School Without Walls

Washington, D.C.

Tech Report # 2

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Structural Option

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10/28/09

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EXECUTIVE SUMMARY

The 127 year old School Without Walls, located in the heart of the George Washington University campus in Washington D.C. underwent a modernization and expansion project in 2008. This provided the high school with up to date electrical and mechanical systems, a 68,000 square foot addition along the south and east sides of the existing building, and an overall LEED gold rated facility.

This second technical report for the School Without Walls project investigates the current floor system, and three alternative floor systems. For the analysis, an interior 34'x32' bay, located on the south side of the existing building was chosen. For this assignment, the calculations and analysis are considered preliminary; therefore assumptions concerning the bay size were made due to the complexity of the cantilever slab and differing bay sizes. The calculations for the analysis and assumptions made can be located in the appendices at the end of the report.

The existing floor is a composite steel system. The deck is a 2" 20 gage LOK floor with a 3.25" light weight concrete topping. Long headed shear studs, measuring ¾" x4" are used for composite action of the floor system.

The floor systems which are further investigated in this report are:

- Two- Way Slab with Drop Panels
- One-Way Slab with Concrete Beams
- Pre-Cast Hollow Core Planks on Steel Beams

After completing a preliminary analysis of these floor systems and making comparisons based on their ease of constructability, the slab depth, the total construction depth required, fireproofing, lead time, structure impact and total construction cost, it was determined that the two most viable alternate floor systems are the two way slab with drop panels and the precast hollow core plank system on steel beams.

The hollow core plank system is worth further and a more intense investigation due to its relatively easy constructability, long span capabilities, cost efficiency, and LEED recognition. The two way flat slab system with drop panels is also worth a more in depth analysis due to its relatively small construction depth and fireproofing attributes.

INTRODUCTION

The Grant School has stood in the heart of the George Washington University campus since 1882 and has housed the School Without Walls since 1977. The "School Without Walls" name comes from the encouragement for students to use Washington D.C. as an active classroom, thus not restraining learning to the walls of the school.

The original 32,300 square foot, three story school was in dire need of modernization and expansion due to the increasing number of students and outdated mechanical and electrical equipment. The 68,000 square foot addition and renovation blends the 19th century school with a modern design. This is achieved by combining existing brick patterns with glass, steel and curtain walls. The School Without Walls project is expected to receive LEED Gold Certification.

The existing three story school is made up of four large classrooms per floor, one at each corner of the square building. The new addition of the school provides an additional two large classrooms on each floor, an open atrium space, a large student commons, roof terrace area and a library. The basement was also reengineered and redesigned to serve as scientific laboratories for the school.

The purpose of this technical assignment is to investigate and analyze alternate floor systems for the School Without Walls. From this report, the most suitable alternate floor systems will be highlighted and noted for a more in depth analysis based on ease of constructability, the slab depth, the total construction depth required, fireproofing, lead time, structure impact and total construction cost.

LOADS

Live Loads

Load Description	Load
Administrative Office	50 psf+20psf
Classrooms	40 psf+20psf
Corridors Above First Floor	80 psf
First Floor Corridors	100 psf
Student Commons	100 psf
Storage	125psf
Stack Room	150 psf
Roof Load	30 psf + add'l snow drift
Mechanical Room	150 psf
Roof Terrace	100 psf

Dead Loads

Load Description	Load
Metal Decking 20 Gage	3 psf
Normal Weight Concrete	150 pcf
Light Weight Concrete	110 pcf
Finishes	5 psf
M/E/P	10 psf

Snow Loads

Load Description	**Design Load and Factors**
Ground Snow Load	Pg= 25 psf
Snow Exposure Factor	Ce= 0.9
Snow Importance Factor	I= 1.1
Thermal Factor	Ct= 1.0
Flat Roof Snow Load	Pf= 17.3 psf

CODE AND DESIGN REQUIREMENTS

Codes, materials, and computer programs used for Technical Report 2

- International Building Code 2006
- AISC Steel Construction Manual *13th edition*
- ACI 318-05
- CRSI Handbook 2005
- PCA Slab
- PCI Design Handbook
- RS Means

MATERIALS

Structural Steel:

Wide Flanges…………………………………ASTM A-572 or A-992, Grade 50
Channels, Angles, Plates…………………………………… ASTM A-36
Hollow Structural Sections (HSS)……………………………ASTM A-500, Grade B
Pipes………………………………………ASTM A-53, Type E or S, Grade B

Metal Decking:

2" Composite Metal Deck…………………………………… ……..20 Gage

Bolts:

High Strength Steel Bolts……………………………ASTM A-325 or ASTM A-490
Anchor Bolts…………………………………………ASTM F-1554, Grade 36

Concrete:

Over Composite Metal Deck………………………………………f'c = 4,000 psi
Grout for CMU walls…………………………………………… f'c = 3,000 psi
All Concrete Components U.O.N…………………………………f'c = 4,000 psi

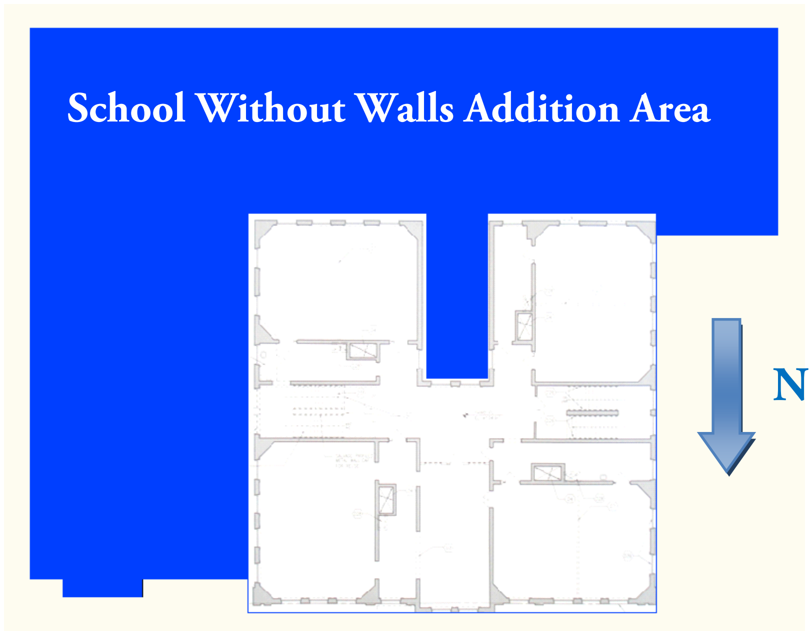
Reinforcing Steel:

Reinforcing Bars……………………………………ASTM A-615, Grade 60
Welded Reinforcing…………………………………ASTM A-706, Grade 60

Wood:

All Wood U.O.N……………………………………… No. 2 Hem-Fir (North)

EXISTING STRUCTURAL SYSTEM



G Street

Figure 1: Floor Plan Showing Expansion

The 68,000 square foot addition to the School Without Walls project is located in blue in Figure 1. Due to expansion joints located at the interface of the addition and the existing building, the structural systems work independently. This expansion joint can be viewed in Figure 2. As stated in the drawing, along the expansion joint along the east side of the existing building is 4", and is 2" along the south side.

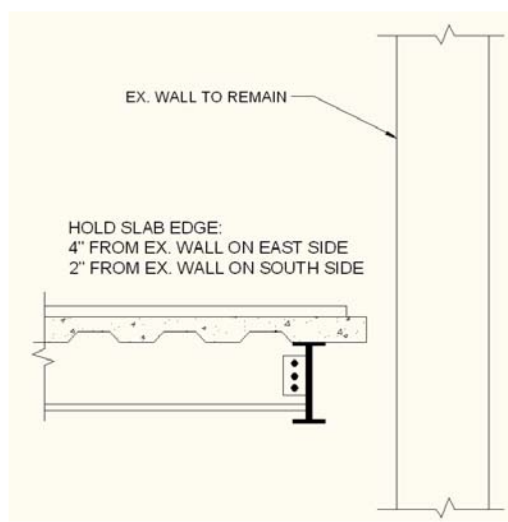
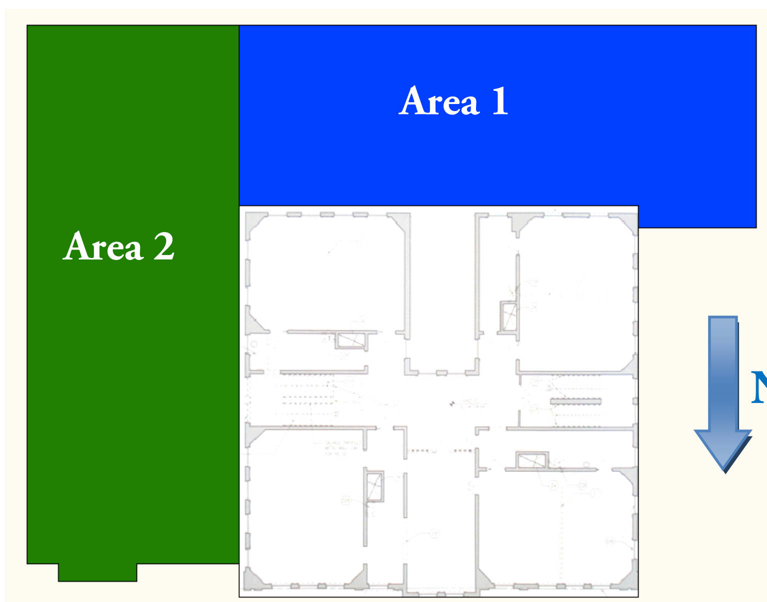


Figure 2: Expansion Joint Detail

The new addition to the School Without Wall itself is divided by an expansion joint; therefore creating a total of three self supporting structural systems. This division of the new addition can be viewed in Figure 3. These spaces will be referred to as "Area 1" and "Area 2" throughout this report, as located on the Figures 3 and 4.



