The Towers at Greenville Place

Tower 'B'

Wilmington, DE

Technical Report #2

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Executive Summary

This report is a structural study of alternative floor systems for the Towers at Greenville Place: Tower 'B'. The existing system, precast hollow core concrete plank, and three alternative floor systems were designed, analyzed, and then compared to determined which systems were viable for the building and worth further investigating. Items of interest in the comparisons included weight, system depth, cost, and constructability. A representative section of the building was taken into consideration for each floor system. The four investigated systems are as follows:

Precast Hollow Core Plank (Existing)
Two-Way Concrete Slab
Composite Steel Beam and Decking
Composite Steel Joist and Decking

The existing and two types of composite systems distinctly stood apart from the two-way slab system. The two-way concrete slab proved for several reasons that it was not a viable alternative. In almost every category, it fails to line up with the three other systems. It is far too heavy and expensive, as well as difficult and time consuming to construct. The only discrepancy that the other two alternative systems have is in there depth. They take up more space for the structure and can reduce floor to ceiling height, or increase overall building height. This preliminary design has concluded that, precast hollow core, composite steel beam, and composite steel joist are all viable floor systems for Tower 'B' and should be further investigated.

Introduction

Tower 'B' of The Towers at Greenville Place is one of three virtually identical buildings. The towers, 'A', 'B', and 'C', are all directly neighboring upscale apartment buildings in Wilmington, Delaware. The project was complete in July of 2007 at an overall cost of $11.5 Million by a Design-Bid-Build delivery method. It is owned and managed by Pettinaro Real Estate Development Company.

The 180,000 square foot building consists of 89 different apartment units. One level is partially below grade and, on top of that, there are seven. The partially below grade ground floor is 12' and houses the lobby, exercise room, game room/café, storage, housekeeping, and electrical room. The ground floor lobby entrance opens to ground level, where as the opposite side of the building is nearly entirely below grade. The first floor is 10' and begins the typical apartment unit layout. Floors two through seven are also typical in layout, but only rise 9 feet and 4 inches each. The roof, though accessible, is virtually bare and houses no mechanical equipment.

Figure 1: North-west view of Tower 'B', showing canopy entrance.

Structural System Overview

Foundation

Foundations were designed according to recommendations on the geotechnical engineer's reports prepared by Advanced Geoservices Corp. The building's foundation is made up of a combination of spread and continuous reinforced cast-in-place concrete footings. The design was based on an allowable soil bearing capacity of 3000 psf and calls for 3000 psi concrete.

The ground floor slab is 4 inch slab on grade laid on 4 mil poly vapor barrier and 4 inches of crushed stone. It is reinforced with 6x6 W1.4xW1.4 welded wire fabric (WWF). The slab on grade is designed to have a strength of 3500 psi.

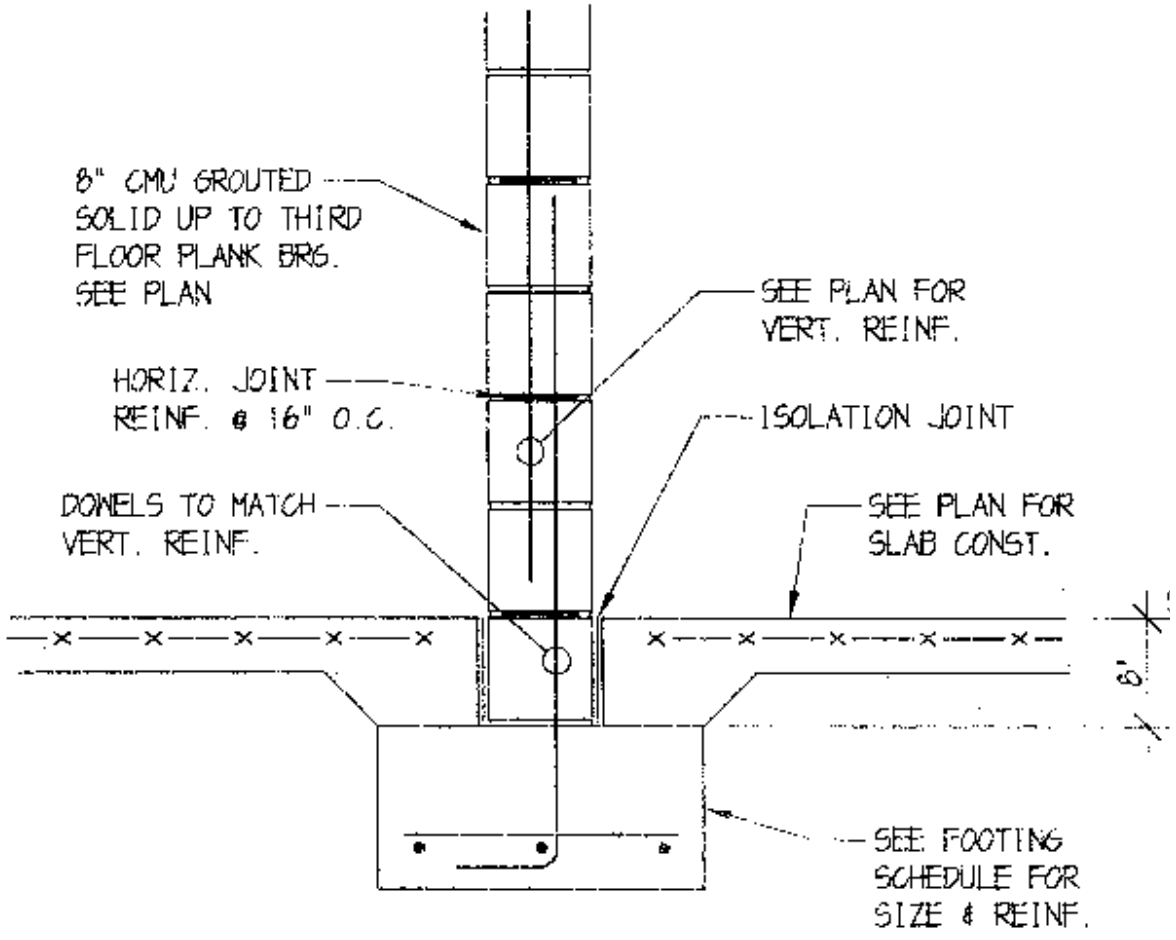


Figure 2: Typical interior foundation sections.

Shear Walls

The shear walls are 8 inch CMU with reinforced grouted cells that go all the way down to the foundation. Tower 'B' has three different strengths of shear walls. Each shear wall is essentially laid out the same, only differing slightly by the size and spacing of steel reinforcing used, depending on which level they reside. These walls each have two different spacing criteria. As you can see in Figure 3, the reinforcing at the ends of the walls are spaced more tightly than that compared to the middle portion.

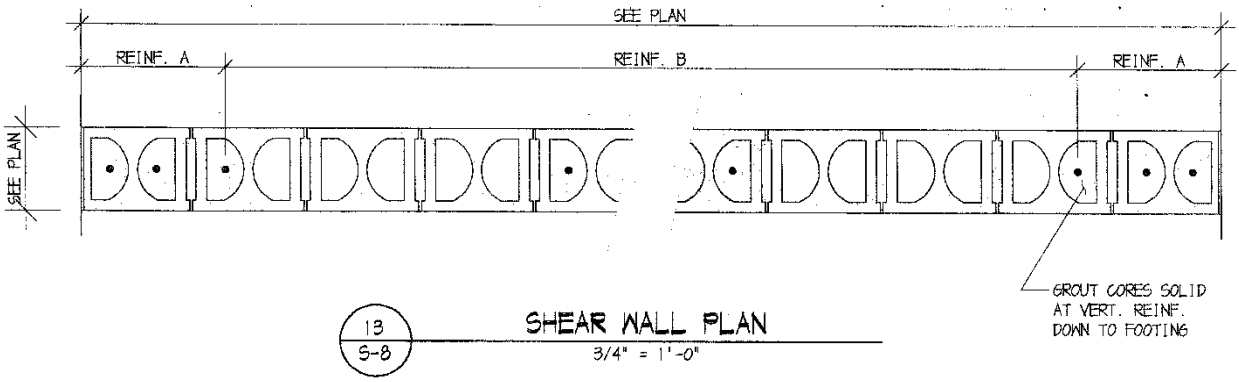


Figure 3: Typical shear wall plan.

Typical Wall

Nearly every wall in Tower 'B' contributes to supporting the gravity loads. With the exception of cast in place concrete on the partially below grade ground floor, every wall is CMU. Figure 4 shows all load bearing CMU walls have regularly spaced reinforcing in grouted cells. Walls on floors 1 through 3 call for #4 reinforcing bar spaced at 32 inches on center. Walls on floors 4 through 7 call for #4 reinforcing bars spaced at 48 inches on center. Window and door opening are supported by precast concrete lintels, as can been see in plan in figure 4 and in detail in figure 5.

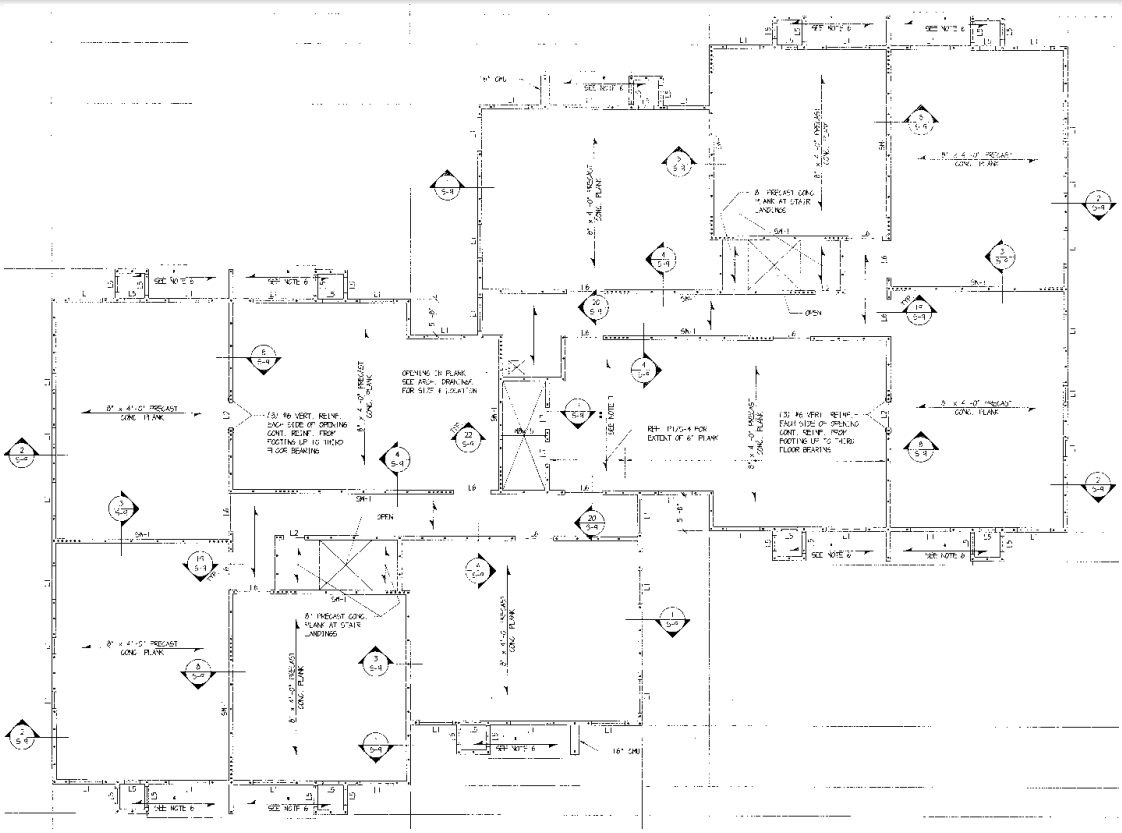


Figure 4: Typical plan layout showing reinforced CMU walls.

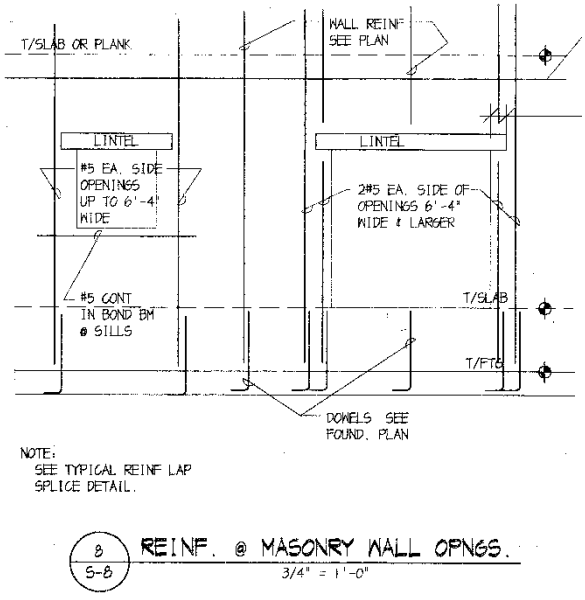


Figure 5: Typical wall openings supported by lintels.

Floor System

The floors of Tower 'B' are precast hollow core concrete plank. The corridor floors are 6 inch plank and all others are 8 inch plank. Referring back to figure 4, the planks span one direction each, but alternate per floor section. Special attention was given to certain plank joints due to the camber and direction of the planks. Said joints were off level where mid spans met perpendicularly with plank ends. Joints and level corrections were filled solid with 3000 psi flowable grout.

The support for the floor planks, as stated before, comes from the CMU walls. At the top of each level's CMU wall is a CMU bond beam with one continuous #5 reinforcing bar. The planks sit directly on a 3 inch bearing strip on the top of the wall. The floors are tied in using #4 reinforcing bars spaced at 48 inches and bent to suit each locations condition. Figures 6 through 8 display a variety of floor plank to wall connection conditions.

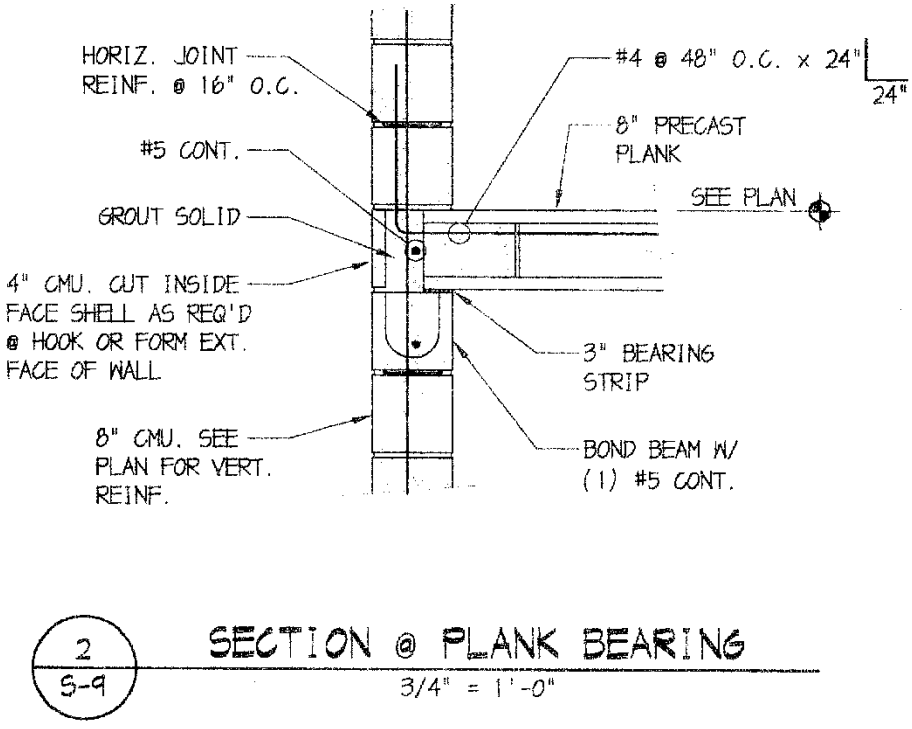


Figure 6: Detail of floor plank bearing on CMU wall.

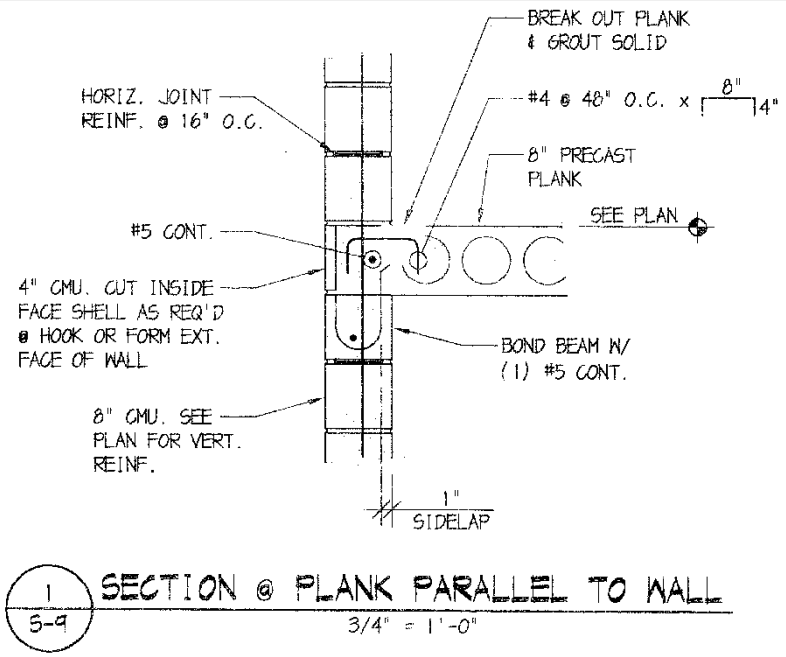


Figure 7: Detail of floor plank running parallel to wall connection.

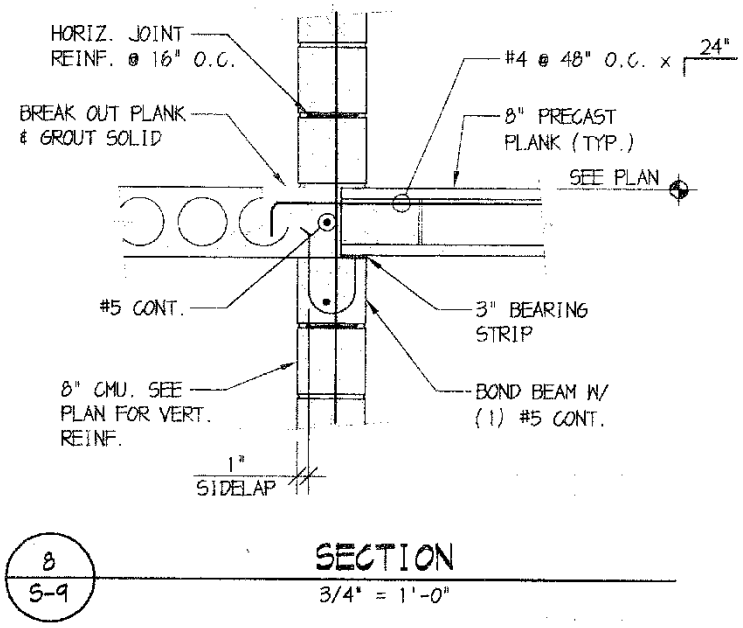


Figure 8: Detail of both bearing and parallel connection conditions.

