Floor System Exploration (Tech 2)

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Executive Summary

The structural study of alternative floor systems report compares three alternative floor systems to the structure used in Global Village Building 400. Global Village is a European-inspired complex that provides commercial and residential space for the campus at the Rochester Institute of Technology in Rochester, NY. Each location has been designed to incorporate themes and materials that represent different regions from around the world, including marble from Italy and wood siding from Denmark. Global Village is a four-story building that also supports a fifth story dedicated to mechanical equipment; making it rise to an overall height of 62.5 feet. The building is constructed of steel with metal deck and lightweight concrete at the first, second, and third floors while the fourth floor and mechanical penthouse have wood framing.

Due to the varying bay sizes throughout the building, the largest typical bay located on the second floor of the north wing was chosen to be conservative. To make calculations easier, the 29’-3” x 34’-4” bay was rounded up to 30’-0” x 34’-0”. This bay size would then be altered along with floor heights and slab depths as needed throughout the report.

The existing floor type consists of a 3.25” lightweight concrete slab on 3” composite metal deck supported by W16x31 [+24] beams which rest on W24x62 [+50] girders. The three alternative floor systems that were analyzed are:

- Pre-Cast Hollow Core Planks on Steel Framing
- Two-Way Flat Plate (Without Drop Panels)
- Solid One-Way Slab with Beams

Nitterhouse Concrete Products Catalogs were used in designing the Hollow Core system. The typical bay size of 30’-0” x 34’-0” needed to be changed to 30’-0” x 32’-0” in order to accommodate the planks 4’-0” increments. From the tables in the catalog, an 8” thick x 4’-0” wide plank with (7) ½”ø strands was to considered to be adequate. W21x201 girders would then be needed to support the planks and the applied loading. Overall, the Hollow Core weight was the closest to the existing system but the cost and total depth were the worst out of all the floor types analyzed. Due to this and the change in bay size, the Hollow Core system is determined not to be feasible.

To design the Flat Plate floor slab, the Direct Design Method was used. Punching shear was the main controlling factor which changed the minimum slab thickness of 12”, found by code, to a thickness of 17”. Comparing this to all the other floor types; it had the lowest total floor depth and cost but had the largest system weight. The weight was more than four times that of the existing system which could bring up foundation concerns. However, this is a viable alternative to the existing system.

Through the use of the CRSI Handbook, the Solid One-Way Slab was designed to have a 4" slab with 12" x 18" beams and 20" x 26" girders. This floor type is mainly in the middle for each category except for constructability. Due to this system being comprised mostly of concrete, formwork is needed and weather conditions need to be taken into account. As a result, this system is feasible and may be considered an alternative to the existing system.

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Purpose

The purpose of Technical Report 2 is to design and analyze three alternative floor types and compare them to the existing system used in Global Village. This report will give a background on each system and list the advantages and disadvantages based on the outcomes of the design. An overall summary at the end will compare each system with one another and test if the alternative system is feasible.

Introduction



Global Village is a mixed-use building that provides commercial and residential space for the campus at RIT. Global Village has achieved LEED Gold certification and has been designed to be community friendly. In total, the Global Village project provides 414 beds for on campus living and 24,000 square feet of commercial and retail space.

The $57.5 million dollar project consists of three independent structures on the campus at RIT. The main four-story Global Village building (Building 400) is 122,000 square feet and the two additional three-story Global Way buildings (Buildings 403 and 404) are 32,000 square feet each. The main project team includes RIT as the owner, Architectural Resources Cambridge as the architect, and The Pike Company as the CM-at-Risk. Eleven other firms were also employed to handle MEP, lighting, acoustics, and so forth.

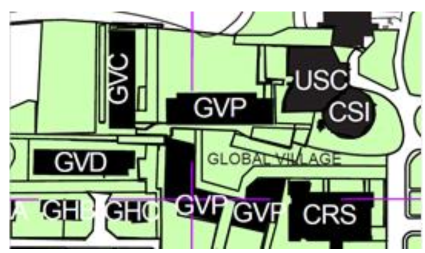


Figure 1: GVP is Building 400 (Global Village Building). GVC and GVD are Buildings 403 and 404 (Global Way Buildings). Courtesy of RIT.

Commercial space is located on the first and second floors, which consist of two dining facilities, a post office, salon, wellness center, sports outfitter, and a convenience store. Campus housing is located on the third and fourth floor which provides room for 210 beds. There is also a fifth floor; however, it is used primarily as a mechanical penthouse. Building 400's unique "U" shape creates a courtyard that features a removable stage, gas fireplace, and a glass fountain. See Figure 1 for a campus map of the Global Village complex. The area also includes outdoor seating with tables equipped with umbrellas.

The 28,000 square foot courtyard is also heated to extend its use during the winter and to minimize winter maintenance.

The façade of Building 400 is made up of a cement fiber board rain screen, brick masonry veneer, and flat seamed sheet metal with aluminum clad wood windows, and a coated extruded aluminum storefront.

Global Village Building 400 is a LEED Gold Certified Building. Green aspects include a green roof above the restaurant, daylight sensor lighting, and sensors to shut off mechanical equipment when windows are opened. Global Village is located on a sustainable site that is walk-able and transit oriented, encourages low-emitting vehicles, and reflects solar heat. The building reduces water consumption through water efficient landscaping and technologies such as high-efficiency toilets, faucets, and shower heads. Through the implementation of several energy efficient systems, the building is predicted to use 29.4% less energy. To encourage sustainable energy, seventy percent of the building's electricity consumption is provided from renewable sources (wind) through the engagement in a two-year renewable energy contract. Construction of Global Village included waste management recycling, air quality control, and low emitting materials. Along with regional materials, recycled content were also installed that constitute 20% of the total value of the materials in the project.

Global Village is a part of RIT's campus outreach program. The buildings not only provide student housing and retail space, but were also designed to be community friendly and to provide students with a global living experience. Global Village is LEED Gold certified and the courtyard created promotes outdoor activity.

Structural Overview

The structure of Global Village Building 400 consists of steel framing on a concrete foundation wall. The first, second, and third floor slabs use a lightweight concrete on metal decking system while the fourth floor, mechanical penthouse, and roof use wood framing. The lateral system consists of concentrically braced frames in both directions.

Foundation

In January 2009, Tierney Geotechnical Engineering, PC (TGE) provided a subsurface exploration and geotechnical investigation for Global Village. TGE performed 14 test borings and 2 test pits on the site of Building 400 and recommended foundation types and allowable bearing pressures along with seismic, floor slab, and lateral earth pressure design parameters.

In general, the borings and test pits encountered up to 8 inches of topsoil at the ground surface, or fill. The fill, generally consists of varying amounts of silt, sand, and gravel. At several locations, the fill also contained varying amounts of construction-type debris and deleterious material such as asphalt, topsoil, and wood. The fill was generally encountered to depths of approximately 4 to 8 feet. Below the fill, native soils with a very high compactness were encountered. Overall, most of the structure's foundation is on very compact glacial fill.

From these results, it was determined that the structure may then be supported on a foundation system consisting of isolated spread and continuous strip footings. TGE recommends an allowable bearing pressure of 7,500 psf to be used in the foundation design. It was also recommended by TGE that, due to lateral earth pressure, retaining walls are to be backfilled to a minimum distance of 2 feet behind the walls with an imported structural fill. To prevent storm run-off, permanent drains should also be installed behind all retaining walls.

Floor System

The first floor consists of a 6" concrete on grade slab. For the second and third floors, the floor system is comprised of 3¼" lightweight concrete slab on 3" composite metal (18-gage) decking. Individual steel deck panels are to be continuous over two or more spans except where limited by the structural steel layout. The rest of the floors are made up of wood framing with ¾" plywood sheathing. Shear stud connectors are welded to beams and girders where appropriate. See **Figure 2** for details.

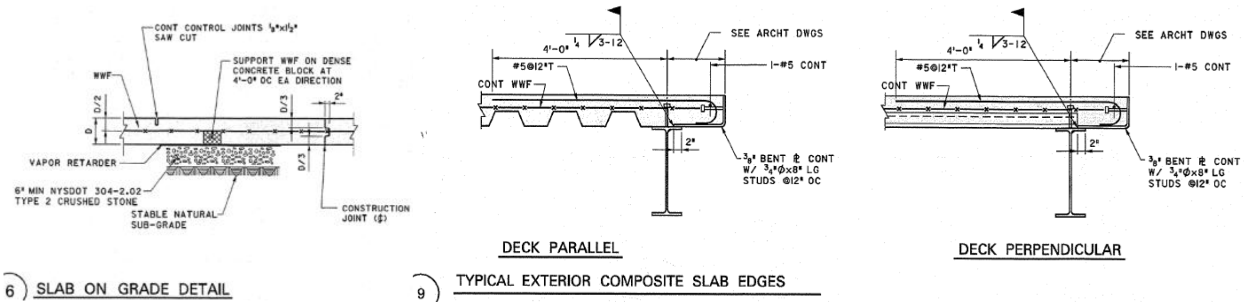


Figure 2: Typical composite slab details. Courtesy of RIT. Drawings not to scale.

Framing System

The framing grid that Global Village possesses is very unique and very complicated. The bay sizes on each floor vary dramatically and the beams don't line up on each side of the transfer girders. The framing is also not consistent between floors. There is no simple consistent grid except for a couple areas highlighted in Figure 3. In these highlighted areas, the beams vary from W18x35 to W16x31 while the transfer girders vary from W14x22 to W21x44. Column sizes also vary significantly throughout the structure where the majority is in between W10x54 to W12x106.

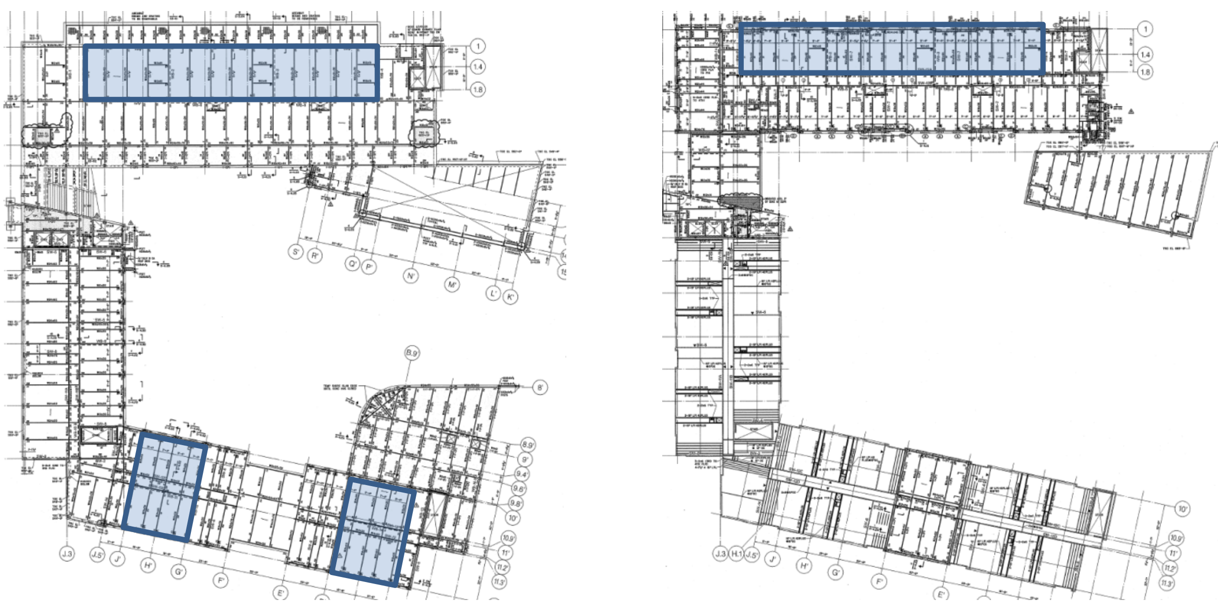
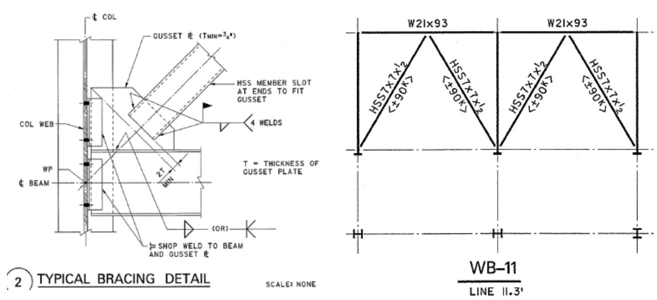


Figure 3: 2nd Floor (left) and 3rd Floor (right) framing plans. Typical bays on each level highlighted. Courtesy of RIT. Drawings not to scale.

Lateral System

The main lateral load resisting system consists of concentrically braced frames in both the N-S direction as well as the E-W direction. The lateral HSS bracing ranges in size where the majority is HSS7x7x½. See **Figure 4** for details and placements.



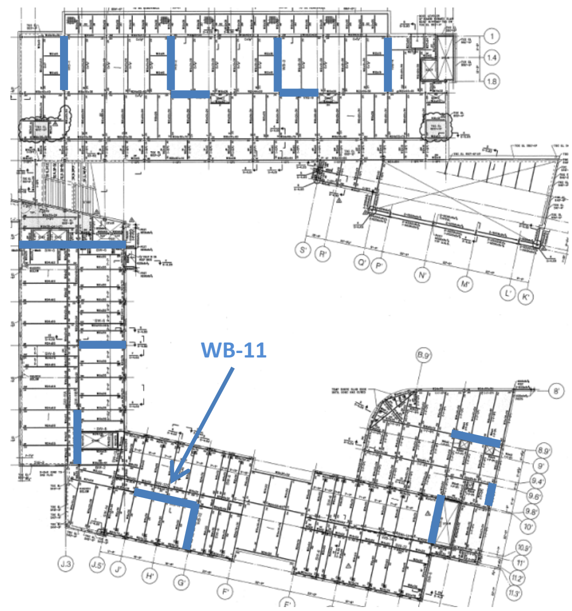


Figure 4: Typical bracing details and placement of bracing on 2nd Floor. Courtesy of RIT. Drawings not to scale.

Design Codes

Below is a list of codes and standards that the design team used on Global Village. As a comparison, codes, standards, and aids used for this report are given.

Design Codes

Design Codes:

- American Concrete Institute (ACI) 318-99, Building Code Requirements for Reinforced Concrete
- American Concrete Institute (ACI) 301-99, Specifications for Structural Concrete for Buildings
- CRSI Manual of Standard Practice (MSP 1-97)
- Specification for structural Steel Buildings – Allowable Stress Design and Plastic Design (AISC 1989)
- Code of Standard Practice for Steel Buildings & Bridges (AISC 1992)
- National Design Specification for Wood Construction (NF.PA, 1991 Edition)

Model Codes:

- 2007 Building Code of New York State / 2003 International Building Code
- 2007 Fire Code of New York State / 2003 International Fire Code
- Electrical Code of New York, NFPA 70 2005
- 2007 Mechanical Code of New York State / 2003 International Mechanical Code
- 2007 Plumbing Code of New York State / 2003 International Plumbing Code

Standards:

- American Society of Civil Engineers (ASCE) 7-02, Minimum Design Loads for buildings and Other Structures

Thesis Codes

Design Codes:

- AISC Steel Construction Manual, 14th Edition
- American Concrete Institute (ACI) 318-08, Building Code Requirements for Structural Concrete

Standards:

- American Society of Civil Engineers (ASCE) 7-10, Minimum Design Loads for buildings and Other Structures

Design Aids:

- CRSI Design Handbook 2008, 10th Edition

Material Properties

Listed below are materials and their strengths used in Global Village. These material strengths are followed best as possible in this report.