G Street

Figure 3: Floor Plan Showing Building Separation

G Street

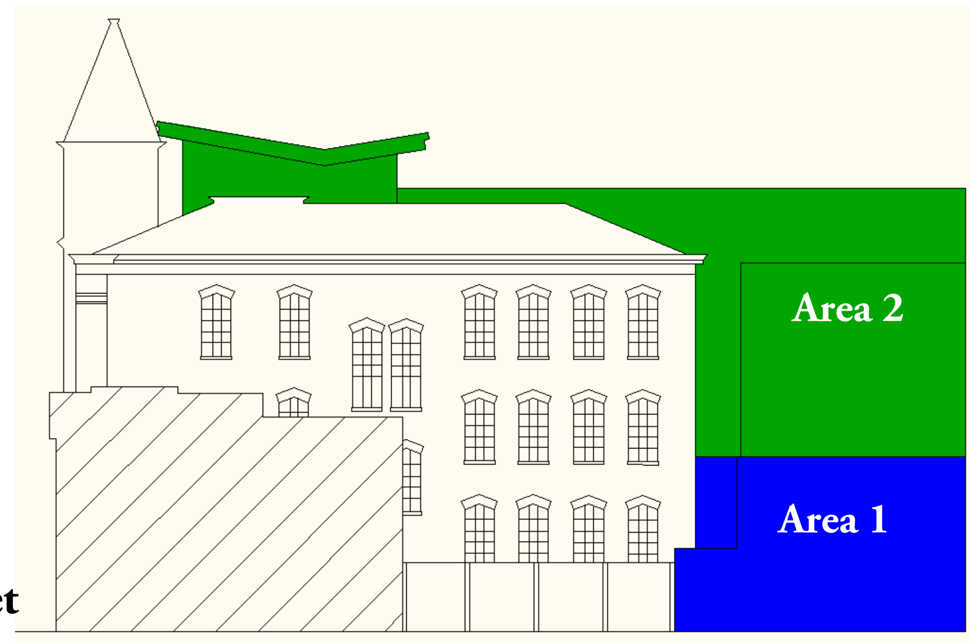


Figure 4: West Elevation

Foundation

The geotechnical engineering study was performed by Thomas L. Brown Associates, P.C. on January 28, 2007. After performing a series of in-situ tests, considering the lab test results, anticipated loads, and settlement analyses, a shallow foundation consisting of reinforced cast-in-place spread footings and grade beams was deemed appropriate. Based on the testing and analysis, the footings should be designed for an allowable bearing capacity of 3.0 ksf. Typical footings of the addition are 2' 6" wide by 2'0" deep and rest on compacted earth 3'0" below the top of the slab-on-grade. Grade beams are also used in the foundation of the new addition. The beams

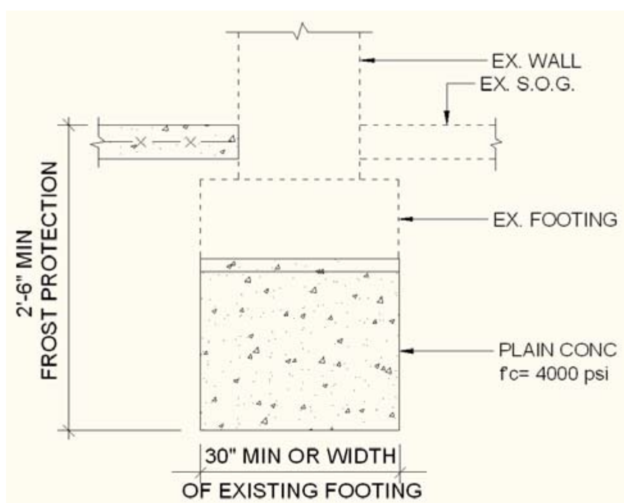


Figure 5: Underpinning Detail

measure 30"x30" along the east side and 30"x24" along the south side of the building.

Due to the increased load and the disruption of earth, underpinning the existing footings of the school became necessary. An underpinning detail is located in Figure 5. The underpinning sequence will be performed in sections no larger than 4 feet wide, approximately spaced 12-15 feet apart.

Lateral System

The lateral system of School Without Walls works as three different systems due to expansion joints as stated before and show in Figures 3 and 4. The two story structure supporting the outside roof terrace, Area 1 acts independently, as well as the four story structure supporting the library, Area 2.

Area 1 utilizes lateral braced frame for lateral support, comprised of HSS6x6x3/8 sections. Area 2 uses a combination of an HSS braced frame, ranging from the ground to the roof level, and shear walls around both the elevator core and the stair core. The stair core creates a 12" concrete shear wall, and the elevator core creates an 8" concrete shear wall located in blue and red respectively in Figure 6. The lateral braced frame locations are located in green in Figure 6.

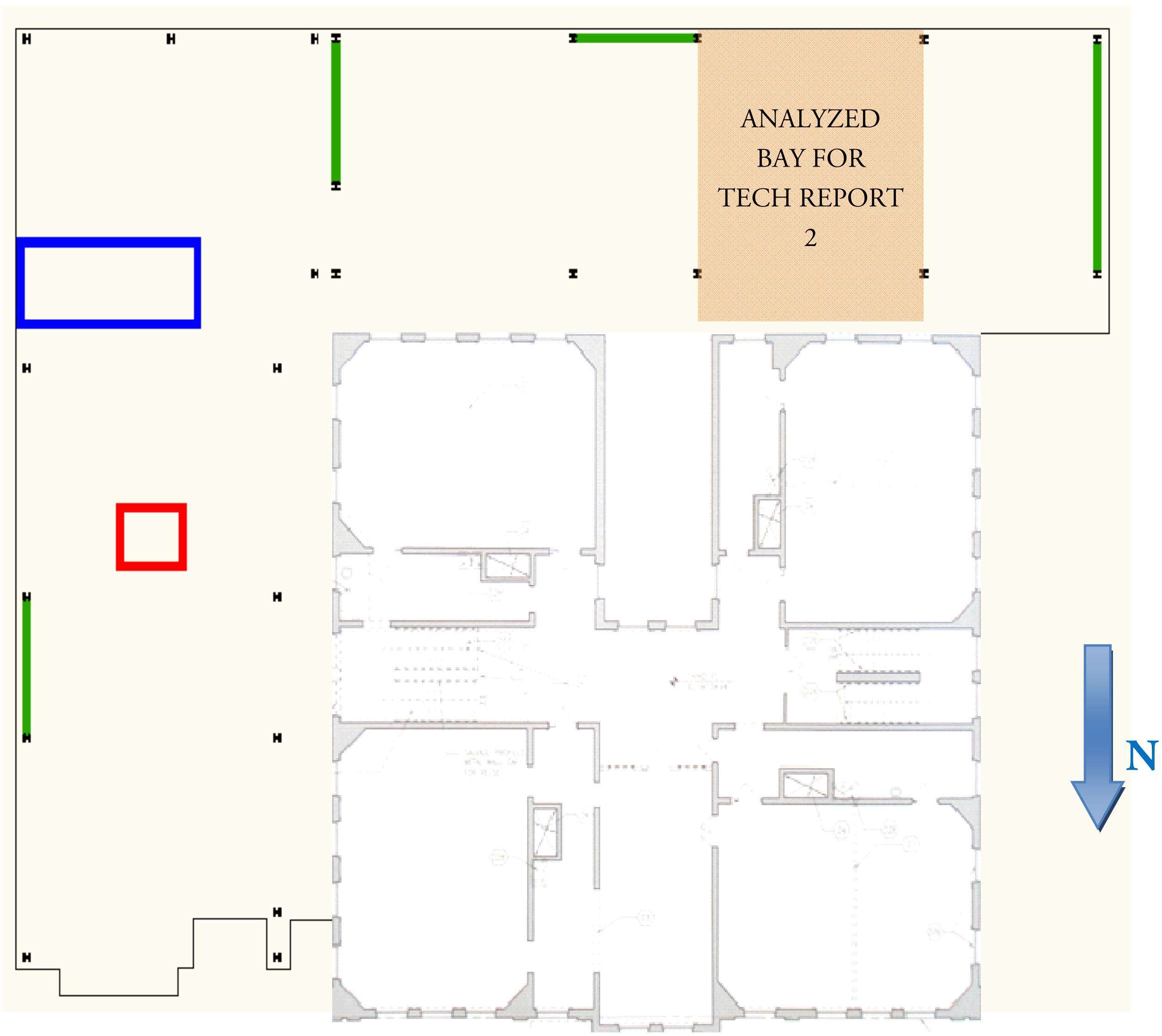


Figure 6: Lateral Systems

Floor System

For the purposes of this report, the bay located in orange in Figure 6 will be analyzed for alternate floor system comparison. This bay is located in "Area 1" and measures 34'x32'. The structural system supporting the first floor student commons will be investigated. A more detailed description of this bay is located below in Figure 7.

The columns are set back 8 feet from the face of the existing building, creating a cantilever. Moment connections at this column line, located as ◄H► in Figure 7, are required to support the cantilevered slab. The beams terminate at a 12" structural concrete wall at the south end of the frame and are connected through the use of bearing plates.

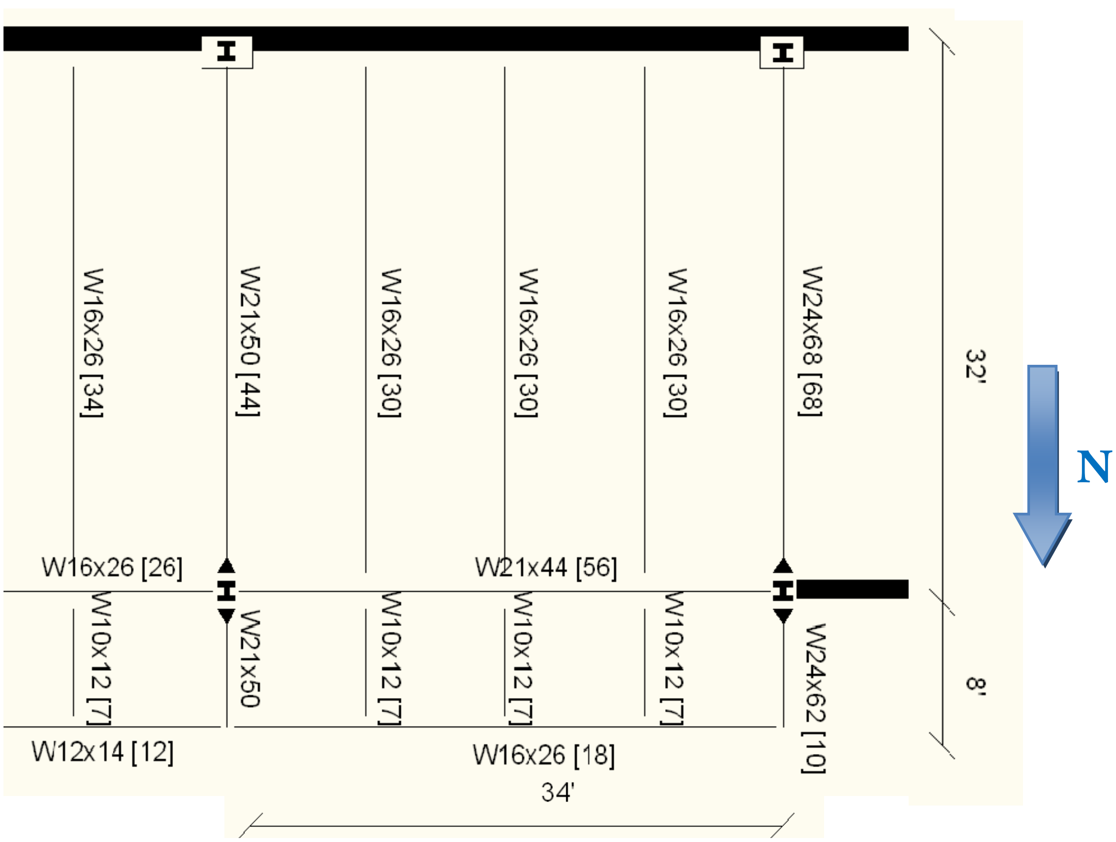


Figure 7: Analyzed Bay

Composite Metal Deck (Existing Structure)

Material Properties:

Concrete: 3.25" LWC topping
f'_c = 4,000psi

Decking: 2" LOK- Floor
20 Gage

Loading:

Dead (self weight): 41psf
Live: 100psf
Superimposed: 25 psf

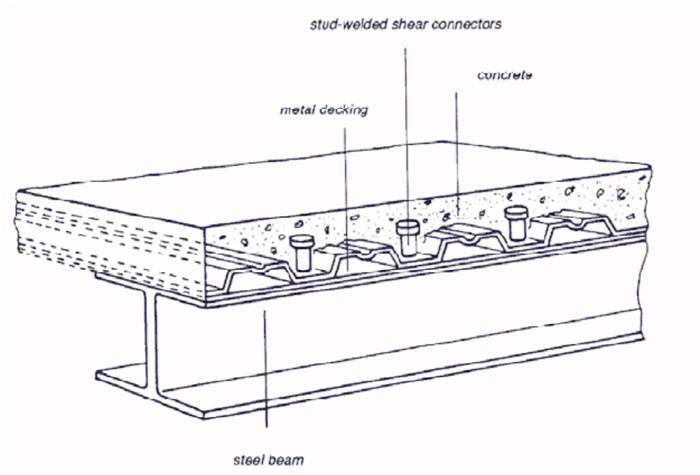


Figure 7: Typical Compostite Steel Construction (www.epitech.com)

Description:

The floor system of School Without Walls is a composite steel system. The floor slab of the new addition is 3 ¼" LWC topping over a 2" 20 GA composite steel floor decking, bringing the total floor slab to 5 ¼" thick. Along the top flange of the beam, ¾"x4" long headed shear studs are used for composite action. A section of this floor system is shown above in Figure 7.