Roof System

The roof of Tower 'B' is the same basic design as the typical floor system. It is accessible but the layout is mostly empty. Much like the other floors, the roof consists of 8 inch plank throughout except over the corridors where it is 6 inch plank and bears on the CMU wall. Joints, again, are filled solid with 3000 psi flowable grout. Figures 9 and 10 show two connection conditions.

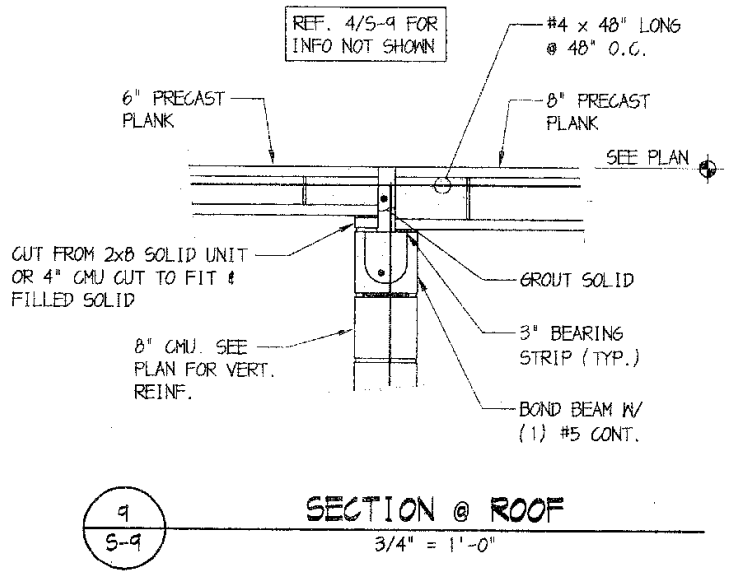


Figure 9: Detail of roof floor connection.

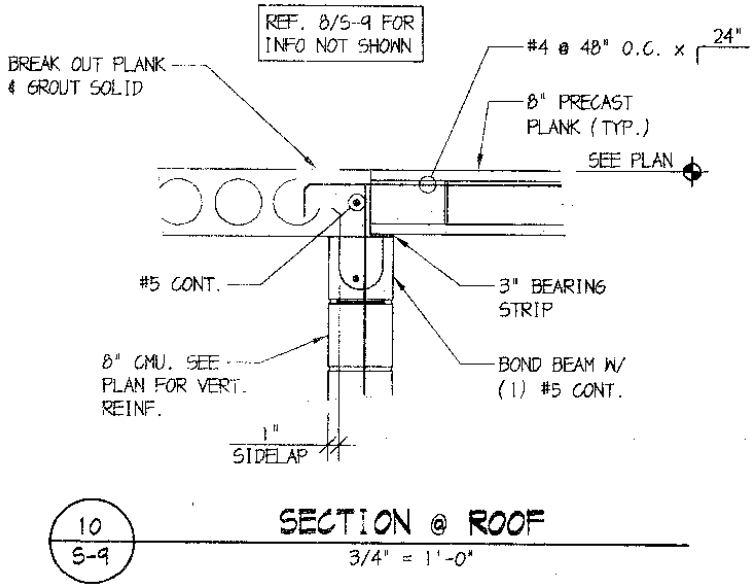


Figure 10: Detail of roof floor connection.

Applicable Codes

Original Design Codes

- International Building Code (IBC), 2003 edition
  - With Amendments adopted by New Castle County (DE)
- American Concrete Institute (ACI)
  - Building Code Commentary 318-02
- American Institute of Steel Construction (AISC)
  - Steel Construction Manual

Additional References Used for Thesis

- American Society of Civil Engineers (ASCE)
  - ASCE 7 – 05
- Precast/Prestressed Concrete Design Handbook
  - PCI Manual for the Design of Hollow Core Slabs
- National Concrete and Masonry Association (NCMA) TEK
  - TEK 14-5A (2006)
- Vulcraft Steel Decking Catalog
- RS Means Assemblies Costs Data

Material Strengths

Masonry

8" CMU – ASTM C90 Grade N	1900 psi
Core Grout	3000 psi
Bond Beam Grout	2500 psi

Precast

8" x 4' Hollow Core Plank	5000 psi
Joint Grout	3000 psi

Concrete

Foundation Wall	3000 psi
Slab on Grade	3500 psi
Footings	3000 psi
Reinforcement	60 ksi (A615)

Cold Formed Steel Framing

12, 14, & 16 Gage Studs	50 ksi (A653)
18 & 20 Gage Studs	33 ksi (A653)

Loads

Loads used for design	
Superimposed dead load for partitions, finishes, and MEP	20 psf
Live load for apartments (ASCE 7-05)	40 psf

Table 1: Loads used for existing and alternative floor systems

Alternative Floor Systems

For analysis of the existing and alternative floor systems, the section indicated in figure 11 will be considered.

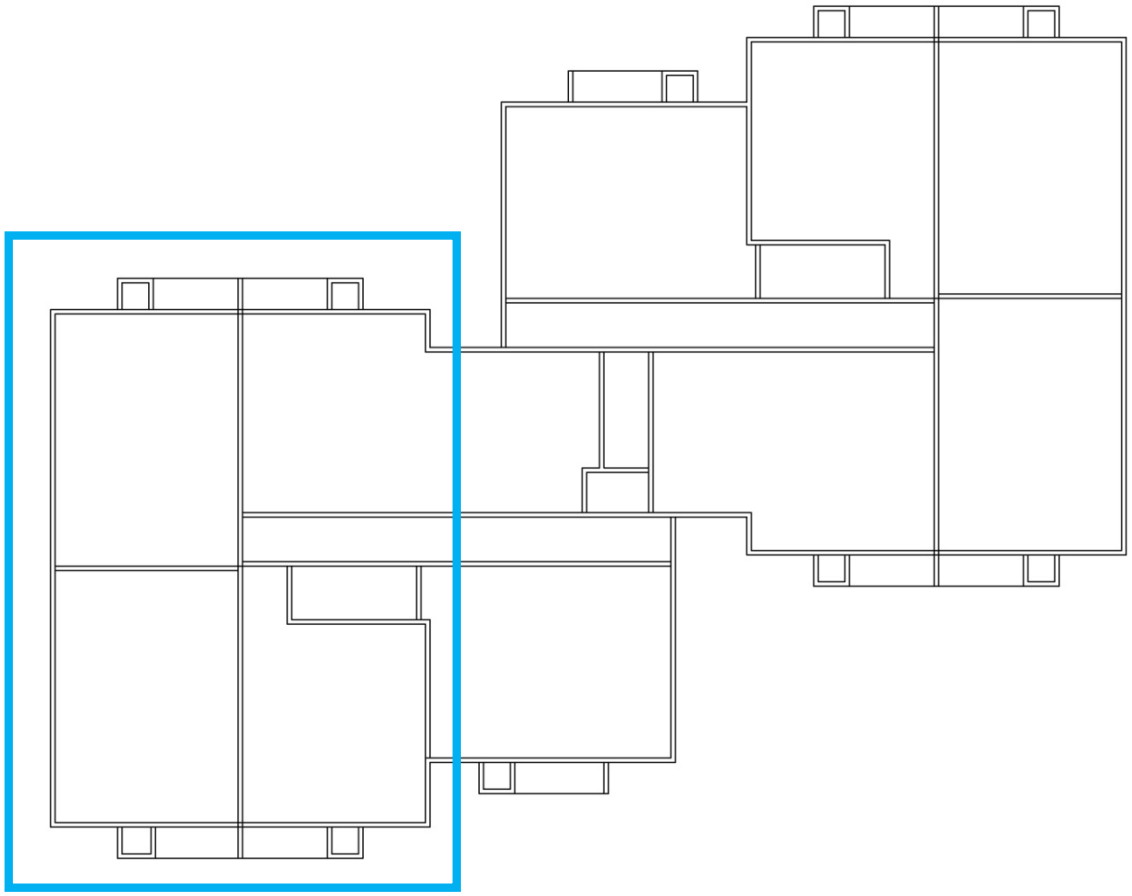


Figure 11: Building plan with indication of section to be analyzed.

Precast Hollow Core Plank (existing)

The existing floor system for Tower 'B' is 8-inch thick precast hollow core concrete plank. A typical span is about 28 feet. This particular precast system is able to work without support from any beams or girders. Not having a need for any extra structural supports allow the total floor system depth to stay very shallow. These precast planks weigh about 65 psf. The only topping specified for this is 3000 psi flowable grout for correcting levels and filling joints. With the exception of 2 inch thick framing for the electrical, ceiling finish, and some plumbing, the structural dimensions are virtually the same as the floor to finished ceiling heights. This, in turn, keeps the overall building height efficient with very little wasted space. On the other hand, HVAC and some MEP must be housed by other means, such as framed out wall sections. Refer to Figure 12 for view of layout.

Construction using this floor system is fast and can be done efficiently. Since the members are factory cast, they can be made well in advance to the erection date and shipped when needed. Construction time depends more on the curing of the CMU walls on which the plank rests. Discrepancies in lead time, however, maybe arise because of ordering and shipping. The cost of this system is approximately $6.41 per sq. ft. (plank alone, load bearing all not included). This extremely low cost is a result of the simple nature of the system and lack of a thicker topping.

Advantages

- Very little wasted space by structural system
- Construction is efficient and fast
- Very low cost

Disadvantages

- Lead time may be longer for ordering and shipping.
- No room for HVAC and MEP

This is a very viable system for Tower 'B' and it is clear why it was chosen as its floor system.

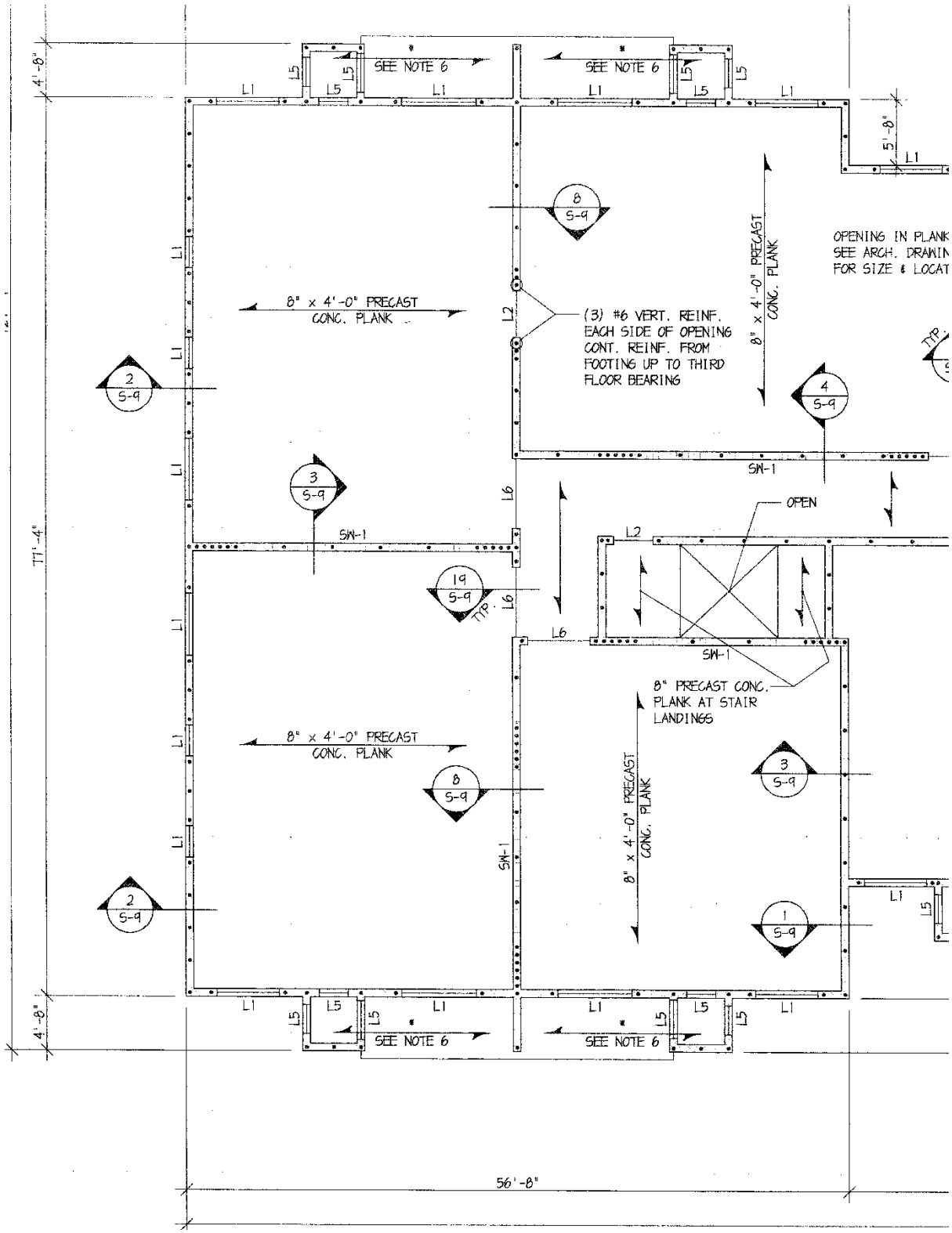


Figure 12: Building plan showing precast span direction.

2-Way Concrete Slab

A goal for the alternative floors systems is to match the original floor plan as much as possible. Unfortunately, the original plans were design with the span capabilities of precast planks in mind. The essential breakdown of the plan for a column supported system revealed that a typical bay is about 28'x38'. To maintain the open plans of the apartments this is one of the best options for a building grid. The system designed for this comparison is a 13 inch thick two-way concrete slab on 18"x20" beams and 18"x18" columns. This floor system is 5 inches thicker than the original floor system and a great deal heavier at 162.5 psf. Even though it is slightly thicker than the original system, it shares the same characteristic of being a relatively shallow structure system. That being said, it shares the same flaw by not being able to conceal HVAC and MEP. Refer to figure 13 for view of the section considered.

Construction time for this method would increase significantly from the original due to formwork and shoring. The entire building would need to be drastically redesigned. Everything from the foundations and lateral systems, to building façade and even some layout would change. The approximate cost of this alternative floor system would be $13.52 per sq. ft.. This is more than twice the original designs estimated cost.

Advantages

- Shallow depth of structural system
- Maintains the open floor plan

Disadvantages

- Cost is relatively high
- Construction time is long
- Weight is very high

The two-way slab appears to be one of the least viable systems for this application. The spans are on the height end for this type of system. They demand an inefficient use of material for a residential building. Cost and weight are twice what the current system is. The only advantages mimic that which is already achieved by the precast plank.

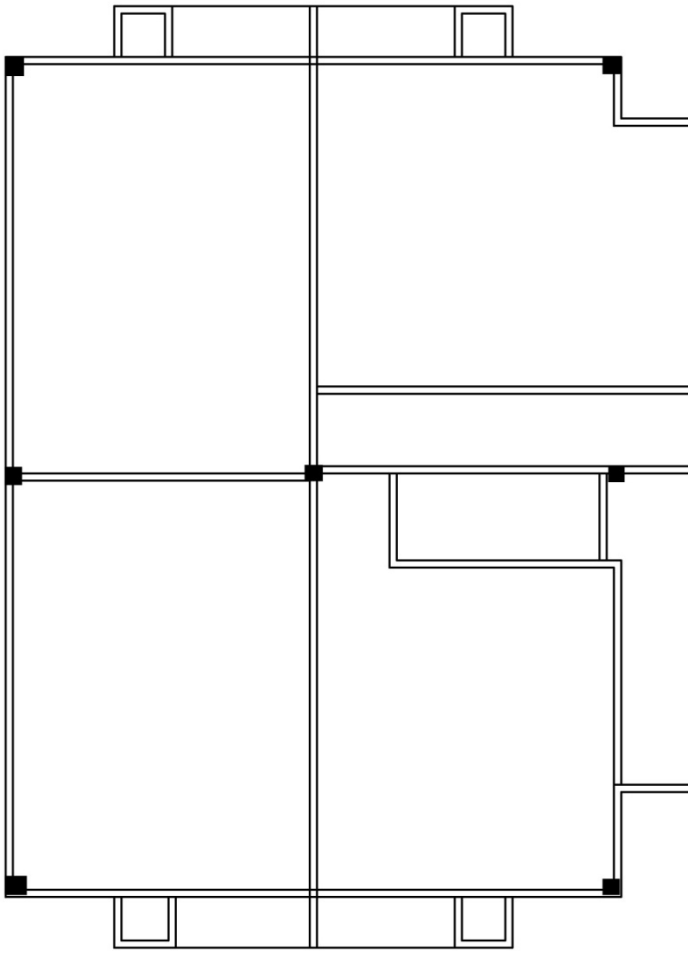


Figure 13: View of section considered for two-way slab with column location indications.

Composite Steel Deck and Beam

One of the first benefits for this alternative system is its ability to maintain the open floor spaces and efficiently span necessary widths. The overall depth of this system is about 22". With this system there is a considerable reduction in the floor to ceiling height. However, some of this wasted space can now be recovered by the HVAC and MEP systems. The approximate weight of this system is only 60.4 psf, which is light when compared to the proposed two-way slab system. A typical bay is a 3 span system with composite steel deck and beams. The 4 inch slab which aids in the compression of the system is relatively shallow which helps with keeping the overall system weight low. The deck is Vulcraft 2VLI18 with 3.5 inch studs. Refer to figure 14 for a view of beam layout.

Construction for this system is fairly quick compared to some of the other system proposed. Unlike structural concrete, there is no formwork or shoring to work with. This floor system is less expensive than two-way concrete at only approximately $10.21 per sq. ft.. This system, however, will also require a drastic change in the entire design of the building structural systems and aesthetics.

Advantages

- Light weight floor system
- Reasonable cost
- More capable of required spans

Disadvantages

- Increases depth of floor structural system

This system is far more viable than the previously proposed structural system. The advantages easily overcome the disadvantages.

