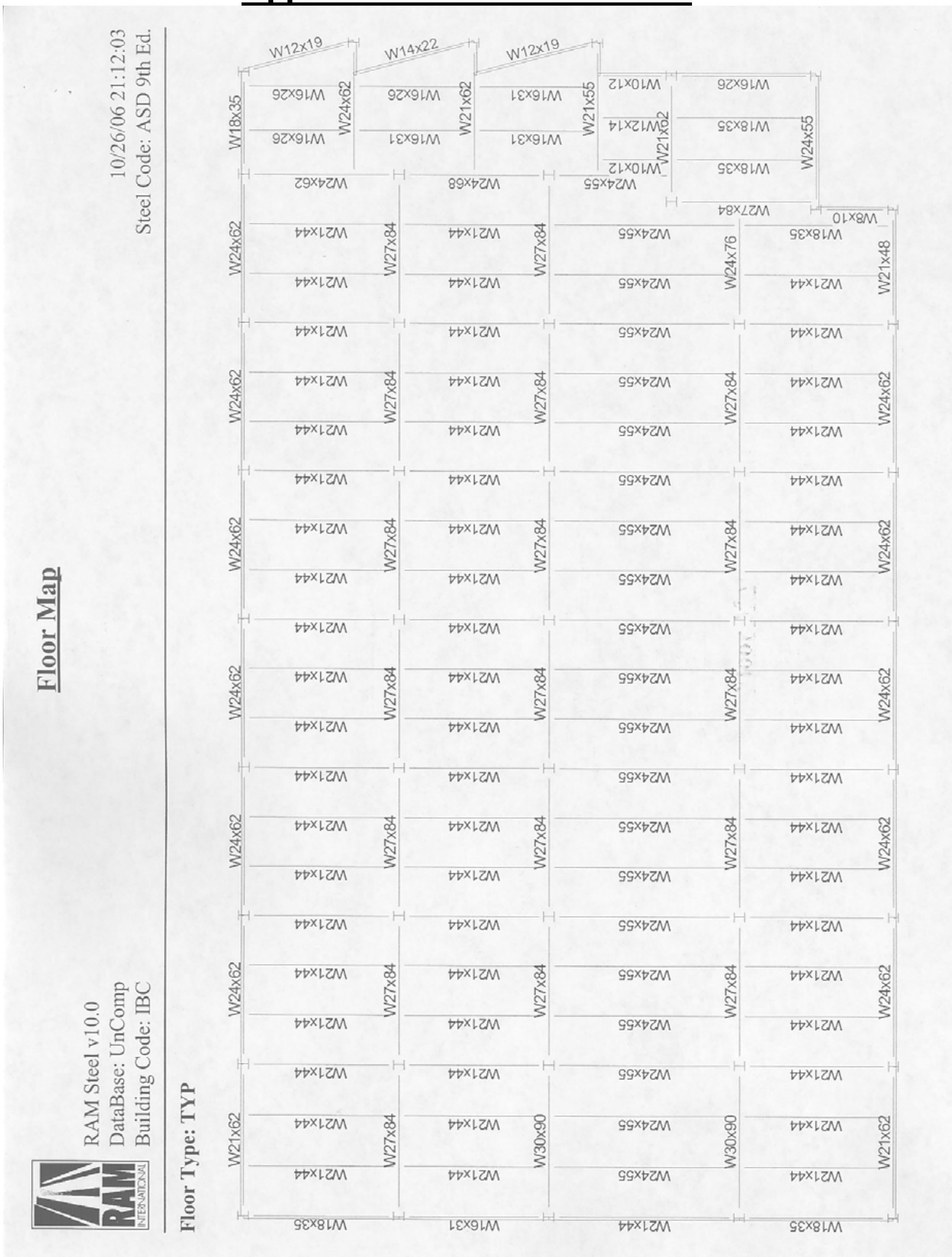
Floor Map

RAM Steel v10.0
DataBase: TRUE
Building Code: IBC

10/26/06 21:49:18
Steel Code: ASD 9th Ed.