A bay located in "Area 1", supporting the first floor was analyzed and spot checks were performed on the joists and girders. These spot calculations can be located in Appendix A of this report. The steel beams and girders are both wide flange shapes and range from W16 to W24 sections. Currently, the height from the basement floor to the top of the slab on the first floor is 11' 10". The floor of the basement to the ceiling is 9', leaving a total of 2' 10", or 34" of room to contain the structure, mechanical and electrical systems. With the 5.25" total slab thickness, the total depth of this structural system is 30.25"

Advantages:

This floor system takes advantage of a composite action and light weight concrete, thus creating an overall light structure for long spans. Because of the relatively light weight, the foundations size is kept to a minimum. This floor system is commonly used in the industry and is relatively easy to construct.

Disadvantages:

Spray fireproofing is required for the steel members to reach the specified fire rating, which ranges from one to two hours. The depth of this floor system is also a concern because of the small clearance area between the bottom of the steel member and the ceiling of the floor below. A larger clearance area results for an easier coordination of the mechanical and electrical systems.

TWO WAY FLAT SLAB

Material Properties:

Concrete floor: 11" NWC slab
f'_c = 4,000psi
Drop Panels: 3.5" thick

Loading:

Dead (self weight): 137.5 psf
Live: 100psf
Superimposed: 25 psf

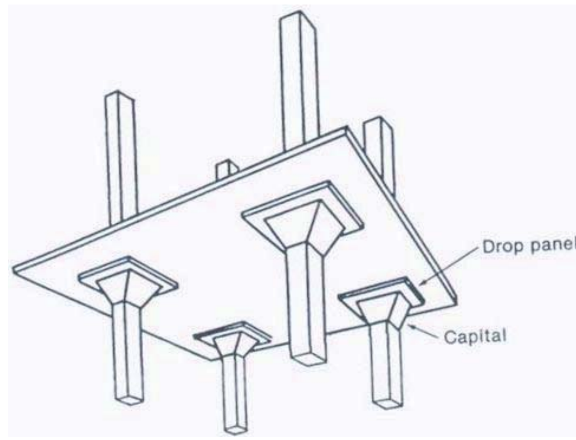


Figure 8: Two Way Flat Slab With Drop Panels
stommell.tamu.edu

Description:

For the analysis of the two way flat plate system, bays are assumed to be equally spaced apart for calculation simplification, bringing each bay to measure 30'x32'. Punching shear and wide beam action were checked through hand method calculation can be referenced in Appendix B of this report. The depth of the drop panels were estimated to be 3.5". The resulting depth of this system is 14" including the slab and drop panels. This dimension however does not take into account the presence of the column capital. Using the CRSI Handbook 2005 for a 32'x32', it was estimated that the total depth of the drop panel for a system without the use of column capitals was 10.25". The total depth of construction based on this design aid is 21.25". Reinforcement for this system was determined by using PCA Slab. It was determined that #5 bars would be appropriate for this floor system. An output of this analysis can be also located in Appendix B of this report. Columns for this system are estimated to be 20"x20", as determined from the CRSI Handbook.

Advantages:

This floor system is very attractive to a designer due to its reduced construction depths. When using this system, more clearance for the mechanical and electrical systems are provided and therefore creates an easier coordination of these systems. There is no additional fireproofing required for this type of floor system, which eliminates labor and material cost. Concrete systems are very applicable to Washington D.C. due to the height restrictions in the area. Because of the large number of buildings in the area utilizing this structural system, skilled labor in this field is readily available.

Disadvantages:

This structural system adds significant weight as compared to the existing structural system. This extra dead load may have a significant impact on the current foundation which would have to be investigated further. The structure would require formwork and shoring of the floor slab and column drop panels, both not needed in the existing structure, therefore labor costs may increase.

ONE WAY SLAB

Material Properties:

Concrete floor:	$f'_c = 4{,}000$psi
	4.5" thick
Beams:	5' spacing
	12"x16"
Girders:	20"x26"

Loading:

Dead (self weight):	41psf
Live:	100psf
Superimposed:	25 psf

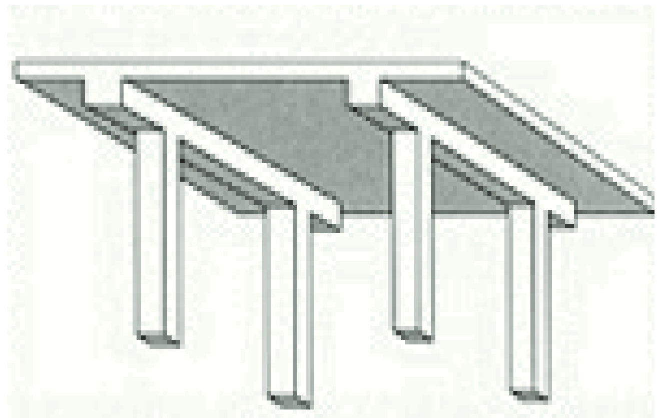


Figure 9: One Way Slab
pages.drexel.edu

Description:

Calculations for this analysis, similar to those in the two way slab analysis, were performed on a 30'x32' bay. All bays of the floor system are assumed to be equal for this investigation. A 4.5"normal weight concrete floor slab was chosen for this system. Beams for this concrete floor system run in the east-west direction and have a tributary width of 5'. A 12"x16" rectangular beam using #7 bars and #3 stirrups for reinforcement appears appropriate for this application. The girders, which support the beams, measure 20"x26" and will require (5) #11 bars at the interior column location. The total floor construction depth due to the girder depth is 26". In the analysis, the cantilevered section was not investigated because, by inspection, the 20"x26" would be the controlling member in the depth of the structural system.

Advantages:

The floor depth when utilizing this floor system would be decreased, allowing for more room for mechanical and electrical equipment. No additional fireproofing will be necessary for the concrete construction.

Disadvantages:

The disadvantages for this system outweigh its advantages, mainly due to its intensive amount of formwork required for beams and slab. The spans required in this building are too long to construct an efficient solid slab, therefore a combination of beams and girders must be used. This system results in a labor intensive process and a longer time of construction creating significantly higher cost. The foundation will likely be majorly affected due to the large increase of dead load from the system.

PRECAST HOLLOW CORE PLANK ON STEEL BEAMS

Material Properties:

Concrete: 4'-0"x 6" with 2" NWC topping
$f'_c = 5{,}000$psi

Tendons: 87-S
$f_{pu} = 270{,}00$ psi

Loading:

Dead (self weight): 74 psf
Live: 100psf
Superimposed: 25 psf

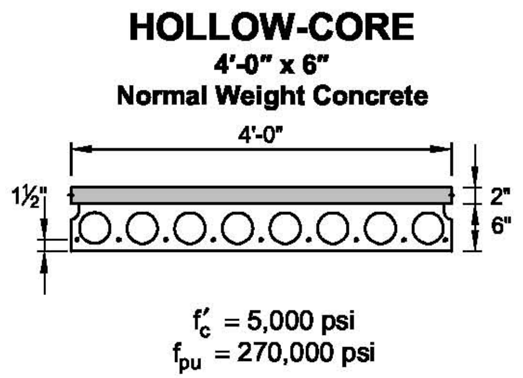


Figure 10: Hollow Core Slab

Description:

Pre-cast hollow core planks were analyzed due to their long span ability, and easy constructability. For my design of the selected bay, located in "Area 1", I have chosen to run the slab in the north-south direction due to the presence of the 8 foot cantilever. When designing for "Area 2" planks would run in the east-west direction to account for the same cantilever issue. These planks are fabricated in 4 foot sections, which either requires the adjustment of columns or the need for infill between planks. The plank chosen for the bay design is a 6" thick with a 2" normal weight concrete topping using 87-S tendons. This particular plank has 8 straight tendons which are 7/16" in diameter. The plank is fire rated between 1 and 2 hours. Steel beams and girders will support the load for the plank. A moment connection will occur at each column along the existing building wall in order to account for the moment created by the cantilever. Steel beams for the selected bay range from W14 to W24 sections. Calculations showing loading, beam calculations and construction costs can be found in Appendix D of this report.

Advantages:

Due to hollow core planks ability to span relatively large distances, numerous steel beams are eliminated that are necessary for the existing structure. Because the plank is fabricated off site, it can be installed in any weather condition. Using this construction method is also labor efficient due to the fact that formwork is not needed. Hollow core pre-cast plank also is considered a LEED rated system, which complements the LEED gold rating for the School Without Walls.

Disadvantages:

Due to the large lead time due to ordering and shipping, careful planning and coordination is essential to the project. This can affect the coordination of the other trades on the construction site. Another disadvantage is the large floor depth. After analyzing the typical bay, I determined that the floor depth is 38", which will affect the ceiling heights. This depth can be reduced; however, it will call to use a less efficient steel member. Even though the plank is fire proofed, the steel members still call for the necessary fireproofing.

CONCLUSION

	Floor Systems			
	Existing Composite Slab on Steel Beams	2-Way Slab With Drop Panels	One- Way Slab	Hollow Core Plank on Steel Beams
Slab Depth (in)	5.25"	11"	4.5"	8"
Total Depth (in)	29.25"	21.25"	26"	32"
Effect on Column grid	No	No	Possible	Possible
Lead Time	Medium	Short	Short	Long
Formwork	No	Yes	Yes	No
Construction Difficulty	Medium	Medium	More Difficult	Easy
Impact on Foundation	--	Major	Major	Little
Fireproofing Req'd	Yes	No	No	Yes
Fire Rating	2hr	2hr	2hr	2hr
Cost per ft^2	\$12.37	\$12.30	\$13.38	\$8.42
Viable Alternative	--	Yes	No	Yes
Additional Study	--	Yes	No	Yes

In the second technical report for the School Without Walls expansion and modernization project, the existing and three alternative structural floor systems were studied and analyzed. The ease of constructability and the potential for spanning large distances were very important factors when determining whether or not a system was a viable alternative.

After investigating the floor systems, it appears that the 2 way slab with drop panels and hollow core plank on steel beams are the most appropriate alternatives.