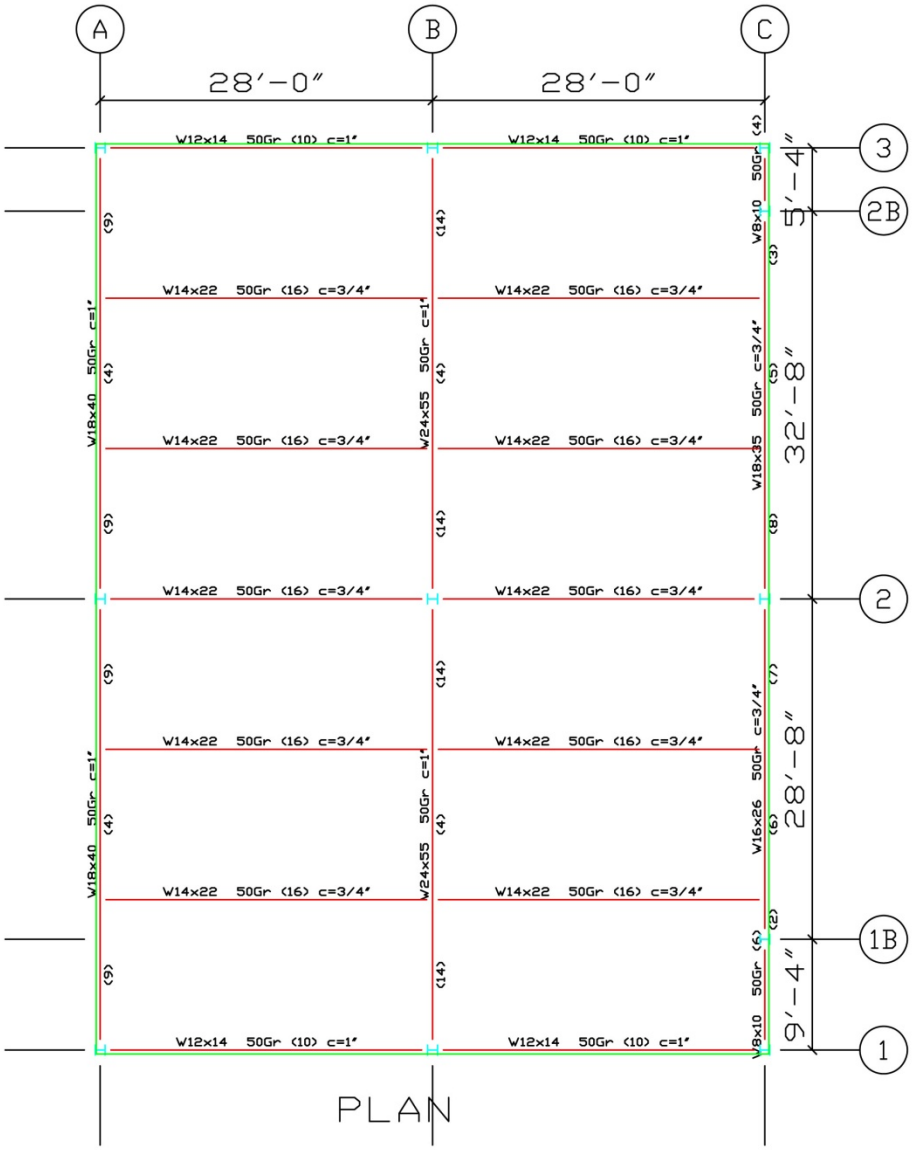


Figure 14: Layout of steel beams for composite system.

Composite Open Web Steel Joists and Decking

This system is very similar to that of the previously presented system. Like steel beams, it handles the spans very easily. Open web steel joists, however, will bring the total floor depth to about 26 inches. The joists are spaced at 4" o.c. and span the 28 foot direction. The deck running perpendicular to the joists is the same Vulcraft 2VLI18 with 3.5 inch studs in 4" concrete slab. It will weigh slightly more than the steel beam system at 70 psf. The open web steel joist design actually makes it easier to work in the HVAC and MEP and reclaim any wasted space in the floor system. Refer to figure 15 for a view of the steel joists layout.

Even though this analysis was performed with joists connecting into steel girders, this system can easily be implemented into the existing load bearing walls. Construction time would be relatively short, as with steel beams. The cost would come in around $8.74 for this system. Fireproofing for this open web steel joists is more of a hassle with this system compared to most. This must be taken into account in the comparison.

Advantages

- Light weight floor system
- Reasonable cost
- More capable of required spans
- Easily implements HVAC and MEP

Disadvantages

- Increases depth of floor structural system
- Hard to apply fireproofing

This system, like the steel beam system is very viable. Some of the bigger down falls would be the difficulty with fireproofing changes in floor-to-floor height or overall building height.

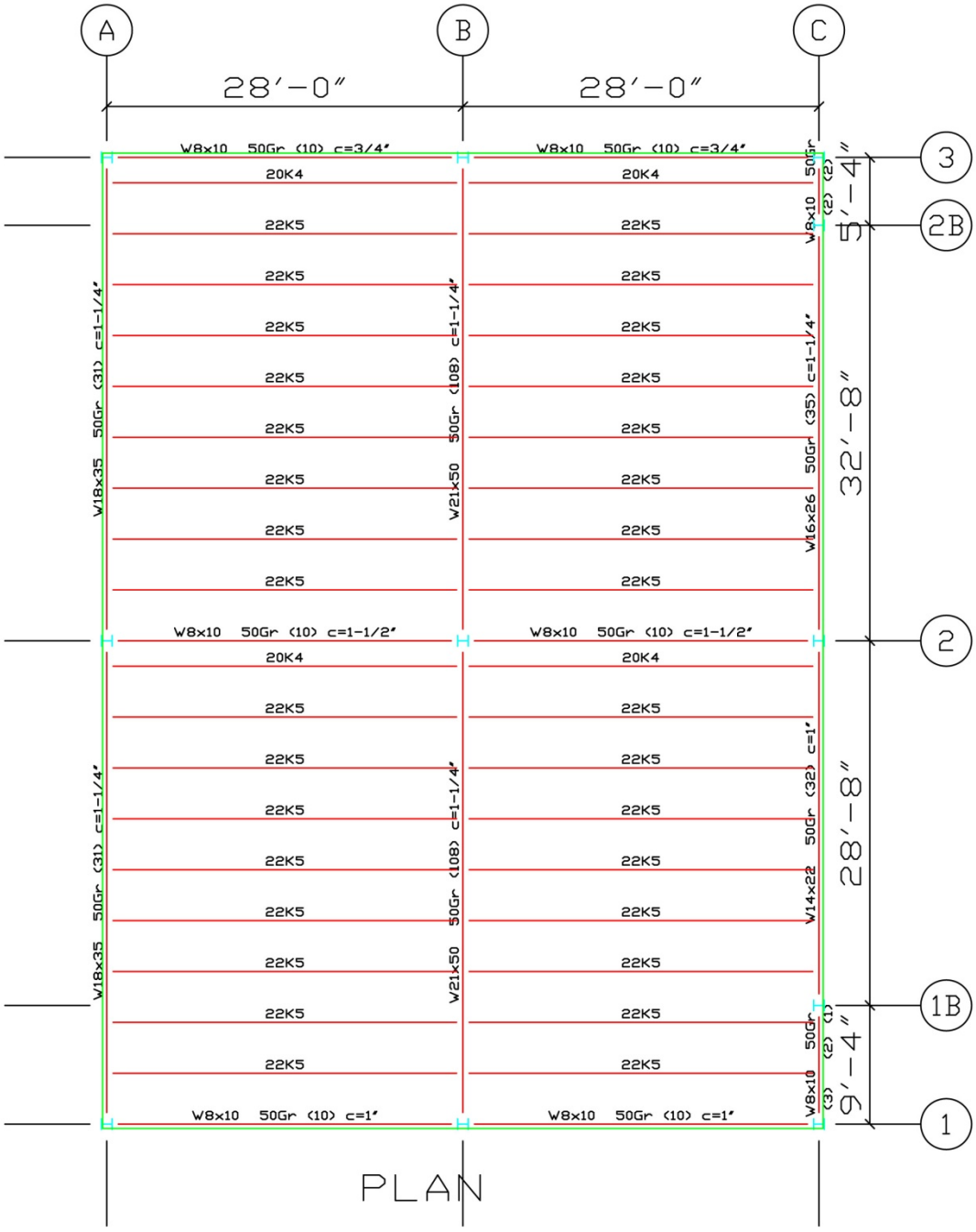


Figure 15: Layout of open web steel joists.

Conclusion

Comparison Chart				
Item	Precast	Two-way Slab	Composite Beam	Composite Joist
Cost (per sq. ft)	$6.41	$13.53	$10.21	$8.74
Depth (inches)	8	13	22	26
Weight (psf)	65	162.5	60.4	70
Fire Rating	2Hr	2Hr	2Hr	2Hr
Effect Architecture?	No	Yes	Yes	No
Construction Difficulty	Easy	Hard	Medium	Medium
Deflection	Low	Medium	Medium	Medium
Further Investigation	Existing	No	Yes	Yes

Table 2: Alternative Floor Systems Comparison

The objective of this report was to investigate and compare the original floor system and three alternatives for Tower 'B' of the Towers at Greenville Place. The summary of the comparisons can be found in table, which details several key elements important to considering floor designs. From this analysis it was concluded that the best alternative floor systems were composite steel beam and composite steel joist. The best choice for design was the existing precast hollow core plank.

The existing and two types of composite systems distinctly stood apart from the two-way slab system. The two-way concrete slab proved for several reasons that it was not a viable alternative. In almost every category, it fails to line up with the three other systems. It is far too heavy and expensive, as well as difficult and time consuming to construct. The only discrepancy that the other two alternative systems have is in there depth. They take up more space for the structure and can reduce floor to ceiling height, or increase overall building height.

This preliminary design has concluded that, precast hollow core, composite steel beam, and composite steel joist are all viable floor systems for Tower 'B' and should be further investigated.

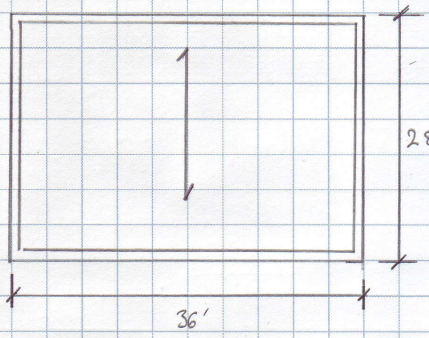
Appendix A: Precast Hollow Core Calculations

BAKER, INGRAM & ASSOCIATES
STRUCTURAL ENGINEERS
www.bakeringram.com

SHEET
PROJECT
PROJECT NO.
BY DATE

Existing Pre Cast Hollow Core Plank

Longest span



Load:

Superimposed DL = 20 psf
LL = 40 psf
(use unfactored total load for ACI)
Total load = 60 psf
28'-8" span
4'-0" x 8" Normal Weight
Hollow-Core Plank.

See PCI Attachment

Strand Pattern Designation
76-S

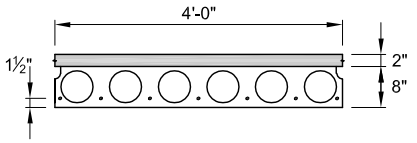
S = straight
Diameter of strand in 16ths
No. of Strand (7)

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Capacity of sections of other configurations are similar. For precise values, see local hollow-core manufacturer.

Key
458 – Safe superimposed service load, psf
0.1 – Estimated camber at erection, in.
0.2 – Estimated long-time camber, in.

HOLLOW-CORE
4′-0″ x 8″
Normal Weight Concrete



f'_c = 5,000 psi
f_{pu} = 270,000 psi

Section Properties

	Untopped		Topped	
A =	215	in.^{2}	311	in.^{2}
I =	1,666	in.^{4}	3,071	in.^{4}
y_b =	4.00	in.	5.29	in.
y_t =	4.00	in.	4.71	in.
S_b =	417	in.^{3}	581	in.^{3}
S_t =	417	in.^{3}	652	in.^{3}
wt =	224	plf	324	plf
DL =	56	psf	81	psf
V/S =	1.92	in.		

4HC8

Table of safe superimposed service load (psf) and cambers (in.) — **No Topping**

Strand Designation Code	Span, ft																														
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
66-S	458	415	378	346	311	269	234	204	179	158	140	124	110	98	87	77	69	61	54	48	43	38	33	29						
	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.0	0.0	–0.1	–0.2	–0.3	–0.5	–0.6						
	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.0	–0.1	–0.2	–0.3	–0.5	–0.7	–0.9	–1.2	–1.4						
76-S	470	424	387	355	326	303	276	242	213	188	167	149	133	119	106	95	86	77	69	62	55	50	44	39	35	31	26			
	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.0	–0.1	–0.2	–0.4	–0.5	–0.7	–0.9			
	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.1	0.0	–0.1	–0.2	–0.4	–0.6	–0.8	–1.1	–1.4	–1.7	–2.0			
58-S	464	421	384	352	323	300	280	260	244	229	211	194	177	160	144	130	118	107	97	88	80	72	66	60	54	48	42	37	32	28
	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.2	0.1	0.0	–0.4	–0.3	–0.5	–0.7	–0.9
	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.0	–0.2	–0.4	–0.6	–0.9	–1.2	–1.6	–2.0	–2.4	
68-S	476	430	393	361	332	309	286	269	253	235	223	209	200	180	165	153	142	132	121	110	101	92	84	77	70	63	56	51	45	40
	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.2	0.1	–0.1	–0.3
	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.6	0.4	0.2	0.0	–0.2	–0.5	–0.8	–1.1	–1.5
78-S	488	442	402	370	341	318	295	275	259	241	229	215	203	195	180	168	1	144	13	126	118	110	101	92	84	77	70	64	58	52
	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1	1.1	1.	1.1	1.1	1.1	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.3
	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.2	1.3	1.3	1	1.3	1.	1.2	1.2	1.1	1.0	0.8	0.7	0.5	0.3	0.0	–0.3	–0.7

4HC8 + 2

Table of safe superimposed service load (psf) and cambers (in.) — **2 in. Normal Weight Topping**

Strand Designation Code	Span, ft																													
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		
66-S	489	445	394	340	294	256	224	197	173	153	135	119	105	93	82	68	56	45	36	26										
	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.0	–0.0	–0.1	–0.2	–0.3										
	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.2	–0.3	–0.4	–0.6	–0.7	–0.9	–1.2	–1.4										
76-S	498	457	420	387	347	304	267	235	208	184	164	146	130	116	103	88	74	62	51	41	31									
	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	–0.0	–0.1	–0.2									
	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.0	–0.1	–0.2	–0.4	–0.5	–0.7	–0.9	–1.2	–1.4									
58-S	492	451	414	384	357	333	310	293	274	245	219	196	177	159	143	126	110	95	82	70	59	49	40	32						
	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.1	0.3	0.2	0.1	0.0	–0.1						
	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.1	–0.1	–0.2	–0.4	–0.6	–0.9	–1.2	–1.5	–1.8						
68-S		463	426	393	366	342	319	299	282	267	251	239	216	195	177	158	140	124	110	97	84	73	62	53	44	36	28			
		0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.2	0.1	–0.1			
		0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.0	–0.2	–0.4	–0.6	–0.9	–1.2	–1.6	–2.0	–2.4			
78-S		472	435	402	375	348	325	305	288	273	257	245	232	220	207	186	167	149	133	119	106	94	83	73	64	55	46	38		
		0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	0.9	0.9	0.7	0.6	0.5	0.3		
		0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.4	0.3	0.1	–0.1	–0.3	–0.6	–0.9	–1.3	–1.7	–2.2		

Strength is based on strain compatibility; bottom tension is limited to $7.5\sqrt{f'_c}$; see pages 2–7 through 2–10 for explanation.

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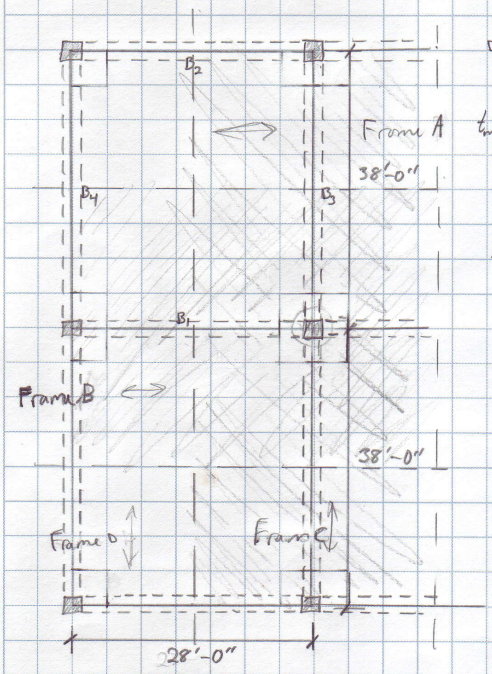
Two-Way Flat Slab With Drop Panels

Assumptions: $f'_c = 5000$ psi
$f_y = 60000$ psi

Columns => 18"x18"
Beams => 18 x 20

Superimposed DL = 20 psf
LL = 40 psf



Determine slab thickness

min slab thickness:

$t_{min} = \frac{l_n}{36} = \frac{38\times12 - 18}{36} = 12.17 \Rightarrow$ try 13"

$W_u = 1.2\left[\left(\frac{13}{12}\right)\times150 + 20\right] + 1.6(40) = 283^{\#}$

Determine α

interior Beam B_1

$b_e = b_w + 2h_w = 18 + 7(6) = 32" \leq b_w + 8t = 114"$

$b_e/b_w = 1.67$

$t/h = 13/20 = 0.65$

$K = 1.295$

$I_b = 1.295\left(\frac{18\times20^3}{12}\right) = 15540$

$I_s = \frac{l_2 t^3}{12} = \frac{38(12)(13)^3}{12} = 83486$

$\alpha_{B_1} = \frac{15540}{83486} = 0.1861$

Edge Beam B_2

$b_e = b_w + h_w = 18 + 7 = 25" \leq b_w + 4t = 66"$

$b_e/b_w = 4.33$ $\quad t/h = 13/20 = 0.65$

$K = 1.156$

$I_b = 1.156\left(\frac{18\times20^3}{12}\right) = 13860$

$I_s = \frac{l_2 t^3}{12} = \frac{19(12)(13)^3}{12} = 41743$

$\alpha_{B_2} = \frac{13860}{41743} = 0.332$

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Edge Beam B_4

$b_e = b_w + h_w = 18 + 7 = 25'' \le b_w + 4t = 66''$

$b_e/b_w = 1.33$ $\quad t/h = 13/20 = 0.65$

$K = 1.1587$

$I_b = 1.1587\left(\frac{18 \times 20^3}{12}\right) = 13860$

$I_s = \frac{lt^3}{12} = \frac{14 \times 12 \times 13^3}{12} = 30758$

$\alpha = \frac{13860}{30758} = 0.451$

Interior Beam B_3

$b_e = b_w + 2h_w = 18 + 2(7) = 32'' \le b_w + 8t = 114''$

$b_e/b_w = 1.67$ $\quad t/h = 13/20 = 0.65$

$K = 1.2952$

$I_b = 1.2952\left(\frac{18 \times 20^3}{12}\right) = 15540$

$I_s = \frac{lt^3}{12} = \frac{28 \times 12 \times 13^3}{12} = 61516$

$\alpha = \frac{15540}{61516} = 0.253$

$\alpha_m = \frac{0.1861 + 0.332 + 0.451 + 0.253}{4} = 0.3055$ $\therefore$ medium stiff Beam