Steel

Unless Noted Otherwise	F_y = 50 ksi (A992 or A588 Grade 50)
Where Noted by (*) on Drawings	F_y = 36 ksi (A36)
Square and Rectangular HSS (Tubes)	F_y = 46 ksi (A500 Grade B)
Round HSS (Pipes)	F_y = 46 ksi (A500 Grade C)
Anchor Bolts (Unless Noted Otherwise)	F_y = 36 ksi (F1554)
High Strength Bolts (Unless Noted Otherwise)	F_u = 105 ksi (A325)
Metal Deck	F_y = 33 ksi (A653)
Weld Strength	F_y = 70 ksi (E70XX)

Concrete

Slabs-on-Grade	4000 psi (Normal Weight)
Walls, Piers	4000 psi (Normal Weight)
Concrete on Steel Deck	3000 psi (Light Weight)
Topping Slabs & Housekeeping Pads	3000 psi (Normal Weight)

Other

Bars, Ties, and Stirrups	60 ksi
Masonry	F'_m = 3000 psi
Wood	F_b = 1000 psi (Bending Stress)
	F_v = 70 psi (Shear Stress)

* Material strengths are based on American Society for Testing and Materials (ASTM) standard rating

* Other wood strengths are given in the structural drawings

Design Loads

Due to the fact that the structural drawings only gave a typical floor partition allowance of 20 psf as a dead load, other dead loads were found or assumed by using Vulcraft catalogs and textbooks on structural design. For a summary of assumed superimposed dead loads used, see Table 1.

Superimposed Dead Loads	
Description	Load (psf)
Framing	10
Superimposed DL	10
MEP Allowance	10
Partitions	20
Composite Decking	46
Roofing	60

Table 1: Summary of superimposed dead loads

Live loads, however, were provided in the structural drawings. These loads were compared to live loads found using Table 4-1 in ASCE 7-10 based on the usage of the spaces. The results are given in Table 2. Most live loads found match designer loads except for fan and mechanical equipment room loadings. Since these were not able to be found in ASCE 07-10, the loads were taken from the design team to be consistent.

Live Loads			
Space	Design Live Load (psf)	Live Load Used (psf)	Notes
Lobbies and Common Areas	100	100	ASCE 7-10: Residential
1st Floor Corridors	100	100	ASCE 7-10: Schools
Typical Floors	40	40	ASCE 7-10: Residential
Corridors above 1st Floor	80	80	ASCE 7-10: Schools
Stairways	100	100	ASCE 7-10: Stairways
Fan Room	80	80	Assumed
Mechanical Equipment Rooms	150	150	Assumed

Table 2: Comparison of design live loads and live loads used

Floor System Analysis

Four different floor systems were designed and analyzed using a typical bay in the existing structural system of Global Village. Since bay sizes vary considerably throughout the building, the largest typical bay located on the second floor of the north wing was chosen to be conservative, see **Figure 5.** To make calculations easier, the 29'-3" x 34'-4" bay was rounded up to 30'-0" x 34'-0" which would then be altered as needed.

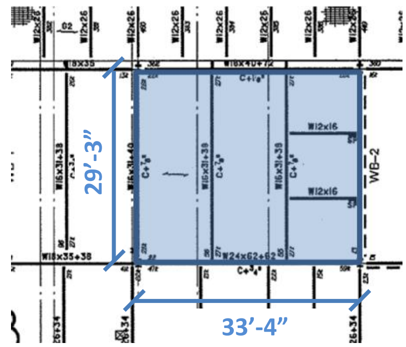


Figure 5: Typical Bay used for floor system designs. Courtesy of RIT.

Upon completion of designing each floor system, an analysis was done to test if each was a feasible alternative. Various criteria such as cost, system weight, system depth, constructability, etc. was used to find the most viable alternative to the existing floor system used in Global Village Building 400.

As a note, only gravity loads were taken into account when designing each floor type. Also, the effects on the lateral system from each type of floor were not analyzed in this report.

2012 RSMeans Assemblies Cost Data was used to estimate each floor systems cost per square foot. The 2008 CRSI Handbook was used to aid in the design of a Solid One-Way Slab with Beams. All other values were hand-calculated and can be found in the appendices.

Existing Light Weight Concrete on Composite Deck

The existing superstructure of Global Village consists of 3¼" lightweight concrete slab on a 3" metal (18-gage) decking supported by structural steel framing, see **Figure 6.** To find an adequate deck, the composite section in the Vulcraft Floor Decking Systems Catalog was used. Deck units were determined to be continuous over three or more spans with a typical bay size of 29'-3" x 33'-4" and a total thickness of 6¼". From these considerations and the gravity loads given above, it was determined that a Vulcraft 3VLI18 would be sufficient. An unshored span check was also performed and proved to be adequate. From these results, the composite slab matches the designed slab's dimensions and has an overall weight of 46 psf.

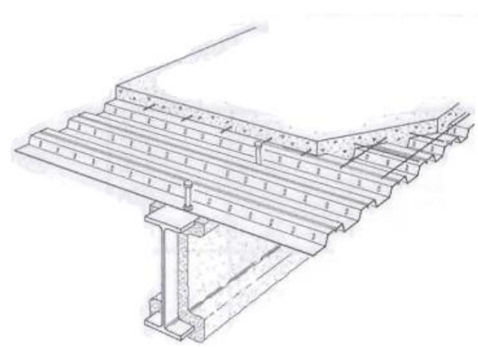


Figure 6: Composite Deck floor construction. Courtesy of RSMeans.

The decking is supported on W16x31 [+24] beams spaced at approximately 11'-1". The beams rest on W24x62 [+50] girders spanning 33'-4" which frame into W12x120 columns. The analysis was found to be very close to the existing structural system components only varying by the number of studs.

System Summary

- Slab: Vulcraft 3VLI18 – 3¼" lightweight concrete slab on a 3" metal (18-gage) decking
- Beam: W16x31 [+24]
- Girder: W24x62 [+50] girders
- Bay Size: 29'-3" x 33'-4"

Advantages

Light Weight Concrete on Composite Deck has a very low self-weight. The low composite slab weight reduces steel member sizes which further reduces the total self-weight. This system is also easy to construct as there is no need for shoring and no formwork is needed since the decking itself acts as a formwork. The slab has a fire rating of 2 hours and also provides a reasonable total floor thickness.

Disadvantages

The cost of the floor system is more expensive given it contains steel. The steel also affects architectural designs and serviceability. Since spray-on fire proofing is needed, the structure is usually not left exposed which constricts aesthetic designs. Spray-on fire proofing also increases the cost and construction time. Serviceability could also become a concern, although not in this structure, due to deflections and if the building has vibratory concerns.

Pre-Cast Hollow Core Planks on Steel Framing

Hollow Core Planks on Steel Framing was the first alternative system to be analyzed. Hollow Core concrete slabs are precision-manufactured pre-stressed planks produced with normal-weight high strength concrete, see **Figure 7.** The planks were sized using the Nitterhouse Concrete Products Catalog with a 2-hour fire rating and a 2"concrete topping. A 2" topping was used to create a more rigid system. The typical bay size was changed to 30'-0" x 32'-0" in order to accommodate a whole plank count. A superimposed service load of 110 psf (LL + SDL) and a span of 30'-0" were then used to find an 8" thick x 4'-0" wide plank with (7) ½"ø strands, see **Table 3.** The plank chosen has a capacity of 114 psf and has a weight of 86.25 psf.

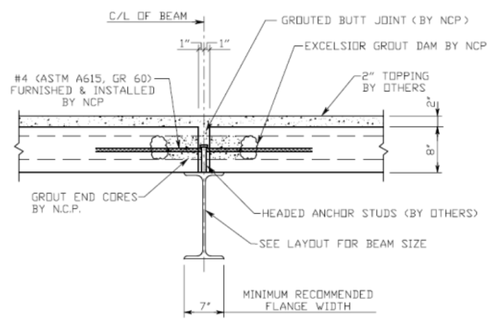


Figure 7: Hollow Core Plank connection on a steel beam detail. Courtesy of Nitterhouse Concrete Products.

The system has no beams but is, however, supported by girders spanning perpendicular to the planks. A W21x201 girder was sized by calculating the required moment of inertia for live load and total load deflections. The girder was then picked out of other possible wide-flanges to create the lowest floor depth.

SAFE SUPERIMPOSED SERVICE LOADS		IBC 2006 & ACI 318-05 (1.2 D + 1.6 L)																		
Strand Pattern		SPAN (FEET)																		
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
4 - 1/2"ø	LOAD (PSF)	280	248	214	185	159	138	118	102	87	74	62	52	42						
6 - 1/2"ø	LOAD (PSF)	366	341	318	299	271	239	211	187	165	146	129	114	101	88	77	67	58	50	42
7 - 1/2"ø	LOAD (PSF)	367	342	320	300	282	265	243	221	202	181	161	144	128	114	101	90	79	70	61

Table 3: Table used to size Hollow Core Plank Slab. Courtesy of Nitterhouse Concrete Products.

System Summary

- Slab: 8" thick x 4'-0" wide plank with (7) ½"ø strands and a 2" concrete topping
- Girder: W21x201
- Bay Size: 30'-0" x 32'-0"

Advantages

Hollow Core slabs offer the advantages of being pre-cast. The planks are constructed under controlled conditions and can be erected at full strength in various weather conditions. Due to this and the fast installation time, the construction process is accelerated. The system, including the girders, is also on the lighter side but still offers superior durability, low maintenance, and natural sound attenuation.

Disadvantages

The greatest disadvantage of Hollow Core is the very high cost. It has the highest material and total cost out of all the floor systems since it is pre-cast. This floor type also has the greatest total floor thickness which brings a concern to the total height of the building given zoning requirements. This might force the ceiling height to be lower which may be unpleasing. In this case, the thickness only varies by 1" from the existing system so the difference in the ceiling height would be nearly unperceivable. The fact that Hollow Core is pre-cast also constricts the bay sizes into 4'-0" increments. For this case, the bay size needed to be changed from a 30'-0" x 34'-0" bay to a 30'-0" by 32'-0" bay. Architectural designs are further constricted due to fireproofing as in the existing system.

Two-Way Flat Plate (Without Drop Panels)

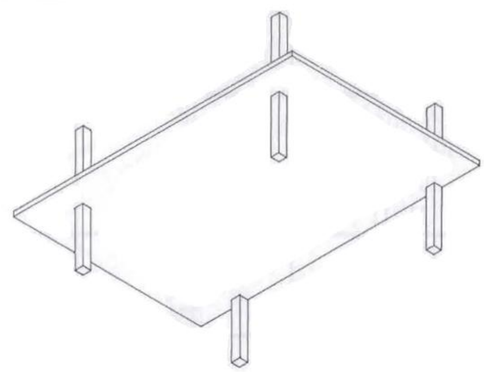


Figure 8: Two-Way Flat Plate floor construction. Courtesy of RSMeans.

The second alternative to be analyzed was a Two-Way Flat Plate. A Flat Plate differs from a Flat Slab by not having drop panels, see **Figure 8.** This system has a two-way slab with reinforcing spanning orthogonally in two directions supported only by columns. The Direct Design Method was used to design the slab reinforcing on a 30'-0" x 34'-0" bay. A summary of the reinforcement needed in each direction is shown in **Figure 9.** The controlling factor in this analysis was punching shear. The minimum thickness of the slab was found to be 12" by code but a slab thickness of 17" was needed to have the adequate punching shear capacity.

Assumptions in this analysis include the use of normal-weight concrete, 24" square columns, #5 rebar, story height of 12'-0", and a compressive concrete strength of 4,000 psi. The loads used include the dead and live loads given in the design loads section of this report: superimposed DL, MEP, partitions, self DL (212.5 psf for this system), and live load.

System Summary

- Slab: 17" thick with reinforcement shown in **Figure 8** below
- Bay Size: 30'-0" x 34'-0"

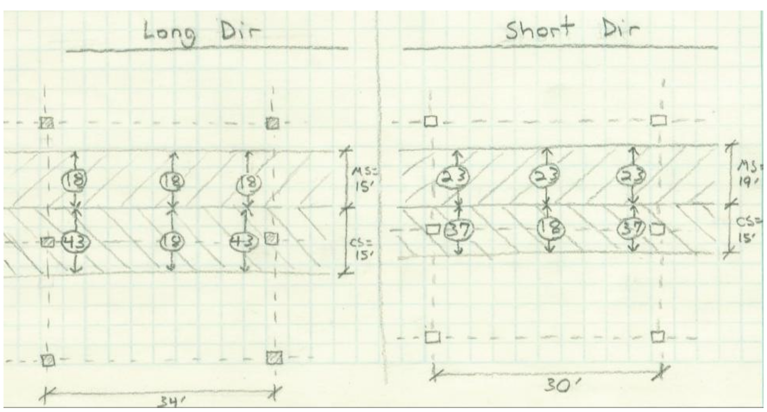


Figure 9: Summary of #5 rebar reinforcement needed in each direction. Drawing not to scale.

Advantages

The Two-Way Flat Plate provides a thinner and lower costing floor than the other floor types analyzed. Since concrete is the main material, cost of materials is very cheap. Although the slab is very thick, there are no beams or girders that add to the depth which has a positive effect on floor-to-floor heights. If a Flat Plate floor is used instead of the existing system, the ceiling height could be increased by over a foot or the total height of the building could be decreased. Other benefits of using a Flat Plate are that they offer flat ceilings which reduce ceiling finishing and they provide a relatively stiffer system.

Disadvantages

The main concern of using a Flat Plate is the large dead load or total weight of the structure. When comparing the weight between this system and the existing system, the total weight is more than four times greater. This can seriously affect the foundation design. For this building, strip footings were used. If the floor system was changed to a Flat Plate, the foundation design would probably need to be changed.

Solid One-Way Slab with Beams

Solid One-Way Slab with Beams was the final alternative system analyzed, see **Figure 10.** The slab was designed using the 2008 CRSI Design Handbook, 10th Edition. A minimum slab thickness of 4" was first found using Table 9.5a in ACI 318-08, see **Table 5.** The beam spacing in the 30'-0" x 34'-0" bay was determined to be 8'-6" to make values correspond to those in the CRSI tables (4 @ 8'-6" = 34'-0"), see **Figure 11.** The design loads here consist of: superimposed DL, MEP, partitions, and live load. The reinforcement was found on page 7-7 in the CRSI Handbook using these values with grade 60 bars and a compressive concrete strength of 4,000 psi. From **Table 6,** the slab has a capacity of 224 psf and a weight of 50 psf at ρ = .0050. Crack control was also checked and considered to be adequate.

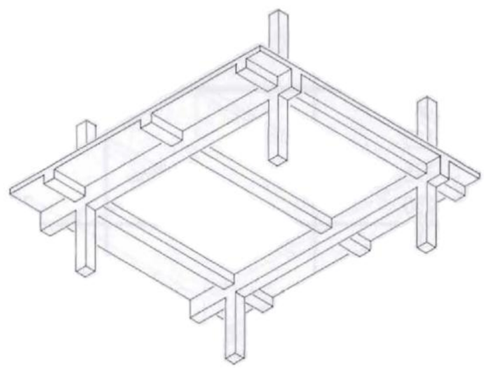


Figure 10: One-Way Slab with Beams floor construction. Courtesy of RSMeans.

Beams and girders were also found using the CRSI Handbook with relatively the same procedure as the slab. For the beam, a minimum beam height was found to be 18". Using page 12-59 with a span of 28'-0" and a loading of 2.28 k/ft, a beam width of 12" and a capacity of 2.56 k/ft was found. The design moment strengths for this beam are $+\Phi M_n$ = 125 ft-k and $-\Phi M_n$ = 182 ft-k, see **Table 7.** For the girder, a minimum height was found to be 20" but would not be used since that height would not have an adequate capacity under any width. Instead, the height and width were found by finding the first cross section that had a capacity greater than 6.75 k/ft under a 32'-0" span. From page 12-61, a girder that has a height of 26" and a width of 20" has a capacity of 7.55 k/ft. The design moment strengths for this girder are $+\Phi M_n$ = 482 ft-k and $-\Phi M_n$ = 735 ft-k, see **Table 8.**

System Summary

A summary which includes reinforcement sizes for the slab, beams, and girders on a 30'-0" x 34'-0" bay can be found in Table 4 below

Summary of Sizes and Reinforcement found from CRSI Handbook							
Component	l_n (ft)	Loading	t or h (in)	b (in)	Bottom Reinforcement	Top Reinforcement	Stirrups (each side)
Slab	8.5	208 psf	4	-	#4 @ 12"	#3 @ 12"	-
Beam	28	2.28 k/ft	18	12	(2) #9	(2) #11	(19) #3: 1@2", 18@7"
Girder	32	6.75 k/ft	26	20	(2) #10 (2) #10	(4) #14	(17) #5: 1@2", 4@8", 12@11"

Table 4: Summary of sizes and reinforcement found from 2008 CRSI Handbook, 10th Edition

Advantages

The Solid One-Way Slab with Beams provides a reasonable cost and floor thickness compared to the other floor systems. Since concrete is the main material, cost due to materials is cheap similar to that of the Flat Plate. Another benefit of the structure being comprised of all concrete is that no fireproofing is needed which allows for different aesthetic designs. Compared to the existing floor system, the total floor thickness is essentially the same and therefore can be considered to have no effect on floor-to-floor heights.