The ability of hollow core plank to span relatively large distances is attractive because numerous steel beams are eliminated. The system is also a relatively light system, which would minimize the amount of alterations in the foundation system. The depth of the system is the main concern of the structure and will have to be further investigated.

The benefits of the two way slab with drop panels comes from its reduced construction depths. When using this system, larger clearances for the mechanical and electrical systems are possible, therefore creating easier coordination of these systems. The main disadvantage to this system is the amount of dead load that it will create on the foundation of the school. Further analysis must be done in order to investigate this issue.

The one way slab will not be investigated further and is eliminated an alternative floor system option. The spans required in this building are too long to construct an efficient solid slab, therefore a combination of beams and girders must be used. This system results in a labor intensive process and a longer time of construction creating significantly higher cost. The foundation will also likely be majorly affected due to the large increase of dead load from the system.

APPENDIX A

Composite Steel System

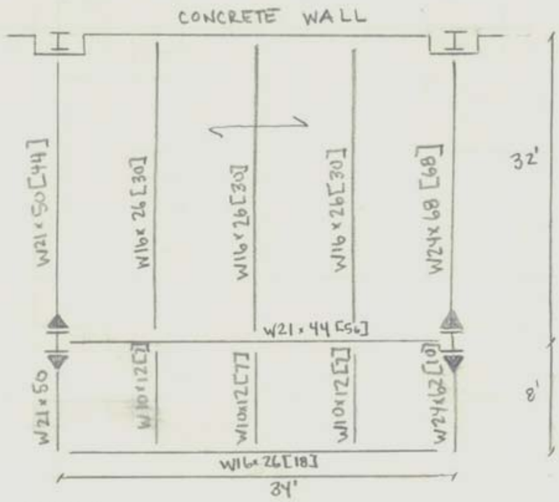
20 gage 2''LOK-FLOOR   Fy = 50 ksi   115 pcf concrete   f'c = 3 ksi

DECK PROPERTIES:
t = .0358   w = 1.8 psf
As = .54   I = .39
Sp = .316   Sn = .329
Rb = 1700   φVnt= 3550
req'd studs/ft. = .78

slab depth	wc psf	Sc in^3	φVt lbs.	Ac in^2	Iav in^4	Max Unshored Spans, ft. 1 span	2 spans	3 spans	WWF
4.50	34	1.19	4557	32.6	4.8	8.75	11.07	11.44	0.023
5.00	38	1.41	5238	37.5	6.5	8.32	10.59	10.94	0.027
5.25	41	1.52	5591	40.0	7.4	8.12	10.37	10.72	0.029
5.50	43	1.63	5953	42.6	8.5	7.94	10.17	10.51	0.032
6.00	48	1.86	6704	48.0	10.9	7.62	9.79	10.12	0.036
6.25	50	1.98	7093	50.8	12.2	7.47	9.61	9.94	0.038
6.50	53	2.10	7295	53.6	13.6	7.34	9.45	9.77	0.041
7.00	58	2.34	7705	59.5	16.9	7.08	9.14	9.45	0.045

Stud Spacing	Slab Depth	φMn in.k	Superimposed Live Load, psf Spans, ft. 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0
ONE FOOT	4.50	70.20	400	400	400	400	400	340	290	245	210	180	160	140	120
	5.00	81.68	400	400	400	400	400	400	390	330	285	245	210	185	165
	5.25	87.41	400	400	400	400	400	400	400	370	325	280	245	215	190
	5.50	93.15	400	400	400	400	400	400	400	395	355	320	280	245	215
	6.00	104.63	400	400	400	400	400	400	400	400	400	360	325	290	265
	6.25	110.36	400	400	400	400	400	400	400	400	400	380	340	310	280
	6.50	116.10	400	400	400	400	400	400	400	400	400	400	360	325	295
	7.00	127.58	400	400	400	400	400	400	400	400	400	400	395	355	325
TWO FEET	4.50	63.23	400	400	400	400	385	340	290	245	210	180	160	140	120
	5.00	73.89	400	400	400	400	400	395	350	310	280	245	210	185	165
	5.25	79.26	400	400	400	400	400	400	375	335	300	270	240	215	190
	5.50	84.66	400	400	400	400	400	400	400	355	320	285	260	235	210
	6.00	95.52	400	400	400	400	400	400	400	400	360	325	290	265	240
	6.25	100.98	400	400	400	400	400	400	400	400	380	345	310	280	255
	6.50	106.45	400	400	400	400	400	400	400	400	400	360	325	295	265
	7.00	117.43	400	400	400	400	400	400	400	400	400	400	360	325	295
THREE FEET	4.50	59.07	400	400	400	400	360	315	275	245	210	180	160	140	120
	5.00	69.23	400	400	400	400	400	370	325	290	260	230	210	185	165
	5.25	74.39	400	400	400	400	400	395	350	310	280	250	225	200	185
	5.50	79.58	400	400	400	400	400	400	375	335	300	265	240	215	195
	6.00	90.08	400	400	400	400	400	400	400	380	340	305	275	245	225
	6.25	95.37	400	400	400	400	400	400	400	400	360	320	290	260	235
	6.50	100.68	400	400	400	400	400	400	400	400	380	340	305	275	250
	7.00	111.37	400	400	400	400	400	400	400	400	400	375	340	305	280
NO STUDS	4.50	50.74	400	400	400	350	305	265	235	210	185	165	150	135	120
	5.00	59.92	400	400	400	400	360	315	280	245	220	195	175	160	145
	5.25	64.64	400	400	400	400	390	340	300	265	235	210	190	170	155
	5.50	69.43	400	400	400	400	400	365	325	285	255	230	205	185	165
	6.00	79.19	400	400	400	400	400	400	370	330	295	260	235	210	190
	6.25	84.14	400	400	400	400	400	400	395	350	310	280	250	225	205
	6.50	89.14	400	400	400	400	400	400	400	370	330	295	265	240	215
	7.00	99.24	400	400	400	400	400	400	400	400	370	330	295	270	245

BEAM SPOT CHECK (W16x26 [30])



LOADS:
- LIVE = 100 psf
- DEAD:
  - SLAB = 41 psf
  - SDL = 25 psf
  - BEAM SW = 26 plf

TRIBUTARY WIDTH = 8.5 ft

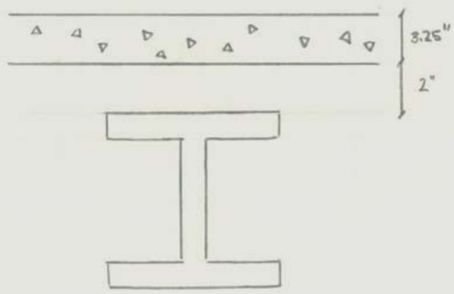
LOAD COMBINATION

$1.2D + 1.6L = 1.2(41+25)(8.5) + 1.2(26) + 1.6(100)(8.5)$

$W_u = 2.06\ k/ft$

$M_u = \frac{w_u l^2}{8} = \frac{(2.06)(32^2)}{8} = 263.68'^k$

$b_{eff} = \min \begin{cases} \text{SPACING} = 8.5(12) = 102'' \\ \text{SPAN}/4 = 96'' \leftarrow \text{CONTROLS} \end{cases}$



ASSUME $a = 1$

$Y2 = 5.25 - 1/2 = 4.75$ USE $Y2 = 4.5$

CHECK a: $a = \frac{\Sigma Q_n}{.85 f'_c \, b_{eff}} = \frac{145}{.85(4)(96)} = .44 < 1.0 \therefore$ OK

$\Sigma Q_n = 145^k \rightarrow$ AT PNA 6

CHECK NUMBER OF SHEAR STUDS (3/4" STUDS)

$Q_N = 17.2$

$\#$ STUDS $= \frac{145}{17.2}(2) = 18$ SHEAR STUDS $\rightarrow$ COMPARED TO 30 STUDS

CHECK DEFLECTION

$Y_2 = 4.5 \rightarrow I_{LB} = 622_{in}^4$

$\Delta = \frac{5(.85)(32^4)(1728)}{384(29000)(622)} = 1.11'' \rightarrow$ BEAM IS CAMBERED

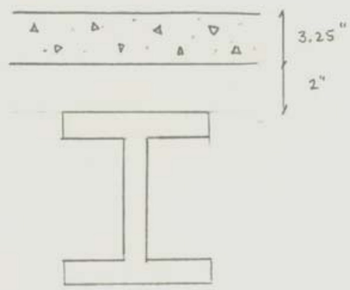
BEAM SPOT CHECK (W10x12 [7])

$w_u = 1.2(41+25)(8.5) + 1.2(12) + 1.6(100)(8.5)$

$w_u = 2.05\ ^{k}/_{ft}$

$M_u = \frac{w_u l^2}{8} = \frac{(2.05)(8^2)}{8} = 16.4\ 'k$

$b_{eff} =$ MIN of:
- SPACING = 8.5(12) = 102"
- 8(12)/4 = 24" ← CONTROLS



ASSUME $a = 1$

$Y_2 \longrightarrow 4.5$

CHECK a: $\frac{44.2}{.85(4)(24)} = .54 < 1.0 \therefore$ OK

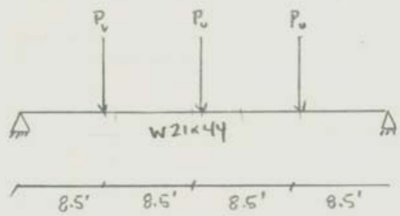
$\Sigma Q_n = 44.2$

CHECK NUMBER OF STUDS

$Q_N = 17.2$

$\#STUDS = \frac{44.2}{17.2}(2) = 6$ STUDS → COMPARED TO 7 STUDS

GIRDER SPOT CHECK



DECK IS PARALLEL TO GIRDER

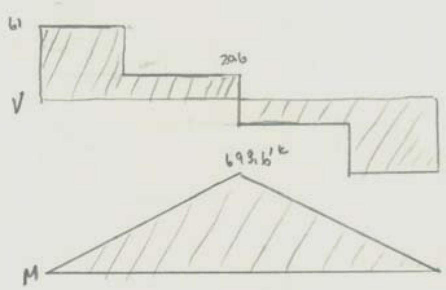
$P_u = \frac{2.06(32)}{2} + \frac{2.05(8)}{2} = 41.2^k$

SLAB TOTAL = 5.25"
DECK = 2"