Floor Type: TYP

Appendix C: Alternative Steel

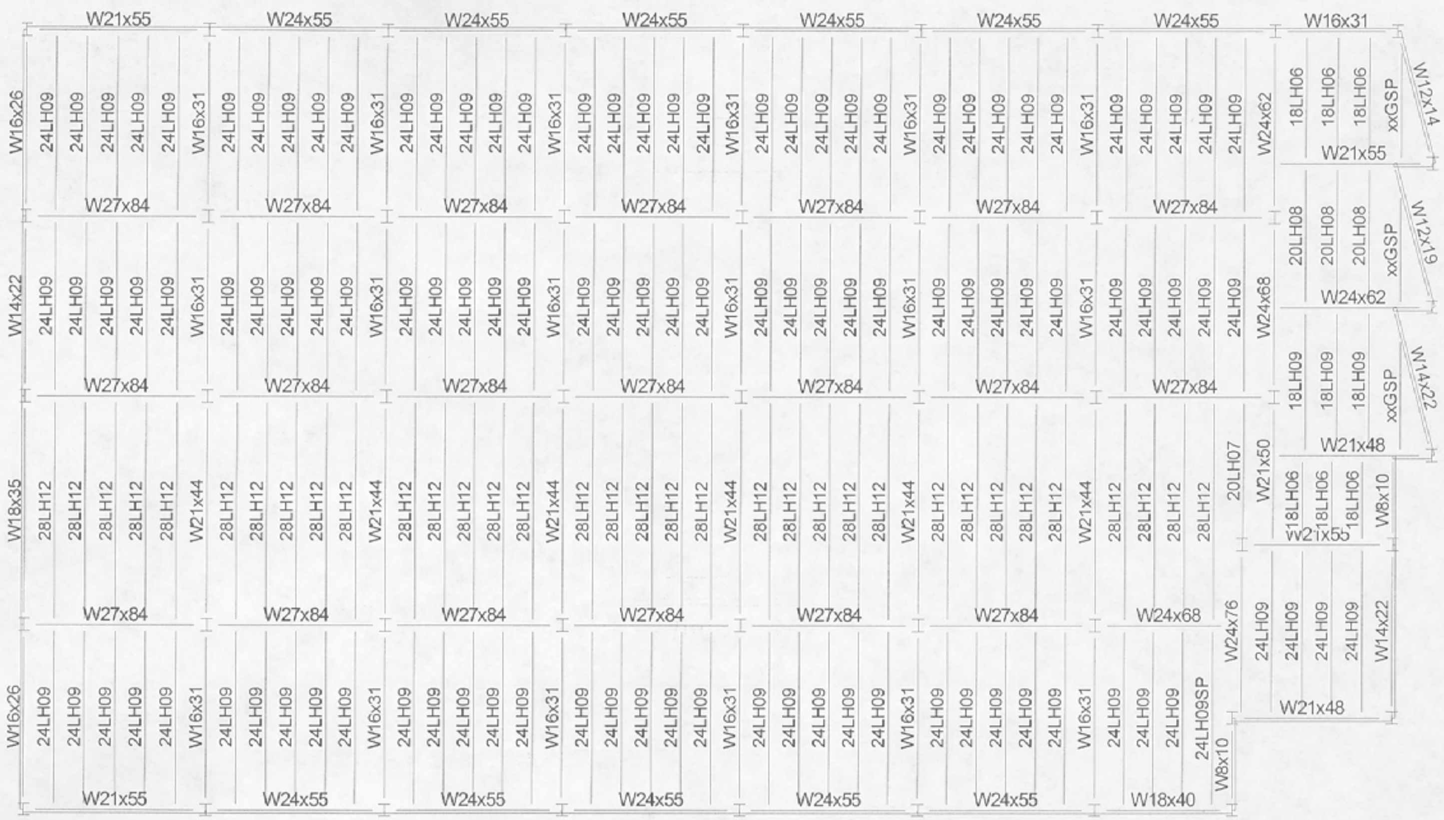


Floor Map

RAM Steel v10.0
DataBase: Joist
Building Code: IBC

10/26/06 20:51:47
Steel Code: ASD 9th Ed.

Floor Type: TYP



Appendix D: Alternative Concrete

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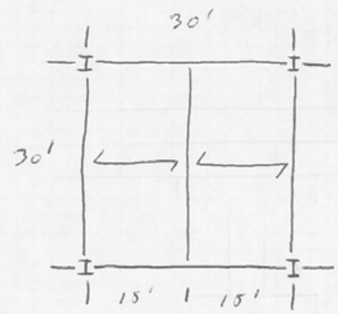
ASSIGNMENT: Hollow Core Concrete Plank

PAGE: 1 of 1



15' spans

Service Load: LL = 100 psf
DL ≈ 20 psf
Total = 120 psf

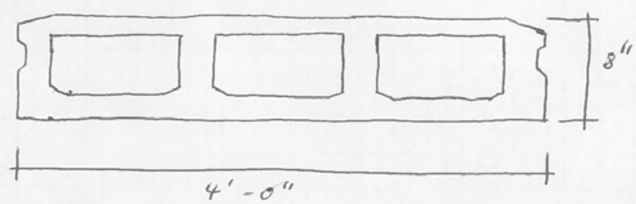
Nitterhouse Design Table

Use 8" x 4' Spandeck - UL-J952 (no topping)
Strand Pattern 4 - ½" ϕ

Allowable Service load = 263 psf > 120 psf

f'_c = 5 ksi

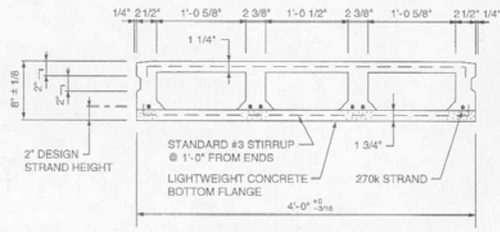
Self Weight = 57.5 psf



Prestressed Concrete
8" x 4' SpanDeck – U.L. – J952
(NO TOPPING)

PHYSICAL PROPERTIES
Precast

$A = 199\ in.^2$	$S_b = 332\ in.^3$
$I = 1370\ in.^4$	$S_t = 354\ in.^3$
$Y_b = 4.13\ in.$	Wt. = 230 PLF
$Y_t = 3.87\ in.$	Wt. = 57.5 PSF
$e = 2.13\ in.$	



8" SPANDECK CROSS SECTION

UL FIRE RATED J952

DESIGN DATA

1. Precast Strength @ 28 days = 5000 PSI.
2. Precast Strength @ release = 3000 PSI.
3. Precast Density = 150 PCF (Top and Webs)
   = 115 PCF (Soffit)
4. Strand = 1/2"ø, 270 K Lo-Relaxation.
5. Strand Height = 2.00 in.
6. Ultimate moment capacities (when fully developed) . . .
   4 – 1/2"ø, 270K = 68.0'K
   6 – 1/2"ø, 270K = 96.3'K
7. Maximum bottom tensile stress is $6\sqrt{f'c} = 424$ PSI.
8. All superimposed load is treated as live load in the strength analysis of flexure and shear.
9. Flexural strength capacity is based on stress/strain strand relationships.
10. Shear values are the maximum allowable before shear reinforcement is required.
11. Deflection limits were not considered when determining allowable loads in this table.
12. All values in this table are based on ultimate strength and are not governed by service stress.