$t_{min} = \frac{l_n\left(0.8 + \frac{f_y}{200000}\right)}{36 + 5\beta(\alpha_m - 0.2)} \ge 5''$

$l_n = 38 - \frac{18}{12} = 36.5$ $\quad s_n = 28 - \frac{18}{12} = 26.5$ $\quad \beta = \frac{l_n}{s_n} = \frac{36.5}{26.5} = 1.377$

$t_{min} = \frac{36.5(12)\left(0.8 + \frac{60000}{200000}\right)}{36 + 5(1.377)(0.306 - 0.2)} = 13.12'' > 13''$ $\therefore$ need to check deflection → SEE PCA Slab Attachment

Frame B: $M_o = \frac{w_u l_2 l_n^2}{8} = \frac{(1.283)(28)(38 - 18/12)^2}{8} = 1110^{'k}$

Frame A: $= \frac{(1.283)(38)(38 - 18/12)^2}{8} = 1506^{'k}$

Frame C: Check punching $= \frac{(1.283)(28)(38 - 18/12)^2}{8} = 1110^{'k}$

Frame D: $= \frac{(1.283)(38)(38 - 18/12)^2}{8} = 1506^{'k}$

$d_{avg} = 13'' - .75'' - 0.625'' = 11.63''$

$b_o = (18 + 11.63)4 = 118.5$

Int span factored M_o

$M_o^- = 0.65$

$M_o^+ = 0.35$

Exterior Span factored M_o

$M_{int}^- = 0.70$

$M^+ = 0.57$

$M_{ext}^- = 0.16$

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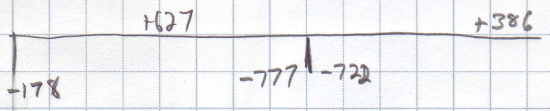
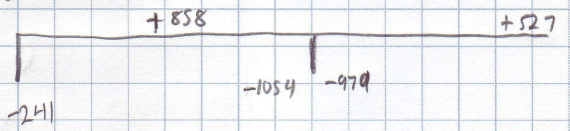
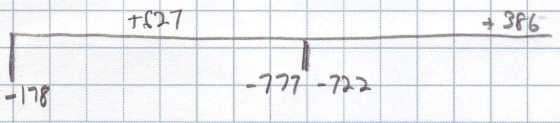
Frame A



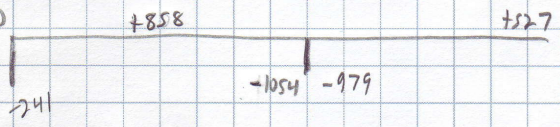
Frame B



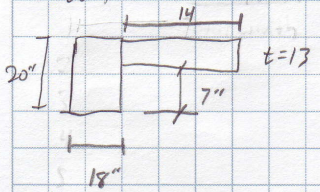
Frame C



Frame D

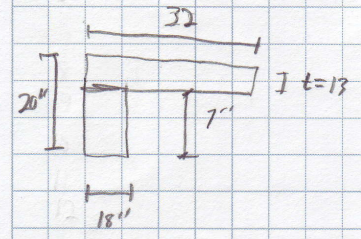


design for Frame: B



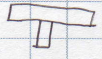
$$C = \left[1 - 0.63\left(\frac{18}{20}\right)\right]\left[\frac{18^3 \times 20}{3}\right] + \left[1 - 0.63\left(\frac{13}{7}\right)\right]\left[\frac{13^3 \times 7}{3}\right]$$

$$= 15964$$



$$C = \left[1 - 0.63\left(\frac{13}{32}\right)\right]\left[\frac{13^3 \times 32}{3}\right] + \left[1 - 0.63\frac{18}{7}\right]\left[\frac{18^3 \times 7}{3}\right]$$

$$= 37850$$

for 

$C = 29413$

$\therefore$ use 37850

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$\beta_t = \frac{C}{2I_s} = \frac{37850}{2(83480)} = 0.227$

$\frac{l_1}{l_2} = \frac{28}{38} = .74$ $\quad \alpha = 0.1861$ $\quad \alpha\frac{l_1}{l_2} = 0.137$

M^-_{ext} $\frac{l_1}{l_2}$	0.5	.74	1.0
$\beta_t = 0$	100	100	100
$\beta_t = 0.227$	97.8	96.2	
$\beta \geq 1$	90	82.8	75

M^-_{int}	.5	.74	1.0
$\alpha\frac{l_1}{l_2} = 0$	90	82.8	75

M^+	.5	.74	1.0
$\alpha\frac{l_1}{l_2} = 0$	60	60	60
$\alpha\frac{l_1}{l_2} = .177$		63.12	
$\alpha\frac{l_1}{l_2} = 1$	90	82.8	75

M^-_{ext}

$-241^{'k}$ → 96.2% to CS = 231.8'k → 85% to beam = 197'k
→ 3.8 to MS = 9.2'k → 15% to slab = 34.8'k

M^-_{int}

-1054 → 82.8% to CS = 872.7'k → 85% to beam = 741.8'k
→ 15% to slab = 131.3'k
→ 17.2% to MS = 181'k

-979 → 82.8% to CS = 810.6'k → 85% to beam = 689.0'k
→ 15% to slab = 121.6'k
→ 17.2% to MS = 168.4'k

M^+

858 → 63.12% to CS = 541.4'k → 85% to beam = 460'k
→ 36.9% to MS = 316.6'k → 15% to slab = 51.2'k

527 → 63.12% to CS = 332.5'k → 85% to beam = 282.7'k
→ 36.9% to MS = 194.5'k → 15% to slab = 49.9'k

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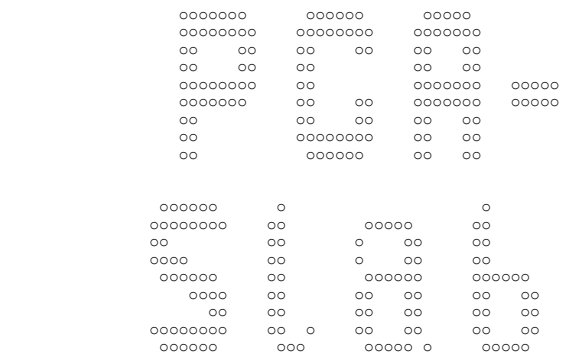
Frame B: Total width = 38' CS = 19' M_s = 19'

	M^-_{ext}	M^+	M^-_{int}	M^-	M^+
Total Moment	241	858	1054	979	527
Beam	197	460	742	689	283
CS	35	81	111	122	195
M_s slab	9	317	181	168	50

Refer to Attached P&A Slab Calcs for Reinf

pcaSlab v1.51 © Portland Cement Association 10-26-2009, 10:19:43 PM
Licensed to: Penn State University, License ID: 52416-1010277-4-22545-28F4D



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==========================================================================
                          pcaSlab v1.51 (TM)
        A Computer Program Analysis, Design, and Investigation of
          Reinforced Concrete Slab and Continuous Beam Systems
==========================================================================
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[7] SEGMENTAL DEFLECTIONS

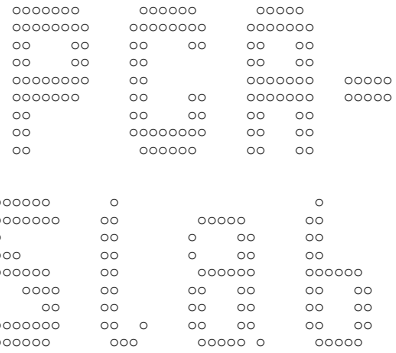
Units: x (ft), Dz (in)

Span	x	Dz (DEAD)	Dz (LIVE)	Dz (TOTAL)
1	0.000	-0.000	-0.000	-0.000
	0.250	-0.004	-0.002	-0.006
	0.500	-0.008	-0.003	-0.011
	0.750	-0.013	-0.005	-0.017
	0.750	-0.013	-0.005	-0.017
	1.015	-0.017	-0.006	-0.023
	1.280	-0.021	-0.008	-0.029
	1.545	-0.026	-0.009	-0.035
	1.810	-0.030	-0.011	-0.041
	2.075	-0.034	-0.012	-0.047
	2.340	-0.039	-0.014	-0.053
	2.605	-0.043	-0.016	-0.058
	2.870	-0.047	-0.017	-0.064
	3.135	-0.051	-0.019	-0.069
	3.400	-0.055	-0.020	-0.075
	3.665	-0.059	-0.022	-0.080
	3.930	-0.063	-0.023	-0.086
	4.195	-0.066	-0.024	-0.091
	4.460	-0.070	-0.026	-0.096
	4.725	-0.074	-0.027	-0.101
	4.990	-0.077	-0.028	-0.106
	5.255	-0.081	-0.030	-0.110
	5.520	-0.084	-0.031	-0.115
	5.785	-0.087	-0.032	-0.119
	6.050	-0.090	-0.033	-0.123
	6.315	-0.093	-0.034	-0.127
	6.580	-0.096	-0.036	-0.131
	6.845	-0.099	-0.037	-0.135
	7.110	-0.101	-0.038	-0.139
	7.375	-0.104	-0.039	-0.142
	7.640	-0.106	-0.040	-0.146
	7.905	-0.108	-0.041	-0.149
	8.170	-0.110	-0.041	-0.152
	8.435	-0.112	-0.042	-0.154
	8.700	-0.114	-0.043	-0.157

	8.965	-0.116	-0.044	-0.159
	9.230	-0.117	-0.045	-0.162
	9.495	-0.119	-0.045	-0.164
	9.760	-0.120	-0.046	-0.166
	10.025	-0.121	-0.046	-0.167
	10.290	-0.122	-0.047	-0.169
	10.555	-0.123	-0.047	-0.170
	10.820	-0.123	-0.048	-0.171
	11.085	-0.124	-0.048	-0.172
	11.350	-0.124	-0.048	-0.173
	11.615	-0.125	-0.049	-0.173
	11.880	-0.125	-0.049	-0.174
	12.145	-0.125	-0.049	-0.174
	12.410	-0.125	-0.049	-0.174
	12.675	-0.124	-0.049	-0.174
	12.940	-0.124	-0.049	-0.173
	13.205	-0.123	-0.049	-0.173
	13.470	-0.123	-0.049	-0.172
	13.735	-0.122	-0.049	-0.171
	14.000	-0.121	-0.049	-0.170
	14.265	-0.120	-0.049	-0.169
	14.530	-0.119	-0.049	-0.167
	14.795	-0.117	-0.048	-0.166
	15.060	-0.116	-0.048	-0.164
	15.325	-0.114	-0.048	-0.162
	15.590	-0.113	-0.047	-0.160
	15.855	-0.111	-0.047	-0.158
	16.120	-0.109	-0.046	-0.155
	16.385	-0.107	-0.046	-0.153
	16.650	-0.105	-0.045	-0.150
	16.915	-0.103	-0.044	-0.147
	17.180	-0.100	-0.044	-0.144
	17.445	-0.098	-0.043	-0.141
	17.710	-0.096	-0.042	-0.138
	17.975	-0.093	-0.042	-0.135
	18.240	-0.090	-0.041	-0.131
	18.505	-0.088	-0.040	-0.128
	18.770	-0.085	-0.039	-0.124
	19.035	-0.082	-0.038	-0.120
	19.300	-0.079	-0.037	-0.116
	19.565	-0.076	-0.036	-0.112
	19.830	-0.073	-0.035	-0.108
	20.095	-0.070	-0.034	-0.104
	20.360	-0.067	-0.033	-0.100
	20.625	-0.064	-0.032	-0.096
	20.890	-0.061	-0.031	-0.092
	21.155	-0.058	-0.030	-0.088
	21.420	-0.055	-0.029	-0.084
	21.685	-0.052	-0.027	-0.079
	21.950	-0.049	-0.026	-0.075
	22.215	-0.046	-0.025	-0.071
	22.480	-0.043	-0.024	-0.067
	22.745	-0.040	-0.023	-0.062
	23.010	-0.037	-0.021	-0.058
	23.275	-0.034	-0.020	-0.054
	23.540	-0.031	-0.019	-0.050
	23.805	-0.028	-0.018	-0.046
	24.070	-0.026	-0.017	-0.042
	24.335	-0.023	-0.015	-0.038
	24.600	-0.020	-0.014	-0.035
	24.865	-0.018	-0.013	-0.031
	25.130	-0.016	-0.012	-0.027
	25.395	-0.013	-0.011	-0.024
	25.660	-0.011	-0.009	-0.021
	25.925	-0.009	-0.008	-0.018
	26.190	-0.008	-0.007	-0.015
	26.455	-0.006	-0.006	-0.012
	26.720	-0.004	-0.005	-0.009
	26.985	-0.003	-0.004	-0.007
	27.250	-0.002	-0.003	-0.005
	27.250	-0.002	-0.003	-0.005
	27.500	-0.001	-0.002	-0.003
	27.750	-0.001	-0.001	-0.001
	28.000	-0.000	-0.000	-0.000
2	0.000	-0.000	-0.000	-0.000
	0.250	0.000	0.001	0.001
	0.500	0.000	0.002	0.002
	0.750	0.000	0.003	0.003
	0.750	0.000	0.003	0.003
	1.015	0.000	0.003	0.004
	1.280	-0.000	0.004	0.004
	1.545	-0.001	0.005	0.004
	1.810	-0.001	0.006	0.004
	2.075	-0.002	0.007	0.004
	2.340	-0.003	0.007	0.004
	2.605	-0.005	0.008	0.003

2.870	-0.006	0.009	0.003
3.135	-0.008	0.009	0.002
3.400	-0.009	0.010	0.001
3.665	-0.011	0.010	-0.001
3.930	-0.013	0.011	-0.002
4.195	-0.015	0.011	-0.003
4.460	-0.017	0.012	-0.005
4.725	-0.019	0.012	-0.006
4.990	-0.021	0.013	-0.008
5.255	-0.023	0.013	-0.010
5.520	-0.025	0.013	-0.012
5.785	-0.028	0.014	-0.014
6.050	-0.030	0.014	-0.016
6.315	-0.032	0.014	-0.018
6.580	-0.035	0.015	-0.020
6.845	-0.037	0.015	-0.022
7.110	-0.040	0.015	-0.025
7.375	-0.042	0.015	-0.027
7.640	-0.045	0.015	-0.029
7.905	-0.047	0.016	-0.031
8.170	-0.049	0.016	-0.034
8.435	-0.052	0.016	-0.036
8.700	-0.054	0.016	-0.038
8.965	-0.057	0.016	-0.041
9.230	-0.059	0.016	-0.043
9.495	-0.061	0.016	-0.045
9.760	-0.064	0.016	-0.047
10.025	-0.066	0.016	-0.050
10.290	-0.068	0.016	-0.052
10.555	-0.070	0.016	-0.054
10.820	-0.072	0.016	-0.056
11.085	-0.074	0.016	-0.058
11.350	-0.076	0.016	-0.060
11.615	-0.078	0.016	-0.062
11.880	-0.080	0.016	-0.064
12.145	-0.081	0.016	-0.065
12.410	-0.083	0.016	-0.067
12.675	-0.084	0.016	-0.069
12.940	-0.086	0.016	-0.070
13.205	-0.087	0.015	-0.072
13.470	-0.089	0.015	-0.073
13.735	-0.090	0.015	-0.074
14.000	-0.091	0.015	-0.076
14.265	-0.092	0.015	-0.077
14.530	-0.093	0.015	-0.078
14.795	-0.093	0.014	-0.079
15.060	-0.094	0.014	-0.080
15.325	-0.094	0.014	-0.080
15.590	-0.095	0.014	-0.081
15.855	-0.095	0.014	-0.082
16.120	-0.095	0.013	-0.082
16.385	-0.095	0.013	-0.082
16.650	-0.095	0.013	-0.082
16.915	-0.095	0.013	-0.083
17.180	-0.095	0.012	-0.083
17.445	-0.095	0.012	-0.082
17.710	-0.094	0.012	-0.082
17.975	-0.094	0.012	-0.082
18.240	-0.093	0.011	-0.081
18.505	-0.092	0.011	-0.081
18.770	-0.091	0.011	-0.080
19.035	-0.090	0.011	-0.079
19.300	-0.089	0.010	-0.078
19.565	-0.087	0.010	-0.077
19.830	-0.086	0.010	-0.076
20.095	-0.085	0.009	-0.075
20.360	-0.083	0.009	-0.074
20.625	-0.081	0.009	-0.072
20.890	-0.079	0.009	-0.071
21.155	-0.077	0.008	-0.069
21.420	-0.075	0.008	-0.067
21.685	-0.073	0.008	-0.066
21.950	-0.071	0.007	-0.064
22.215	-0.069	0.007	-0.062
22.480	-0.066	0.007	-0.059
22.745	-0.064	0.006	-0.057
23.010	-0.061	0.006	-0.055
23.275	-0.058	0.006	-0.052
23.540	-0.055	0.005	-0.050
23.805	-0.053	0.005	-0.047
24.070	-0.050	0.005	-0.045
24.335	-0.047	0.004	-0.042
24.600	-0.043	0.004	-0.039
24.865	-0.040	0.004	-0.037
25.130	-0.037	0.003	-0.034
25.395	-0.034	0.003	-0.031
25.660	-0.031	0.003	-0.028

25.925	-0.027	0.003	-0.025
26.190	-0.024	0.002	-0.022
26.455	-0.020	0.002	-0.019
26.720	-0.017	0.002	-0.015
26.985	-0.013	0.001	-0.012
27.250	-0.010	0.001	-0.009
27.250	-0.010	0.001	-0.009
27.500	-0.007	0.001	-0.006
27.750	-0.003	0.000	-0.003
28.000	-0.000	0.000	-0.000



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Reinforced Concrete Slab and Continuous Beam Systems