$b_{eff} = \frac{34(12)}{4} = 102"$

$Q_N = 21.2^k$

ASSUME $a = 1$ $\quad Y_2 = 5.25 - a/2 = 4.75 \rightarrow Y_2 = 4.5$



$\Sigma Q_n = 576$

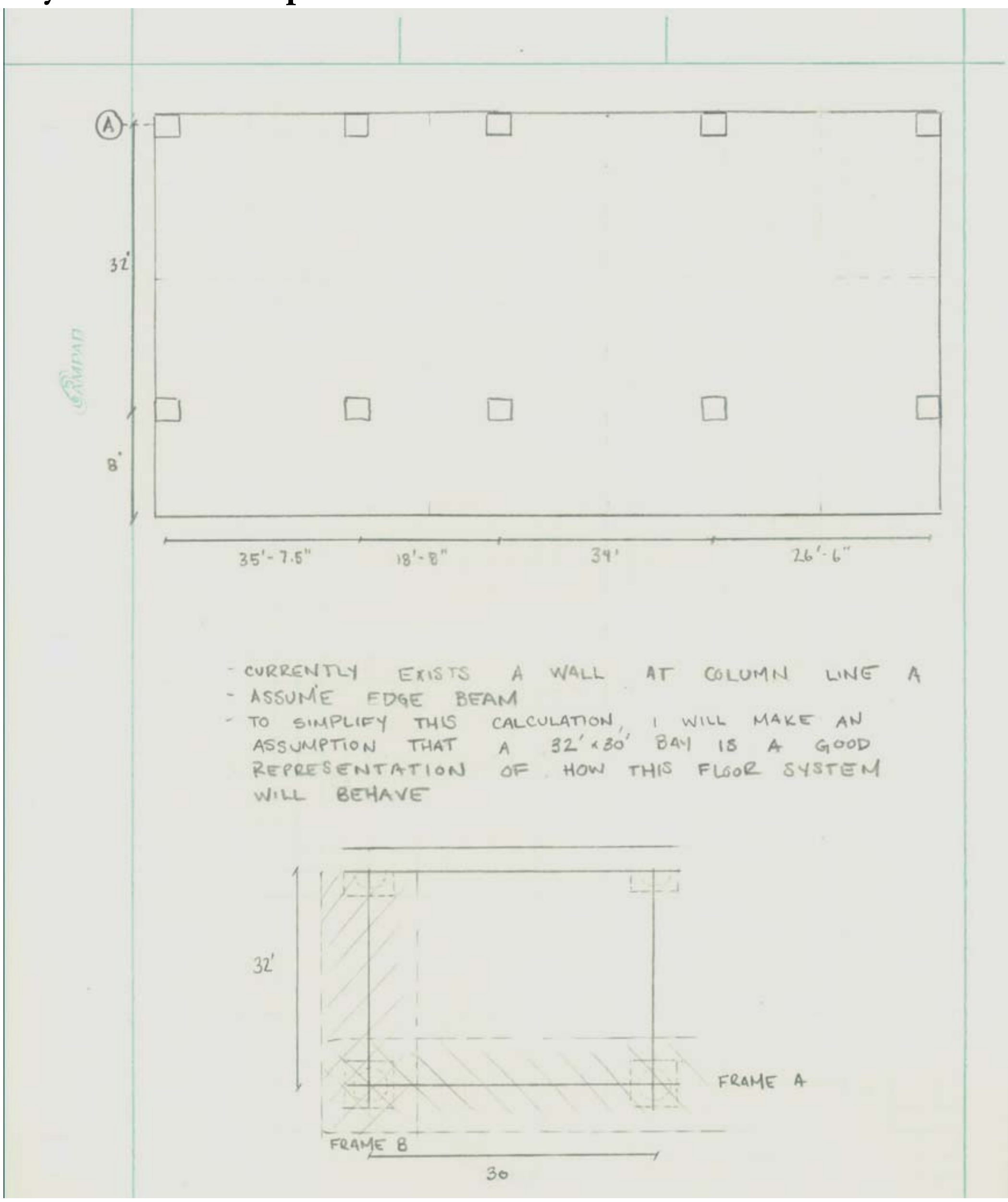
CHECK a: $\frac{576}{.85(102)(4)} = 1.66 > 1.0$??? → SHOULD BE < 1.0

W21×55 $\Sigma Q_n = 292$

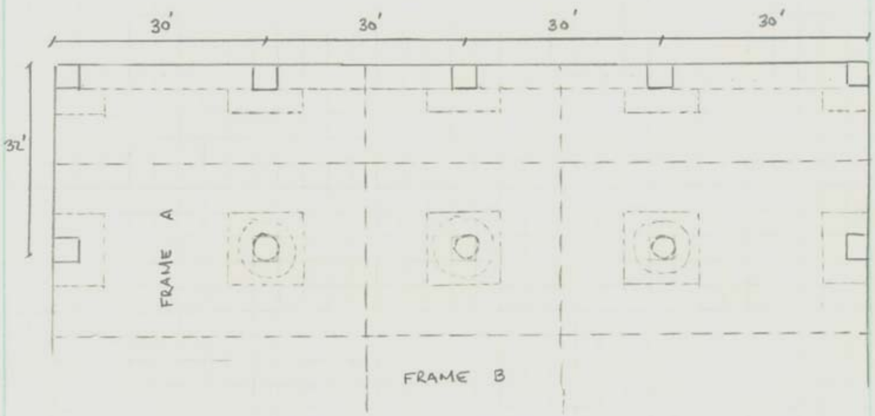
CHECK a: $\frac{292}{.85(102)4} = .842 < 1.0$

APPENDIX B

Two Way Slab With Drop Panels



AFTER MAKING MY BEFORE STATED ASSUMPTIONS, MY FLOOR SYSTEM APPEARS AS:



ASSUMPTIONS: (DIRECT DESIGN METHOD CAN BE USED)

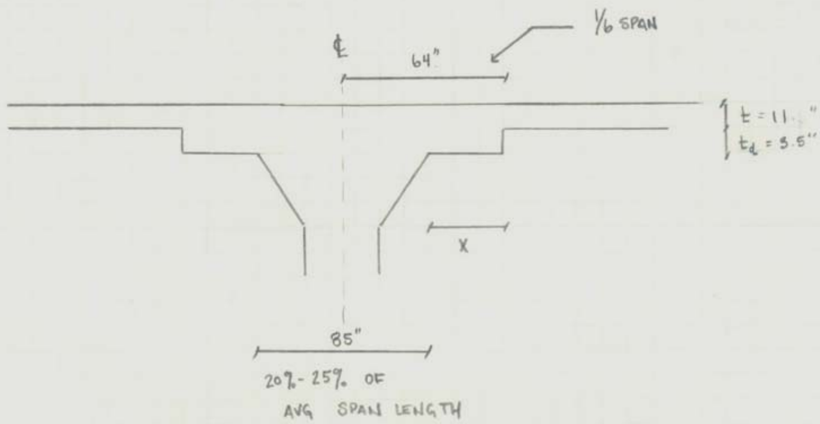
$f'_c = 4000psi$
$f_y = 60,000psi$
LL = 100 psf (STUDENT COMMONS)
SDL: 25 psf

MINIMUM SLAB THICKNESS (TABLE 9.5(c))

$t_{min} = \ell_n / 36$

$\ell_n = 32(12) - 20 = 364"$
$S_n = 30(12) - 20 = 340"$

$t_{min} = \frac{364}{36} = 10.11$ → TRY 11" SLAB

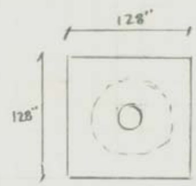


$t = 11"$

$\frac{t}{4} \leq t_d \leq \frac{1}{4} x$

$X = 5.33 - 7.08/2 = 1.79' = 22"$

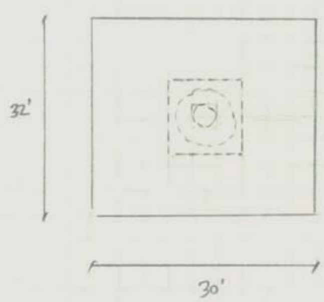
$t_d = 3.5"$



CHECK PUNCHING SHEAR

ASSUME #6 BAR

$D_{BAR} = .75"$

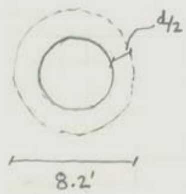


$d_{long} = 14.5 - 3/4" - 1/2(.75) = 13.375"$

$d_{short} = 12.875 - .75 = 12.625"$

$d_{avg} = 13"$

CHECKING PUNCHING SHEAR AROUND COLUMN CAPITALS



$b_o = \pi(8.2 \times 12) = 308''$

$b_o/d = 23.7''$

$\beta_c = 1 \qquad \alpha_s = 40$

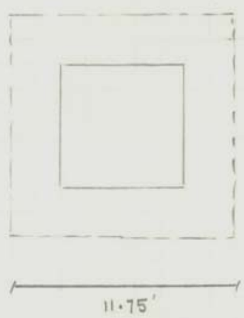
$w_u = 1.2((11/12)156 + 25) + 1.6(100) = .355^k/ft$

$V_u = .355(30 \times 32 - \pi(8.2)^2/4) = 322^k$

$V_c = \begin{cases} 4\sqrt{f'_c}\, b_o d = 1013'^k \\ (2 + 4/\beta_c)\sqrt{f'_c}\, b_o d = 1519'^k \\ \left(\frac{\alpha_s d}{b_o} + 2\right)\sqrt{f'_c}\, b_o d = 934'^k \end{cases}$

$\phi V_n = 700.5^k > 322 \therefore$ OK

CHECK PUNCHING SHEAR AROUND DROP



$b_o = 11.75(12)(4) = 564''$

$b_o/d = 43.4$

$V_u = .355(30 \times 32 - 11.75^2) = 291.8^k$

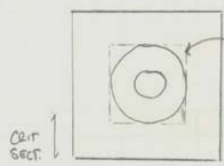
$\beta_c = 1$

$\alpha_s = 40$

$V_c = \begin{cases} 4\sqrt{f'_c}\, b_o d = 1854.86^k \\ (2 + 4/\beta_c)\sqrt{f'_c}\, b_o d = 2782^k \\ \left(\frac{\alpha_s d}{b_o} + 2\right)\sqrt{f'_c}\, b_o d = 1354.91 \end{cases}$

$\phi V_c = 1016.2^k > 291.8 \therefore$ OK

CHECK WIDE BEAM ACTION



DIAMETER OF EQUIVALENT SQUARE = a^2

$$a^2 = \frac{\pi(7.08)^2}{4}$$

$$a = 6.27'$$

CRIT SECTION

$$16 - \frac{6.27}{2} - \frac{13}{(12)} = 11.78'$$

CONSEVATIVELY TAKE $d = 13" - 3" = 10"$

$$V_u = .355(11.78)(30) = 125.47^k$$

$$V_c = 2\sqrt{f'_c}\, b_w d = 455.4^k$$

$$\phi V_c = 341.53^k > V_u \therefore \text{ok}$$

FIND MOMENTS AT CRITICAL SECTION

FRAME A:

$$M_o = \frac{1}{8} w_u \ell_2 \ell_1^2 \left(1 - \frac{2c}{3\ell_1}\right)^2$$

$$M_o = \frac{1}{8}(.355)(32)(30)^2\left(1 - \frac{2(7.1)}{3(30)}\right)^2$$

$$M_o = 906.5'^k$$

FRAME B:

$$M_o = \frac{1}{8}(.355)(30)(32)^2\left(1 - \frac{2(7.1)}{3(32)}\right)^2$$

$$M_o = 989.7'^k$$

MOMENT DISTRIBUTION (ACI 13.6.3.2)

INTERIOR SPAN

$M_u^- = .65M_o$
$M_u^+ = .35M_o$

END SPAN W/ EDGE BEAM

$M_{int}^- = .7M_o$
$M^+ = .5M_o$
$M_{ext}^- = .3M_o$

END SPAN W/OUT EDGE BEAM

$M_{int}^- = .7M_o$
$M^+ = .5M_o$
$M_{ext}^- = .25M_o$

FRAME A:

$M_u^- = .65M_o = 589.2'^k$ $M_u^+ = .35M_o = 317.3'^k$

FRAME B:

$M_{int}^- = .7M_o = 692.79'^k$
$M^+ = .5M_o = 494.85'^k$
$M_{ext}^- = .3M_o = 296.9'^k$

REINFORCING DETAILS LOCATED IN PCA REPORT

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A Computer Program Analysis, Design, and Investigation of
Reinforced Concrete Slab and Continuous Beam Systems

[2] DESIGN RESULTS

Top Reinforcement:

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

Span	Strip	Zone	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars
1	Column	Left	15.50	20.93	0.833	4.489	34.719	12.400	0.367	15-#5
		Middle	15.50	0.00	16.000	0.000	36.536	0.000	0.000	---
		Right	15.00	1279.10	31.167	4.370	34.719	2.118	26.107	85-#5
	Middle	Left	14.50	0.00	0.833	3.445	34.179	14.500	0.000	12-#5
		Middle	14.50	0.00	16.000	0.000	34.179	0.000	0.000	---
		Right	15.00	0.00	31.167	3.564	35.357	15.000	0.000	12-#5
2	Column	Left	15.00	279.24	0.833	4.370	34.719	2.118	5.028	85-#5
		Middle	15.00	116.70	3.342	3.564	48.827	10.588	2.060	17-#5
		Right	15.00	33.57	5.492	3.564	35.357	10.588	0.816	17-#5
	Middle	Left	15.00	0.00	0.833	3.564	35.357	15.000	0.000	12-#5
		Middle	15.00	0.00	3.342	3.564	35.357	15.000	0.000	12-#5
		Right	15.00	0.00	5.492	3.564	35.357	15.000	0.000	12-#5

Top Bar Details:

Units: Length (ft)

		Left				Continuous		Right			
Span	Strip	Bars	Length	Bars	Length	Bars	Length	Bars	Length	Bars	Length
1	Column	15-#5	10.84	---		---		43-#5	10.95	42-#5	6.90
	Middle	12-#5	7.51	---		---		12-#5	7.51	---	
2	Column	34-#5	3.20	34-#5	2.27	17-#5	8.00	---		---	
	Middle	---		---		12-#5	8.00	---		---	

Bottom Reinforcement:

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

Span	Strip	Width	Mmax	Xmax	AsMin	AsMax	SpReq	AsReq	Bars

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1	Column	15.50	396.79	12.031	3.683	36.536	5.636	10.127	33-#5
	Middle	14.50	264.53	12.031	3.445	34.179	7.909	6.642	22-#5
2	Column	15.00	0.00	8.000	0.000	35.357	0.000	0.000	---
	Middle	15.00	0.00	8.000	0.000	35.357	0.000	0.000	---

Bottom Bar Details:

Units: Start (ft), Length (ft)

		Long Bars			Short Bars		
Span	Strip	Bars	Start	Length	Bars	Start	Length
1	Column	33-#5	0.00	32.00	---		
	Middle	12-#5	0.00	32.00	10-#5	3.64	28.36
2	Column	---			---		
	Middle	---			---		

Flexural Capacity:

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

Span	Strip	From	To	AsTop	AsBot	PhiMn-	PhiMn+
1	Column	0.000	0.833	4.65	10.23	-258.78	400.61
		0.833	5.333	4.65	10.23	-258.78	400.61
		5.333	9.844	4.65	10.23	-187.63	400.61
		9.844	10.844	0.00	10.23	0.00	400.61
		10.844	11.450	0.00	10.23	0.00	400.61
		11.450	16.000	0.00	10.23	0.00	400.61
		16.000	20.550	0.00	10.23	0.00	400.61
		20.550	21.050	0.00	10.23	0.00	400.61
		21.050	22.784	0.00	10.23	0.00	400.61
		22.784	25.099	13.33	10.23	-511.92	400.61
		25.099	26.667	13.33	10.23	-511.92	400.61
		26.667	26.833	13.33	10.23	-705.94	400.61
		26.833	31.167	26.35	10.23	-1289.03	400.61
		31.167	32.000	26.35	10.23	-1289.03	400.61
	Middle	0.000	0.833	3.72	3.72	-150.64	150.64
		0.833	3.640	3.72	3.72	-150.64	150.64
		3.640	4.795	3.72	3.72	-150.64	150.64
		4.795	6.507	3.72	6.82	-150.64	271.35
		6.507	7.507	0.00	6.82	0.00	271.35
		7.507	11.450	0.00	6.82	0.00	271.35
		11.450	16.000	0.00	6.82	0.00	271.35
		16.000	20.550	0.00	6.82	0.00	271.35
		20.550	24.493	0.00	6.82	0.00	271.35
		24.493	25.493	0.00	6.82	0.00	271.35
		25.493	31.167	3.72	6.82	-150.75	271.35
		31.167	32.000	3.72	6.82	-150.75	271.35
2	Column	0.000	0.833	26.35	0.00	-1289.03	0.00
		0.833	1.267	26.35	0.00	-1289.03	0.00
		1.267	2.199	15.81	0.00	-825.11	0.00
		2.199	2.267	5.27	0.00	-292.27	0.00
		2.267	3.199	5.27	0.00	-292.27	0.00
		3.199	3.342	5.27	0.00	-292.27	0.00
		3.342	4.000	5.27	0.00	-294.76	0.00
		4.000	5.333	5.27	0.00	-294.76	0.00
		5.333	5.492	5.27	0.00	-211.76	0.00
		5.492	8.000	5.27	0.00	-211.76	0.00
	Middle	0.000	0.833	3.72	0.00	-150.75	0.00
		0.833	3.342	3.72	0.00	-150.75	0.00
		3.342	4.000	3.72	0.00	-150.75	0.00
		4.000	5.492	3.72	0.00	-150.75	0.00
		5.492	8.000	3.72	0.00	-150.75	0.00

Slab Shear Capacity:

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

Span	b	d	Vratio	PhiVc	Vu	Xu
1	360.00	9.19	1.000	355.61	166.58	27.69
2	360.00	9.19	1.000	355.61	39.90	4.31

Flexural Transfer of Negative Unbalanced Moment at Supports:

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

Supp	Width	GammaF*Munb	Comb	Pat	AsReq	AsProv	Additional Bars
1	--- Not checked ---						
2	128.50	663.25	U1	All	12.461	18.811	---

Punching Shear Around Columns:

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

Supp	Vu	vu	Munb	Comb	Pat	GammaV	vu	Phi*vc

```
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      1 --- Not checked ---
      2        279.57     76.5      -726.84 U1    All   0.400    105.6    176.4

Punching Shear Around Drops:
============================
   Units: Vu (kip), vu (psi), Phi*vc (psi)
   Supp           Vu Comb Pat        vu   Phi*vc
   ---- ------------ ---- ---- -------- --------
      1 --- Not checked ------
      2       256.74 U1   All      69.4    142.8

Maximum Deflections:
====================
   Units: Dz (in)
        __________Frame___________  _______Column Strip________  ________Middle Strip_______
   Span Dz(DEAD) Dz(LIVE) Dz(TOTAL)  Dz(DEAD) Dz(LIVE) Dz(TOTAL)  Dz(DEAD) Dz(LIVE) Dz(TOTAL)
   ---- -------- -------- ---------  -------- -------- ---------  -------- -------- ---------
      1   -0.265   -0.280    -0.545    -0.410   -0.434    -0.844    -0.110   -0.116    -0.225
      2    0.031    0.023     0.053     0.049    0.036     0.085     0.012    0.009     0.021

Material Takeoff:
=================
   Reinforcement in the Direction of Analysis
   ------------------------------------------
   Top Bars:      1586.8 lb    <=>  39.67 lb/ft    <=>  1.322 lb/ft^2
   Bottom Bars:   1797.7 lb    <=>  44.94 lb/ft    <=>  1.498 lb/ft^2
   Stirrups:         0.0 lb    <=>   0.00 lb/ft    <=>  0.000 lb/ft^2
   Total Steel:   3384.5 lb    <=>  84.61 lb/ft    <=>  2.820 lb/ft^2
   Concrete:      1149.8 ft^3 <=>  28.74 ft^3/ft <=>  0.958 ft^3/ft^2
```