8" SPANDECK W/O 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	565	510	460	420	361	309	265	231	199	175	152	133	118	105	91	80	71	62	54	47	41	35	X
Shear 4 – 1/2"ø	429	383	345	313	286	263	241	225	209	195	177	159	143	130	118	110	104	95	88	79	72	66	X
Flexure 6 – 1/2"ø	825	745	675	619	531	456	395	344	302	265	236	209	186	167	149	134	120	107	96	86	78	70	63
Shear 6 – 1/2"ø	446	398	359	326	298	274	253	234	218	204	191	179	169	159	150	138	126	115	106	97	89	82	76

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

NITTERHOUSE
CONCRETE PRODUCTS

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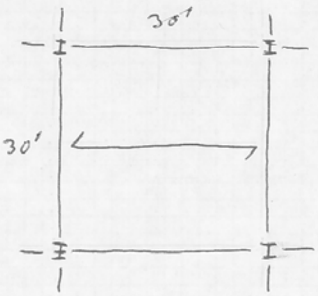


30' spans

Service load: LL = 100 psf
DL = 20 psf

Total = 120 psf

High Concrete Design Table

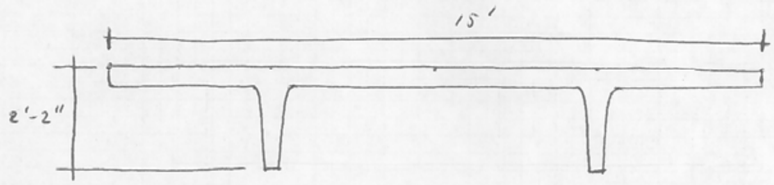
use 15DT26 strand pattern 128-S

conservative strand pattern chosen

live load capacity = 226 psf > 120 psf > 100 psf

$f'_c = 6$ ksi

Self weight = 75 psf

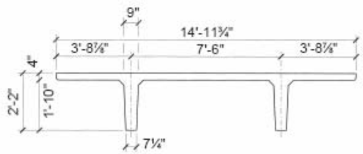


# of strands

128-S

Straight strands
no depression

Diameter of strand in 16ths



Concrete:
f'_c = 6000 psi
w_c = 150 pcf
Strand: ½" dia. low relaxation, 270ksi special, A = 0.167 in^2

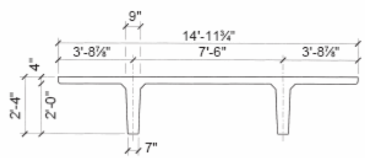
15DT26

Live load capacity in pounds per square foot (psf)

Strand Pattern	e_e	DESIGN SPAN (FT)																				
		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
88-S	13.69	123	112	101	91	82	74	67	60	54	48	42	37	33	28	24	21					
128-S	14.57	226	208	191	176	163	150	138	128	118	109	100	93	85	79	72	66	61	56	51	46	42
168-S	14.57						219	203	189	176	164	153	143	133	124	116	108	101	94	87	81	76
208-S	14.22																				113	106
248-S	13.69																					

Section Properties
A = 1076 in.^{2}
I = 52,958 in.^{4}
Y_b = 19.84 in.
Y_t = 6.16 in.
S_b = 2669 in.^{3}
S_t = 8597 in.^{3}
wt = 1121 plf
75 psf
V/S = 2.38 in.

Strand Pattern	e_e	DESIGN SPAN (FT)																			
		51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
88-S	13.69																				
128-S	14.57	38	34	31	27	24	21														
168-S	14.57	70	65	61	56	52	48	44	40	37	34	31	28	25	22	20					
208-S	14.22	99	93	88	82	77	72	67	63	59	55	51	47	44	41	38	35	32	29	26	24
248-S	13.69									78	73	69	65	61	57	53	50	47	43	40	38



Concrete:
f'_c = 6000 psi
w_c = 150 pcf
Strand: ½" dia. low relaxation, 270ksi special, A = 0.167 in^2

15DT28

Live load capacity in pounds per square foot (psf)

Strand Pattern	e_e	DESIGN SPAN (FT)																				
		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
88-S	15.17	141	128	116	105	96	87	78	71	64	57	52	46	41	36	32	27	24	20			
128-S	16.05	253	233	215	198	183	169	156	145	134	124	115	106	98	91	84	77	71	66	60	55	51
168-S	16.05						245	228	212	198	185	173	161	151	141	132	123	115	108	101	94	88
208-S	15.70																				129	121
248-S	15.17																					

Section Properties
A = 1104 in.^{2}
I = 64,938 in.^{4}
Y_b = 21.30 in.
Y_t = 6.70 in.
S_b = 3049 in.^{3}
S_t = 9692 in.^{3}
wt = 1150 plf
77 psf
V/S = 2.40 in.

Strand Pattern	e_e	DESIGN SPAN (FT)																			
		51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
88-S	15.17																				
128-S	16.05	46	42	38	34	31	28	24	21												
168-S	16.05	82	76	71	66	62	57	53	49	45	42	38	35	32	29	26	23	21			
208-S	15.70	114	107	101	95	89	84	79	74	69	65	61	57	53	49	46	43	40	37	34	31
248-S	15.17										86	81	76	72	68	64	60	56	53	50	46