Disadvantages

As in the Flat Plate, the drawback of using a concrete structure is that the weight is almost double that of the existing system. This may have an effect on the soil capacity and therefore a new foundation design may have to be created. Out of all the systems, a One-Way Slab with Beams has the highest labor construction cost and the longest construction time. This is due to the concrete since weather and other factors slow down the construction process.

TABLE 9.5(a) — MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED

	Minimum thickness, h			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections			
Solid one-way slabs	$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$
Beams or ribbed one-way slabs	$\ell/16$	$\ell/18.5$	$\ell/21$	$\ell/8$

Notes:
Values given shall be used directly for members with normalweight concrete and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
a) For lightweight concrete having equilibrium density, w_c, in the range of 90 to 115 lb/ft³, the values shall be multiplied by $(1.65 - 0.005w_c)$ but not less than 1.09.
b) For f_y other than 60,000 psi, the values shall be multiplied by $(0.4 + f_y/100{,}000)$.

Table 5: Table 9.5a from ACI 318-08 used to calculate minimum slab, beam, and girder thickness. Courtesy of American Concrete Institute.

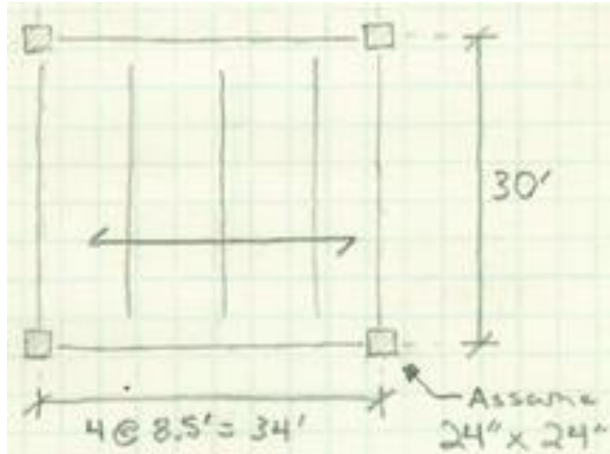


Figure 11: Framing used for the Solid One-Way Slab with Beams. Drawing not to scale.

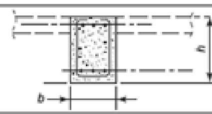
SOLID ONE-WAY SLABS—SINGLE SPAN — Bottom Steel for $+M_u$
f'_c = 4,000 psi — Grade 60 Bars — $\rho \approx 0.0050$

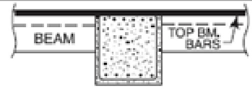
Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Bottom Bars Spacing (in.)	#4 12	#4 11	#4 10	#4 8	#5 12	#5 11	#5 10	#5 9	#6 12	#6 11	#6 11	#6 10	#6 9
Top Bars Spacing (in.)	#3 12	#3 12	#3 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12
T-S Bars Spacing (in.)	#3 11	#3 11	#3 11	#3 11	#3 10	#3 9	#3 8	#3 8	#3 7	#3 7	#3 6	#4 11	#4 11
Areas of Steel (in.²/ft) Bottom	0.200	0.218	0.240	0.300	0.310	0.338	0.372	0.413	0.440	0.480	0.480	0.528	0.587
Slab Wt. (psf) Steel Wt. (psf)	50 1.25	56 1.31	63 1.38	69 1.73	75 1.83	81 1.96	88 2.15	94 2.29	100 2.48	106 2.61	113 2.72	119 2.84	125 3.04
CLEAR SPAN	FACTORED USABLE SUPERIMPOSED LOAD (psf)												
6'-0"	510	661	841										
6'-6"	425	553	705										
7'-0"	359	467	598	860	982								
7'-6"	305	398	511	738	844								
8'-0"	260	342	440	639	730	889							
8'-6"	224	295	381	556	637	776	943						
9'-0"	193	256	332	487	558	682	830						
9'-6"	167	223	290	429	492	602	734	898					
10'-0"	145	194	254	379	435	534	652	799	917				
10'-6"	126	170	223	336	386	475	582	714	821	973			

Table 6: Table from CRSI Handbook used to calculate slab reinforcement. Courtesy of Concrete Reinforcing Steel Institute.

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

RECTANGULAR BEAMS, INTERIOR SPANS



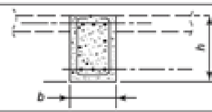


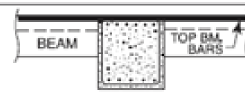
STEM		BARS(1)				TOTAL CAPACITY $U = 1.2D + 1.6L$(3)																				+φMn −φMn	DEFL (C)
		BOTTOM				SPAN, ℓ_n = 24 ft					SPAN, ℓ_n = 26 ft.					SPAN, ℓ_n = 28 ft.					SPAN, ℓ_n = 30 ft.						
h in.	b in.	ℓ_n + 12 in.	0.875 ℓ_n	Layers (2)	TOP	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	(6) ft-kip	(7) × 10⁻⁶ in.
	10	2# 5		1	2# 7	1.17	113E	3	-	151	1.00	113E	3	-	161	0.86	103E	3	-	168	0.75	103E	3	-	177	42	1005
				1			293C	10	0.6	241		303C	10	0.6	255		323C	10	0.6	273		343C	10	0.6	291	78	
		2# 6		1	2# 8	1.63	143E	3	-	204	1.39	143E	3	-	217	1.20	153E	3	-	233	1.05	153E	3	-	246	58	1293
				1			293C	10	0.6	284		303C	10	0.6	302		323C	10	0.6	323		343C	10	0.6	345	100	
		2# 8		1	2# 9	2.35	163E	3	-	291	2.00	173E	3	-	314	1.73	183E	3	-	337	1.50*	193E	3	-	360	100	1189
				1			293C	10	0.6	366		303C	10	0.6	390		323C	10	0.6	418		343C	10	0.6	446	123	
		2# 8		1	2#10	2.79	173E	3	-	323	2.37*	183E	3	-	349	2.05*	193E	3	-	374	1.78*	203E	3	-	399	100	1121
				1			473A	10	0.6	471		503A	10	0.6	506		533A	10	0.6	541		343C	10	0.6	483	150	
	12	2# 6		1	2# 7	1.51	123E	3	-	179	1.29	123E	3	-	190	1.11	123E	3	-	202	0.97	113E	3	-	210	59	945
				1			243D	14	0.7	249		263D	14	0.7	269		273D	14	0.7	285		293D	13	0.7	306	79	
		2# 7		1	2# 9	2.20	153E	3	-	259	1.88	153E	3	-	276	1.62	163E	3	-	297	1.41	163E	3	-	314	79	1108
				1			244D	14	0.7	431		263D	14	0.7	346		273D	14	0.7	367		293D	13	0.7	394	125	
		2# 8		1	2#10	2.83	163E	3	-	322	2.41	173E	3	-	348	2.08*	183E	3	-	373	1.81*	193E	3	-	398	101	1031
				[illegible]			244D	14	0.7	491		264D	14	0.7	532		[illegible]	[illegible]	[illegible]	[illegible]		294D	13	0.7	604	[illegible]	
		2# 9		1	2#11	3.49	173E	3	-	394	2.97*	183E	3	-	425	2.56*	193E	3	-	456	2.23*	203E	3	-	487	125	923
18				1			244D	14	0.7	560		264D	14	0.7	606		[illegible]	[illegible]	[illegible]	[illegible]		294D	13	0.7	689	182	

Table 7: Table from CRSI Handbook used to calculate beam size and reinforcement. Courtesy of Concrete Reinforcing Steel Institute.

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

RECTANGULAR BEAMS, INTERIOR SPANS





STEM		BARS(1)				TOTAL CAPACITY $U = 1.2D + 1.6L$(3)																				+φMn −φMn	DEFL (C)
		BOTTOM				SPAN, ℓ_n = 32 ft					SPAN, ℓ_n = 34 ft.					SPAN, ℓ_n = 36 ft.					SPAN, ℓ_n = 38 ft.						
h in.	b in.	ℓ_n + 12 in.	0.875 ℓ_n	Layers (2)	TOP	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	φTn ft-kips	Aℓ sq. in.	STEEL WGT lb.	(6) ft-kip	(7) × 10⁻⁶ in.
26	14	2# 8		1	3# 8	2.50	123I	7	-	399	2.21	123I	7	-	420	1.98	123I	7	-	442	1.77	123I	7	-	463	160	304
				1			244F	30	1.2	622		264F	30	1.2	667		274F	29	1.2	699		284F	29	1.2	732	234	
		2# 9		1	3# 9	3.12	133I	7	-	498	2.76	143I	7	-	530	2.46	143I	7	-	557	2.21	143I	7	-	584	199	308
				1			244F	30	1.2	717		264F	30	1.2	767		274F	29	1.2	806		284F	29	1.2	845	290	
		2#11		1	3#11	4.60	154I	7	-	816	4.08	164I	7	-	867	3.64	164I	7	-	910	3.26	174I	7	-	961	299	252
				1			245F	30	1.2	1141		265F	30	1.2	1221		275F	29	1.2	1283		285F	29	1.2	1344	428	
		2#10	1#10	1	4#11	5.19	165I	7	-	1055	4.59	164I	7	-	1027	4.10	174I	7	-	1067	3.68	174I	7	-	1139	359	231
				2			245F	30	1.2	1291		265F	30	1.2	1381		275F	29	1.2	1452		285F	29	1.2	1522	482	
	16	2# 9		1	3# 9	3.14	133I	9	-	500	2.78	133I	9	-	527	2.48	133I	9	-	554	2.23	133I	9	-	581	200	272
				1			225G	37	1.4	870		234G	37	1.3	743		244G	37	1.3	783		284F	36	1.3	858	294	
		2#10		1	3#10	3.92	143I	9	-	622	3.47	143I	9	-	656	3.09	153I	9	-	695	2.78	153I	9	-	729	251	262
				1			225G	37	1.4	988		235G	37	1.3	1042		245G	37	1.3	1096		255G	36	1.3	1149	364	
		2#11		1	4#10	4.73	154I	9	-	847	4.19	154I	9	-	891	3.74	164I	9	-	944	3.36	164I	9	-	988	302	230
				1			225G	37	1.3	1146		235G	37	1.3	1210		245G	37	1.3	1274		255G	36	1.3	1337	470	
		2#14		1	3#14	6.30	165I	9	-	1214	5.58	165I	9	-	1275	4.98	175I	9	-	1350	4.47*	185I	9	-	1425	418	192
				1			325D	37	1.3	1618		345D	37	1.3	1718		365D	36	1.3	1818		375D	36	1.3	1898	586	
	18	2# 8	1# 8	1	3# 9	3.19	123I	11	-	513	2.82	123I	11	-	541	2.52	123I	11	-	569	2.26	123I	11	-	598	238	228
				1			224G	45	1.5	730		234G	44	1.5	771		314E	44	1.5	898		324E	44	1.5	939	296	
		2# 9	1# 9	1	3#11	4.63	144I	11	-	770	4.10	154I	11	-	818	3.66	153I	11	-	795	3.29	153I	11	-	835	296	225
				1			225G	45	1.5	1090		235G	44	1.5	1150		245G	44	1.5	1210		265G	44	1.5	1290	442	
		2#10	1#10	1	3#14	5.76	155I	11	-	1088	5.10	164I	11	-	1072	4.55	164I	11	-	1127	4.08	174I	11	-	1190	368	190
				1			325D	45	1.5	1522		345D	44	1.5	1617		365D	44	1.5	1711		265G	44	1.5	1564	602	
		2#11	1#11	1	3#14	6.48	155I	11	-	1179	5.74	165I	11	-	1253	5.12	175I	11	-	1327	4.59	175I	11	-	1387	442	181
				1			325D	45	1.5	1613		345D	44	1.5	1713		365D	44	1.5	1813		385D	44	1.5	1913	602	
	20	2# 8	1# 8	1	3#10	3.74	123I	13	-	572	3.31	133I	13	-	609	2.96	133I	13	-	641	2.65	133I	13	-	672	239	212
				1			195H	53	1.7	912		215H	53	1.6	986		225H	52	1.6	1038		235H	52	1.6	1091	371	
		2# 9	1# 9	1	3#11	4.66	143I	13	-	712	4.13	143I	13	-	752	3.69	143I	13	-	792	3.31	153I	13	-	836	298	211
				1			195H	53	1.6	1042		215H	53	1.6	1124		225H	52	1.6	1185		235H	52	1.6	1246	447	
		2#11	1#11	1	3#14	6.58	155I	13	-	1184	5.83	165I	13	-	1258	5.20	165I	13	-	1318	4.67	174I	13	-	1301	447	174
				[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		295E	52	1.6	1633		315E	52	1.6	1734		335E	52	1.6	1836	[illegible]	
		2#10	2#10	1	4#14	7.55	175Fdl	13	-	1389	6.68	165I	13	-	1445	5.96	175I	13	-	1530	5.35	185I	13	-	1616	482	153
				1			[illegible]	[illegible]	[illegible]	[illegible]		345D	52	1.6	1924		315E	52	1.6	1932		335E	52	1.6	2044	735	

Table 8: Table from CRSI Handbook used to calculate girder size and reinforcement. Courtesy of Concrete Reinforcing Steel Institute.

Floor System Summary

Table 9 below summarizes the results and compares the different floor systems to various criteria.

	Floor System			
	Existing:	Alternative 1:	Alternative 2:	Alternative 3:
	Composite Steel	Pre-Cast Hollow Core Planks	Two-Way Flat Plate	One-Way Slab with Beams
Bay Size	29'-3" x 33'-0"	30'-0" x 32'-0"	30'-0" x 34'-0"	30'-0" x 34'-0"
System Cost	$25.64 / S.F.	$29.55 / S.F.	**$16.69 / S.F.**	$22.23 / S.F.
System Weight	**50.91 psf**	92.95 psf	212.5 psf	94.56 psf
System Depth	29.95"	31"	**17"**	30"
Slab Depth	6¼"	8"	17"	**4"**
Foundation Impact	**No**	Yes	Yes	Yes
Vibratory Control	Average	Fair	Average	**Good**
Constructability	**Good**	**Good**	Average	Fair
Schedule Impact	N/A	**Speed Up**	Slow Down	Slow Down
Fire Protection Method	Spray-On	Spray-On	N/A	N/A
Fire Rating	2 Hour	2 Hour	> 2 Hour	2 Hour
Formwork	No	No	Yes	Yes
Main Material	Steel	Concrete / Steel	Concrete	Concrete
Feasible:	N/A	No	**Yes**	Yes

* All costs are calculated using RSMeans Assemblies Cost Data 2012 which carries an approximate error of ± 15%. Costs include materials, installation, and labor.

Table 9: Comparison of the four floor systems to various criteria

Conclusion

Technical Report 2 compared the existing floor system of Global Village Building 400 at RIT with three alternative floor types. Upon completion of designing each floor system, an analysis was done to test if each was a feasible alternative to the existing system. The comparison table, Table 9, shows that the Flat Plate system is the most viable alternative but a One-Way Slab with Beams is also feasible.

Pre-Cast Hollow Core Plank was the only system that was found to be inadequate. Although the constructability is good and has the closest weight to the existing system, this floor type has the highest cost and system depth. Since this is a campus building, there is a budget and this type of floor might be too expensive. Due to 4'-0" wide planks being pre-cast, the bay size needed to be changed by 2'-0" in the long direction. This along with the larger floor depth could have an architectural impact on the building. This system was therefore rejected, and will not be considered as an alternative.

The Two-Way Flat Plate was considered to be the most viable option due to its cost, preservation of bay sizes, and ability to maintain or even increase ceiling heights. The drawback of using this type of floor is that the weight of structure may be four times greater than the existing structure. This could have serious impacts on the foundation design which needs to be further explored. Although lateral loads are not taken into account in this report, this system may need shear walls which would drive up cost and further impact the buildings overall weight.