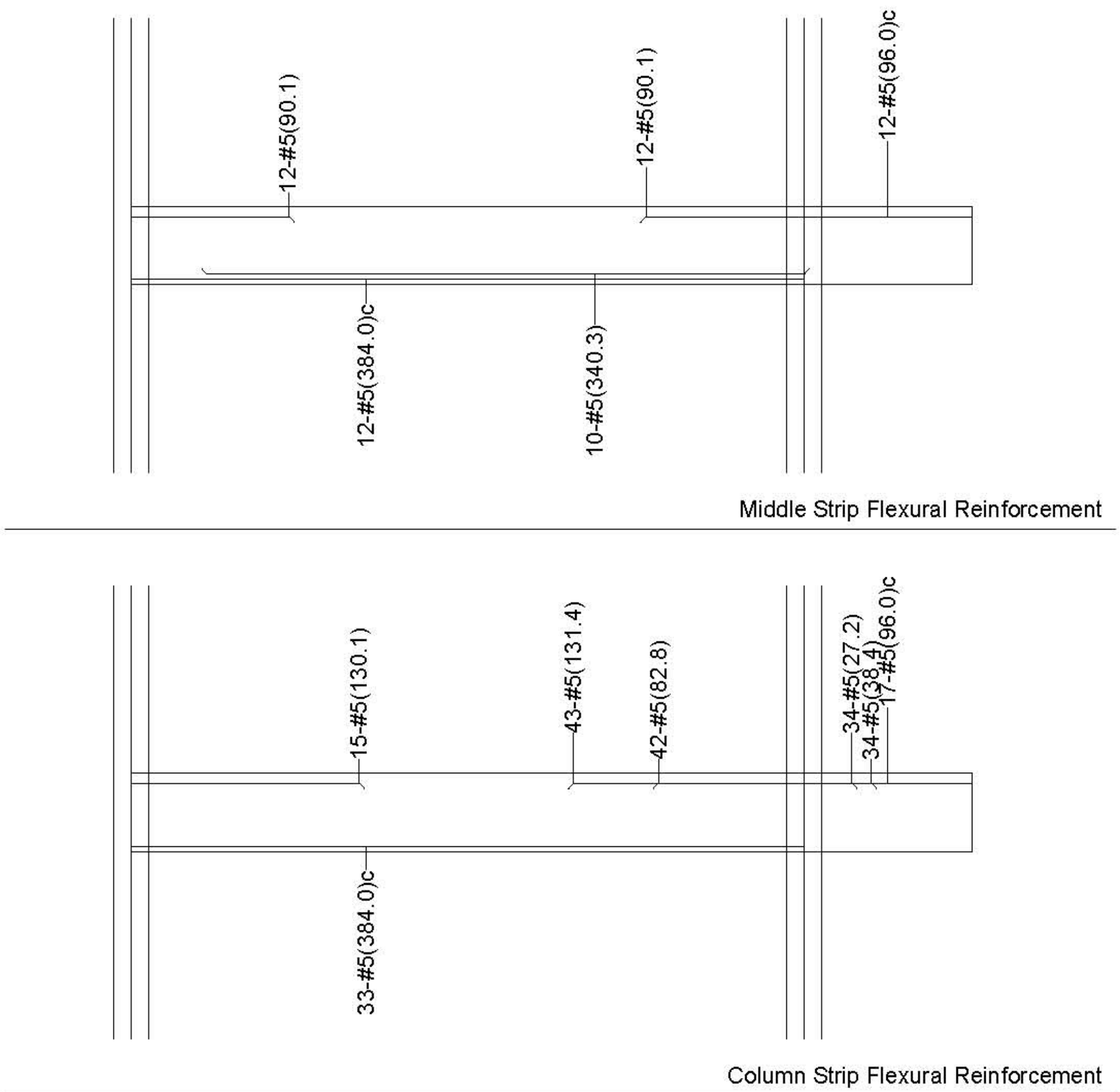


Figure 10: Reinforcement Design

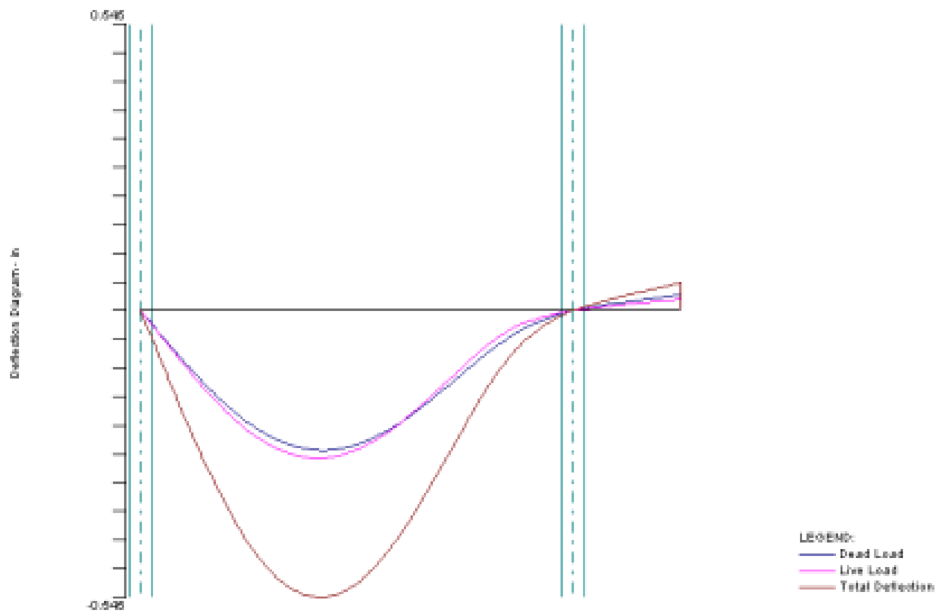


Figure 11: Deflection Calculation

10-32

CONCRETE REINFORCING STEEL INSTITUTE

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM
SQUARE EDGE PANEL With Drop Panels
No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	Square Drop Panel Depth (in.)	Square Drop Panel Width (ft)	(3) Square Column Size (in.)	Square Column γ_f	Reinforcing Bars (E. W.) Column Strip (1) Top Ext. +	Column Strip Bottom	Column Strip Top Int.	Middle Strip Bottom	Middle Strip Top Int.	Total Steel (psf)	Moments Edge (−) (ft-k)	Moments Bot. (+) (ft-k)	Moments Int. (−) (ft-k)
h = 11 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS														
31	100	8.25	10.33	12	0.746	14-#5 2	12-#7	15-#6	15-#5	13-#5	2.93	243.9	487.8	656.7
31	200	8.25	10.33	17	0.745	14-#5 4	22-#6	14-#7	20-#5	12-#6	3.74	322.3	644.7	867.8
31	300	10.25	10.33	20	0.660	15-#5 3	13-#9	16-#7	18-#6	15-#6	4.76	403.4	806.9	1086.2
31	400	12.25	12.40	22	0.634	17-#5 2	16-#9	14-#8	22-#6	11-#8	5.63	485.3	970.6	1306.6
31	500	12.25	12.40	24	0.728	19-#5 5	19-#9	16-#8	12-#9	16-#7	6.82	564.8	1129.5	1520.5
32	100	8.25	10.67	12	0.794	15-#5 4	18-#6	16-#6	12-#6	14-#5	3.11	268.9	537.7	723.9
32	200	10.25	10.67	17	0.637	15-#5 2	11-#9	19-#6	12-#7	19-#5	4.06	356.6	713.2	960.1
32	300	10.25	10.67	20	0.754	17-#5 6	14-#9	18-#7	12-#8	13-#7	5.16	445.5	891.0	1199.4
32	400	12.25	12.80	22	0.716	18-#5 5	18-#9	15-#8	14-#8	12-#8	6.13	536.2	1072.4	1443.7
32	500	12.25	12.80	26	0.765	15-#6 5	21-#9	17-#8	13-#9	11-#9	7.19	620.6	1241.2	1670.9
33	100	10.25	11.00	12	0.731	15-#5 3	15-#7	16-#6	13-#6	11-#6	3.24	296.5	593.1	798.4
33	200	10.25	11.00	17	0.717	15-#5 4	20-#7	16-#7	13-#7	11-#7	4.24	392.3	784.6	1056.2
33	300	12.25	11.00	20	0.656	17-#5 4	16-#9	18-#7	22-#6	11-#8	5.37	491.3	982.6	1322.7
33	400	12.25	13.20	23	0.746	20-#5 5	19-#9	16-#8	13-#9	13-#8	6.60	588.9	1177.9	1585.6

SQUARE INTERIOR PANEL
With Drop Panels(2)
No Beams

SPAN c.-c. $\ell_1 = \ell_2$ (ft)	Factored Superimposed Load (psf)	(3) Square Column Size (in.)	Reinforcing Bars (E. W.) Column Strip Top	Column Strip Bottom	Middle Strip Top	Middle Strip Bottom	Total Steel (psf)	Concrete (cu. ft / sq. ft)
h = 11 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS								
31	100	12	14-#6	11-#6	12-#5	12-#5	2.62	0.993
31	200	20	18-#6	20-#5	11-#6	14-#5	3.29	0.993
31	300	23	15-#7	18-#6	14-#6	12-#6	4.10	1.012
31	400	27	16-#7	22-#6	13-#7	20-#5	4.77	1.080
31	500	28	15-#8	12-#9	12-#8	13-#7	5.94	1.080
32	100	12	15-#6	12-#6	13-#5	13-#5	2.76	0.993
32	200	20	18-#6	12-#7	17-#5	15-#5	3.50	1.012
32	300	23	16-#7	15-#7	12-#7	19-#5	4.43	1.012
32	400	27	18-#7	11-#9	11-#8	12-#7	5.24	1.080
32	500	28	16-#8	13-#9	16-#7	11-#8	6.16	1.080
33	100	12	15-#6	19-#5	15-#5	13-#5	2.80	1.012
33	200	20	27-#5	13-#7	19-#5	16-#5	3.63	1.012
33	300	23	16-#7	22-#6	13-#7	11-#7	4.57	1.030
33	400	27	15-#8	13-#9	12-#8	13-#7	5.72	1.080

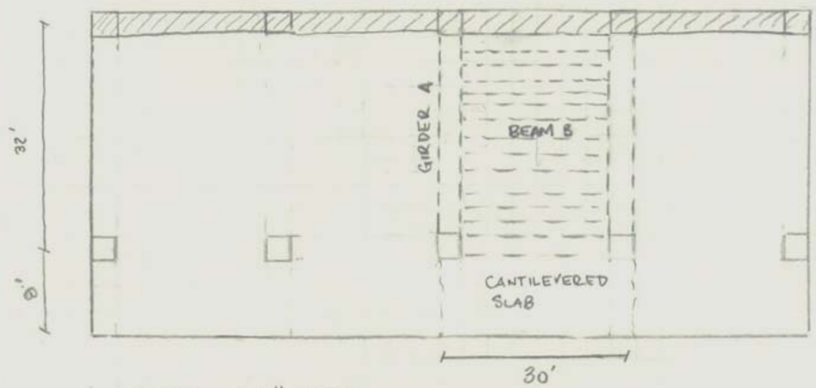
NOTES: (1) 50 percent of these bars may be placed in the middle third of column strip. (2) Drop panels same size as for edge panels. (3) Same column size above and below slab.

Figure 12: NRCI Design Guide

APPENDIX C

One Way Slab

ONE WAY SLAB



ASSUME 4.5" FLOOR
ASSUME 12"x16" BEAM

f'_c = 4000 psi
f_y = 60000 psi

ASSUME 5' SPACING
ASSUME l_1 = 30'
ASSUME S_n = 28'

BEAM ANALYSIS

DEAD LOAD:

SDL = 25 psf

SLAB CONTRIBUTION = $\frac{4.5(150)}{12}$ = 56.3 psf

BEAM CONTRIBUTION = $\frac{12(16-4.5)150}{144 \cdot 5'}$ = 28.8 psf

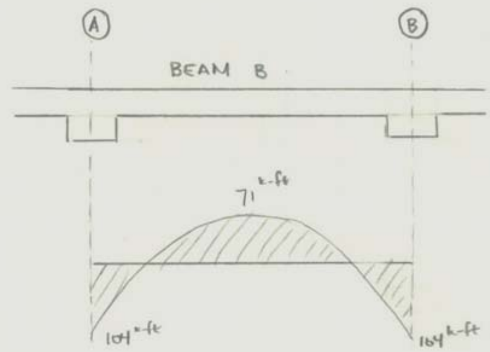
LIVE LOAD = 100 psf

$w_u = 1.2(110)(5) + 1.6(100)(5) = 1460\ ^{lb}/_{ft} = 1.46\ ^{k}/_{ft}$

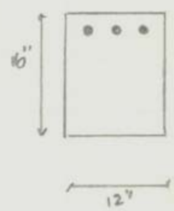
$M^-_{u,l} = \frac{1.46}{11}(28^2) = 104^{k\text{-}ft}$

$M^-_{u,r} = 104^{k\text{-}ft}$

$M_u^+ = \frac{1.46}{16}(28^2) = 71^{k\text{-}ft}$



SECTION AT A



ASSUME #3 STIRRUP
ASSUME #7 BAR

$d = 16 - 1.5 - 3/8 - (7/8)/2 = 13.7"$

$A_{s,MIN} = \begin{cases} \frac{3\sqrt{f'_c}}{f_y} bd = .52 in^2 \\ \frac{200bd}{f_y} = .55 in \end{cases}$

$A_{s,MAX} = 3.39 in$ (3)#7 → $A_s = 1.8 in^2$

ASSUME $f_s > f_y$

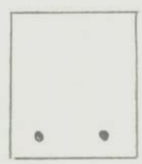
$a = \frac{1.8(60)}{.85(4)(12)} = 2.65"$

$c = a/\beta_1 = 3.11"$

$\varepsilon_t = .003\left(\frac{13.7 - 2.65}{2.65}\right) = .0125 > \varepsilon_y$

$\phi M_n = .9(1.8)(60)(13.7 - \frac{2.65}{2}) = 1202.85^{k\text{-}in} = 100^k \approx 104^k$