Appendix E: Cost & Pricing

05100 | Structural Metal Framing

5 METALS

	05120 Structural Steel		Crew	Daily Output	Labor-Hours	Unit	2006 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
560	2350	1" thick (R051223-80)				Cwt.	40			40	44
	2400	2" thick					41.50			41.50	45.50
	2450	4" thick					43.50			43.50	48
	2500	6" thick					46			46	50.50
	2550	8" thick					46			46	50.50
600	0010	STRESSED SKIN ROOF & CEILING SYSTEM									
	0020	Double panel flat roof, spans to 100′	E-2	1150	.049	S.F.	7.60	1.89	1.24	10.73	13
	0100	Double panel convex roof, spans to 200′		960	.058		12.35	2.27	1.49	16.11	19.15
	0200	Double panel arched roof, spans to 300′		760	.074		19	2.87	1.88	23.75	28
640	0010	STRUCTURAL STEEL MEMBERS (R051223-10)									
	0020	Shop fab'd for 100-ton, 1-2 story project, bolted conn's.									
	0100	W 6 x 9	E-2	600	.093	L.F.	9.40	3.63	2.38	15.41	19.20
	0120	x 16		600	.093		16.70	3.63	2.38	22.71	27.50
	0140	x 20		600	.093		21	3.63	2.38	27.01	32
	0300	W 8 x 10		600	.093		10.45	3.63	2.38	16.46	20.50
	0320	x 15		600	.093		15.70	3.63	2.38	21.71	26
	0350	x 21		600	.093		22	3.63	2.38	28.01	33
	0360	x 24		550	.102		25	3.96	2.59	31.55	37
	0370	x 28		550	.102		29.50	3.96	2.59	36.05	41.50
	0500	x 31		550	.102		32.50	3.96	2.59	39.05	45
	0520	x 35		550	.102		36.50	3.96	2.59	43.05	49.50
	0540	x 48		550	.102		50	3.96	2.59	56.55	64.50
	0600	W 10 x 12		600	.093		12.55	3.63	2.38	18.56	22.50
	0620	x 15		600	.093		15.70	3.63	2.38	21.71	26
	0700	x 22		600	.093		23	3.63	2.38	29.01	34.50
	0720	x 26		600	.093		27	3.63	2.38	33.01	39
	0740	x 33		550	.102		34.50	3.96	2.59	41.05	47.50
	0900	x 49		550	.102		51	3.96	2.59	57.55	66
	1100	W 12 x 14		880	.064		14.65	2.48	1.62	18.75	22
	1300	x 22		880	.064		23	2.48	1.62	27.10	31.50
	1500	x 26		880	.064		27	2.48	1.62	31.10	36
	1520	x 35		810	.069		36.50	2.69	1.76	40.95	46.50
	1560	x 50		750	.075		52.50	2.90	1.90	57.30	64.50
	1580	x 58		750	.075		60.50	2.90	1.90	65.30	73.50
	1700	x 72		640	.088		75	3.40	2.23	80.63	91.50
	1740	x 87		640	.088		91	3.40	2.23	96.63	108
	1900	W 14 x 26		990	.057		27	2.20	1.44	30.64	35.50
	2100	x 30		900	.062		31.50	2.42	1.59	35.51	40.50
	2300	x 34		810	.069		35.50	2.69	1.76	39.95	45.50
	2320	x 43		810	.069		45	2.69	1.76	49.45	56
	2340	x 53		800	.070		55.50	2.72	1.78	60	67.50
	2360	x 74		760	.074		77.50	2.87	1.88	82.25	92
	2380	x 90		740	.076		94	2.94	1.93	98.87	110
	2500	x 120		720	.078		125	3.03	1.98	130.01	145
	2700	W 16 x 26		1000	.056		27	2.18	1.43	30.61	35.50
	2900	x 31		900	.062		32.50	2.42	1.59	36.51	41.50
	3100	x 40		800	.070		42	2.72	1.78	46.50	52.50
	3120	x 50		800	.070		52.50	2.72	1.78	57	64
	3140	x 67		760	.074		70	2.87	1.88	74.75	84
	3300	W 18 x 35	E-5	960	.083		36.50	3.28	1.58	41.36	47.50
	3500	x 40		960	.083		42	3.28	1.58	46.86	53.50
	3520	x 46		960	.083		48	3.28	1.58	52.86	60.50
	3700	x 50		912	.088		52.50	3.46	1.66	57.62	65.50
	3900	x 55		912	.088		57.50	3.46	1.66	62.62	71
	3920	x 65		900	.089		68	3.50	1.68	73.18	82.50

148 **Important: See the Reference Section for supporting data - Crews, Rental Equipment, City Cost Indexes and Reference Dat**