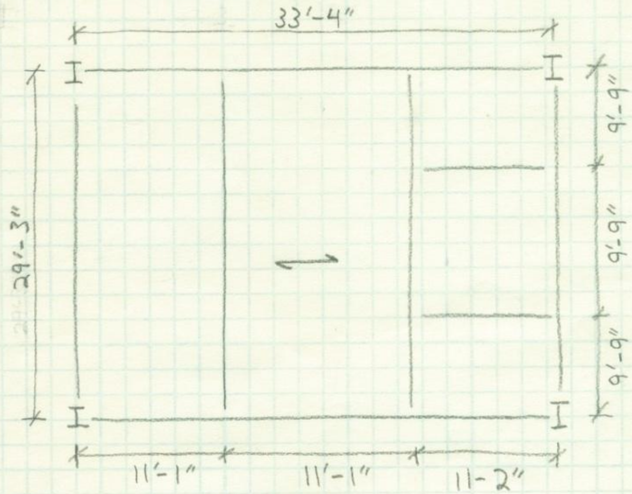
One-Way Slab with Beams is another feasible alternative design due to its great vibratory control and ability to preserve the bay size. However, it was not selected to be the most viable since there are really no standout features. The cost, weight, and system depth are in between the other floor types. For this reason and a longer construction time, a One-Way Slab is not the most viable alternative but should still be further investigated.

From the information gathered in this report, it was determined that the One-Way Slab with Beams and Two-Way Flat Plate systems shall be further investigated as alternative floor systems for Global Village Building 400.

Appendix A: 2nd Floor Framing Plan

Appendix B: Existing Composite Steel

Total: 1 | Chris Vandelogt | Tech 1 | Floor Sys: Steel Deck | 1



Location:
- Northwest End
- 2nd Floor

Loads:

→ Dead:
- Framing: 10 psf
- Super-imposed DL: 10 psf
- MEP: 10 psf
- Partition: 20 psf

→ Live: According to ASCE 7-10
- Office Buildings-Lobbies: 100 psf

since area is considered to be a lobby in the code occupancy types in arch drawings

For Floor system: Slab construction shall be 3¼" lightweight conc w/ WWF - W2.9 x W2.9 on 3", 18 GA min. Total Thickness = 6¼". Composite Stl Deck.
- Span: 11'-1" ≈ 11'-6" (cons)
- Loading: 100 psf (LL) + 10 psf (super DL) = 110 psf
- Since 3" deep deck is needed, use Vulcraft 3VLI
- Use slab depth of 6.25" (t = 3.25") 46 psf
- Per 18 GA min eq, use 3VLI 18.

Loading check at 11'-6": 191 psf > 110 psf ✓

Unshored Span check: 15' > 11'-1" ✓ (3-span)

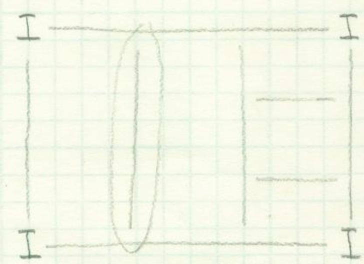
Use Vulcraft 3VLI 18.

Total: 2	Chris Vandelogt	Tech 1	Floor Sys: Beam	1

→ Same Bay as used in steel deck analysis

→ Loads:

- Framing: 10 psf
- Super-imposed DL: 10 psf
- MEP: 10 psf
- Partitions: 20 psf
- LL: 100 psf
- Slab: 46 psf



$A_T = 11.083(29.25) = 324.18\ ft^2$

LL Reduction

Live load is not reducible

$w_u = 1.2(96) + 1.6(100) = 275.2$

$w_u = 275.2(11.083) = 3.05\ k/ft$, $M_u = \frac{w l^2}{8} = \frac{3.05(29.25^2)}{8} = 326.18$

From Table 3-19

assume $a \approx 1.5$ ∴ $Y_2 = 6.25 - \frac{1.5}{2} = 5.5$

Rough Economy

* 40(10) + 29.25(26) = 1160.5 · W16×26: $\Sigma Q_n = 289$
$\phi M_n = 345$ ↳ $\frac{289}{14.6} = 19.8$ so 40 studs
(Table 3-21, 2 per rib, lightweight conc, deck perp, 3/4" studs)

→ * 1146.8 (most economic) · W16×31: $\Sigma Q_n = 164$
$\phi M_n = 332$ ↳ $\frac{164}{14.6} = 11.2$ so 24 studs

* 1253 · W16×36: $\Sigma Q_n = 133$
$\phi M_n = 353$ ↳ $\frac{133}{14.6} = 9.1$ so 20 studs

Check $a = \frac{164}{.85(3)(87.75)} = .73$ ∴ $Y_2 = 5.5''$ ok

$b_{eff} = \min \begin{cases} 2(29.25(12)/8) = 87.75 \leftarrow \text{controls} \\ 11.083(12) = 132.9 \end{cases}$

Total: 3 | Chris Vandelogt | Tech 1 | Floor Sys: Beam | 2

→ Check unshored strength:

W16x31 $\phi_p M_p = 203'^k$

$\omega_u = 1.2(46)(11.083) + 1.2(31) + 1.6(20)(11.083) = 1.003$ klf

$\omega_u = 1.4(46)(11.083) + 1.4(31) = .757$ klf

$M_u = \frac{1.003(29.25)^2}{8} = 107.3'^k < 203'^k$ ∴ ok for shoring

→ Check wet conc deflection:

$\omega_{wc} = 46(11.083) + 31 = .541$ klf

$\Delta_{wc} = \frac{5(.541)(29.25^4)(1728)}{384(29000)(375)} = .778$ in

camber: $.8 \times .778 = .62 \approx .75''$

$\Delta_{wc\,max} = \frac{29.25(12)}{240} = 1.46$ in — since $.778 < 1.46$, ok

→ Check LL deflection:

$\omega_{LL} = 100(11.083) = 1.11$ — From Table 3-20

$I_{LB} = 812$

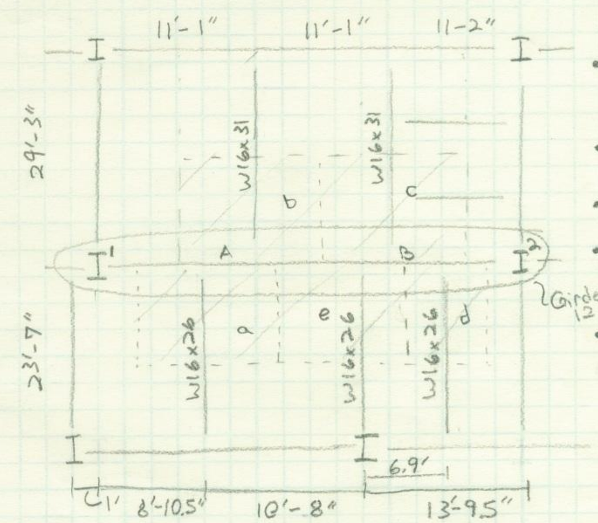
$\Delta_{LL} = \frac{5(1.11)(29.25^4)(1728)}{384(29000)(812)} = .776$

$\Delta_{LL\,max} = \frac{29.25(12)}{360} = .975$ — since $.776 < .975$ ok

→ Summary:

W16x31 w/ 24 studs & ¾" Camber

Total: 4 | Chris Vandelogt | Tech 1 | Floor Sys: Girder | 1



Areas:

- $a = \frac{9.875 + 10.66}{2}\left(\frac{23.583}{2}\right) = 121.1\ ft^2$
- $b = 11.083\left(\frac{29.25}{2}\right) = 162.1\ ft^2$
- $c = 11.125\left(\frac{29.25}{2}\right) = 162.7\ ft^2$
- $d = \left(\frac{13.79}{2}\right)\left(\frac{23.583}{2}\right) = 81.3\ ft^2$
- $e = \left(\frac{10.66 + 6.9}{2}\right)\left(\frac{23.583}{2}\right) = 103.5\ ft^2$

Since beams contact girder in 5 different locations, assume to take it as two unequal concentrated Loads unsymmetrically placed

→ Total Load on girder:

- Loads:
  - Super-imposed DL: 10 psf
  - MEP: 10 psf
  - Partitions: 20 psf
  - LL: 100 psf
  - Slab: 46 psf
  - Beam wt: Depends on beams
  - Girder wt Allowance: 50 lb/ft

Total: 5 | Chris Vandelogt | Tech 1 | Floor Sys: Girder | 2

→ Location A:

• From a: $P = 1.2(26(11.79) + (10+10+20+46)(121.1)) + 1.6(100(121.1)) = 32.24^k$

• From b: $P = 1.2(31(14.625) + (10+10+20+46)(162.1)) + 1.6(100(162.1)) = 43.21^k$

• Location: $\frac{8.875(32.24) + 11.083(43.21)}{(32.24 + 43.21)} = 10.14'$ → in from col 1

→ Location B:

• From c: $P = 1.2(31(14.625) + (10+10+20+46)(162.7)) + 1.6(100(162.7)) = 43.37^k$

• From d: $P = 1.2(26(11.79) + (10+10+20+46)(81.3)) + 1.6(100(81.3)) = 21.77^k$

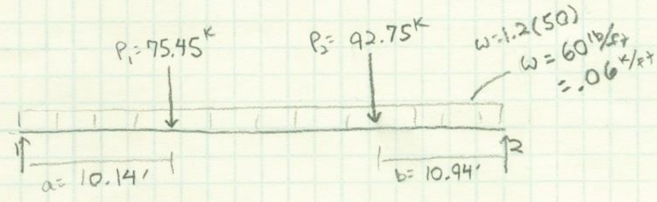
• From e: $P = 1.2(26(11.79) + (10+10+20+46)(103.5)) + 1.6(100(103.5)) = 27.61^k$

• Location: $\frac{11.16(43.37) + 6.89(21.77) + 13.79(27.61)}{(43.37 + 21.77 + 27.61)}$

$= 10.94'$ ← in from col 2

Result:

Girder 12:



Total: 6 | Chris Vandelogt | Tech 1 | Floor Sys: Girder | 3

→ Find Moment (From Table 3-23 in Manual)

$$R_2 = V_2 = \frac{P_1(l-a) + P_2 b}{l} = \frac{75.45(33.33-10.14) + 92.75(10.94)}{33.33}$$

from point loads $= 82.94$

$M_{max} = R_2 b = 82.94(10.94) = 907.36'^k$

$M_{x=22.39} = \frac{.06(22.39)}{2}(33.33-22.39) = 7.35'^k$

$M_{max,tot} = 914.71'^k$

→ Find composite girder

$M_u = 914.71'^k$

Assume $Y_2 = 5.5$ (From Beam Analysis)
↳ assume $a \approx 1.5''$

Rough Economy

*2593 • W24x55: $\Sigma Q_n = 544$
$\Phi M_n = 938$ ↳ $\frac{544}{14.6} = 37.3$ so 76 studs

→ *2566 most economic • W24x62: $\Sigma Q_n = 361$
$\Phi M_n = 929$ ↳ $\frac{361}{14.6} = 24.7$ so 50 studs

*2626 • W24x68: $\Sigma Q_n = 251$
$\Phi M_n = 933$ ↳ $\frac{251}{14.6} = 17.2$ so 36 studs

check $a = \frac{361}{.85(3)(100)} = 1.42''$ ∴ $Y_2 = 5.5''$ ok

$b_{eff} = \min \begin{cases} 2(33.33(12)/8) = 100 \leftarrow \text{controls} \\ 26.42(12) = 317.04 \end{cases}$

Total: 7 | Chris Vandelogt | Tech 1 | Floor Sys: Girder | 4

→ Check unshored strength:

W24x62 $\phi_b M_p = 574'^k$

$\omega_u = 1.2(46)(26.42) + 1.2(62) + 1.6(20)(26.4)$
$= 2.38$ klf

$\omega_u = 1.4(46)(26.42) + 1.4(62) = 1.78$ klf

$M_u = \frac{2.38(33.33)^2}{8} = 330.5'^k < 574'^k$ ∴ ok for shoring

→ Check wet conc deflection:

$\omega_{wc} = 46(26.42) + 62 = 1.28$ klf

$\Delta_{wc} = \frac{5(1.28)(33.33^4)(1728)}{384(29000)(1550)} = .79$

Camber
$.8 \times .79$
$= .63 \approx .75''$

$\Delta_{wc\,max} = \frac{33.33(12)}{240} = 1.67$ in since $.79 < 1.67$ ok

→ Check LL deflection

$\omega_{LL} = 100(26.42) = 2.64$

$I_{LB} = 3110$ — From Table 3-20

$\Delta_{LL} = \frac{5(2.64)(33.33^4)(1728)}{384(29000)(3110)} = .813$

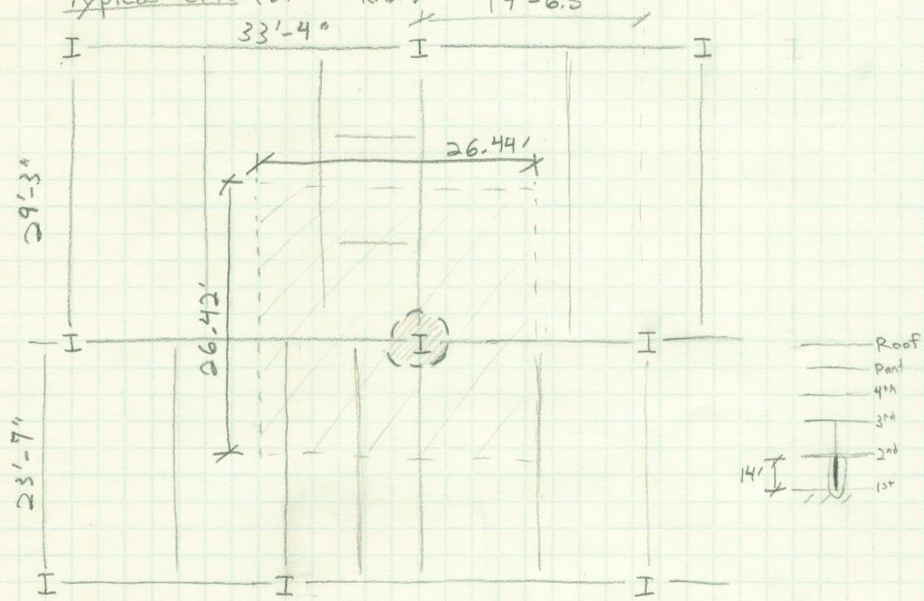
$\Delta_{LL\,max} = \frac{33.33(12)}{360} = 1.11$ since $.813 < 1.11$, ok

→ Summary:

W24x62 w/ 50 studs & 3/4" camber

Total: 11 | Chris Vandelogt | Tech 1 | Interior Column

Typical Grid (2nd Floor)



→ Tributary area:

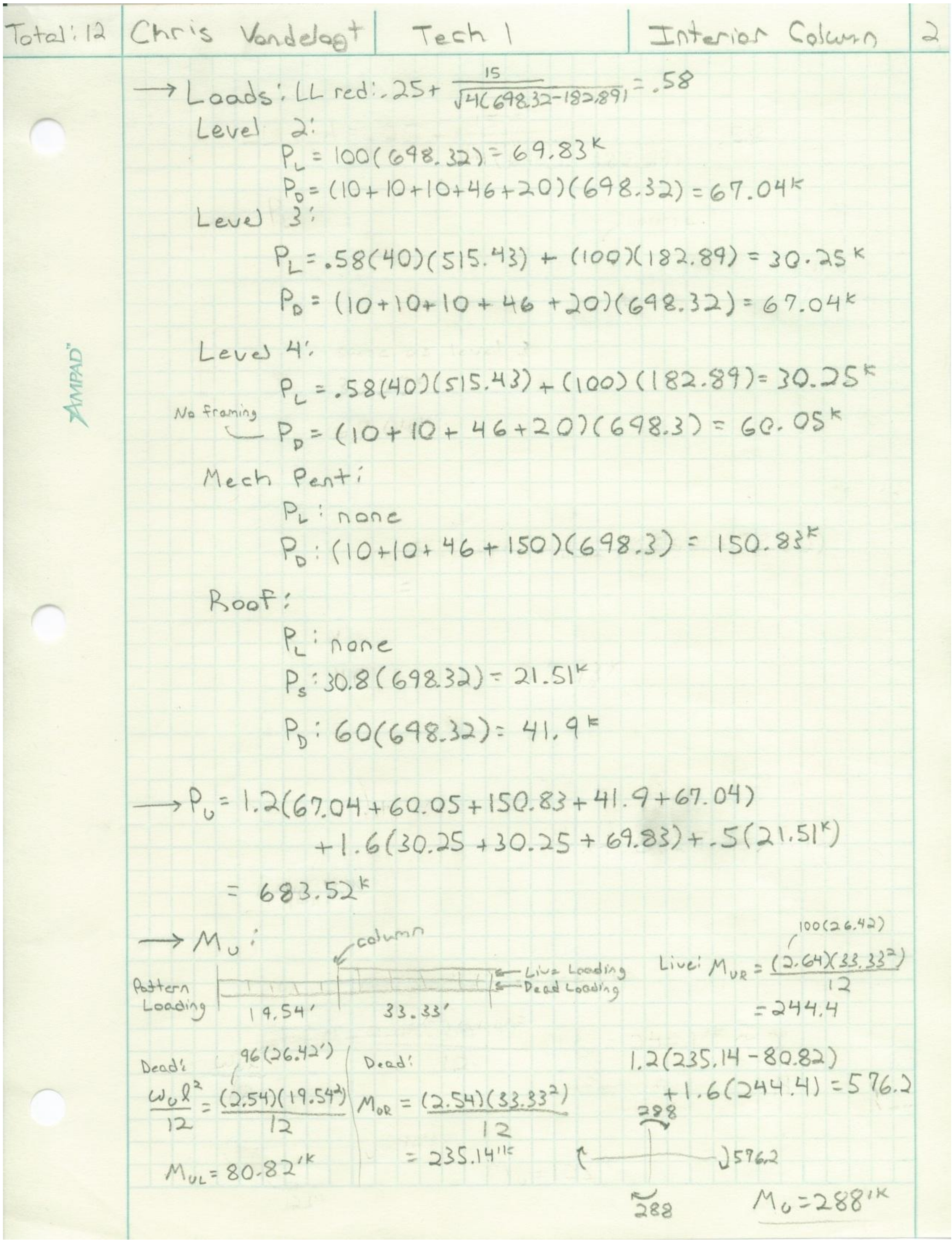
$$\left(\frac{23.583+24.25}{2}\right)\left(\frac{33.33+19.54}{2}\right) = 698.32 \text{ ft}^2$$