[2] DESIGN RESULTS

Top Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Zone	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	Left	14.00	0.00	0.750	3.931	42.617	12.923	0.000	13-#5
		Middle	14.00	0.00	14.000	0.000	42.617	0.000	0.000	---
		Right	14.00	1141.61	27.250	3.931	42.617	2.182	23.136	77-#5
	Middle	Left	62.00	0.00	0.750	17.410	188.732	13.053	0.000	57-#5
		Middle	62.00	0.00	14.000	0.000	188.732	0.000	0.000	---
		Right	62.00	380.56	27.250	17.410	188.732	13.053	7.125	57-#5
2	Column	Left	14.00	1171.23	0.750	3.931	42.617	2.182	23.796	77-#5
		Middle	14.00	0.00	14.000	0.000	42.617	0.000	0.000	---
		Right	14.00	0.00	27.250	3.931	42.617	12.923	0.000	13-#5
	Middle	Left	62.00	390.43	0.750	17.410	188.732	13.053	7.311	57-#5
		Middle	62.00	0.00	14.000	0.000	188.732	0.000	0.000	---
		Right	62.00	0.00	27.250	17.410	188.732	13.053	0.000	57-#5

Top Bar Details:

Units: Length (ft)

		Left		Continuous		Right	
Span	Strip	Bars	Length	Bars	Length	Bars	Length
1	Column	13-#5	9.50	---		39-#5	9.50
	Middle	57-#5	6.58	---		57-#5	8.50
2	Column	39-#5	10.36	38-#5	6.05	---	
	Middle	57-#5	10.36	---		57-#5	6.58

Bottom Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars

1	Column	14.00	774.31	11.085	3.931	42.617	3.360	15.231	50-#5
	Middle	62.00	516.20	11.085	17.410	188.732	13.053	9.684	57-#5
2	Column	14.00	465.96	17.710	3.931	42.617	5.793	8.956	29-#5
	Middle	62.00	310.64	17.710	17.410	188.732	13.053	5.810	57-#5

Bottom Bar Details:

Units: Start (ft), Length (ft)

		Long Bars			Short Bars		
Span	Strip	Bars	Start	Length	Bars	Start	Length
1	Column	50-#5	0.00	28.00	---		
	Middle	57-#5	0.00	28.00	---		
2	Column	29-#5	0.00	28.00	---		
	Middle	57-#5	0.00	28.00	---		

Flexural Capacity:

Units: From, To (ft), As (in^2), PhiMn (k-ft)

Span	Strip	From	To	AsTop	AsBot	PhiMn-	PhiMn+
1	Column	0.000	0.750	4.03	15.50	-213.42	787.22
		0.750	8.495	4.03	15.50	-213.42	787.22
		8.495	9.495	0.00	15.50	0.00	787.22
		9.495	10.025	0.00	15.50	0.00	787.22
		10.025	14.000	0.00	15.50	0.00	787.22
		14.000	17.975	0.00	15.50	0.00	787.22
		17.975	18.505	0.00	15.50	0.00	787.22
		18.505	20.016	0.00	15.50	0.00	787.22
		20.016	21.949	12.09	15.50	-621.82	787.22
		21.949	23.461	12.09	15.50	-621.82	787.22
		23.461	27.250	23.87	15.50	-1174.54	787.22
		27.250	28.000	23.87	15.50	-1174.54	787.22
	Middle	0.000	0.750	17.67	17.67	-935.88	935.88
		0.750	5.581	17.67	17.67	-935.88	935.88
		5.581	6.581	0.00	17.67	0.00	935.88
		6.581	10.025	0.00	17.67	0.00	935.88
		10.025	14.000	0.00	17.67	0.00	935.88
		14.000	17.975	0.00	17.67	0.00	935.88
		17.975	19.499	0.00	17.67	0.00	935.88
		19.499	20.499	0.00	17.67	0.00	935.88
		20.499	27.250	17.67	17.67	-935.88	935.88
		27.250	28.000	17.67	17.67	-935.88	935.88
2	Column	0.000	0.750	23.87	8.99	-1174.54	467.65
		0.750	4.496	23.87	8.99	-1174.54	467.65
		4.496	6.051	12.09	8.99	-621.82	467.65
		6.051	8.801	12.09	8.99	-621.82	467.65
		8.801	10.025	0.00	8.99	0.00	467.65
		10.025	10.356	0.00	8.99	0.00	467.65
		10.356	14.000	0.00	8.99	0.00	467.65
		14.000	17.975	0.00	8.99	0.00	467.65
		17.975	18.505	0.00	8.99	0.00	467.65
		18.505	19.505	0.00	8.99	0.00	467.65
		19.505	27.250	4.03	8.99	-213.42	467.65
		27.250	28.000	4.03	8.99	-213.42	467.65
	Middle	0.000	0.750	17.67	17.67	-935.88	935.88
		0.750	9.356	17.67	17.67	-935.88	935.88
		9.356	10.025	0.00	17.67	0.00	935.88
		10.025	10.356	0.00	17.67	0.00	935.88
		10.356	14.000	0.00	17.67	0.00	935.88
		14.000	17.975	0.00	17.67	0.00	935.88
		17.975	21.419	0.00	17.67	0.00	935.88
		21.419	22.419	0.00	17.67	0.00	935.88
		22.419	27.250	17.67	17.67	-935.88	935.88
		27.250	28.000	17.67	17.67	-935.88	935.88

Slab Shear Capacity:

Units: b, d (in), Xu (ft), PhiVc, Vu(kip)

Span	b	d	Vratio	PhiVc	Vu	Xu
1	912.00	11.94	1.000	1154.74	326.44	26.26
2	912.00	11.94	1.000	1154.74	243.98	1.74

Flexural Transfer of Negative Unbalanced Moment at Supports:

Units: Width (in), Munb (k-ft), As (in^2)

Supp	Width	GammaF*Munb	Comb	Pat	AsReq	AsProv	Additional Bars
1	57.00	19.81	U1	All	0.370	1.367	---
2	57.00	17.53	U1	All	0.327	8.099	---
3	57.00	11.20	U1	Even	0.209	1.367	---

Punching Shear Around Columns:

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Units: Vu (kip), Munb (k-ft), vu (psi), Phi*vc (psi)

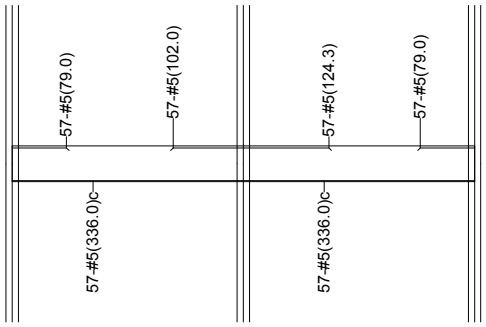
Supp	Vu	vu	Munb	Comb	Pat	GammaV	vu	Phi*vc	
1	237.39	339.5	-191.55	U1	All	0.320	747.6	212.1	*EXCEEDED
2	632.34	452.2	-29.21	U1	All	0.400	462.0	212.1	*EXCEEDED
3	152.72	218.4	125.51	U1	Even	0.320	485.8	212.1	*EXCEEDED

Maximum Deflections:
==========
Units: Dz (in)

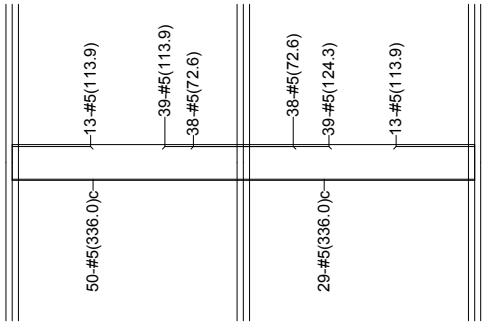
	Frame			Column Strip			Middle Strip		
Span	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)
1	-0.125	-0.049	-0.174	-0.500	-0.198	-0.696	-0.040	-0.016	-0.056
2	-0.095	0.016	-0.083	-0.382	0.065	-0.331	-0.031	0.005	-0.027

Material Takeoff:
==========
Reinforcement in the Direction of Analysis

Top Bars:	3448.1 lb	<=>	61.57 lb/ft	<=>	0.810 lb/ft^2
Bottom Bars:	5636.4 lb	<=>	100.65 lb/ft	<=>	1.324 lb/ft^2
Stirrups:	0.0 lb	<=>	0.00 lb/ft	<=>	0.000 lb/ft^2
Total Steel:	9084.5 lb	<=>	162.22 lb/ft	<=>	2.135 lb/ft^2
Concrete:	4610.7 ft^3	<=>	82.33 ft^3/ft	<=>	1.083 ft^3/ft^2



Middle Strip Flexural Reinforcement



Column Strip Flexural Reinforcement

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Project:

Frame: Engineer:

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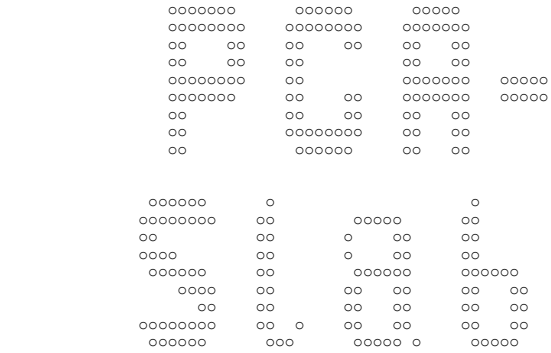

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[7] SEGMENTAL DEFLECTIONS

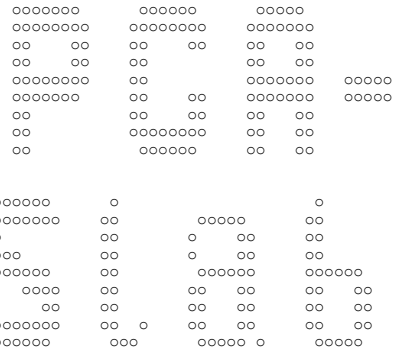
Units: x (ft), Dz (in)

Span	x	Dz (DEAD)	Dz (LIVE)	Dz (TOTAL)
1	0.000	-0.000	-0.000	-0.000
	0.250	-0.014	-0.008	-0.022
	0.500	-0.029	-0.015	-0.044
	0.750	-0.043	-0.023	-0.066
	0.750	-0.043	-0.023	-0.066
	1.115	-0.064	-0.034	-0.098
	1.480	-0.085	-0.045	-0.129
	1.845	-0.106	-0.056	-0.161
	2.210	-0.126	-0.067	-0.193
	2.575	-0.147	-0.077	-0.224
	2.940	-0.167	-0.088	-0.255
	3.305	-0.187	-0.099	-0.286
	3.670	-0.207	-0.109	-0.317
	4.035	-0.227	-0.120	-0.347
	4.400	-0.246	-0.130	-0.377
	4.765	-0.265	-0.141	-0.406
	5.130	-0.284	-0.151	-0.434
	5.495	-0.302	-0.160	-0.463
	5.860	-0.320	-0.170	-0.490
	6.225	-0.337	-0.180	-0.517
	6.590	-0.354	-0.189	-0.543
	6.955	-0.371	-0.198	-0.569
	7.320	-0.387	-0.207	-0.594
	7.685	-0.403	-0.215	-0.618
	8.050	-0.418	-0.224	-0.641
	8.415	-0.432	-0.232	-0.664
	8.780	-0.446	-0.239	-0.685
	9.145	-0.459	-0.247	-0.706
	9.510	-0.472	-0.254	-0.726
	9.875	-0.484	-0.261	-0.745
	10.240	-0.496	-0.267	-0.763
	10.605	-0.507	-0.274	-0.780
	10.970	-0.517	-0.280	-0.797
	11.335	-0.526	-0.285	-0.812
	11.700	-0.535	-0.291	-0.826

	12.065	-0.544	-0.296	-0.839
	12.430	-0.551	-0.300	-0.851
	12.795	-0.558	-0.304	-0.863
	13.160	-0.564	-0.308	-0.873
	13.525	-0.570	-0.312	-0.882
	13.890	-0.575	-0.315	-0.890
	14.255	-0.579	-0.318	-0.897
	14.620	-0.583	-0.320	-0.903
	14.985	-0.585	-0.323	-0.908
	15.350	-0.587	-0.324	-0.912
	15.715	-0.589	-0.326	-0.915
	16.080	-0.589	-0.327	-0.916
	16.445	-0.589	-0.328	-0.917
	16.810	-0.589	-0.328	-0.917
	17.175	-0.587	-0.328	-0.915
	17.540	-0.585	-0.328	-0.913
	17.905	-0.583	-0.327	-0.909
	18.270	-0.579	-0.326	-0.905
	18.635	-0.575	-0.324	-0.900
	19.000	-0.571	-0.323	-0.893
	19.365	-0.565	-0.320	-0.886
	19.730	-0.559	-0.318	-0.877
	20.095	-0.553	-0.315	-0.868
	20.460	-0.546	-0.312	-0.858
	20.825	-0.538	-0.309	-0.847
	21.190	-0.530	-0.305	-0.835
	21.555	-0.521	-0.301	-0.822
	21.920	-0.512	-0.297	-0.808
	22.285	-0.502	-0.292	-0.794
	22.650	-0.491	-0.287	-0.778
	23.015	-0.480	-0.282	-0.762
	23.380	-0.469	-0.276	-0.745
	23.745	-0.457	-0.271	-0.728
	24.110	-0.445	-0.265	-0.710
	24.475	-0.433	-0.258	-0.691
	24.840	-0.420	-0.252	-0.672
	25.205	-0.407	-0.245	-0.652
	25.570	-0.393	-0.239	-0.632
	25.935	-0.379	-0.232	-0.611
	26.300	-0.365	-0.224	-0.590
	26.665	-0.351	-0.217	-0.568
	27.030	-0.337	-0.209	-0.546
	27.395	-0.322	-0.202	-0.524
	27.760	-0.307	-0.194	-0.501
	28.125	-0.292	-0.186	-0.479
	28.490	-0.277	-0.178	-0.456
	28.855	-0.262	-0.170	-0.433
	29.220	-0.248	-0.162	-0.410
	29.585	-0.233	-0.154	-0.387
	29.950	-0.218	-0.146	-0.364
	30.315	-0.203	-0.138	-0.341
	30.680	-0.189	-0.129	-0.318
	31.045	-0.174	-0.121	-0.296
	31.410	-0.160	-0.113	-0.273
	31.775	-0.146	-0.105	-0.252
	32.140	-0.133	-0.097	-0.230
	32.505	-0.120	-0.090	-0.209
	32.870	-0.107	-0.082	-0.189
	33.235	-0.095	-0.074	-0.169
	33.600	-0.083	-0.067	-0.150
	33.965	-0.072	-0.060	-0.132
	34.330	-0.062	-0.053	-0.114
	34.695	-0.052	-0.046	-0.098
	35.060	-0.042	-0.040	-0.082
	35.425	-0.034	-0.034	-0.068
	35.790	-0.026	-0.028	-0.054
	36.155	-0.020	-0.022	-0.042
	36.520	-0.014	-0.017	-0.031
	36.885	-0.009	-0.013	-0.022
	37.250	-0.005	-0.008	-0.013
	37.250	-0.005	-0.008	-0.013
	37.500	-0.003	-0.005	-0.009
	37.750	-0.001	-0.003	-0.004
	38.000	-0.000	-0.000	-0.000
2	0.000	-0.000	-0.000	-0.000
	0.250	0.001	0.003	0.004
	0.500	0.002	0.005	0.007
	0.750	0.002	0.008	0.010
	0.750	0.002	0.008	0.010
	1.115	0.002	0.011	0.014
	1.480	0.002	0.015	0.017
	1.845	-0.000	0.019	0.018
	2.210	-0.002	0.022	0.020
	2.575	-0.006	0.025	0.020
	2.940	-0.009	0.029	0.019
	3.305	-0.014	0.032	0.018

3.670	-0.019	0.035	0.016
4.035	-0.024	0.038	0.014
4.400	-0.030	0.041	0.011
4.765	-0.037	0.044	0.007
5.130	-0.044	0.047	0.003
5.495	-0.051	0.049	-0.002
5.860	-0.059	0.052	-0.007
6.225	-0.067	0.055	-0.012
6.590	-0.075	0.057	-0.018
6.955	-0.084	0.060	-0.024
7.320	-0.093	0.062	-0.031
7.685	-0.102	0.064	-0.038
8.050	-0.111	0.066	-0.045
8.415	-0.121	0.068	-0.052
8.780	-0.130	0.070	-0.060
9.145	-0.140	0.072	-0.068
9.510	-0.150	0.074	-0.076
9.875	-0.160	0.076	-0.084
10.240	-0.170	0.078	-0.092
10.605	-0.179	0.079	-0.100
10.970	-0.189	0.081	-0.109
11.335	-0.199	0.082	-0.117
11.700	-0.209	0.083	-0.125
12.065	-0.218	0.085	-0.134
12.430	-0.228	0.086	-0.142
12.795	-0.237	0.087	-0.150
13.160	-0.246	0.088	-0.158
13.525	-0.255	0.089	-0.166
13.890	-0.264	0.090	-0.174
14.255	-0.273	0.090	-0.182
14.620	-0.281	0.091	-0.190
14.985	-0.289	0.092	-0.197
15.350	-0.297	0.092	-0.205
15.715	-0.304	0.093	-0.212
16.080	-0.311	0.093	-0.218
16.445	-0.318	0.093	-0.225
16.810	-0.325	0.093	-0.231
17.175	-0.331	0.093	-0.237
17.540	-0.337	0.093	-0.243
17.905	-0.342	0.093	-0.249
18.270	-0.347	0.093	-0.254
18.635	-0.352	0.093	-0.259
19.000	-0.356	0.093	-0.263
19.365	-0.360	0.092	-0.267
19.730	-0.363	0.092	-0.271
20.095	-0.366	0.091	-0.275
20.460	-0.369	0.091	-0.278
20.825	-0.371	0.090	-0.281
21.190	-0.372	0.089	-0.283
21.555	-0.374	0.089	-0.285
21.920	-0.374	0.088	-0.287
22.285	-0.375	0.087	-0.288
22.650	-0.374	0.086	-0.289
23.015	-0.374	0.085	-0.289
23.380	-0.373	0.084	-0.289
23.745	-0.371	0.082	-0.289
24.110	-0.369	0.081	-0.288
24.475	-0.366	0.080	-0.287
24.840	-0.363	0.078	-0.285
25.205	-0.360	0.077	-0.283
25.570	-0.356	0.075	-0.280
25.935	-0.351	0.074	-0.278
26.300	-0.346	0.072	-0.274
26.665	-0.341	0.070	-0.271
27.030	-0.335	0.069	-0.266
27.395	-0.329	0.067	-0.262
27.760	-0.322	0.065	-0.257
28.125	-0.315	0.063	-0.252
28.490	-0.307	0.061	-0.246
28.855	-0.299	0.059	-0.240
29.220	-0.291	0.057	-0.234
29.585	-0.282	0.055	-0.227
29.950	-0.273	0.053	-0.220
30.315	-0.263	0.051	-0.212
30.680	-0.253	0.049	-0.205
31.045	-0.243	0.046	-0.197
31.410	-0.232	0.044	-0.188
31.775	-0.221	0.042	-0.180
32.140	-0.210	0.040	-0.171
32.505	-0.199	0.037	-0.161
32.870	-0.187	0.035	-0.152
33.235	-0.175	0.033	-0.142
33.600	-0.162	0.030	-0.132
33.965	-0.150	0.028	-0.122
34.330	-0.137	0.025	-0.111
34.695	-0.124	0.023	-0.101
35.060	-0.110	0.020	-0.090