05120 | Structural Steel

Line	Description	Ref.	Crew	Daily Output	Labor-Hours	Unit	2006 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
0640 3940	x 76	R051223-10	E-5	900	.089	L.F.	79.50	3.50	1.68	84.68	95.50
3960	x 86			900	.089		90	3.50	1.68	95.18	107
3980	x 106			900	.089		111	3.50	1.68	116.18	130
4100	W 21 x 44			1064	.075		46	2.96	1.42	50.38	57.50
4300	x 50			1064	.075		52.50	2.96	1.42	56.88	64.50
4500	x 62			1036	.077		65	3.04	1.46	69.50	78.50
4700	x 68			1036	.077		71	3.04	1.46	75.50	85
4720	x 83			1000	.080		86.50	3.15	1.52	91.17	103
4740	x 93			1000	.080		97	3.15	1.52	101.67	114
4760	x 101			1000	.080		106	3.15	1.52	110.67	123
4780	x 122			1000	.080		127	3.15	1.52	131.67	147
4900	W 24 x 55			1110	.072		57.50	2.84	1.37	61.71	69.50
5100	x 62			1110	.072		65	2.84	1.37	69.21	78
5300	x 68			1110	.072		71	2.84	1.37	75.21	84.50
5500	x 76			1110	.072		79.50	2.84	1.37	83.71	94
5700	x 84			1080	.074		88	2.92	1.40	92.32	103
5720	x 94			1080	.074		98	2.92	1.40	102.32	115
5740	x 104			1050	.076		109	3	1.44	113.44	127
5760	x 117			1050	.076		122	3	1.44	126.44	141
5780	x 146			1050	.076		153	3	1.44	157.44	175
5800	W 27 x 84			1190	.067		88	2.65	1.27	91.92	103
5900	x 94			1190	.067		98	2.65	1.27	101.92	114
5920	x 114			1150	.070		119	2.74	1.32	123.06	137
5940	x 146			1150	.070		153	2.74	1.32	157.06	174
5960	x 161			1150	.070		168	2.74	1.32	172.06	191
6100	W 30 x 99			1200	.067		103	2.63	1.26	106.89	120
6300	x 108			1200	.067		113	2.63	1.26	116.89	130
6500	x 116			1160	.069		121	2.72	1.31	125.03	139
6520	x 132			1160	.069		138	2.72	1.31	142.03	158
6540	x 148			1160	.069		155	2.72	1.31	159.03	176
6560	x 173			1120	.071		181	2.82	1.35	185.17	205
6580	x 191			1120	.071		200	2.82	1.35	204.17	226
6700	W 33 x 118			1176	.068		123	2.68	1.29	126.97	142
6900	x 130			1134	.071		136	2.78	1.34	140.12	155
7100	x 141			1134	.071		147	2.78	1.34	151.12	168
7120	x 169			1100	.073		177	2.87	1.38	181.25	201
7140	x 201			1100	.073		210	2.87	1.38	214.25	238
7300	W 36 x 135			1170	.068		141	2.70	1.30	145	161
7500	x 150			1170	.068		157	2.70	1.30	161	178
7600	x 170			1150	.070		178	2.74	1.32	182.06	201
7700	x 194			1125	.071		203	2.80	1.35	207.15	229
7900	x 230			1125	.071		240	2.80	1.35	244.15	270
7920	x 260			1035	.077		272	3.05	1.46	276.51	305
8100	x 300		▼	1035	.077		315	3.05	1.46	319.51	350
8490	For projects 75 to 99 tons, add						10%				
8492	50 to 74 tons, add						20%				
8494	25 to 49 tons, add						30%	10%			
8496	10 to 24 tons, add						50%	25%			
8498	2 to 9 tons, add						75%	50%			
8499	Less than 2 tons, add					▼	100%	100%			
0680 0010	**STRUCTURAL STEEL PROJECTS**	R050516-30									
0020	Shop fab'd for 100-ton, 1-2 story project, bolted conn's.										
0200	Apartments, nursing homes, etc., 1 to 2 stories	R050523-10	E-5	10.30	7.767	Ton	1,900	305	147	2,352	2,800
0300	3 to 6 stories		"	10.10	7.921		1,950	310	150	2,410	2,825
0400	7 to 15 stories	R051223-10	E-6	14.20	9.014		1,975	355	115	2,445	2,925
0500	Over 15 stories		"	13.90	9.209	▼	2,050	365	118	2,533	3,025

05200 | Metal Joists

05210 | Steel Joists

	05210 Steel Joists	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2006 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
600 0160	12K3, 5.7 Lb/LF	E-7	1500	.053	L.F.	3.76	2.10	1.07	6.93	9	600
0180	14K3, 6.0 Lb/LF		1500	.053		3.96	2.10	1.07	7.13	9.20	
0200	16K3, 6.3 Lb/LF		1800	.044		4.16	1.75	.89	6.80	8.60	
0220	16K6, 8.1 Lb/LF		1800	.044		5.35	1.75	.89	7.99	9.95	
0240	18K5, 7.7 Lb/LF		2000	.040		5.10	1.58	.80	7.48	9.25	
0260	18K9, 10.2 Lb/LF		2000	.040		6.75	1.58	.80	9.13	11.05	
0410	Span 30' to 50', minimum		17	4.706	Ton	1,150	186	94.50	1,430.50	1,700	
0440	Average CN		17	4.706		1,300	186	94.50	1,580.50	1,850	
0460	Maximum		10	8		1,375	315	161	1,851	2,250	
0500	20K5, 8.2 Lb/LF		2000	.040	L.F.	5.35	1.58	.80	7.73	9.50	
0520	20K9, 10.8 Lb/LF		2000	.040		7	1.58	.80	9.38	11.35	
0540	22K5, 8.8 Lb/LF		2000	.040		5.70	1.58	.80	8.08	9.95	
0560	22K9, 11.3 Lb/LF		2000	.040		7.35	1.58	.80	9.73	11.75	
0580	24K6, 9.7 Lb/LF		2200	.036		6.30	1.43	.73	8.46	10.25	
0600	24K10, 13.1 Lb/LF		2200	.036		8.50	1.43	.73	10.66	12.65	
0620	26K6, 10.6 Lb/LF		2200	.036		6.90	1.43	.73	9.06	10.90	
0640	26K10, 13.8 Lb/LF		2200	.036		8.95	1.43	.73	11.11	13.15	
0660	28K8, 12.7 Lb/LF		2400	.033		8.25	1.31	.67	10.23	12.15	
0680	28K12, 17.1 Lb/LF		2400	.033		11.10	1.31	.67	13.08	15.30	
0700	30K8, 13.2 Lb/LF		2400	.033		8.60	1.31	.67	10.58	12.50	
0720	30K12, 17.6 Lb/LF		2400	.033		11.45	1.31	.67	13.43	15.65	
1010	CS series, horizontal bridging										
1020	Spans to 30', minimum	E-7	15	5.333	Ton	1,225	210	107	1,542	1,825	
1040	Average		12	6.667		1,350	263	134	1,747	2,100	
1060	Maximum		9	8.889		1,600	350	178	2,128	2,550	
1100	10CS2, 7.5 Lb/LF		1200	.067	L.F.	5.10	2.63	1.34	9.07	11.65	
1120	12CS2, 8.0 Lb/LF		1500	.053		5.40	2.10	1.07	8.57	10.80	
1140	14CS2, 8.0Lb/LF		1500	.053		5.40	2.10	1.07	8.57	10.80	
1160	16CS2, 8.5 Lb/LF		1800	.044		5.75	1.75	.89	8.39	10.40	
1180	16CS4, 14.5 Lb/LF		1800	.044		9.80	1.75	.89	12.44	14.85	
1200	18CS2, 9.0 Lb/LF		2000	.040		6.10	1.58	.80	8.48	10.35	
1220	18CS4, 15.0 Lb/LF		2000	.040		10.15	1.58	.80	12.53	14.80	
1240	20CS2, 9.5 Lb/LF		2000	.040		6.45	1.58	.80	8.83	10.75	
1260	20CS4, 16.5 Lb/LF		2000	.040		11.15	1.58	.80	13.53	15.95	
1280	22CS2, 10.0 Lb/LF		2000	.040		6.75	1.58	.80	9.13	11.10	
1300	22CS4, 16.5 Lb/LF		2000	.040		11.15	1.58	.80	13.53	15.95	
1320	24CS2, 10.0 Lb/LF		2200	.036		6.75	1.43	.73	8.91	10.75	
1340	24CS4, 16.5 Lb/LF		2200	.036		11.15	1.43	.73	13.31	15.60	
1360	26CS2, 10.0 Lb/LF		2200	.036		6.75	1.43	.73	8.91	10.75	
1380	26CS4, 16.5 Lb/LF		2200	.036		11.15	1.43	.73	13.31	15.60	
1400	28CS2, 10.5 Lb/LF		2400	.033		7.10	1.31	.67	9.08	10.85	
1420	28CS4, 16.5 Lb/LF		2400	.033		11.15	1.31	.67	13.13	15.35	
1440	30CS2, 11.0 Lb/LF		2400	.033		7.45	1.31	.67	9.43	11.25	
1460	30CS4, 16.5 Lb/LF		2400	.033		11.15	1.31	.67	13.13	15.35	
2000	LH series, bolted cross bridging										
2020	Spans to 96', minimum	E-7	16	5	Ton	1,325	197	100	1,622	1,925	
2040	Average		13	6.154		1,450	243	124	1,817	2,150	
2080	Maximum		11	7.273		1,725	287	146	2,158	2,550	
2200	18LH04, 12 Lb/LF		1400	.057	L.F.	8.75	2.25	1.15	12.15	14.85	
2220	18LH08, 19 Lb/LF		1400	.057		13.90	2.25	1.15	17.30	20.50	
2240	20LH04, 12 Lb/LF		1400	.057		8.75	2.25	1.15	12.15	14.85	
2260	20LH08, 19 Lb/LF		1400	.057		13.90	2.25	1.15	17.30	20.50	
2280	24LH05, 13 Lb/LF		1400	.057		9.50	2.25	1.15	12.90	15.65	
2300	24LH10, 23 Lb/LF		1400	.057		16.80	2.25	1.15	20.20	23.50	
2320	28LH06, 16 Lb/LF		1800	.044		11.70	1.75	.89	14.34	16.90	
2340	28LH11; 25 Lb/LF		1800	.044		18.25	1.75	.89	20.89	24	