→ Loadings: Per ASCE 7-10 Residential,

- 2nd Floor: 100 psf
- Corridors: 100 psf (non-red)
- Private Rooms: 40 psf (reducible) (3rd + 4th Floor, Pent)
- Mechanical: 150 psf (assumed)
- Roof: Dead: 60 psf (assumed)
  - Snow: 30.8 psf — See Snow Load Calcs
- slab: 46 psf
- Framing: 10 psf
- Super-imposed: 10 psf
- MEP: 10 psf
- Partition: 20 psf

→ Corridor Area:

Width: 6.917'
Length: 26.44'
Trib Area: 182.89 ft²



Total: 12 | Chris Vandelogt | Tech 1 | Interior Column | 2

→ Loads: LL red: $.25 + \frac{15}{\sqrt{4(698.32-182.89)}} = .58$

Level 2:

$P_L = 100(698.32) = 69.83^k$

$P_D = (10+10+10+46+20)(698.32) = 67.04^k$

Level 3:

$P_L = .58(40)(515.43) + (100)(182.89) = 30.25^k$

$P_D = (10+10+10+46+20)(698.32) = 67.04^k$

Level 4:

$P_L = .58(40)(515.43) + (100)(182.89) = 30.25^k$

No framing → $P_D = (10+10+46+20)(698.3) = 60.05^k$

Mech Pent:

P_L: none

P_D: $(10+10+46+150)(698.3) = 150.83^k$

Roof:

P_L: none

P_s: $30.8(698.32) = 21.51^k$

P_D: $60(698.32) = 41.9^k$

→ $P_u = 1.2(67.04+60.05+150.83+41.9+67.04) + 1.6(30.25+30.25+69.83) + .5(21.51^k)$

$= 683.52^k$

→ M_u:

Live: $M_{uR} = \frac{(2.64)(33.33^2)}{12} = 244.4$ (100(26.42))

Dead: $\frac{w_u l^2}{12} = \frac{(2.54)(19.54^2)}{12}$ (96(26.42'))

$M_{uL} = 80.82'^k$

Dead: $M_{uR} = \frac{(2.54)(33.33^2)}{12} = 235.14'^k$

$1.2(235.14-80.82) + 1.6(244.4) = 576.2$

288 ; 576.2 ; 288

$M_u = 288'^k$

Total: 13 | Chris Vandelogt | Tech 1 | Interior Column | 3

→ Estimate Column sizes

$P_{eq} = P_u + 24M_u/d$

$P_{eq} = 683.52 + 24\left(\frac{288}{12}\right)$

$= 1259.5^{K}$

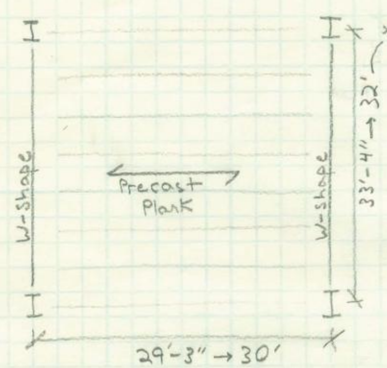
Assume $k = 1$
$L = 14'$
$d = 12''$

Using Table 4-1:

W12 × 120, $\Phi_c P_n = 1280^{K} > 1259.5^{k}$ ✓

Appendix C: Hollow Core Plank

10/14/11 | Chris Vandelogt | Tech 2 | Pre-Cast Core Planks on Steel Framing | 1



→ Loads: (From existing analysis)
- Framing: 10 psf
- SDL: 10 psf
- MEP: 10 psf
- Partitions: 20 psf
- LL: 100 psf (not reducible)

→ Bay size: 34' x 30'

→ Superimposed Service Load:

LL + SDL = 100 + 10 = 110 psf

→ Choose a Plank (Use Nitterhouse)
- 2hr fire rating
- 2" topping

Try: 8" x 4'-0" w/ 2" Topping and (7) ½"Ø strands

- At 30' Span and (7)½Ø: 114 psf > 110 psf ✓ok
- Note: • f'_c = 6000 psi
  - NWC = 150 pcf
  - Plank + Topping Self Wt = 61.25 + 25 = 86.25 psf

→ Design Girder

$\omega_D = (10+10+10+20+86.25)(30') = 4.09$ klf

$\omega_L = (100)(30') = 3$ klf

$\omega_u = 1.2(4.09) + 1.6(3) = 9.71$ klf

$$I_{req,LL} = \frac{5[1.6(3)](32)^4(1728)}{384(29000)(32\cdot12/360)} = 3661 \text{ in}^4$$

$$I_{req,TL} = \frac{5(9.71)(32)^4(1728)}{384(29000)(32\cdot12/240)} = \underline{4937 \text{ in}^4}$$

10/14/11 | Chris Vandelogt | Tech 2 | Pre-Cast Core Planks on Steel Framing | 2

From AISC Table 3-3:

- W27x146 $I = 5660 \text{ in}^4$
- W30 x 124 $I = 5360 \text{ in}^4$
- W21 x 201 $I = 5310 \text{ in}^4$ ← Try this (for a lower floor height)
- W24 x 162 $I = 5170 \text{ in}^4$

From Table 3-2 (For W21 x 201)

$\phi M_n = 1990$ k-ft

$\phi V_n = 628^k$

$M_u = \frac{9.71(32)^2}{8} = 1242^{k\text{-ft}} < \phi M_n$ ✓ok

$V_u = \frac{9.71(32)}{2} = 155.4^k < \phi V_n$ ✓ok

Check SW = $\frac{201}{30'} = 6.7 < 10$ psf ✓ok

→ Summary:

Floor: 8" x 4'-0" w/ 2" Topping and (7) ½"Ø Strands
Girder: W21 x 201

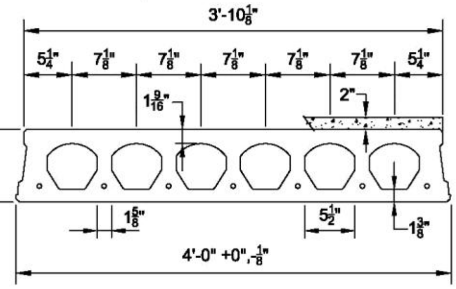
Prestressed Concrete
8"x4'-0" Hollow Core Plank

2 Hour Fire Resistance Rating With 2" Topping

PHYSICAL PROPERTIES
Composite Section

A_c = 301 in.^{2}	Precast b_w = 13.13 in.
I_c = 3134 in.^{4}	Precast S_{bcp} = 616 in.^{3}
Y_{bcp} = 5.09 in.	Topping S_{tct} = 902 in.^{3}
Y_{tcp} = 2.91 in.	Precast S_{tcp} = 1076 in.^{3}
Y_{tct} = 4.91 in.	Precast Wt. = 245 PLF
	Precast Wt. = 61.25 PSF

DESIGN DATA



1. Precast Strength @ 28 days = 6000 PSI
2. Precast Strength @ release = 3500 PSI
3. Precast Density = 150 PCF
4. Strand = 1/2"Ø 270K Lo-Relaxation.
5. Strand Height = 1.75 in.
6. Ultimate moment capacity (when fully developed)...
   4-1/2"Ø, 270K = 92.3 k-ft at 60% jacking force
   6-1/2"Ø, 270K = 130.6 k-ft at 60% jacking force
   7-1/2"Ø, 270K = 147.8 k-ft at 60% jacking force
7. Maximum bottom tensile stress is $10\sqrt{f'c}$ = 775 PSI
8. All superimposed load is treated as live load in the strength analysis of flexure and shear.
9. Flexural strength capacity is based on stress/strain strand relationships.
10. Deflection limits were not considered when determining allowable loads in this table.
11. Topping Strength @ 28 days = 3000 PSI. Topping Weight = 25 PSF.
12. These tables are based upon the topping having a uniform 2" thickness over the entire span. A lesser thickness might occur if camber is not taken into account during design, thus reducing the load capacity.
13. Load values to the left of the solid line are controlled by ultimate shear strength.
14. Load values to the right are controlled by ultimate flexural strength or fire endurance limits.
15. Load values may be different for IBC 2000 & ACI 318-99. Load tables are available upon request.
16. Camber is inherent in all prestressed hollow core slabs and is a function of the amount of eccentric prestressing force needed to carry the superimposed design loads along with a number of other variables. Because prediction of camber is based on empirical formulas it is at best an estimate, with the actual camber usually higher than calculated values.

SAFE SUPERIMPOSED SERVICE LOADS — IBC 2006 & ACI 318-05 (1.2 D + 1.6 L)

Strand Pattern		SPAN (FEET) 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
4 - 1/2"ø	LOAD (PSF)	280	248	214	185	159	138	118	102	87	74	62	52	42						
6 - 1/2"ø	LOAD (PSF)	366	341	318	299	271	239	211	187	165	146	129	114	101	88	77	67	58	50	42
7 - 1/2"ø	LOAD (PSF)	367	342	320	300	282	265	243	221	202	181	161	144	128	114	101	90	79	70	61

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Chambersburg, PA 17202-9203
717-267-4505 Fax 717-267-4518

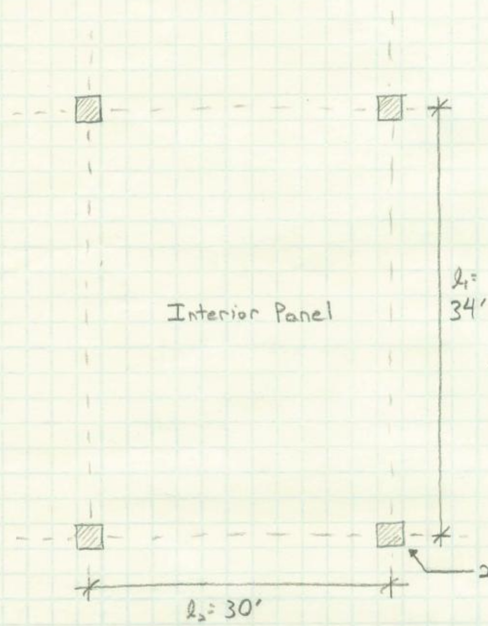
This table is for simple spans and uniform loads. Design data for any of these span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, flange or stem openings and narrow widths. The allowable loads shown in this table reflect a 2 Hour & 0 Minute fire resistance rating.

11/03/08

8SF2.0T

Appendix D: Two-Way Flat Plate

10/17/11 | Chris Vandelogt | Tech 2 | Flat Plate | 1



→ Story Height: 12 ft

→ Assume:
- f'_c = 4000 psi
- f_y = 60 ksi
- NW Concrete
- 24" Square Columns

→ Loads:
- SDL: 10 psf
- MEP: 10 psf
- Partitions: 20 psf
- DL: self
- LL: 100 psf (not red)

→ Minimum Slab Thickness (Per ACI 318-08 Table 9.5c)

$t_{min} = \ell_n / 33$ where $\ell_n = 34(12) - 24 = 384"$

$= 384/33$

$= 11.63$

$t_{min} = 12"$

→ Design Method

Direct Design can be used

✓ • Atleast 3 spans in each direction

✓ • $\ell_1 / \ell_2 = 34/30 = 1.13 \le 2$

✓ • Successive Span Lengths: $30' \ge 2/3(34)$

✓ • Column offsets

✓ • Gravity Loads Only & $w_L \le 2 w_D$

$w_D = 10 + 10 + 20 + 150 = 190$

$100 \le 380$

10/17/11 | Chris Vandelogt | Tech 2 | Flat Plate | 2

→ Punching Shear Check

12" • $\omega_u = 1.2\,\omega_D + 1.6\,\omega_L$

$= 1.2(140) + 1.6(100)$

$= .388$ ksf

$V_u = \omega_u \cdot \text{Area}$

$= .388\left[(34 \times 30) - \left(\frac{24+10.6}{12}\right)^2\right]$

$= 392.5^k$

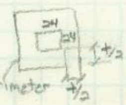
$\phi V_n = 4\sqrt{f'_c}\, b_o\, d\, (\phi)$

$= \frac{4\sqrt{4000}\,(138)(10.6)(.75)}{1000}$

$= 277.54^k$

$V_u > \phi V_n$ ✗

$b_o =$



└ = perimeter

$d = 12 - \frac{.625}{2} - .75$

$= 10.93$

$d' = 10.93 - .625 = 10.305$

$d_{avg} = \frac{10.305 + 10.93}{2} = 10.6$

16" • $\omega_u = 1.2\left(10+10+20+\frac{16}{12}(150)\right) + 1.6(100) = .448$ ksf

$d_{avg} = 14.63$

$V_u = 452.3$

$\phi V_n = 428.9$

$V_u > \phi V_n$, use thicker slab

17" • $\omega_u = 1.2\left(10+10+20+\frac{17}{12}(150)\right) + 1.6(100) = .463$ ksf

$d_{avg} = 15.63$

$V_u = 467.21$

$\phi V_n = 470$

$\phi V_n > V_u$

Try a 17" slab

10/17/11	Chris Vandelogt	Tech 2	Flat Plate	3

→ Moments in Column and Middle Strips (Long Dir)

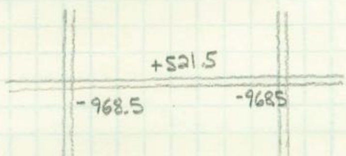
$\omega_u = .463$ ksf

$$M_o = \frac{\omega_u l_2 l_n^2}{8} = \frac{.463(30)(32)^2}{8} = 1777.92 \text{ ft-k}$$

According to ACI 13.6.3.2

Neg Moment: .65 $M^- = -1155.6$ ft-k

Pos Moment: .35 $M^+ = +622.2$ ft-k



→ $\frac{l_2}{l_1} = \frac{30}{34} = .88$

→ $\alpha = 0$ since no bms

Negative Column strip: -866.7 ft-k

From ACI 13.6.4, Column strip receives 75% of M^-

Positive Column strip: +373.3 ft-k

Receives 60% of M^+

Total width 30', col. strip = 15', middle strip = 15'

Total M	-1155.6	+622.2	-1155.6
M_{col}	-866.7	+373.3	-866.7
M_{mid}	-288.9	+248.9	-288.9

10/17/11	Chris Vandelogt	Tech 2	Flat Plate	4

→ Reinforcement Design and Distribution (Long Dir)