35.425	-0.097	0.018	-0.079
35.790	-0.083	0.015	-0.068
36.155	-0.070	0.013	-0.057
36.520	-0.056	0.010	-0.046
36.885	-0.042	0.008	-0.035
37.250	-0.028	0.005	-0.023
37.250	-0.028	0.005	-0.023
37.500	-0.019	0.003	-0.016
37.750	-0.009	0.002	-0.008
38.000	-0.000	0.000	-0.000



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                          pcaSlab v1.51 (TM)
        A Computer Program Analysis, Design, and Investigation of
          Reinforced Concrete Slab and Continuous Beam Systems
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[2] DESIGN RESULTS

Top Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Zone	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	Left	19.00	0.00	0.750	5.335	57.837	12.667	0.000	18-#5
		Middle	19.00	0.00	19.000	0.000	57.837	0.000	0.000	---
		Right	19.00	1623.72	37.250	5.335	57.837	2.131	33.061	107-#5
	Middle	Left	37.00	0.00	0.750	10.390	112.630	13.059	0.000	34-#5
		Middle	37.00	0.00	19.000	0.000	112.630	0.000	0.000	---
		Right	37.00	541.26	37.250	10.390	112.630	13.059	10.215	34-#5
2	Column	Left	19.00	1607.64	0.750	5.335	57.837	2.131	32.700	107-#5
		Middle	19.00	0.00	19.000	0.000	57.837	0.000	0.000	---
		Right	19.00	0.00	37.250	5.335	57.837	12.667	0.000	18-#5
	Middle	Left	37.00	535.90	0.750	10.390	112.630	13.059	10.112	34-#5
		Middle	37.00	0.00	19.000	0.000	112.630	0.000	0.000	---
		Right	37.00	0.00	37.250	10.390	112.630	13.059	0.000	34-#5

Top Bar Details:

Units: Length (ft)

		Left		Continuous		Right	
Span	Strip	Bars	Length	Bars	Length	Bars	Length
1	Column	18-#5	12.80	---		54-#5	12.80
	Middle	34-#5	8.78	---		34-#5	11.43
2	Column	54-#5	13.98	53-#5	8.05	18-#5	12.80
	Middle	34-#5	13.98	---		34-#5	8.78

Bottom Reinforcement:

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Strip	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars

1	Column	19.00	1029.03	14.985	5.335	57.837	3.455	20.216	66-#5
	Middle	37.00	686.02	14.985	10.390	112.630	10.571	12.996	42-#5
2	Column	19.00	625.56	23.745	5.335	57.837	5.846	12.020	39-#5
	Middle	37.00	417.04	23.745	10.390	112.630	13.059	7.845	34-#5

Bottom Bar Details:

Units: Start (ft), Length (ft)

		Long Bars			Short Bars		
Span	Strip	Bars	Start	Length	Bars	Start	Length
1	Column	66-#5	0.00	38.00	---		
	Middle	34-#5	0.00	38.00	8-#5	5.70	26.60
2	Column	39-#5	0.00	38.00	---		
	Middle	34-#5	0.00	38.00	---		

Flexural Capacity:

Units: From, To (ft), As (in^2), PhiMn (k-ft)

Span	Strip	From	To	AsTop	AsBot	PhiMn-	PhiMn+
1	Column	0.000	0.750	5.58	20.46	-295.41	1040.77
		0.750	11.795	5.58	20.46	-295.41	1040.77
		11.795	12.795	0.00	20.46	0.00	1040.77
		12.795	13.525	0.00	20.46	0.00	1040.77
		13.525	19.000	0.00	20.46	0.00	1040.77
		19.000	24.475	0.00	20.46	0.00	1040.77
		24.475	25.205	0.00	20.46	0.00	1040.77
		25.205	26.759	0.00	20.46	0.00	1040.77
		26.759	29.949	16.74	20.46	-860.21	1040.77
		29.949	31.504	16.74	20.46	-860.21	1040.77
		31.504	37.250	33.17	20.46	-1628.57	1040.77
		37.250	38.000	33.17	20.46	-1628.57	1040.77
	Middle	0.000	0.750	10.54	10.54	-558.25	558.25
		0.750	5.700	10.54	10.54	-558.25	558.25
		5.700	7.257	10.54	10.54	-558.25	558.25
		7.257	7.781	10.54	13.02	-558.25	687.29
		7.781	8.781	0.00	13.02	0.00	687.29
		8.781	13.525	0.00	13.02	0.00	687.29
		13.525	19.000	0.00	13.02	0.00	687.29
		19.000	24.475	0.00	13.02	0.00	687.29
		24.475	26.574	0.00	13.02	0.00	687.29
		26.574	28.086	0.00	13.02	0.00	687.29
		28.086	30.743	10.54	13.02	-558.25	687.29
		30.743	32.300	10.54	10.54	-558.25	558.25
		32.300	37.250	10.54	10.54	-558.25	558.25
		37.250	38.000	10.54	10.54	-558.25	558.25
2	Column	0.000	0.750	33.17	12.09	-1628.57	629.10
		0.750	6.513	33.17	12.09	-1628.57	629.10
		6.513	8.051	16.74	12.09	-860.21	629.10
		8.051	12.443	16.74	12.09	-860.21	629.10
		12.443	13.525	0.00	12.09	0.00	629.10
		13.525	13.981	0.00	12.09	0.00	629.10
		13.981	19.000	0.00	12.09	0.00	629.10
		19.000	24.475	0.00	12.09	0.00	629.10
		24.475	25.205	0.00	12.09	0.00	629.10
		25.205	26.205	0.00	12.09	0.00	629.10
		26.205	37.250	5.58	12.09	-295.41	629.10
		37.250	38.000	5.58	12.09	-295.41	629.10
	Middle	0.000	0.750	10.54	10.54	-558.25	558.25
		0.750	12.485	10.54	10.54	-558.25	558.25
		12.485	13.525	0.00	10.54	0.00	558.25
		13.525	13.981	0.00	10.54	0.00	558.25
		13.981	19.000	0.00	10.54	0.00	558.25
		19.000	24.475	0.00	10.54	0.00	558.25
		24.475	29.219	0.00	10.54	0.00	558.25
		29.219	30.219	0.00	10.54	0.00	558.25
		30.219	37.250	10.54	10.54	-558.25	558.25
		37.250	38.000	10.54	10.54	-558.25	558.25

Slab Shear Capacity:

Units: b, d (in), Xu (ft), PhiVc, Vu(kip)

Span	b	d	Vratio	PhiVc	Vu	Xu
1	672.00	11.94	1.000	850.86	334.93	36.26
2	672.00	11.94	1.000	850.86	248.80	1.74

Flexural Transfer of Negative Unbalanced Moment at Supports:

Units: Width (in), Munb (k-ft), As (in^2)

Supp	Width	GammaF*Munb	Comb	Pat	AsReq	AsProv	Additional Bars
1	57.00	65.71	U1	All	1.239	1.395	---

2	57.00	54.65 U1	All	1.028	8.293	---	
3	57.00	37.71 U1	Even	0.707	1.395	---	

Punching Shear Around Columns:

Units: Vu (kip), Munb (k-ft), vu (psi), Phi*vc (psi)

Supp	Vu	vu	Munb	Comb	Pat	GammaV	vu	Phi*vc	
1	238.77	341.5	-125.30	U1	All	0.320	608.4	212.1	*EXCEEDED
2	628.97	449.8	-91.09	U1	All	0.400	480.2	212.1	*EXCEEDED
3	154.26	220.7	87.94	U1	Even	0.320	408.0	212.1	*EXCEEDED

Maximum Deflections:

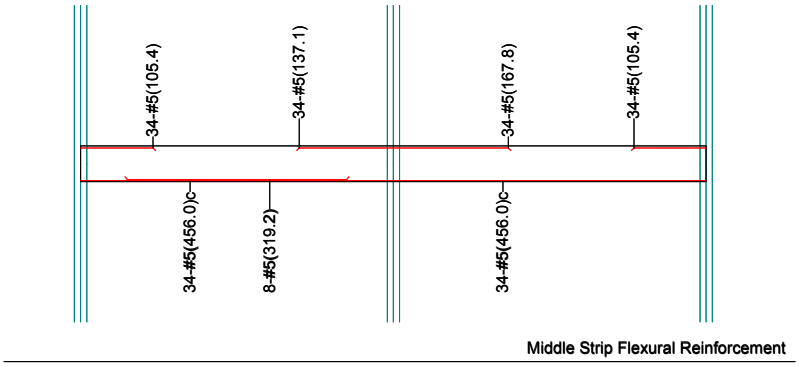
Units: Dz (in)

	Frame			Column Strip			Middle Strip		
Span	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)	Dz(DEAD)	Dz(LIVE)	Dz(TOTAL)
1	-0.589	-0.328	-0.917	-1.281	-0.713	-1.993	-0.234	-0.130	-0.364
2	-0.375	0.093	-0.289	-0.814	0.203	-0.628	-0.149	0.037	-0.115

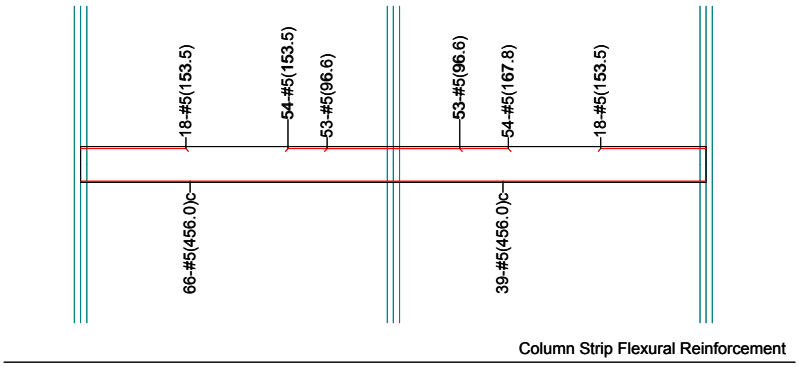
Material Takeoff:

Reinforcement in the Direction of Analysis

Top Bars:	4402.3 lb	<=>	57.93 lb/ft	<=>	1.034 lb/ft^2	
Bottom Bars:	7078.6 lb	<=>	93.14 lb/ft	<=>	1.663 lb/ft^2	
Stirrups:	0.0 lb	<=>	0.00 lb/ft	<=>	0.000 lb/ft^2	
Total Steel:	11481.0 lb	<=>	151.07 lb/ft	<=>	2.698 lb/ft^2	
Concrete:	4610.7 ft^3	<=>	60.67 ft^3/ft	<=>	1.083 ft^3/ft^2	



Middle Strip Flexural Reinforcement



Column Strip Flexural Reinforcement

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Project:

Frame: Engineer:

Appendix C: Composite Steel Beam and Deck Calculations

Gravity Beam Design

RAM Steel v12.1
DataBase: composite steel
Building Code: IBC

10/26/09 17:25:24
Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 2**

SPAN INFORMATION (ft): I-End (0.00,38.00) J-End (0.00,76.00)

Beam Size (Optimum) = W18X40 Fy = 50.0 ksi
Total Beam Length (ft) = 38.00

COMPOSITE PROPERTIES (Not Shored):

		Left			**Right**
Concrete thickness (in)		2.00			2.00
Unit weight concrete (pcf)		145.00			145.00
f'c (ksi)		5.00			5.00
Decking Orientation		parallel			parallel
Decking type		VULCRAFT 2.0VL			VULCRAFT 2.0VL
beff (in)	= 61.00	Y bar(in)		=	16.03
Mnf (kip-ft)	= 569.32	Mn (kip-ft)		=	465.56
C (kips)	= 164.52	PNA (in)		=	14.17
Ieff (in4)	= 1177.39	Itr (in4)		=	1615.71
Stud length (in)	= 3.50	Stud diam (in)		=	0.63

Stud Capacity (kips) Qn = 15.0 Rg = 1.00 Rp = 0.75
# of studs per stud segment: Full = 34,4,34
Partial = 9,4,9
Actual = 9,4,9
Number of Stud Rows = 1 Percent of Full Composite Action = 26.82

POINT LOADS (kips):

Dist	DL	CDL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%	CLL
12.667	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00
25.333	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.013	0.013	0.000	---	NonR	0.000
	38.000	0.013	0.013	0.000			0.000
2	0.000	0.007	0.000	0.013	---	NonR	0.000
	38.000	0.007	0.000	0.013			0.000
3	0.000	0.040	0.040	0.000	---	NonR	0.000
	38.000	0.040	0.040	0.000			0.000

SHEAR: Max Va (DL+LL) = 19.05 kips Vn/1.50 = 112.77 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	98.5	19.0	12.7	1.00	1.67	123.29
	Init DL	DL	98.5	19.0	---	---		
	Max +	DL+LL	236.9	19.0	---	---	1.67	278.78
Controlling		DL+LL	236.9	19.0	---	---	1.67	278.78

REACTIONS (kips):

Gravity Beam Design

	Left	Right
Initial reaction	8.03	8.03
DL reaction	11.70	11.70
Max +LL reaction	7.35	7.35
Max +total reaction (factored)	19.05	19.05

DEFLECTIONS: (Camber = 1)

Initial load (in)	at	19.00 ft	=	-1.472	L/D =	310
Live load (in)	at	19.00 ft	=	-0.717	L/D =	636
Post Comp load (in)	at	19.00 ft	=	-1.076	L/D =	424
Net Total load (in)	at	19.00 ft	=	-1.548	L/D =	295

Gravity Beam Design

RAM Steel v12.1
DataBase: composite steel
Building Code: IBC

Page 3/12
10/26/09 17:25:24
Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 11**

SPAN INFORMATION (ft): I-End (0.00,38.00) J-End (28.00,38.00)

Beam Size (Optimum) = W14X22 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

		Left			**Right**
Concrete thickness (in)		2.00			2.00
Unit weight concrete (pcf)		145.00			145.00
f'c (ksi)		5.00			5.00
Decking Orientation		perpendicular			perpendicular
Decking type		VULCRAFT 2.0VL			VULCRAFT 2.0VL
beff (in)	= 84.00	Y bar(in)		=	14.58
Mnf (kip-ft)	= 281.11	Mn (kip-ft)		=	206.82
C (kips)	= 95.72	PNA (in)		=	11.01
Ieff (in4)	= 471.51	Itr (in4)		=	700.74
Stud length (in)	= 3.50	Stud diam (in)		=	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
# of studs: Max = 28 Partial = 16 Actual = 16
Number of Stud Rows = 1 Percent of Full Composite Action = 29.50

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.480	0.480	0.000	---	NonR	0.000
	28.000	0.480	0.480	0.000			0.000
2	0.000	0.253	0.000	0.507	---	NonR	0.000
	28.000	0.253	0.000	0.507			0.000
3	0.000	0.022	0.022	0.000	---	NonR	0.000
	28.000	0.022	0.022	0.000			0.000

SHEAR: Max Va (DL+LL) = 17.66 kips Vn/1.50 = 63.02 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	49.2	14.0	0.0	1.00	1.67	82.83
	Init DL	DL	49.2	14.0	---	---		
	Max +	DL+LL	123.7	14.0	---	---	1.67	123.84
Controlling		DL+LL	123.7	14.0	---	---	1.67	123.84

REACTIONS (kips):

	Left	**Right**
Initial reaction	7.02	7.02
DL reaction	10.57	10.57
Max +LL reaction	7.09	7.09
Max +total reaction (factored)	17.66	17.66

DEFLECTIONS: (Camber = 3/4)

Initial load (in) at 14.00 ft = -1.202 L/D = 279

Gravity Beam Design

Live load (in)	at	14.00 ft	=	-0.512	L/D	= 656
Post Comp load (in)	at	14.00 ft	=	-0.769	L/D	= 437
Net Total load (in)	at	14.00 ft	=	-1.221	L/D	= 275

Gravity Beam Design

RAM Steel v12.1
DataBase: composite steel
Building Code: IBC

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Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 52**

SPAN INFORMATION (ft): I-End (0.00,50.67) J-End (28.00,50.67)

Beam Size (Optimum) = W14X22 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

		Left			Right
Concrete thickness (in)		2.00			2.00
Unit weight concrete (pcf)		145.00			145.00
f'c (ksi)		5.00			5.00
Decking Orientation		perpendicular			perpendicular
Decking type		VULCRAFT 2.0VL			VULCRAFT 2.0VL
beff (in)	= 84.00	Y bar(in)		=	14.58
Mnf (kip-ft)	= 281.11	Mn (kip-ft)		=	206.82
C (kips)	= 95.72	PNA (in)		=	11.01
Ieff (in4)	= 471.51	Itr (in4)		=	700.74
Stud length (in)	= 3.50	Stud diam (in)		=	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
# of studs: Max = 28 Partial = 16 Actual = 16
Number of Stud Rows = 1 Percent of Full Composite Action = 29.50

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.480	0.480	0.000	---	NonR	0.000
	28.000	0.480	0.480	0.000			0.000
2	0.000	0.253	0.000	0.507	---	NonR	0.000
	28.000	0.253	0.000	0.507			0.000
3	0.000	0.022	0.022	0.000	---	NonR	0.000
	28.000	0.022	0.022	0.000			0.000

SHEAR: Max Va (DL+LL) = 17.66 kips Vn/1.50 = 63.02 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	49.2	14.0	0.0	1.00	1.67	82.83
	Init DL	DL	49.2	14.0	---	---		
	Max +	DL+LL	123.7	14.0	---	---	1.67	123.84
Controlling		DL+LL	123.7	14.0	---	---	1.67	123.84

REACTIONS (kips):

	Left	Right
Initial reaction	7.02	7.02
DL reaction	10.57	10.57
Max +LL reaction	7.09	7.09
Max +total reaction (factored)	17.66	17.66

DEFLECTIONS: (Camber = 3/4)

Initial load (in) at 14.00 ft = -1.202 L/D = 279

Gravity Beam Design

Live load (in)	at	14.00 ft	=	-0.512	L/D	= 656
Post Comp load (in)	at	14.00 ft	=	-0.769	L/D	= 437
Net Total load (in)	at	14.00 ft	=	-1.221	L/D	= 275

Gravity Beam Design

RAM Steel v12.1
DataBase: composite steel
Building Code: IBC

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Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 53**