PENN STATE UNIVERSITY

CLASS:
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ASSIGNMENT: Steel Price / Bay
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Existing

W 18 x 35 = \$47.5 / ft

$$\frac{\$47.5}{ft} \cdot \frac{30 ft}{span} \cdot \frac{2 span}{bay} = \$2,850. / bay$$

Noncomposite - Beam

W 21 x 44 = \$57.5 / ft

$$\frac{\$57.5}{ft} \cdot \frac{30 ft}{span} \cdot \frac{2 span}{bay} = \$3,450 / bay$$

Steel Joist

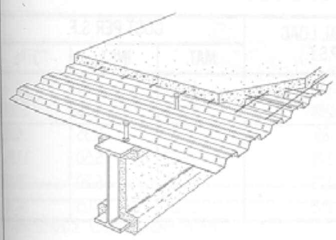
24LH09

RS Means

24LH10 = \$23.5 / ft

$$\frac{\$23.5}{ft} \cdot \frac{30 ft}{span} \cdot \frac{5 spans}{bay} = \$3,525. / Bay$$

B1010 Floor Construction



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

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

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

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 256 2400					
20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS					
Structural steel	4.320	Lb.	4.62	1.52	6.14
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.10	.26	.36
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	1.76	.80	2.56
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.045	L.F.	.15	.09	.24
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.13	.30	.43
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	2.23		2.23
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.42	.42
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.74	.74
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
Shores, erect and strip vertical to 10' high	.020	Ea.		.34	.34
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.23	.38	.61
TOTAL			9.28	4.92	14.20

B1010 256 Composite Beams, Deck & Slab

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2400	20x25	40	5-1/2	1 - 5-1/2	80	9.30	4.91	14.21
2500	RB1010 -100	75	5-1/2	1 - 9-1/2	115	9.65	4.92	14.57
2750		125	5-1/2	1 - 9-1/2	167	11.75	5.75	17.50
2900		200	6-1/4	1 - 11-1/2	251	13.25	6.20	19.45
3000	25x25	40	5-1/2	1 - 9-1/2	82	9.15	4.68	13.83
3100		75	5-1/2	1 - 11-1/2	118	10.15	4.75	14.90
3200		125	5-1/2	2 - 2-1/2	169	10.60	5.15	15.75
3300		200	6-1/4	2 - 6-1/4	252	14.30	6	20.30
3400	25x30	40	5-1/2	1 - 11-1/2	83	9.35	4.65	14
3600		75	5-1/2	1 - 11-1/2	119	10.05	4.70	14.75
3900		125	5-1/2	1 - 11-1/2	170	11.60	5.30	16.90
4000		200	6-1/4	2 - 6-1/4	252	14.35	6	20.35
4200	30x30	40	5-1/2	1 - 11-1/2	81	9.40	4.79	14.19
4400		75	5-1/2	2 - 2-1/2	116	10.10	5	15.10
4500		125	5-1/2	2 - 5-1/2	168	12.20	5.60	17.80
4700		200	6-1/4	2 - 9-1/4	252	14.60	6.50	21.10
4900	30x35	40	5-1/2	2 - 2-1/2	82	9.80	4.95	14.75
5100		75	5-1/2	2 - 5-1/2	117	10.70	5.05	15.75
5300		125	5-1/2	2 - 5-1/2	169	12.55	5.75	18.30
5500		200	6-1/4	2 - 9-1/4	254	14.75	6.50	21.25
5750	35x35	40	5-1/2	2 - 5-1/2	84	10.45	4.98	15.43
6000		75	5-1/2	2 - 5-1/2	121	11.90	5.30	17.20