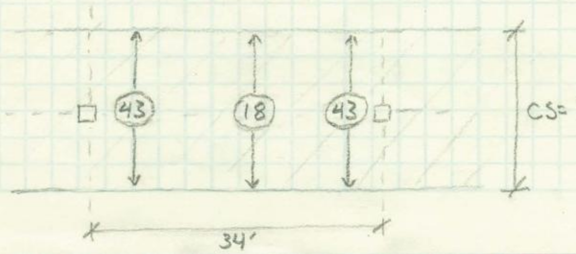
- Design of slab Reinf in Col strip

Description	M^-	M^+	
• M_u	−866.7	+373.3	
• b	180	180	b=15'×12=180"
• Eff depth	15.3	15.3	Assuming #5 bars $=17-.75-\frac{.625}{2}-.625$ $=15.3$
• $M_u \times {}^{12}/_b$	−57.8	+24.9	
• M_u/ϕ (ϕ=.9)	−963	+414.8	
• R	274.3	118.1	
• ρ	.0048	.002	
• $A_s = \rho bd$	13.2	5.5	
• $A_{s,min} = .0018bt$ (t=17")	5.5	5.5	
• $N = A_s/.31$	43	18	
• $N_{min} = b/2t$	6	6	
• ρ_{max}	.0206	.0206	ρ_{max} for Table A.4 in Nilson et al. 2004

$$R = \frac{M_n}{bd^2} = \frac{963\ (12000)}{180(15.3)^2} = 274.3$$

From Table A.5a in Nilson et al. 2004

	ρ	R	
M^-	.0045	259	
	.005	287	→ ρ=.0048



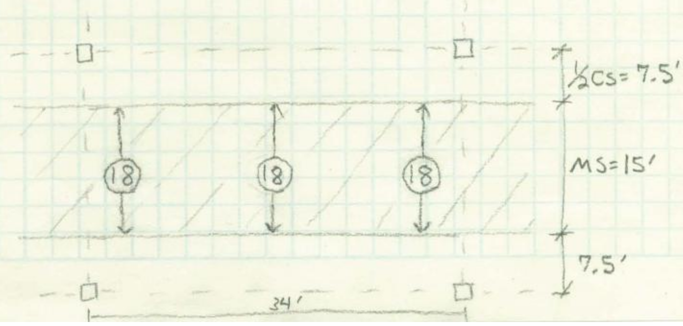
10/17/11 | Chris Vandelogt | Tech 2 | Flat Plate | 5

- Design of slab Reinf in Middle Strip

Desciption	M^-	M^+
• M_u	−288.9	+248.9
• b	180	180
• d_{eff}	15.3	15.3
• $M_u \times 12/b$	−19.3	+16.6
• M_u/ϕ	−321	+276.6
• R	91.4	78.8
• ρ	.00154	.00133
• $A_s = \rho bd$	4.2	3.7
• $A_{s\,min} = .0018\,bt$	5.5	5.5 ← use this A_s
• $N = A_s/.31$	18	18
• $N_{min} = b/2t$	6	6
• ρ_{max}	.0206	.0206

From Table A.5a in Nilson et al. 2004

	ρ	R	
M^-	.0015	89	→ $\rho = .00154$
	.002	118	
M^+	.001	59	→ $\rho = .00133$
	.0015	89	



10/17/11 | Chris VandeLogt | Tech 2 | Flat Plate | 6

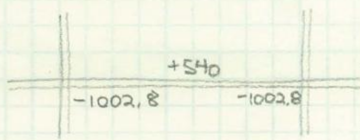
→ Moments in Column and Middle Strips (Short Dir)

$\omega_u = .463$ $M_o = \frac{.463(34)(28)^2}{8}$

$= 1542.7$ ft-k

$.65M_o$ $M^- = {}^-1002.8$ ft-k

$.35M_o$ $M^+ = {}^+540$ ft-k



→ $\frac{\ell_2}{\ell_1} = .88$

→ $\alpha = 0$ since no bms

Negative Col Strip: − 752.1 ft-k

Pos Col Strip: 324 ft-k

Total width 34′, col strip = 15′, mid strip = 19′

Total M	-1002.8	+540	-1002.8
M_{col}	-752.1	+324	-752.1
M_{mid}	-250.7	+216	-250.7

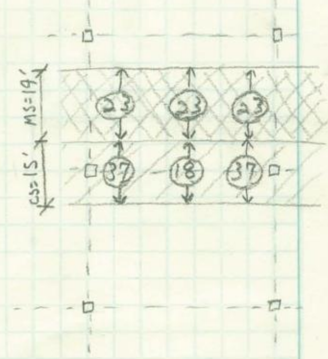
10/17/11	Chris Vandelogt	Tech 2	Flat Plate	7

→ Reinforcement Design and Distribution (Short Dir)

Description	Col Strip M^-	Col Strip M^+	Mid Strip M^-	Mid Strip M^+
• M_u	-752.1	+324	-250.7	+216
• b (smaller of $\frac{\ell_1}{2}\cdot 12$ or $\frac{\ell_2}{2}\cdot 12$)	180	180	228	228 ← (34·12) − 180
• d_{eff}	15.3	15.3	15.3	15.3
• $M_u \times 12/b$	-50.1	+21.6	-13.2	+11.4
• M_u/ϕ	-835.7	+360	-278.6	+240
• R	238	102.5	62.6	54
• ρ	.0041	.00173	.00106	.00091
• $A_s = \rho bd$	11.3	4.8	3.7	3.2
• $A_{s\,min} = .0018\,bt$	5.5	5.5	7.0	7.0
• $N = A_s/.31$	37	18	23	23
• $N_{min} = b/2t$	6	6	7	7
• ρ_{max}	.0206	.0206	.0206	.0206

From Table A.5a in Nilson et al. 2004

		ρ	R	
Col	M^-	.004	232	→ ρ = .00411
		.0045	259	
	M^+	.0015	89	→ ρ = .00173
		.002	118	
Mid	M^-	.001	59	→ ρ = .00106
		.0015	89	
	M^+	.0005	30	→ ρ = .00091
		.001	59	



10/17/11	Chris Vandelogt	Tech 2	Flat Plate	8

→ Wide Beam Checks

• Long Dir: $\left(\frac{34}{2}\right)-\left(\frac{24/2}{2}\right)-\left(\frac{15.63}{12}\right)=14.7'$

$V_u=(.463)(14.7)(30)$
$=204.2^k$

$\phi V_n=\phi(2\sqrt{f'_c}\,b_w d_{eff})$
$=\frac{.75(2\sqrt{4000}(30)(15.3)(12)}{1000}$
$=522.5^k$

$\phi V_n > V_u$ ∴ shear checks in long dir ✓

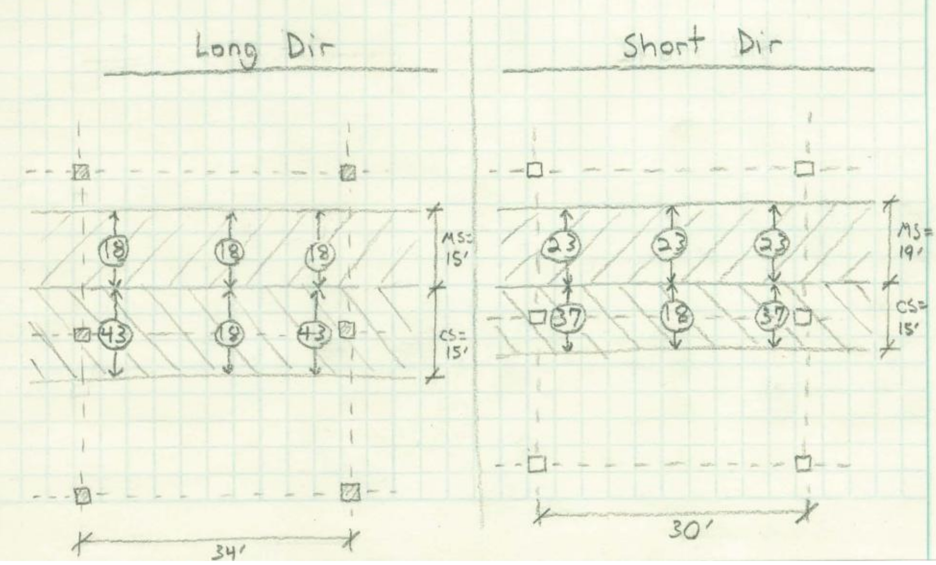
• Short Dir: $\left(\frac{30}{2}\right)-\left(\frac{2}{2}\right)-\left(\frac{15.63}{12}\right)=12.7'$

$V_u=(.463)(12.7)(34)$
$=199.9^k$

$\phi V_n=\frac{.75(2\sqrt{4000}(34)(15.3)(12)}{1000}$
$=592.2^k$

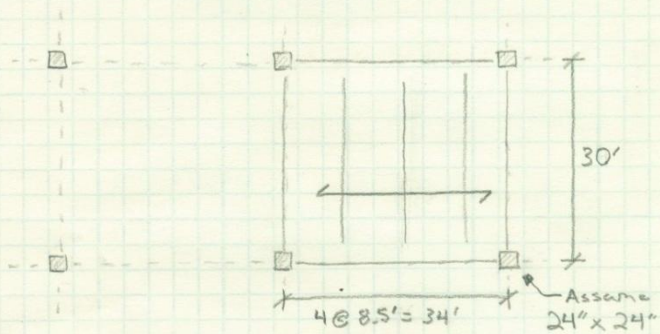
$\phi V_n > V_u$ ∴ shear checks in short dir ✓

→ Summary



Appendix E: One-Way Slab with Beams

10/18/11 | Chris Vandelogt | Tech 2 | Solid One Way Slab with Beams | 1



→ Min Slab Thickness (Per ACI 318-08 Table 9.5a)

For solid One-Way slab w/ Both Ends Cont: $t_{min} = \ell/28 = \frac{8.5' \times 12}{28}$

$= 3.64 \approx 4"$

Try a slab thickness of 4"

→ Reinforcement Design (Per Ch. 7 in the 2008 CRSI Handbook pg 7-7)

$\omega_u = 1.2(10+10+20) + 1.6(100) = 208$ psf

use $f'_c = 4000$ psi and Grade 60 bars

From tables, $\rho = .005$ is need for an 8.5' span w/ a 4" thick slab

224 psf > 208 psf ✓ ok

- Bottom Bars: #4 @12" spacing
- Top Bars: #3 @12" spacing
- T-S Bars: #3 @11" spacing
- Area of steel (Bottom): 0.200 in²/ft
- Slab Wt: 50 psf
- Steel Wt: 1.25 psf

10/18/11	Chris Vandelogt	Tech 2	Solid One Way Slab with Beams	2

→ Crack Control

Max Spacing $(s) = 12\left(\frac{40000}{f_s}\right)$

$= 12\left(\frac{40000}{40000}\right)$

$= 12''$ ✓ok since spacing is 12" and under

→ Beam Design

From ACI 318-08 Table 9.5a

$h_{min} = \ell/21 = \frac{30 \times 12}{21} = 17.14 \rightarrow 18''$ (for use with CRSI Tables)

Slab weight $= \frac{4}{12}(150) = 50 \rightarrow 1.2(50) = 60$

$w_u = (208 + 60) \times 8.5' = 2.28$ k/ft

$\ell_n = 30 - \left(\frac{24}{12}\right) = 28'$

Using Table on pg 12-59 & $h = 18''$, $\ell_n = 28'$

- $b = 12''$ $2.56 > 2.28$ ✓ok
- Bottom Reinf: (2) #9
- Top Reinf: (2) #11
- Stirrups: 193E → (19) #3: 1@2", 18@7" Each End
- Design Moment Strengths:
  - $+\phi M_n = 125$ ft-k
  - $-\phi M_n = 182$ ft-k

10/18/11	Chris Vandelogt	Tech 2	Solid One Way Slab with Beams	3

→ Girder Design

$2.28 + 1.2(.225) = 2.55$

$2.55(30') = 76.5\ (3) = 229.5^k$ ← # of bms

$\frac{229.5}{34'} = 6.75\ ^k/ft$ — assume a uniform load on girder

$t_{min} = 17.14'' + 2'' = 19.14 \rightarrow 20''$ (for use with CRSI Tables) ← beam

$\ell_n = 34 - (\frac{24}{12}) = 32'$

Using Table on pg 12-61 & $h = 20''$, $\ell_n = 32'$

$h = 20$ will doesn't have the capacity for a $6.75\ ^k/ft$ @ $\ell_n = 32'$

↓ Find h value that works @ $\ell_n = 32'$ (use Table on pg 12-67)

- $h = 26''$
- $b = 20''$ $7.55 > 6.75$ ✓ ok
- Bottom Reinf: (2)#10, (2)#10
- Top Reinf: (4)#14
- Stirrups: 175 Fdl → (17)#5: 1@2", 4@8", 12@11" Each End
- Design Moment Strengths:
  $+\phi M_n = 482^{ft\text{-}k}$
  $-\phi M_n = 735^{ft\text{-}k}$

SOLID ONE-WAY SLABS—SINGLE SPAN $f'_c = 4{,}000$ psi						Grade 60 Bars						Bottom Steel for $+M_u$ $\rho \approx 0.0050$	
Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Bottom Bars Spacing (in.)	#4 12	#4 11	#4 10	#4 8	#5 12	#5 11	#5 10	#5 9	#6 12	#6 11	#6 11	#6 10	#6 9
Top Bars Spacing (in.)	#3 12	#3 12	#3 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12	#4 12
T-S Bars Spacing (in.)	#3 11	#3 11	#3 11	#3 11	#3 10	#3 9	#3 8	#3 8	#3 7	#3 7	#3 6	#4 11	#4 11
Areas of Steel ($in.^2/ft$) Bottom	0.200	0.218	0.240	0.300	0.310	0.338	0.372	0.413	0.440	0.480	0.480	0.528	0.587
Slab Wt. (psf) Steel Wt. (psf)	50 1.25	56 1.31	63 1.38	69 1.73	75 1.83	81 1.96	88 2.15	94 2.29	100 2.48	106 2.61	113 2.72	119 2.84	125 3.04
CLEAR SPAN	FACTORED USABLE SUPERIMPOSED LOAD (psf)												
6'-0"	510	661	841										
6'-6"	425	553	705										
7'-0"	359	467	598	860	982								
7'-6"	305	398	511	738	844								
8'-0"	260	342	440	639	730	889							
8'-6"	224	295	381	556	637	776	943						
9'-0"	193	256	332	487	558	682	830						
9'-6"	167	223	290	429	492	602	734	898					
10'-0"	145	194	254	379	435	534	652	799	917				
10'-6"	126	170	223	336	386	475	582	714	821	973			
11'-0"	109	149	197	299	344	424	521	641	737	875	938		
11'-6"	95	131	174	266	307	380	467	577	664	790	847		
12'-0"	82	114	153	238	274	341	421	520	600	715	766	911	
12'-6"	71	100	135	212	246	306	379	471	544	649	696	828	991
13'-0"	61	87	119	190	220	276	343	427	493	590	633	755	905
13'-6"	52	76	105	170	198	249	310	387	449	538	577	690	828
14'-0"	44	66	92	152	178	225	281	352	409	491	527	631	759
14'-6"		57	81	136	159	203	255	321	373	449	482	579	698
15'-0"		49	71	122	143	183	231	292	341	411	441	531	642
15'-6"		41	61	109	128	165	210	266	311	377	405	488	592
16'-0"			53	97	115	149	190	243	285	346	372	450	546
16'-6"			45	86	102	134	172	222	261	318	341	414	504
17'-0"				77	91	121	156	202	239	292	314	382	466
17'-6"				68	81	109	142	185	218	268	288	352	432
18'-0"				59	72	97	128	168	200	247	265	325	400
18'-6"				52	63	87	115	153	183	227	244	300	370
19'-0"				45	55	77	104	139	167	208	224	277	343
19'-6"					48	68	93	127	152	191	206	256	318
20'-0"					41	60	83	115	139	176	189	236	295

Note: See Fig. 7-1 for reinforcing bar details.
*Service loads corresponding to 1/1.6 of the tabulated superimposed load results in calculated immediate deflection of 1/360 span.
"H" – Use hooked or headed bars.