SPAN INFORMATION (ft): I-End (0.00,63.33) J-End (28.00,63.33)

Beam Size (Optimum) = W14X22 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

		Left			Right
Concrete thickness (in)		2.00			2.00
Unit weight concrete (pcf)		145.00			145.00
f'c (ksi)		5.00			5.00
Decking Orientation		perpendicular			perpendicular
Decking type		VULCRAFT 2.0VL			VULCRAFT 2.0VL
beff (in)	= 84.00	Y bar(in)		=	14.58
Mnf (kip-ft)	= 281.11	Mn (kip-ft)		=	206.82
C (kips)	= 95.72	PNA (in)		=	11.01
Ieff (in4)	= 471.51	Itr (in4)		=	700.74
Stud length (in)	= 3.50	Stud diam (in)		=	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
# of studs: Max = 28 Partial = 16 Actual = 16
Number of Stud Rows = 1 Percent of Full Composite Action = 29.50

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.480	0.480	0.000	---	NonR	0.000
	28.000	0.480	0.480	0.000			0.000
2	0.000	0.253	0.000	0.507	---	NonR	0.000
	28.000	0.253	0.000	0.507			0.000
3	0.000	0.022	0.022	0.000	---	NonR	0.000
	28.000	0.022	0.022	0.000			0.000

SHEAR: Max Va (DL+LL) = 17.66 kips Vn/1.50 = 63.02 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	49.2	14.0	0.0	1.00	1.67	82.83
	Init DL	DL	49.2	14.0	---	---		
	Max +	DL+LL	123.7	14.0	---	---	1.67	123.84
Controlling		DL+LL	123.7	14.0	---	---	1.67	123.84

REACTIONS (kips):

	Left	Right
Initial reaction	7.02	7.02
DL reaction	10.57	10.57
Max +LL reaction	7.09	7.09
Max +total reaction (factored)	17.66	17.66

DEFLECTIONS: (Camber = 3/4)

Initial load (in) at 14.00 ft = -1.202 L/D = 279

Gravity Beam Design

Live load (in)	at	14.00 ft	=	-0.512	L/D	= 656
Post Comp load (in)	at	14.00 ft	=	-0.769	L/D	= 437
Net Total load (in)	at	14.00 ft	=	-1.221	L/D	= 275

Gravity Beam Design

Floor Type: plan **Beam Number = 13**

SPAN INFORMATION (ft): I-End (0.00,76.00) J-End (28.00,76.00)

Beam Size (Optimum) = W12X14 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

		Left			**Right**
Concrete thickness (in)		2.00			2.00
Unit weight concrete (pcf)		145.00			145.00
f'c (ksi)		5.00			5.00
Decking Orientation		perpendicular			perpendicular
Decking type		VULCRAFT 2.0VL			VULCRAFT 2.0VL
beff (in)	= 46.00	Y bar(in)		=	12.72
Mnf (kip-ft)	= 163.25	Mn (kip-ft)		=	114.18
C (kips)	= 59.83	PNA (in)		=	8.94
Ieff (in4)	= 226.11	Itr (in4)		=	345.00
Stud length (in)	= 3.50	Stud diam (in)		=	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
# of studs: Max = 28 Partial = 10 Actual = 10
Number of Stud Rows = 1 Percent of Full Composite Action = 28.76

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.013	0.013	0.000	---	NonR	0.000
	28.000	0.013	0.013	0.000			0.000
2	0.000	0.007	0.000	0.013	---	NonR	0.000
	28.000	0.007	0.000	0.013			0.000
3	0.000	0.240	0.240	0.000	---	NonR	0.000
	28.000	0.240	0.240	0.000			0.000
4	0.000	0.127	0.000	0.253	---	NonR	0.000
	28.000	0.127	0.000	0.253			0.000
5	0.000	0.014	0.014	0.000	---	NonR	0.000
	28.000	0.014	0.014	0.000			0.000

SHEAR: Max Va (DL+LL) = 9.33 kips Vn/1.67 = 42.75 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	26.1	14.0	0.0	1.00	1.67	43.41
	Init DL	DL	26.1	14.0	---	---		
	Max +	DL+LL	65.3	14.0	---	---	1.67	68.37
Controlling		DL+LL	65.3	14.0	---	---	1.67	68.37

REACTIONS (kips):

	Left	**Right**
Initial reaction	3.73	3.73
DL reaction	5.60	5.60

Gravity Beam Design

	Left	Right
Max +LL reaction	3.73	3.73
Max +total reaction (factored)	9.33	9.33

DEFLECTIONS: (Camber = 1)

Initial load (in)	at	14.00 ft	=	-1.435	L/D =	234
Live load (in)	at	14.00 ft	=	-0.562	L/D =	597
Post Comp load (in)	at	14.00 ft	=	-0.844	L/D =	398
Net Total load (in)	at	14.00 ft	=	-1.279	L/D =	263

Gravity Beam Design

RAM Steel v12.1
DataBase: composite steel
Building Code: IBC

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Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 4**

SPAN INFORMATION (ft): I-End (28.00,38.00) J-End (28.00,76.00)

Beam Size (Optimum) = W24X55 Fy = 50.0 ksi
Total Beam Length (ft) = 38.00

COMPOSITE PROPERTIES (Not Shored):

	Left	Right
Concrete thickness (in)	2.00	2.00
Unit weight concrete (pcf)	145.00	145.00
f'c (ksi)	5.00	5.00
Decking Orientation	parallel	parallel
Decking type	VULCRAFT 2.0VL	VULCRAFT 2.0VL

beff (in)	=	114.00	Y bar(in)	=	21.63
Mnf (kip-ft)	=	1010.08	Mn (kip-ft)	=	809.85
C (kips)	=	239.30	PNA (in)	=	17.86
Ieff (in4)	=	2636.71	Itr (in4)	=	3717.29
Stud length (in)	=	3.50	Stud diam (in)	=	0.63

Stud Capacity (kips) Qn = 15.0 Rg = 1.00 Rp = 0.75
# of studs per stud segment: Full = 54,2,54
Partial = 14,4,14
Actual = 14,4,14
Number of Stud Rows = 1 Percent of Full Composite Action = 26.11

POINT LOADS (kips):

Dist	DL	CDL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%	CLL
12.667	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00
12.667	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00
25.333	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00
25.333	10.57	7.02	0.00	0.0	7.09	0.00	0.0	0.00	Snow	0.00

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.055	0.055	0.000	---	NonR	0.000
	38.000	0.055	0.055	0.000			0.000

SHEAR: Max Va (DL+LL) = 36.38 kips Vn/1.67 = 167.46 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	187.9	19.0	12.7	1.00	1.67	217.39
	Init DL	DL	187.9	19.0	---	---		
	Max +	DL+LL	457.4	19.0	---	---	1.67	484.94
Controlling		DL+LL	457.4	19.0	---	---	1.67	484.94

REACTIONS (kips):

	Left	Right
Initial reaction	15.10	15.10
DL reaction	22.19	22.19

Gravity Beam Design

	Left	Right
Max +LL reaction	14.19	14.19
Max +total reaction (factored)	36.38	36.38

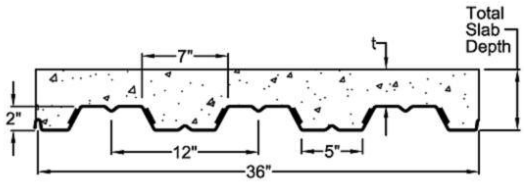
DEFLECTIONS: (Camber = 1)

Initial load (in)	at	19.00 ft	=	-1.274	L/D =	358
Live load (in)	at	19.00 ft	=	-0.624	L/D =	730
Post Comp load (in)	at	19.00 ft	=	-0.937	L/D =	487
Net Total load (in)	at	19.00 ft	=	-1.210	L/D =	377

VULCRAFT

2 VLI

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0
ICBO Approved (No. 3415)



Interlocking side lap is not drawn to show actual detail.

STEEL SECTION PROPERTIES

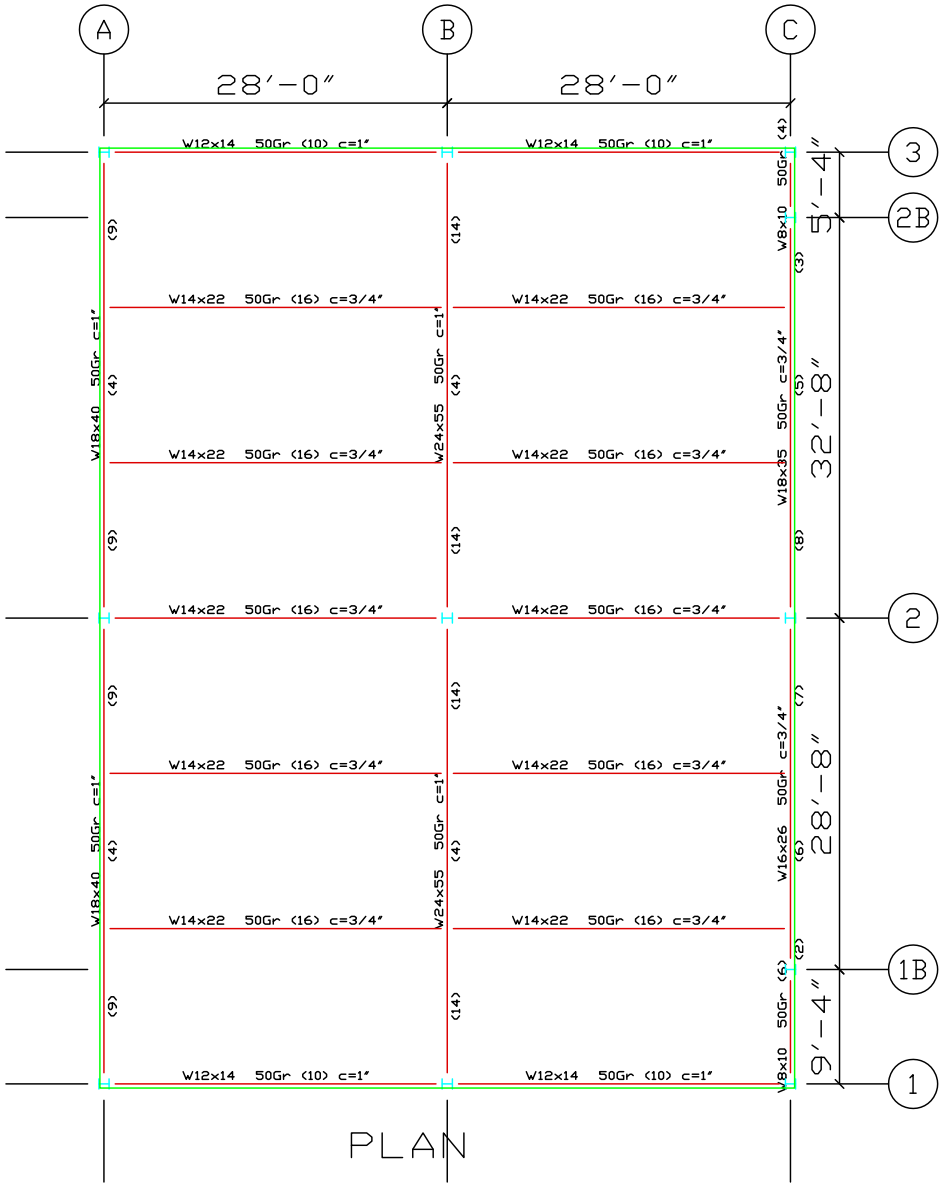
Deck Type	Design Thickness in	Deck Weight psf	Section Properties I_p in^4/ft	S_p in^3/ft	I_n in^4/ft	S_n in^3/ft	V_a lbs/ft	F_y ksi
2VLI22	0.0295	1.62	0.324	0.263	0.321	0.266	1832	50
2VLI20	0.0358	1.97	0.409	0.341	0.406	0.346	2698	50
2VLI19	0.0418	2.30	0.492	0.420	0.489	0.426	3190	50
2VLI18	0.0474	2.61	0.559	0.495	0.558	0.504	3608	50
2VLI16	0.0598	3.29	0.704	0.653	0.704	0.653	3618	40

(N=9.35) NORMAL WEIGHT CONCRETE (145 PCF)

COMPOSITE

TOTAL SLAB DEPTH	DECK TYPE	SDI Max. Unshored Clear Span 1 SPAN	2 SPAN	3 SPAN	Superimposed Live Load, PSF Clear Span (ft.-in.) 5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0	10'-6	11'-0	11'-6	12'-0	12'-6
	2VLI22	7'-4	9'-6	9'-9	274	239	211	188	145	129	115	104	94	85	78	71	65	59	54
4.00	2VLI20	8'-7	10'-10	11'-2	310	269	236	210	188	170	155	117	106	96	87	80	73	67	61
(t=2.00)	2VLI19	9'-9	11'-11	[illegible]	344	298	261	231	207	186	169	155	142	106	97	88	81	74	68
39 PSF	2VLI18	10'-9	12'-9	12'-9	373	324	285	253	228	206	188	172	159	147	137	103	95	87	81
	2VLI16	11'-1	13'-2	[illegible]	400	376	330	292	261	235	214	195	180	166	154	143	109	100	93
	2VLI22	6'-11	9'-0	9'-4	319	278	245	190	168	150	134	121	109	99	90	83	76	69	63
4.50	2VLI20	8'-2	10'-3	10'-7	361	313	275	244	219	198	152	136	123	112	102	93	85	78	72
(t=2.50)	2VLI19	9'-2	11'-5	11'-9	400	346	303	268	240	216	196	180	136	124	113	103	94	86	79
45 PSF	2VLI18	10'-2	12'-4	12'-4	400	376	331	295	264	239	218	200	184	171	130	119	110	102	94
	2VLI16	10'-5	12'-6	12'-11	400	400	383	339	303	274	248	227	209	193	150	137	126	117	108
	2VLI22	6'-7	8'-7	8'-11	364	317	279	217	192	171	153	138	125	113	103	94	86	79	72
5.00	2VLI20	7'-9	9'-10	10'-2	400	356	313	278	249	193	173	156	141	128	116	106	97	89	82
(t=3.00)	2VLI19	8'-9	10'-11	11'-3	400	394	345	306	273	247	224	172	156	141	128	117	107	99	91
51 PSF	2VLI18	9'-7	11'-10	11'-11	400	400	377	336	301	273	249	228	210	162	148	136	126	116	107
	2VLI16	9'-11	12'-0	12'-4	400	400	400	386	346	312	283	259	238	187	171	157	144	133	123
	2VLI22	6'-4	8'-0	8'-6	400	355	278	244	216	192	172	155	140	127	116	106	97	89	81
5.50	2VLI20	7'-5	9'-5	9'-9	400	400	351	312	244	217	194	175	158	143	131	119	109	100	92
(t=3.50)	2VLI19	8'-4	10'-5	10'-9	400	400	388	343	307	277	215	193	175	159	144	132	121	111	102
57 PSF	2VLI18	9'-2	11'-4	11'-7	400	400	400	377	338	306	279	256	199	182	167	153	141	130	121
	2VLI16	9'-5	11'-6	11'-10	400	400	400	400	388	350	318	290	230	210	192	176	162	150	138
	2VLI22	6'-1	7'-5	8'-2	400	394	308	270	239	213	191	172	156	141	129	118	108	99	90
6.00	2VLI20	7'-1	9'-1	9'-4	400	400	390	346	271	241	215	194	175	159	145	132	121	111	102
(t=4.00)	2VLI19	8'-0	10'-1	10'-5	400	400	400	381	340	307	239	215	194	176	160	146	134	123	113
63 PSF	2VLI18	8'-10	10'-11	11'-3	400	400	400	400	375	339	309	243	221	202	185	170	157	145	134
	2VLI16	9'-1	11'-1	11'-5	400	400	400	400	400	388	352	322	255	233	213	195	180	166	154
	2VLI22	5'-11	6'-11	7'-11	400	390	339	297	263	234	210	189	171	155	141	129	118	108	99
6.50	2VLI20	6'-11	8'-9	9'-0	400	400	400	337	297	264	237	213	193	175	159	145	133	122	112
(t=4.50)	2VLI19	7'-10	9'-8	10'-0	400	400	400	400	374	293	262	236	213	193	176	161	147	135	124
69 PSF	2VLI18	8'-7	10'-6	10'-11	400	400	400	400	400	373	340	268	243	222	203	187	172	159	147
	2VLI16	8'-10	10'-8	11'-0	400	400	400	400	400	400	387	309	280	256	234	215	198	183	169

Notes: 1. Minimum exterior bearing length required is 2.00 inches. Minimum interior bearing length required is 4.00 inches. If these minimum lengths are not provided, web crippling must be checked.
2. Always contact Vulcraft when using loads in excess of 200 psf. Such loads often result from concentrated, dynamic, or long term load cases for which reductions due to bond breakage, concrete creep, etc. should be evaluated.
3. All fire rated assemblies are subject to an upper live load limit of 250 psf.