B1010 Floor Construction

B1010 254 W Shape, Composite Deck, & Slab

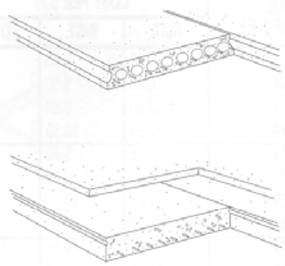
	BAY SIZE (FT.) BEAM X GIRD	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
1400	25x30	40	5	2-5	91	10.95	6	16.95
1500		75	5	2-5	128	13.25	6.70	19.95
1600		125	5	2-8	180	15.05	7.40	22.45
1700		200	5	2-11	259	18.75	8.55	27.30
1800	30x25	40	5	2-5	92	11.60	6.30	17.90
1900		75	5	2-5	129	13.65	7	20.65
2000		125	5	2-8	181	15.55	7.70	23.25
2100		200	5-1/2	2-11	200	18.95	8.90	27.85
2200	30x30	40	5	2-2	92	12.10	6.40	18.50
2300		75	5	2-5	129	14.15	7.10	21.25
2400		125	5	2-11	182	16.75	8	24.75
2500		200	5	3-2	263	22.50	10.10	32.60
2600	30x35	40	5	2-5	94	13.20	6.80	20
2700		75	5	2-11	131	15.35	7.50	22.85
2800		125	5	3-2	183	18	8.40	26.40
2900		200	5-1/2	3-5-1/2	268	22	9.70	31.70
3400	35x30	40	5	2-5	93	12.75	6.65	19.40
3500		75	5	2-8	130	15.20	7.50	22.70
3600		125	5	2-11	183	18.05	8.50	26.55
3700		200	5	3-5	262	22	9.90	31.90
3800	35x35	40	5	2-8	94	13.55	6.75	20.30
3900		75	5	2-11	131	15.75	7.55	23.30
4000		125	5	3-5	184	18.85	8.65	27.50
4100		200	5-1/2	3-5-1/2	270	24.50	10.20	34.70
4200	35x40	40	5	2-11	94	14.15	7.10	21.25
4300		75	5	3-2	131	16.40	7.95	24.35
4400		125	5	3-5	184	19.40	8.95	28.35
4500		200	5	3-5-1/2	264	24.50	10.75	35.25

B1010 Floor Construction

B1010 250 Steel Joists, Beams & Slab on Columns

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	DEPTH (IN.)	TOTAL LOAD (P.S.F.)	COLUMN ADD	COST PER S.F.		
						MAT.	INST.	TOTAL
3700	20x25	40	44	83		7.80	4.35	12.15
3800					column	.87	.29	1.16
3900	20x25	65	26	110		8.50	4.61	13.11
4000					column	.87	.29	1.16
4100	20x25	75	26	120		8.35	4.37	12.72
4200					column	1.04	.35	1.39
4300	20x25	100	26	145		8.85	4.55	13.40
4400					column	1.04	.35	1.39
4500	20x25	125	29	170		9.90	4.95	14.85
4600					column	1.21	.40	1.61
4700	25x25	40	23	84		8.35	4.53	12.88
4800					column	.83	.27	1.10
4900	25x25	65	29	110		8.85	4.72	13.57
5000					column	.83	.27	1.10
5100	25x25	75	26	120		9.25	4.67	13.92
5200					column	.97	.32	1.29
5300	25x25	100	29	145		10.35	5.10	15.45
5400					column	.97	.32	1.29
5500	25x25	125	32	170		10.90	5.30	16.20
5600					column	1.08	.36	1.44
5700	25x30	40	29	84		8.70	4.74	13.44
5800					column	.81	.27	1.08
5900	25x30	65	29	110		9.05	4.93	13.98
6000					column	.81	.27	1.08
6050	25x30	75	29	120		9.80	4.45	14.25
6100					column	.89	.30	1.19
6150	25x30	100	29	145		10.60	4.71	15.31
6200					column	.89	.30	1.19
6250	25x30	125	32	170		11.35	5.85	17.20
6300					column	1.03	.35	1.38
6350	30x30	40	29	84		9.10	4.25	13.35
6400					column	.75	.25	1
6500	30x30	65	29	110		10.35	4.65	15
6600					column	.75	.25	1
6700	30x30	75	32	120		10.55	4.71	15.26
6800					column	.86	.29	1.15
6900	30x30	100	35	145		11.75	5.10	16.85
7000					column	1	.34	1.34
7100	30x30	125	35	172		12.80	6.35	19.15
7200					column	1.11	.37	1.48
7300	30x35	40	29	85		10.30	4.61	14.91
7400					column	.64	.21	.85
7500	30x35	65	29	111		11.45	5.85	17.30
7600					column	.83	.27	1.10
7700	30x35	75	32	121		11.45	5.85	17.30
7800					column	.84	.28	1.12
7900	30x35	100	35	148		12.40	5.25	17.65
8000					column	1.03	.35	1.38
8100	30x35	125	38	173		13.80	5.70	19.50
8200					column	1.05	.35	1.40
8300	35x35	40	32	85		10.55	4.70	15.25
8400					column	.74	.25	.99

B1010 Floor Construction



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

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

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

Camber and deflection may limit use by depth considerations.