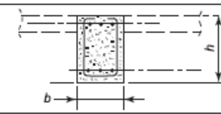
CONCRETE REINFORCING STEEL INSTITUTE

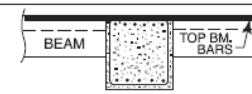
7-7

7

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

RECTANGULAR BEAMS, INTERIOR SPANS





STEM		BARS[1]				TOTAL CAPACITY $U = 1.2D + 1.6L$[3]																				$+\phi M_n$ $-\phi M_n$	DEFL (C)
		BOTTOM		Layers	TOP	SPAN, ℓ_n = 24 ft					SPAN, ℓ_n = 26 ft.					SPAN, ℓ_n = 28 ft.					SPAN, ℓ_n = 30 ft.						
h in.	b in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	(6) ft.-kip	(7) $\times 10^{-9}$ in.
18	10	2# 5		1	2# 7	1.17	113E	3	-	151	1.00	113E	3	-	161	0.86	103E	3	-	168	0.75	103E	3	-	177	42	1005
				1			293C	10	0.6	241		303C	10	0.6	255		323C	10	0.6	273		343C	10	0.6	291	78	
		2# 6		1	2# 8	1.63	143E	3	-	204	1.39	143E	3	-	217	1.20	153E	3	-	233	1.05	153E	3	-	246	58	1293
				1			293C	10	0.6	284		303C	10	0.6	302		323C	10	0.6	323		343C	10	0.6	345	100	
		2# 8		1	2# 9	2.35	163E	3	-	291	2.00	173E	3	-	314	1.73	183E	3	-	337	1.50*	193E	3	-	360	100	1189
				1			293C	10	0.6	366		303C	10	0.6	390		323C	10	0.6	418		343C	10	0.6	446	123	
		2# 8		1	2#10	2.79	173E	3	-	323	2.37*	183E	3	-	349	2.05*	193E	3	-	374	1.78*	203E	3	-	399	100	1121
				1			473A	10	0.6	471		503A	10	0.6	506		533A	10	0.6	541		343C	10	0.6	483	150	
	12	2# 6		1	2# 7	1.51	123E	3	-	179	1.29	123E	3	-	190	1.11	123E	3	-	202	0.97	113E	3	-	210	59	945
				1			243D	14	0.7	249		263D	14	0.7	269		273D	14	0.7	285		293D	13	0.7	306	79	
		2# 7		1	2# 9	2.20	153E	3	-	259	1.88	153E	3	-	276	1.62	163E	3	-	297	1.41	163E	3	-	314	79	1108
				1			244D	14	0.7	431		263D	14	0.7	346		273D	14	0.7	367		293D	13	0.7	394	125	
		2# 8		1	2#10	2.83	163E	3	-	322	2.41	173E	3	-	348	2.08*	183E	3	-	373	1.81*	193E	3	-	398	101	1031
				1			244D	14	0.7	491		264D	14	0.7	532		274D	14	0.7	[illegible]		294D	13	0.7	604	[illegible]	
		2# 9		1	2#11	3.49	173E	3	-	394	2.97*	183E	3	-	425	2.56*	193E	3	-	456	2.23*	203E	3	-	487	125	923
				1			244D	14	0.7	560		264D	14	0.7	606		274D	14	0.7	643		294D	13	0.7	689	182	
	14	2# 7		1	3# 7	2.22	143E	4	-	247	1.89	143E	4	-	263	1.63	143E	4	-	280	1.42	143E	4	-	296	79	964
				1			243D	18	0.8	315		263D	17	0.8	340		283D	17	0.8	366		293D	17	0.8	387	116	
		2# 8		1	3# 8	2.85	163E	4	-	315	2.43	163E	4	-	336	2.10	173E	4	-	361	1.83*	173E	4	-	382	103	954
				1			244D	18	0.8	493		264D	17	0.8	533		284D	17	0.8	574		294D	17	0.8	605	149	
		2# 9		1	3# 9	3.49	173E	4	-	390	2.98	183E	4	-	420	2.57*	183E	4	-	447	2.23*	193E	4	-	478	127	866
				1			244D	18	0.8	564		264D	17	0.8	611		284D	17	0.8	657		294D	17	0.8	694	182	
		2#10		1	3#10	4.24	184E	4	-	539	3.62*	194E	4	-	580	3.12*	203E	4	-	557	2.72*	203E	4	-	591	157	759
				1			245D	18	0.8	806		264D	17	0.8	707		284D	17	0.8	760		294D	17	0.8	804	222	
	16	2# 7		1	3# 7	2.24	133E	5	-	245	1.90	133E	5	-	261	1.64	133E	5	-	278	1.43	133E	5	-	294	80	790
				1			214E	22	0.9	412		223E	21	0.9	327		243E	21	0.9	353		263E	21	0.9	380	118	
		2# 8		1	3# 8	2.89	153E	5	-	313	2.46	153E	5	-	335	2.12	163E	5	-	360	1.85	163E	5	-	381	104	858
				1			214E	22	0.9	474		224E	21	0.9	505		244E	21	0.9	547		264E	21	0.9	588	151	
		2#10		1	3#10	4.34	174E	5	-	537	3.70*	183E	5	-	518	3.19*	193E	5	-	556	2.78*	203E	5	-	594	159	720
				1			215E	22	0.9	772		225E	21	0.9	823		244E	21	0.9	733		264E	21	0.9	787	227	
		2#10		1	3#11	4.43	174E	5	-	585	3.78	183E	5	-	571	3.26*	193E	5	-	613	2.84*	203E	5	-	654	159	671
				1			215E	22	0.9	821		225E	21	0.9	876		245E	21	0.9	948		264E	21	0.9	848	256	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth – 2 inches (b – 2″).
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.2 × stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * – $\ell_n/360$ < deflection < $\ell_n/240$
X – $\ell_n/240$ < deflection < $\ell_n/180$
Y – deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, second line is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-14.

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

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section $b \times h$
(7) Midspan elastic deflection (in.) = $C \times (w/1.4) \times \ell_n^4$, where w = tabulated load (k/ft), ℓ_n in ft.
"Average service load" is taken as $w/1.4$.

CONCRETE REINFORCING STEEL INSTITUTE

12-59

12

$f_c' = 4{,}000$ psi
$f_y = 60{,}000$ psi

RECTANGULAR BEAMS, INTERIOR SPANS

STEM		BARS[1]				TOTAL CAPACITY $U = 1.2D + 1.6L$[3]																				$+\phi M_n$ $-\phi M_n$	DEFL (C)
h	b	BOTTOM		Lay-ers	TOP	SPAN, ℓ_n = 32 ft					SPAN, ℓ_n = 34 ft.					SPAN, ℓ_n = 36 ft.					SPAN, ℓ_n = 38 ft.						
in.	in.	ℓ_n + 12 in.	0.875 ℓ_n	(2)		LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	(6) ft.-kip	(7) $\times 10^{-9}$ in.
26	14	2# 8		1	3# 8	2.50	123I	7	-	399	2.21	123I	7	-	420	1.98	123I	7	-	442	1.77	123I	7	-	463	160	304
				1			244F	30	1.2	622		264F	30	1.2	667		274F	29	1.2	699		284F	29	1.2	732	234	
		2# 9		1	3# 9	3.12	133I	7	-	498	2.76	143I	7	-	530	2.46	143I	7	-	557	2.21	143I	7	-	584	199	308
				1			244F	30	1.2	717		264F	30	1.2	767		274F	29	1.2	806		284F	29	1.2	845	290	
		2#11		1	3#11	4.60	154I	7	-	816	4.08	164I	7	-	867	3.64	164I	7	-	910	3.26	174I	7	-	961	299	252
				1			245F	30	1.2	1141		265F	30	1.2	1221		275F	29	1.2	1283		285F	29	1.2	1344	428	
		2#10	1#10	1	4#11	5.19	165I	7	-	1055	4.59	164I	7	-	1027	4.10	174I	7	-	1087	3.68	174I	7	-	1139	359	231
				2			245F	30	1.2	1291		265F	30	1.2	1381		275F	29	1.2	1452		285F	29	1.2	1522	482	
	16	2# 9		1	3# 9	3.14	133I	9	-	500	2.78	133I	9	-	527	2.48	133I	9	-	554	2.23	133I	9	-	581	200	272
				1			225G	37	1.4	870		234G	37	1.3	743		244G	37	1.3	783		284F	36	1.3	858	294	
		2#10		1	3#10	3.92	143I	9	-	622	3.47	143I	9	-	656	3.09	153I	9	-	695	2.78	153I	9	-	729	251	262
				1			225G	37	1.4	988		235G	37	1.3	1042		245G	37	1.3	1096		255G	36	1.3	1149	364	
		2#11		1	4#10	4.73	154I	9	-	847	4.19	154I	9	-	891	3.74	164I	9	-	944	3.36	164I	9	-	988	302	230
				1			225G	37	1.3	1146		235G	37	1.3	1210		245G	37	1.3	1274		255G	36	1.3	1337	470	
		2#14		1	3#14	6.30	165I	9	-	1214	5.58	165I	9	-	1275	4.98	175I	9	-	1350	4.47*	185I	9	-	1425	418	192
				1			325D	37	1.3	1618		345D	37	1.3	1718		365D	36	1.3	1818		375D	36	1.3	1898	586	
	18	2# 8	1# 8	1	3# 9	3.19	123I	11	-	513	2.82	123I	11	-	541	2.52	123I	11	-	569	2.26	123I	11	-	598	238	228
				1			224G	45	1.5	730		234G	44	1.5	771		314E	44	1.5	898		324E	44	1.5	939	296	
		2# 9	1# 9	1	3#11	4.63	144I	11	-	770	4.10	154I	11	-	818	3.66	153I	11	-	795	3.29	153I	11	-	835	296	225
				1			225G	45	1.5	1090		235G	44	1.5	1150		245G	44	1.5	1210		265G	44	1.5	1290	442	
		2#10	1#10	1	3#14	5.76	155I	11	-	1088	5.10	164I	11	-	1072	4.55	164I	11	-	1127	4.08	174I	11	-	1190	368	190
				1			325D	45	1.5	1522		345D	44	1.5	1617		365D	44	1.5	1711		265G	44	1.5	1564	602	
		2#11	1#11	1	3#14	6.48	155I	11	-	1179	5.74	165I	11	-	1253	5.12	175I	11	-	1327	4.59	175I	11	-	1387	442	181
				1			325D	45	1.5	1613		345D	44	1.5	1713		365D	44	1.5	1813		385D	44	1.5	1913	602	
	20	2# 8	1# 8	1	3#10	3.74	123I	13	-	572	3.31	133I	13	-	609	2.96	133I	13	-	641	2.65	133I	13	-	672	239	212
				1			195H	53	1.7	912		215H	53	1.6	986		225H	52	1.6	1038		235H	52	1.6	1091	371	
		2# 9	1# 9	1	3#11	4.66	143I	13	-	712	4.13	143I	13	-	752	3.69	143I	13	-	792	3.31	153I	13	-	836	298	211
				1			195H	53	1.6	1042		215H	53	1.6	1124		225H	52	1.6	1185		235H	52	1.6	1246	447	
		2#11	1#11	1	3#14	6.58	155I	13	-	1184	5.83	165I	13	-	1258	5.20	165I	13	-	1318	4.67	174I	13	-	1301	447	174
				1			285E	53	1.6	1552		295E	52	1.6	1633		315E	52	1.6	1734		335E	52	1.6	1836	612	
		2#10	2#10	1	4#14	7.55	175FdI	13	-	1389	6.68	165I	13	-	1445	5.96	175I	13	-	1530	5.35	185I	13	-	1616	482	153
							325D	53	1.6	1611		345D	52	1.6	1924		315E	52	1.6	1932		335E	52	1.6	2044	735	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth – 2 inches (b – 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.2 × stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ are designated thus: * – $\ell_n/360$ < deflection < $\ell_n/240$
X – $\ell_n/240$ < deflection < $\ell_n/180$
Y – deflection > $\ell_n/180$

(5) For each beam design, first line is for open stirrups, second line is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-14.

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

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section $b \times h$
(7) Midspan elastic deflection (in.) = $C \times (w/1.4) \times \ell_n^4$, where w = tabulated load (k/ft.), ℓ_n in ft.
"Average service load" is taken as w/1.4.

CONCRETE REINFORCING STEEL INSTITUTE

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Appendix F: System Analysis

10/18/11 | Chris Vandelogt | Tech 2 | Weight Analysis | 1

→ Existing System: Composite Slab

Slab: 46 psf

Steel Framing: 2.12 psf (Girder) + 2.79 psf (Beams) = 4.91 psf

Total Weight: 50.91 psf

→ System 1: Hollow Core

Slab: 86.25 psf

Steel Framing: 6.7 psf

Total Weight: 92.95 psf

→ System 2: Flat Plate

Slab: $\frac{17}{12}(150) = 212.5$ psf

Total Weight: 212.5 psf

→ System 3: One-Way Slab w/ Beams

Slab: $\frac{4}{12}(150) = 50$ psf

Framing: 26.5 (Beam) + 18.06 (Girder) = 44.56 psf

Total Weight: 94.56 psf

10/18/11 | Chris Vandelogt | Tech 2 | Depth Analysis | 1

→ Existing System: Composite Slab

Slab: 6¼" Thick

Girder: W24×62 From Table 1-1 in AISC
d = 23.7"

Total Thickness: 29.95"

→ System 1: Hollow Core System

Slab: 8" Thick

Girder: 21 × 201 (d = 23")

Total Thickness: 31"

→ System 2: Flat Plate

Slab: 17" Thick

Total Thickness: 17"

→ System 3: One-Way Slab w/ Beams

Slab: 4"

Girder: 26"

Total Thickness: 30"

10/18/11	Chris Vandelogt	Tech 2	Cost Analysis	1

• Cost of floor systems taken from
RS Means Assemblies Cost Data 2012 (37th Edition)

• Superimposed Load

10 (SDL) + 10 (MEP) + 20 (Partitions) + 100 (LL) = 140 psf

∴ use 200 psf

• Bay size: 30'×34' or 30'×32'

∴ use 30'×35'

• Location Factor:

Rochester, NY = 97.3

→ Existing System: Composite Beams, Deck & Slab
(Per Table B1010 256 – #5500 on pg 94)

Mat	Inst	Total
18.4	7.95	26.35

$26.35 \times \frac{97.3}{100} = 25.64$

Cost = $25.64 per S.F.

→ System 1: Hollow Core System
(Per Table B1010 230 – #3600 on pg 70
& Table B1010 241 – #8450 on pg 80)

Hollow Core

Mat	Inst	Total
8.8	4.7	13.57

Girders

Mat	Inst	Total
13.25	3.55	16.8

* Note: values were divided by two since only the cost of the girders is needed. To be cons, the girders were assumed to account for 50% of the cost

Hollow Core System

Mat	Inst	Total
22.05	8.25	30.37

$30.37 \times \frac{97.3}{100} = 29.55$

Cost = $29.55 per S.F.

10/18/11	Chris Vandelogt	Tech 2	Cost Analysis	2

→ System 2: Flat Plate
(Per Table B1010 223 - #7600 on pg 64)

Since 30'x35' is not given, estimate values

	Mat	Inst	Total
For 20'x20'	5.75	8.8	14.55
For 25'x25'	6.6	9.25	15.85
Diff	.85	.45	1.3
Assumed for 30'x35'	7.45	9.7	17.15

$17.15 \times \frac{97.3}{100} = 16.69$ Cost = \$16.69 per S.F.

→ System 3: Cast in Place Beam & Slab, One Way
(Per Table B1010 219 - #7800 on pg 59)

Mat	Inst	Total
8.6	14.25	22.85

$22.85 \times \frac{97.3}{100} = 22.23$

Cost = \$22.23 per S.F.