A
B
C
28'-0"
28'-0"
W12x14 50Gr (10) c=1"
W14x22 50Gr (16) c=3/4"
W18x40 50Gr c=1"
W24x55 50Gr c=1"
W18x35 50Gr c=3/4"
W16x26 50Gr c=3/4"
W8x10 50Gr (6)
5'-4"
32'-8"
28'-8"
9'-4"
3
2B
2
1B
1
PLAN

Appendix D: Composite Steel Joist and Deck Calculations

Gravity Beam Design

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 71**

SPAN INFORMATION (ft): I-End (0.00,36.00) J-End (28.00,36.00)
Joist Size (Optimum) = 20K4
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.114	0.000	---	NonR
	28.000	0.114	0.000		
2	0.000	0.060	0.120	---	NonR
	28.000	0.060	0.120		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 293.6

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	173.6	
Live:	120.0	221.0
Total:	293.6	315.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	28.8	14.0

REACTIONS (kips):

	Left	Right
DL reaction	2.43	2.43
Max +LL reaction	1.68	1.68
Max +total reaction	4.11	4.11

DEFLECTIONS:

Dead load (in)	= 0.733	L/D	=	458
Live load (in)	= 0.507	L/D	=	663
Total load (in)	= 1.240	L/D	=	271

Gravity Beam Design

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Steel Code: AISC360-05 ASD

Floor Type: plan **Beam Number = 2**

SPAN INFORMATION (ft): I-End (0.00,38.00) J-End (0.00,76.00)
Beam Size (Optimum) = W18X35 Fy = 50.0 ksi
Total Beam Length (ft) = 38.00

COMPOSITE PROPERTIES (Not Shored):

	Left	Right
Concrete thickness (in)	2.00	2.00
Unit weight concrete (pcf)	145.00	145.00
f'c (ksi)	5.00	5.00
Decking Orientation	parallel	parallel
Decking type	VULCRAFT 2.0VL	VULCRAFT 2.0VL

beff (in)	= 61.00	Y bar(in)	=	16.25
Mnf (kip-ft)	= 508.85	Mn (kip-ft)	=	433.77
C (kips)	= 209.39	PNA (in)	=	15.83
Ieff (in4)	= 1089.71	Itr (in4)	=	1419.16
Stud length (in)	= 3.50	Stud diam (in)	=	0.63

Stud Capacity (kips) Qn = 15.0 Rg = 1.00 Rp = 0.75
\# of studs: Full = 75 Partial = 31 Actual = 31
Number of Stud Rows = 1 Percent of Full Composite Action = 40.66

POINT LOADS (kips):

Dist	DL	CDL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%	CLL
4.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
8.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
12.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
16.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
20.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
24.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
28.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
32.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
36.000	2.43	1.59	0.00	0.0	1.68	0.00	0.0	0.00	Snow	0.00

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.013	0.013	0.000	---	NonR	0.000
	38.000	0.013	0.013	0.000			0.000
2	0.000	0.007	0.000	0.013	---	NonR	0.000
	38.000	0.007	0.000	0.013			0.000
3	0.000	0.035	0.035	0.000	---	NonR	0.000
	38.000	0.035	0.035	0.000			0.000

SHEAR: Max Va (DL+LL) = 25.95 kips Vn/1.50 = 106.20 kips

MOMENTS:

Span	Cond	LoadCombo	Ma kip-ft	@ ft	Lb ft	Cb	Ω	Mn / Ω kip-ft
Center	PreCmp+	DL	104.0	20.0	4.0	1.01	1.67	165.92

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Span	Cond	LoadCombo	Ma	@	Lb	Cb	Ω	Mn / Ω
	Init DL	DL	104.0	20.0	---	---		
	Max +	DL+LL	258.8	20.0	---	---	1.67	259.74
Controlling		DL+LL	258.8	20.0	---	---	1.67	259.74

REACTIONS (kips):

	Left	Right
Initial reaction	9.92	10.45
DL reaction	14.81	15.62
Max +LL reaction	9.77	10.33
Max +total reaction (factored)	24.58	25.95

DEFLECTIONS: (Camber = 1-1/4)

Initial load (in)	at	19.00 ft =	-1.818	L/D = 251
Live load (in)	at	19.00 ft =	-0.844	L/D = 540
Post Comp load (in)	at	19.00 ft =	-1.266	L/D = 360
Net Total load (in)	at	19.00 ft =	-1.834	L/D = 249

Gravity Beam Design

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 11**

SPAN INFORMATION (ft): I-End (0.00,38.00) J-End (28.00,38.00)

Beam Size (Optimum) = W8X10 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

	Left	Right
Concrete thickness (in)	2.00	2.00
Unit weight concrete (pcf)	145.00	145.00
f'c (ksi)	5.00	5.00
Decking Orientation	perpendicular	perpendicular
Decking type	VULCRAFT 2.0VL	VULCRAFT 2.0VL

beff (in) = 36.00		Y bar(in) =	9.32
Mnf (kip-ft) = 92.02		Mn (kip-ft) =	66.80
C (kips) = 59.83		PNA (in) =	7.46
Ieff (in4) = 103.17		Itr (in4) =	144.62
Stud length (in) = 3.50		Stud diam (in) =	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
\# of studs: Full = 26 Partial = 10 Actual = 10
Number of Stud Rows = 1 Percent of Full Composite Action = 40.42

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.114	0.114	0.000	---	NonR	0.000
	28.000	0.114	0.114	0.000			0.000
2	0.000	0.060	0.000	0.120	---	NonR	0.000
	28.000	0.060	0.000	0.120			0.000
3	0.000	0.010	0.010	0.000	---	NonR	0.000
	28.000	0.010	0.010	0.000			0.000

SHEAR: Max Va (DL+LL) = 4.25 kips Vn/1.50 = 26.83 kips

MOMENTS:

Span	Cond	LoadCombo	Ma	@	Lb	Cb	Ω	Mn / Ω
			kip-ft	ft	ft			kip-ft
Center	PreCmp+	DL	12.1	14.0	0.0	1.00	1.67	21.87
	Init DL	DL	12.1	14.0	---	---		
	Max +	DL+LL	29.8	14.0	---	---	1.67	40.00
Controlling		DL+LL	29.8	14.0	---	---	1.67	40.00

REACTIONS (kips):

	Left	Right
Initial reaction	1.73	1.73
DL reaction	2.57	2.57
Max +LL reaction	1.68	1.68
Max +total reaction (factored)	4.25	4.25

DEFLECTIONS: (Camber = 1-1/2)

Initial load (in)	at	14.00 ft =	-1.915	L/D = 175

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Live load (in)	at	14.00 ft	=	-0.555	L/D	=	606
Post Comp load (in)	at	14.00 ft	=	-0.832	L/D	=	404
Net Total load (in)	at	14.00 ft	=	-1.247	L/D	=	269

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
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Floor Type: plan **Beam Number = 54**

SPAN INFORMATION (ft): I-End (0.00,42.00) J-End (28.00,42.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 55**

SPAN INFORMATION (ft): I-End (0.00,46.00) J-End (28.00,46.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 56**

SPAN INFORMATION (ft): I-End (0.00,50.00) J-End (28.00,50.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 57**

SPAN INFORMATION (ft): I-End (0.00,54.00) J-End (28.00,54.00)
Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 58**

SPAN INFORMATION (ft): I-End (0.00,58.00) J-End (28.00,58.00)
Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 59**

SPAN INFORMATION (ft): I-End (0.00,62.00) J-End (28.00,62.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

RAM Steel v12.1
DataBase: open web steel
Building Code: IBC

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Floor Type: plan **Beam Number = 60**

SPAN INFORMATION (ft): I-End (0.00,66.00) J-End (28.00,66.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D	=	470
Live load (in)	=	0.494	L/D	=	679
Total load (in)	=	1.210	L/D	=	278

Standard Joist Selection

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Floor Type: plan **Beam Number = 61**

SPAN INFORMATION (ft): I-End (0.00,70.00) J-End (28.00,70.00)

Joist Size (Optimum) = 22K5
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.151	0.000	---	NonR
	28.000	0.151	0.000		
2	0.000	0.080	0.160	---	NonR
	28.000	0.080	0.160		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 391.5

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	231.5	
Live:	160.0	302.0
Total:	391.5	392.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	38.4	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	3.24	3.24
Max +LL reaction	2.24	2.24
Max +total reaction	5.48	5.48

DEFLECTIONS:

Dead load (in)	=	0.715	L/D =	470
Live load (in)	=	0.494	L/D =	679
Total load (in)	=	1.210	L/D =	278

Standard Joist Selection

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Floor Type: plan **Beam Number = 62**

SPAN INFORMATION (ft): I-End (0.00,74.00) J-End (28.00,74.00)

Joist Size (Optimum) = 20K4
Total Beam Length (ft) = 28.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.114	0.000	---	NonR
	28.000	0.114	0.000		
2	0.000	0.060	0.120	---	NonR
	28.000	0.060	0.120		
3	0.000	0.000	0.000	---	NonR
	28.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 293.6

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	173.6	
Live:	120.0	221.0
Total:	293.6	315.0

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	28.8	14.0

REACTIONS (kips):

	Left	**Right**
DL reaction	2.43	2.43
Max +LL reaction	1.68	1.68
Max +total reaction	4.11	4.11

DEFLECTIONS:

Dead load (in)	=	0.733	L/D =	458
Live load (in)	=	0.507	L/D =	663
Total load (in)	=	1.240	L/D =	271

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Floor Type: plan **Beam Number = 13**

SPAN INFORMATION (ft): I-End (0.00,76.00) J-End (28.00,76.00)
Beam Size (Optimum) = W8X10 Fy = 50.0 ksi
Total Beam Length (ft) = 28.00

COMPOSITE PROPERTIES (Not Shored):

	Left	Right
Concrete thickness (in)	2.00	2.00
Unit weight concrete (pcf)	145.00	145.00
f'c (ksi)	5.00	5.00
Decking Orientation	perpendicular	perpendicular
Decking type	VULCRAFT 2.0VL	VULCRAFT 2.0VL

beff (in)	= 16.00	Y bar(in)	=	8.13
Mnf (kip-ft)	= 82.64	Mn (kip-ft)	=	65.58
C (kips)	= 59.83	PNA (in)	=	7.46
Ieff (in4)	= 88.89	Itr (in4)	=	118.39
Stud length (in)	= 3.50	Stud diam (in)	=	0.63

Stud Capacity (kips) Qn = 12.0 Rg = 1.00 Rp = 0.60
# of studs: Full = 24 Partial = 10 Actual = 10
Number of Stud Rows = 1 Percent of Full Composite Action = 43.99

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.013	0.013	0.000	---	NonR	0.000
	28.000	0.013	0.013	0.000			0.000
2	0.000	0.007	0.000	0.013	---	NonR	0.000
	28.000	0.007	0.000	0.013			0.000
3	0.000	0.038	0.038	0.000	---	NonR	0.000
	28.000	0.038	0.038	0.000			0.000
4	0.000	0.020	0.000	0.040	---	NonR	0.000
	28.000	0.020	0.000	0.040			0.000
5	0.000	0.010	0.010	0.000	---	NonR	0.000
	28.000	0.010	0.010	0.000			0.000

SHEAR: Max Va (DL+LL) = 1.97 kips Vn/1.50 = 26.83 kips

MOMENTS:

Span	Cond	LoadCombo	Ma	@	Lb	Cb	Ω	Mn / Ω
			kip-ft	ft	ft			kip-ft
Center	PreCmp+	DL	5.9	14.0	0.0	1.00	1.67	21.87
	Init DL	DL	5.9	14.0	---	---		
	Max +	DL+LL	13.8	14.0	---	---	1.67	39.27
Controlling		DL+LL	13.8	14.0	---	---	1.67	39.27

REACTIONS (kips):

	Left	Right
Initial reaction	0.85	0.85
DL reaction	1.22	1.22

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	Left	Right
Max +LL reaction	0.75	0.75
Max +total reaction (factored)	1.97	1.97

DEFLECTIONS: (Camber = 3/4)

Initial load (in)	at	14.00 ft =	-0.938	L/D =	358
Live load (in)	at	14.00 ft =	-0.286	L/D =	1174
Post Comp load (in)	at	14.00 ft =	-0.429	L/D =	783
Net Total load (in)	at	14.00 ft =	-0.617	L/D =	545

Gravity Beam Design

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Floor Type: plan **Beam Number = 4**

SPAN INFORMATION (ft): I-End (28.00,38.00) J-End (28.00,76.00)
Beam Size (Optimum) = W21X50 Fy = 50.0 ksi
Total Beam Length (ft) = 38.00

COMPOSITE PROPERTIES (Not Shored):

	Left	Right
Concrete thickness (in)	2.00	2.00
Unit weight concrete (pcf)	145.00	145.00
f'c (ksi)	5.00	5.00
Decking Orientation	parallel	parallel
Decking type	VULCRAFT 2.0VL	VULCRAFT 2.0VL

beff (in) =	114.00	Y bar(in) =	19.58
Mnf (kip-ft) =	835.54	Mn (kip-ft) =	835.54
C (kips) =	735.00	PNA (in) =	23.28
Ieff (in4) =	2803.92	Itr (in4) =	2803.92
Stud length (in) =	3.50	Stud diam (in) =	0.63

Stud Capacity (kips) Qn = 15.0 Rg = 1.00 Rp = 0.75
\# of studs: Full = 106 Partial = 108 Actual = 108
Number of Stud Rows = 1 Percent of Full Composite Action = 100.00

POINT LOADS (kips):

Dist	DL	CDL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%	CLL
4.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
4.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
8.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
8.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
12.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
12.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
16.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
16.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
20.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
20.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
24.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
24.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
28.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
28.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
32.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
32.000	3.24	2.12	0.00	0.0	2.24	0.00	0.0	0.00	Snow	0.00
36.000	2.43	1.59	0.00	0.0	1.68	0.00	0.0	0.00	Snow	0.00
36.000	2.43	1.59	0.00	0.0	1.68	0.00	0.0	0.00	Snow	0.00

LINE LOADS (k/ft):

Load	Dist	DL	CDL	LL	Red%	Type	CLL
1	0.000	0.050	0.050	0.000	---	NonR	0.000
	38.000	0.050	0.050	0.000			0.000

Gravity Beam Design

RAM Steel v12.1 — Page 18/18
DataBase: open web steel — 10/27/09 18:44:06
Building Code: IBC — Steel Code: AISC360-05 ASD

SHEAR: Max Va (DL+LL) = 50.28 kips Vn/1.50 = 158.08 kips

MOMENTS:

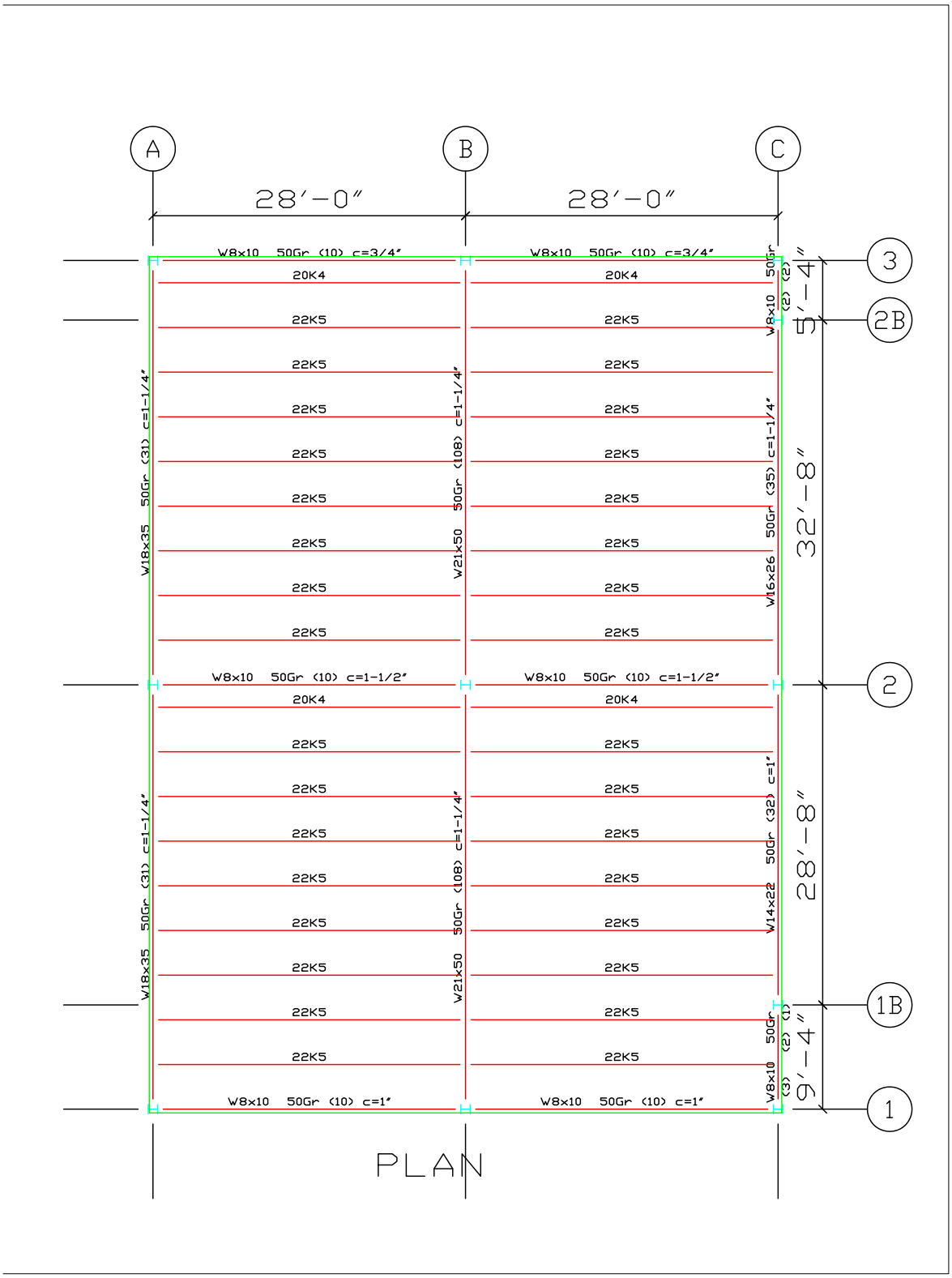
Span	Cond	LoadCombo	Ma	@	Lb	Cb	Ω	Mn / Ω
			kip-ft	ft	ft			kip-ft
Center	PreCmp+	DL	199.9	20.0	4.0	1.01	1.67	274.45
	Init DL	DL	199.9	20.0	---	---		
	Max +	DL+LL	502.3	20.0	---	---	1.67	500.32
Controlling		DL+LL	502.3	20.0	---	---	1.67	500.32

REACTIONS (kips):

	Left	Right
Initial reaction	18.98	20.04
DL reaction	28.50	30.12
Max +LL reaction	19.04	20.16
Max +total reaction (factored)	47.54	50.28

DEFLECTIONS: (Camber = 1-1/4)

Initial load (in)	at	19.00 ft =	-1.810	L/D = 252
Live load (in)	at	19.00 ft =	-0.640	L/D = 712
Post Comp load (in)	at	19.00 ft =	-0.961	L/D = 475
Net Total load (in)	at	19.00 ft =	-1.521	L/D = 300


A
B
C
28'-0"
28'-0"
W8x10 50Gr (10) c=3/4"
W8x10 50Gr (10) c=3/4"
20K4
22K5
W18x35 50Gr (31) c=1-1/4"
W21x50 50Gr (108) c=1-1/4"
W16x26 50Gr (35) c=1-1/4"
W8x10 50Gr (2) (2)
5'-4"
32'-8"
3
2B
W8x10 50Gr (10) c=1-1/2"
W8x10 50Gr (10) c=1-1/2"
W18x35 50Gr (31) c=1-1/4"
W21x50 50Gr (108) c=1-1/4"
W14x22 50Gr (32) c=1"
28'-8"
2
1B
W8x10 50Gr (3) (2) (1)
9'-4"
1
W8x10 50Gr (10) c=1"
W8x10 50Gr (10) c=1"
PLAN

Appendix E: Cost Analysis Calculations

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SHEET
PROJECT
PROJECT NO.
BY DATE

Cost Analyses → Wilmington, DE → 99.4

	per square foot
Two-way Concrete	13.60 (.994) = $13.52
Precast Hollow Core	6.51 (.994) = $6.47
Composite steel Beam	10.27 (.994) = $10.21
Composite open web joist	(6.29 + 2.50) (.994) = $8.74

↑ Fireproofing