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

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

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

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

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

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

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

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

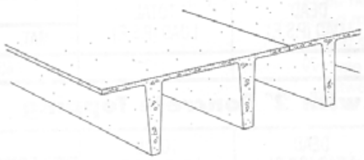
System Components

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 230 2000					
10' SPAN, 40 LBS S.F. WORKING LOAD, 2" TOPPING					
Precast prestressed concrete roof/floor slabs 4" thick, grouted	1.000	S.F.	4.88	2.75	7.63
Edge forms to 6" high on elevated slab, 4 uses	.100	L.F.	.02	.33	.35
Welded wire fabric 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf, 10% lap	.010	C.S.F.	.13	.30	.43
Concrete ready mix, regular weight, 3000 psi	.170	C.F.	.60		.60
Place and vibrate concrete, elevated slab less than 6", pumped	.170	C.F.		.22	.22
Finishing floor, monolithic steel trowel finish for resilient tile	1.000	S.F.		.68	.68
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
TOTAL			5.69	4.35	10.04

B1010 229 Precast Plank with No Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
0720	10	40	4	50	90	4.88	2.75	7.63
0750	RB1010 -010	75	6	50	125	6.05	2.35	8.40
0770		100	6	50	150	6.05	2.35	8.40
0800	15	40	6	50	90	6.05	2.35	8.40
0820	RB1010 -100	75	6	50	125	6.05	2.35	8.40
0850		100	6	50	150	6.05	2.35	8.40
0875	20	40	6	50	90	6.05	2.35	8.40
0900		75	6	50	125	6.05	2.35	8.40
0920		100	6	50	150	6.05	2.35	8.40
0950	25	40	6	50	90	6.05	2.35	8.40
0970		75	8	55	130	6.35	2.06	8.41
1000		100	8	55	155	6.35	2.06	8.41
1200	30	40	8	55	95	6.35	2.06	8.41
1300		75	8	55	130	6.35	2.06	8.41
1400		100	10	70	170	6.70	1.83	8.53
1500	40	40	10	70	110	6.70	1.83	8.53
1600		75	12	70	145	7.60	1.65	9.25

B1010 Floor Construction



Most widely used for moderate span floors and roofs. At shorter spans, they tend to be competitive with hollow core slabs. They are also used as wall panels.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B1010 235 6700					
PRECAST, DOUBLE "T",2" TOPPING,30' SPAN,30 PSF SUP. LOAD, 18" X 8'					
Double "T" beams, reg. wt, 18" x 8' w, 30' span	1.000	S.F.	7.29	1.37	8.66
Edge forms to 6" high on elevated slab, 4 uses	.050	L.F.	.01	.17	.18
Concrete ready mix, regular weight, 3000 psi	.250	C.F.	.89		.89
Place and vibrate concrete, elevated slab less than 6", pumped	.250	C.F.		.32	.32
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.74	.74
Curing with sprayed membrane curing compound	.010	C.S.F.	.06	.07	.13
TOTAL			8.25	2.67	10.92

B1010 234 Precast Double "T" Beams with No Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	DBL. "T" SIZE D (IN.) W (FT.)	CONCRETE "T" TYPE	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1500	30	30	18x8	Reg. Wt.	92	7.30	1.37	8.67
1600	RB1010 -010	40	18x8	Reg. Wt.	102	7.40	1.78	9.18
1700		50	18x8	Reg. Wt	112	7.40	1.78	9.18
1800		75	18x8	Reg. Wt.	137	7.45	1.85	9.30
1900		100	18x8	Reg. Wt.	162	7.45	1.85	9.30
2000	40	30	20x8	Reg. Wt.	87	5.65	1.14	6.79
2100		40	20x8	Reg. Wt.	97	5.70	1.38	7.08
2200	RB1010 -100	50	20x8	Reg. Wt.	107	5.70	1.38	7.08
2300		75	20x8	Reg. Wt.	132	5.75	1.48	7.23
2400		100	20x8	Reg. Wt.	157	5.85	1.82	7.67
2500	50	30	24x8	Reg. Wt.	103	5.95	1.03	6.98
2600		40	24x8	Reg. Wt.	113	6	1.26	7.26
2700		50	24x8	Reg. Wt.	123	6.05	1.34	7.39
2800		75	24x8	Reg. Wt.	148	6.05	1.36	7.41
2900		100	24x8	Reg. Wt.	173	6.15	1.70	7.85
3000	60	30	24x8	Reg. Wt.	82	6.05	1.36	7.41
3100		40	32x10	Reg. Wt.	104	7.05	1.12	8.17
3150		50	32x10	Reg. Wt.	114	7	.97	7.97
3200		75	32x10	Reg. Wt.	139	7.05	1.05	8.10
3250		100	32x10	Reg. Wt.	164	7.10	1.31	8.41
3300	70	30	32x10	Reg. Wt.	94	7.05	1.04	8.09
3350		40	32x10	Reg. Wt.	104	7.05	1.05	8.10
3400		50	32x10	Reg. Wt.	114	7.10	1.31	8.41
3450		75	32x10	Reg. Wt.	139	7.20	1.58	8.78
3500		100	32x10	Reg. Wt.	164	7.35	2.11	9.46
3550	80	30	32x10	Reg. Wt.	94	7.10	1.31	8.41
3600		40	32x10	Reg. Wt.	104	7.30	1.84	9.14
3900		50	32x10	Reg. Wt.	114	7.35	2.10	9.45

Important: See the Reference Section for critical supporting data - Reference Numbers and City Cost Indexes