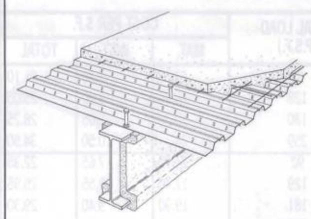
→ Summary

Cheapest ↑

Slab System	Mat	Inst	Total
	Cost per S.F.		
1. Flat Plate	7.25	9.44	16.69
2. One Way Beam & Slab	8.37	13.86	22.23
3. Composite System	17.90	7.74	25.64
4. Hollow Core System	21.46	8.09	29.55

B10 Superstructure

B1010 Floor Construction



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

Design and Pricing Assumptions:
Structural steel is A36, high strength bolted.
Composite steel deck varies from 22 gauge to 16 gauge, galvanized.
Shear Studs are 3/4".
W.W.F., 6 x 6 – W1.4 x W1.4 (10 x 10)
Concrete f'c = 3 KSI, lightweight.
Steel trowel finish and cure.
Fireproofing is sprayed fiber (non-asbestos).
Spandrels are assumed the same as interior beams and girders to allow for exterior wall loads and bracing or moment connections.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 256 2400					
20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS					
Structural steel	4.320	Lb.	6.05	1.86	7.91
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.12	.32	.44
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	2.08	.97	3.05
Sheet metal edge closure form, 12", w/2 bends, 18 ga, galv	.045	L.F.	.18	.11	.29
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.15	.36	.51
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	2.41		2.41
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.51	.51
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.86	.86
Curing with sprayed membrane curing compound	.010	C.S.F.	.08	.09	.17
Shores, erect and strip vertical to 10' high	.020	Ea.		.41	.41
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.28	.47	.75
TOTAL			11.35	5.96	17.31

B1010 256 Composite Beams, Deck & Slab

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT.-IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2400	20x25	40	5-1/2	1 - 5-1/2	80	11.35	5.95	17.30
2500	RB1010 -100	75	5-1/2	1 - 9-1/2	115	11.85	6	17.85
2750		125	5-1/2	1 - 9-1/2	167	14.55	7	21.55
2900		200	6-1/4	1 - 11-1/2	251	16.40	7.55	23.95
3000	25x25	40	5-1/2	1 - 9-1/2	82	11.10	5.70	16.80
3100		75	5-1/2	1 - 11-1/2	118	12.45	5.80	18.25
3200		125	5-1/2	2 - 2-1/2	169	13	6.25	19.25
3300		200	6-1/4	2 - 6-1/4	252	17.60	7.35	24.95
3400	25x30	40	5-1/2	1 - 11-1/2	83	11.35	5.65	17
3600		75	5-1/2	1 - 11-1/2	119	12.25	5.75	18
3900		125	5-1/2	1 - 11-1/2	170	14.35	6.50	20.85
4000		200	6-1/4	2 - 6-1/4	252	17.70	7.35	25.05
4200	30x30	40	5-1/2	1 - 11-1/2	81	11.45	5.85	17.30
4400		75	5-1/2	2 - 2-1/2	116	12.40	6.10	18.50
4500		125	5-1/2	2 - 5-1/2	168	15.15	6.80	21.95
4700		200	6-1/4	2 - 9-1/4	252	18.20	7.95	26.15
4900	30x35	40	5-1/2	2 - 2-1/2	82	12.05	6	18.05
5100		75	5-1/2	2 - 5-1/2	117	13.20	6.15	19.35
5300		125	5-1/2	2 - 5-1/2	169	15.60	7	22.60
5500		200	6-1/4	2 - 9-1/4	254	18.40	7.95	26.35
5750	35x35	40	5-1/2	2 - 5-1/2	84	12.80	6.05	18.85
6000		75	5-1/2	2 - 5-1/2	121	14.70	6.50	21.20

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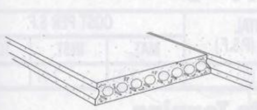
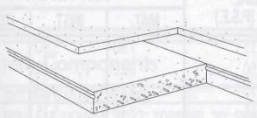
B10 Superstructure

B1010 Floor Construction





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

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

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

Camber and deflection may limit use by depth considerations.

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

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

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

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

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

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

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

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

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 230 2000					
10′ SPAN, 40 LBS S.F. WORKING LOAD, 2″ TOPPING					
Precast prestressed concrete roof/floor slabs 4″ thick, grouted	1.000	S.F.	6.65	3.36	10.01
Edge forms to 6″ high on elevated slab, 4 uses	.100	L.F.	.02	.41	.43
Welded wire fabric 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf, 10% lap	.010	C.S.F.	.15	.36	.51
Concrete ready mix, regular weight, 3000 psi	.170	C.F.	.71		.71
Place and vibrate concrete, elevated slab less than 6″, pumped	.170	C.F.		.26	.26
Finishing floor, monolithic steel trowel finish for resilient tile	1.000	S.F.		1.13	1.13
Curing with sprayed membrane curing compound	.010	C.S.F.	.08	.09	.17
TOTAL			7.61	5.61	13.22

B1010 229 Precast Plank with No Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
0720	10	40	4	50	90	6.65	3.36	10.01
0750	RB1010 -010	75	6	50	125	7.15	2.88	10.03
0770		100	6	50	150	7.15	2.88	10.03
0800	15	40	6	50	90	7.15	2.88	10.03
0820	RB1010 -100	75	6	50	125	7.15	2.88	10.03
0850		100	6	50	150	7.15	2.88	10.03
0875	20	40	6	50	90	7.15	2.88	10.03
0900		75	6	50	125	7.15	2.88	10.03
0920		100	6	50	150	7.15	2.88	10.03
0950	25	40	6	50	90	7.15	2.88	10.03
0970		75	8	55	130	7.85	2.52	10.37
1000		100	8	55	155	7.85	2.52	10.37
1200	30	40	8	55	95	7.85	2.52	10.37
1300		75	8	55	130	7.85	2.52	10.37
1400		100	10	70	170	8.15	2.24	10.39
1500	40	40	10	70	110	8.15	2.24	10.39
1600		75	12	70	145	8.70	2.01	10.71

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B10 Superstructure

B1010 Floor Construction

B1010 229 Precast Plank with No Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1700	45	40	12	70	110	8.70	2.01	10.71

B1010 230 Precast Plank with 2″ Concrete Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
2000	10	40	6	75	115	7.60	5.60	13.20
2100		75	8	75	150	8.10	5.15	13.25
2200		100	8	75	175	8.10	5.15	13.25
2500	15	40	8	75	115	8.10	5.15	13.25
2600		75	8	75	150	8.10	5.15	13.25
2700		100	8	75	175	8.10	5.15	13.25
2800	20	40	8	75	115	8.10	5.15	13.25
2900		75	8	75	150	8.10	5.15	13.25
3000		100	8	75	175	8.10	5.15	13.25
3100	25	40	8	75	115	8.10	5.15	13.25
3200		75	8	75	150	8.10	5.15	13.25
3300		100	10	80	180	8.80	4.77	13.57
3400	30	40	10	80	120	8.80	4.77	13.57
3500		75	10	80	155	8.80	4.77	13.57
3600		100	10	80	180	8.80	4.77	13.57
3700	35	40	12	95	135	9.10	4.49	13.59
3800		75	12	95	170	9.10	4.49	13.59
3900		100	14	95	195	9.65	4.26	13.91
4000	40	40	12	95	135	9.10	4.49	13.59
4500		75	14	95	170	9.65	4.26	13.91
5000	45	40	14	95	135	9.65	4.26	13.91

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B10 Superstructure

B1010 Floor Construction

B1010 241 W Shape Beams & Girders

	BAY SIZE (FT.) BEAM X GIRD	SUPERIMPOSED LOAD (P.S.F.)	STEEL FRAMING DEPTH (IN.)	FIREPROOFING (S.F. PER S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
6550	25x30	40	16	.632	50	7.65	2.87	10.52
6600		40	21	.76	90	10.50	3.85	14.35
6650		75	24	.857	125	12.55	4.54	17.09
6700		125	30	.983	175	15.70	5.85	21.55
6750		200	33	1.11	250	19.95	5.70	25.65
6800	30x25	40	16	.532	50	7.05	2.59	9.64
6850		40	21	.672	96	10.75	3.85	14.60
6900		75	24	.702	131	12.75	4.47	17.22
6950		125	27	1.020	175	16.55	5.90	22.45
7000		200	30	1.160	250	21	7.40	28.40
7100	30x25	40	18	.569	50	7.35	2.71	10.06
7150		40	24	.740	90	10.25	3.75	14
7200		75	24	.787	125	12.80	4.56	17.36
7300		125	24	.874	175	15.90	5.80	21.70
7400		200	30	1.013	250	19.65	5.55	25.20
7450	30x25	40	16	.637	50	7.65	2.87	10.52
7500		40	24	.839	90	10.85	4.03	14.88
7550		75	24	.919	125	13.15	4.78	17.93
7600		125	27	1.02	175	16.55	6.15	22.70
7650		200	30	1.160	250	21	5.95	26.95
7700	30x30	40	21	.52	50	7.85	2.85	10.70
7750		40	24	.629	103	12.10	4.25	16.35
7800		75	30	.715	138	14.40	5	19.40
7850		125	36	.822	206	18.95	6.75	25.70
7900		200	36	.878	281	21	5.80	26.80
7950	30x30	40	24	.619	50	8.20	3.02	11.22
8000		40	24	.706	90	11.05	3.96	15.01
8020		75	27	.818	125	13.05	4.68	17.73
8040		125	30	.910	175	16.75	6.15	22.90
8060		200	33	.999	263	20.50	5.80	26.30
8080	30x30	40	18	.631	50	8.75	3.21	11.96
8100		40	24	.805	90	11.95	4.32	16.27
8120		75	27	.899	125	14.25	5.10	19.35
8150		125	30	1.010	175	17.65	6.50	24.15
8200		200	36	1.148	250	21	6	27
8250	30x35	40	21	.508	50	8.95	3.18	12.13
8300		40	24	.651	109	13.25	4.61	17.86
8350		75	33	.732	150	16.10	5.55	21.65
8400		125	36	.802	225	20	7.10	27.10
8450		200	36	.888	300	26.50	7.10	33.60
8500	30x35	40	24	.554	50	7.90	2.88	10.78
8520		40	24	.655	90	11.60	4.09	15.69
8540		75	30	.751	125	14.45	5.05	19.50
8600		125	33	.845	175	17.55	6.35	23.90
8650		200	36	.936	263	23	6.35	29.35
8700	30x35	40	21	.644	50	8.50	3.13	11.63
8720		40	24	.733	90	12.20	4.35	16.55
8740		75	30	.833	125	15.30	5.35	20.65
8760		125	36	.941	175	17.65	6.45	24.10
8780		200	36	1.03	250	23.50	6.50	30

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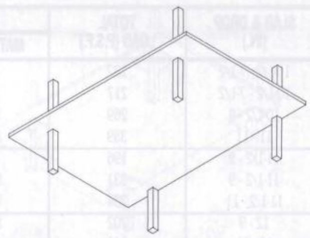
B10 Superstructure

B1010 Floor Construction



General: Flat Plates: Solid uniform depth concrete two-way slab without drops or interior beams. Primary design limit is shear at columns.

Design and Pricing Assumptions:
Concrete f'c to 4 KSI, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 223 2000					
15'X15' BAY, 40 PSF S. LOAD, 12" MIN. COL.					
Forms in place, flat plate to 15' high, 4 uses	.992	S.F.	1.13	5.60	6.73
Edge forms to 6" high on elevated slab, 4 uses	.065	L.F.	.01	.27	.28
Reinforcing in place, elevated slabs #4 to #7	1.706	Lb.	.96	.73	1.69
Concrete ready mix, regular weight, 3000 psi	.459	C.F.	1.91		1.91
Place and vibrate concrete, elevated slab less than 6", pump	.459	C.F.		.70	.70
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.86	.86
Cure with sprayed membrane curing compound	.010	C.S.F.	.08	.09	.17
TOTAL			4.09	8.25	12.34

B1010 223 Cast in Place Flat Plate

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
2000	15 x 15	40	12	5-1/2	109	4.09	8.25	12.34
2200	RB1010 -010	75	14	5-1/2	144	4.11	8.25	12.36
2400		125	20	5-1/2	194	4.31	8.30	12.61
2600		175	22	5-1/2	244	4.41	8.35	12.76
3000	15 x 20	40	14	7	127	4.78	8.35	13.13
3400	RB1010 -100	75	16	7-1/2	169	5.10	8.55	13.65
3600		125	22	8-1/2	231	5.65	8.80	14.45
3800		175	24	8-1/2	281	5.70	8.75	14.45
4200	20 x 20	40	16	7	127	4.79	8.30	13.09
4400		75	20	7-1/2	175	5.15	8.55	13.70
4600		125	24	8-1/2	231	5.70	8.75	14.45
5000		175	24	8-1/2	281	5.75	8.80	14.55
5600	20 x 25	40	18	8-1/2	146	5.65	8.75	14.40
6000		75	20	9	188	5.85	8.85	14.70
6400		125	26	9-1/2	244	6.35	9.10	15.45
6600		175	30	10	300	6.60	9.25	15.85
7000	25 x 25	40	20	9	152	5.85	8.85	14.70
7400		75	24	9-1/2	194	6.20	9	15.20
7600		125	30	10	250	6.60	9.25	15.85
8000								

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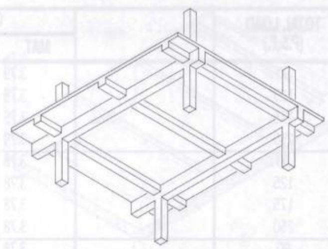
B10 Superstructure

B1010 Floor Construction



General: Solid concrete one-way slab cast monolithically with reinforced concrete support beams and girders.

Design and Pricing Assumptions:
Concrete f'c = 3 KSI, normal weight, placed by concrete pump.
Reinforcement, fy = 60 KSI.
Forms, four use.
Finish, steel trowel.
Curing, spray on membrane.
Based on 4 bay x 4 bay structure.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM B1010 219 3000					
BM. & SLAB ONE WAY 15′ X 15′ BAY, 40 PSF S.LOAD, 12″ MIN. COL.					
Forms in place, flat plate to 15′ high, 4 uses	.858	S.F.	.98	4.85	5.83
Forms in place, exterior spandrel, 12″ wide, 4 uses	.142	SFCA	.13	1.46	1.59
Forms in place, interior beam. 12″ wide, 4 uses	.306	SFCA	.33	2.57	2.90
Reinforcing in place, elevated slabs #4 to #7	1.600	Lb.	.90	.69	1.59
Concrete ready mix, regular weight, 3000 psi	.410	C.F.	1.71		1.71
Place and vibrate concrete, elevated slab less than 6″, pump	.410	C.F.		.63	.63
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.86	.86
Cure with sprayed membrane curing compound	.010	C.S.F.	.08	.09	.17
TOTAL			4.13	11.15	15.28

B1010 219 Cast in Place Beam & Slab, One Way

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	INST.	TOTAL
3000	15x15	40	12	4	120	4.13	11.15	15.28
3100	RB1010 -010	75	12	4	138	4.20	11.20	15.40
3200		125	12	4	188	4.33	11.30	15.63
3300		200	14	4	266	4.61	11.70	16.31
3600	15x20	40	12	4	102	4.23	11.05	15.28
3700	RB1010 -100	75	12	4	140	4.44	11.40	15.84
3800		125	14	4	192	4.70	11.75	16.45
3900		200	16	4	272	5.25	12.55	17.80
4200	20x20	40	12	5	115	4.69	10.75	15.44
4300		75	14	5	154	5.10	11.65	16.75
4400		125	16	5	206	5.30	12.25	17.55
4500		200	18	5	287	6	13.10	19.10
5000	20x25	40	12	5-1/2	121	4.89	10.80	15.69
5100		75	14	5-1/2	160	5.40	11.75	17.15
5200		125	16	5-1/2	215	5.80	12.40	18.20
5300		200	18	5-1/2	294	6.35	13.30	19.65
5500	25x25	40	12	6	129	5.20	10.55	15.75
5600		75	16	6	171	5.65	11.35	17
5700		125	18	6	227	6.65	13.05	19.70
5800		200	2	6	300	7.40	14	21.40
6500	25x30	40	14	6-1/2	132	5.30	10.80	16.10
6600		75	16	6-1/2	172	5.75	11.45	17.20
6700		125	18	6-1/2	231	6.80	13	19.80
6800		200	20	6-1/2	312	7.45	14.10	21.55

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B10 Superstructure

B1010 Floor Construction

B1010 219 Cast in Place Beam & Slab, One Way

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB THICKNESS (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
7000	30x30	40	14	7-1/2	150	6.15	11.65	17.80
7100		75	18	7-1/2	191	6.85	12.25	19.10
7300		125	20	7-1/2	245	7.30	13	20.30
7400		200	24	7-1/2	328	8.15	14.45	22.60
7500	30x35	40	16	8	158	6.55	12	18.55
7600		75	18	8	196	7	12.35	19.35
7700		125	22	8	254	7.85	13.75	21.60
7800		200	26	8	332	8.60	14.25	22.85
8000	35x35	40	16	9	169	7.35	12.35	19.70
8200		75	20	9	213	7.95	13.50	21.45
8400		125	24	9	272	8.80	14	22.80
8600		200	26	9	355	9.70	15	24.70
9000	35x40	40	18	9	174	7.55	12.60	20.15
9300		75	22	9	214	8.15	13.60	21.75
9400		125	26	9	273	8.95	14.10	23.05
9600		200	30	9	355	9.85	15.05	24.90

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