AT MIDSPAN



ASSUME (2) #7 BAR → $A_s = 1.2 in^2$

$a = \frac{A_s f_y}{.85 f'_c b} = 1.76''$

$C = a/\beta_1 = 2.08''$

$\varepsilon_s > \varepsilon_y \rightarrow \phi = .9$

$\phi M_n = .9(1.2)(66)(13.7 - 1.76/2) = 831^{k\text{-}in}$

$\phi M_n = 70^k \approx 71^k$

GIRDER ANALYSIS:

DEAD LOAD:

SDL: 25psf

SLAB CONTRIBUTION = $\frac{4.5}{12}(150) = 56.3\ ^{lb}/_{ft^2}$

BEAM CONTRIBUTION = $\frac{12(16-4.5)(150)}{144\ (5)} = 28.8\ ^{lb}/_{ft^2}$

GIRDER CONTRIBUTION = $20\frac{(26-4.5)(150)}{144} = 448\ ^{lb}/_{ft}$

$w_u = 1.2(56.3+28.8)(30) + 1.2(448) + 1.6(100)(30)$

$w_u = 8.401\ ^{k}/_{ft}$

MOMENTS:

AT WALL

$M = \frac{w_u l^2}{16} = 472.55\ ^{'k}$

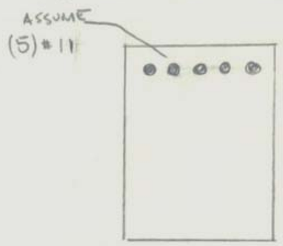
AT COLUMN

$M = \frac{w_u l^2}{10} = 756.09\ ^{'k}$

AT MIDSPAN

$M = \frac{w_u l^2}{14} = 540.06\ ^{'k}$

SECTION AT INTERIOR COLUMN



$A_s = 5(1.56) = 7.8$

$d = 26 - 1.5 - .5 - \left(\frac{1.375}{2}\right) = 23.3125$ (#4 STIRRUP)

$A_{s\,min} = 1.6\ in^2$

$A_{s\,max} = 9.8\ in^2$

DETERMINE M_n ASSUME $f_s \geq f_y$

$a = \frac{7.8(60)}{.85(4)(20)} = 6.88$

$c = 8.1''$

$\varepsilon_s = .00567 > \varepsilon_y$

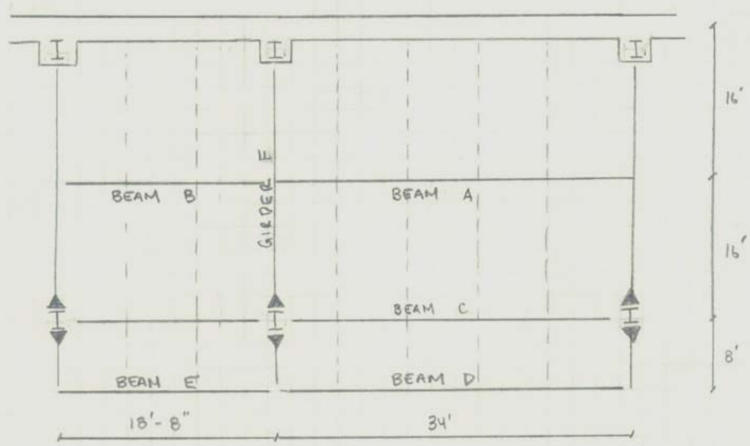
$\phi M_n = .9(8.1)(60)(23.3125 - 6.88/2)$

$\phi M_n = 725'^k$ → THIS IS EXEPTABLE BECAUSE I HAVE OVER ESTIMATE THE SPANS IN MY ASSUMPTIONS

APPENDIX D

Hollow Core Plank on Steel Beams

PRECAST HOLLOW CORE PLANK ON STEEL BEAMS



TRY HOLLOW CORE 4'-0" x 6" NWC 2" TOPPING

LOADS:

DEAD LOADS:
SUPERIMPOSED = 25psf
INCLUDED DEAD LOAD = 15psf (FOR TOPPED MEMBERS)

LIVE LOAD = 100psf (FOR STUDENT COMMONS)

SUPERIMPOSED SERVICE LOAD - 140psf
SPAN 24 ft
SELFWEIGHT : 74ft

USE 87-S 4'-0" x 6' HCP W/ 2" TOPPING NWC
- SAFE SUPERIMPOSED SERVICE LOAD : 147psf
- CAMBER AT ERECTION = .7in
- LONG TIME CAMBER = .2in

DESIGN OF STEEL:

LOADING: $w_u = 1.2(25+74) + 1.6(100) = 278.8$ psf

DEFLECTION LIMITS:

$\Delta_{LL} = L/360$ OR 1"

BEAM A

TRIB WIDTH = 16' SPANS 34'

$$M_u = \frac{(278.8)(16)(34^2)}{8} = 644.586'^k$$

$\phi M_n \rightarrow W24\times68 = 664'^k$

$$\Delta_{LL} = \frac{5(100)(16)(34^4)(1728)}{384(29000)(1000)(1830)} = .907 \text{ in} \leq 1" \text{ AND } L/360$$

BEAM B

TRIB WIDTH = 16' SPANS 18'-8"

$$M_u = \frac{(278.8)(16)(18.67^2)}{8} = 194.3'^k$$

$\phi M_n \rightarrow W14\times22 = 125'^k$

$$\Delta_{LL} = \frac{5(100)(16)(18.67^4)(1728)}{384(29000)(1000)(199)} = .753 \text{ in} \geq L/360$$

$\phi M_n \rightarrow W14\times26 = 151'^k$

$$\Delta_{LL} = \frac{5(100)(16)(18.67^4)(1728)}{384(29000)(1000)(245)} = .616 \text{ in} \leq 1" \text{ AND } L/360$$

BEAM C

TRIB WIDTH = 12' SPANS 34'

$$M_u = \frac{278.8(12)(34^2)}{8} = 482.052'^k$$

$$\phi M_n \rightarrow W24 \times 55 = 503'^k$$

$$\Delta_{LL} = \frac{5(100)(12)(34^4)(1728)}{384(29000)(1000)(1350)} = .9216'' \leq 1'' \text{ AND } L/360$$

BEAM D

TRIB WIDTH = 4' SPANS 34'

$$M_u = \frac{278.8(4)(34^2)}{8} = 161.146'^k$$

$$\phi M_n \rightarrow W16 \times 26 = 166'^k$$

$$\Delta_{LL} = \frac{5(100)(4)(34^4)(1728)}{384(29000)(1000)(301)} = 1.377'' \geq 1'' \therefore \text{ NO GOOD}$$

$$\phi M_n \rightarrow W16 \times 31 = 203$$

$$\Delta_{LL} = \frac{5(100)(4)(34^4)(1728)}{384(29000)(1000)(375)} = 1.11 \geq 1'' \therefore \text{ NO GOOD}$$

$$\phi M_n \rightarrow W18 \times 35 = 249$$

$$\Delta_{LL} = \frac{5(100)(4)(34^4)(1728)}{384(29000)(1000)(510)} = .813'' \leq 1'' \text{ AND } L/360$$

BEAM E

TRIB WIDTH = 4' SPANS 18' 8"

$M_u = \frac{278.8(4)(18.67^2)}{8} = 48.6'^k$

$\phi M_n \rightarrow W12\times14 = 65.2'^k$

$\Delta_{LL} = \frac{5(100)(4)(18.67^4)(1728)}{384(29000)(1000)(88.6)} = .11" < 1"$ AND $L/360$

GIRDER F

LOAD FROM B

$\frac{278.8(16)(18.67)}{2} = 41.64^k$

$\frac{1.2(26)(18.67)}{2} = .3^k$

TOTAL LOAD = 42^k

LOAD FROM A

$\frac{278.8(16)(34)}{2} = 75.83^k$

$\frac{1.2(68)(34)}{2} = 1.39^k$

TOTAL LOAD = 77.2^k

LOAD FROM D

$\frac{278.8(4)(34)}{2} = 18.95^k$

$\frac{35(34)}{2} = .595^k$

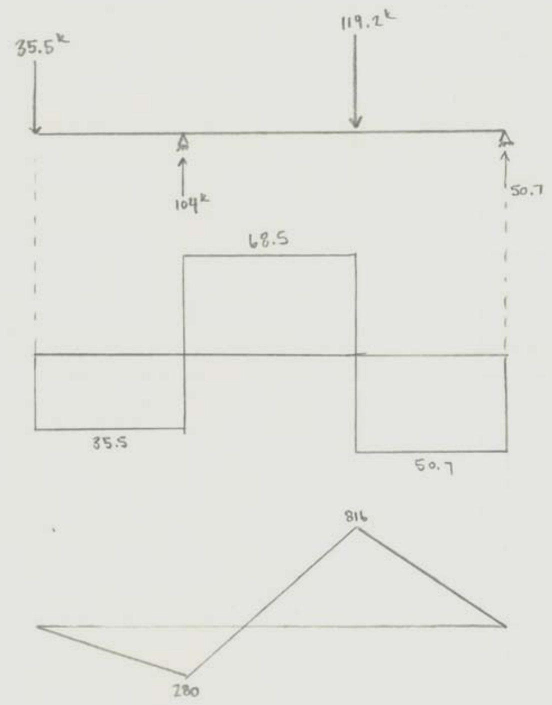
TOTAL LOAD = 25^k

LOAD FROM E

$\frac{278.8(4)(18.67)}{2} = 10.4^k$

$\frac{14(18.67)}{2} = .13^k$

TOTAL LOAD = 10.5^k



TRY W30 x 99

$L_p = 7.42$
$L_r = 21.4$
$I_x = 3990$
$BF = 33.3$
$\phi M_p = 1170'^k$

$\phi M_n = 1170 - 33.3(16 - 7.42)$

$\phi M_n = 884.3'^k$ ∴ OK

Strand Pattern Designation
76-S

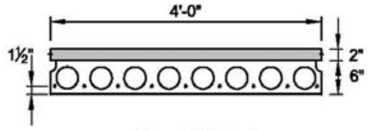
- S = straight
- Diameter of strand in 16ths
- No. of Strand (7)

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

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

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

HOLLOW-CORE
4'-0" x 6"
Normal Weight Concrete



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

Section Properties

	Untopped		Topped	
A =	187	in.^{2}	283	in.^{2}
I =	763	in.^{4}	1,640	in.^{4}
y_b =	3.00	in.	4.14	in.
y_t =	3.00	in.	3.86	in.
S_b =	254	in.^{3}	396	in.^{3}
S_t =	254	in.^{3}	425	in.^{3}
wt =	195	plf	295	plf
DL =	49	psf	74	psf
V/S =	1.73	in.		

4HC6

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

Strand Designation Code	Span, ft																				
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
66-S	444	382	333	282	238	203	175	151	131	114	100	88	77	68	59	52	46	40	33	28	
	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.0	–0.1	–0.2	–0.4	–0.5	–0.7		
	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.3	–0.5	–0.7	–0.9	–1.2	–1.5	–1.9	
76-S		445	388	328	278	238	205	178	155	136	120	105	93	82	73	65	57	49	42	36	31
		0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0.0	–0.1	–0.3	–0.4	–0.6
		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.0	–0.1	–0.2	–0.4	–0.7	–0.9	–1.2	–1.6	–2.0
96-S		466	421	386	338	292	263	229	201	177	157	139	124	110	99	88	78	68	60	53	46
		0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.1	0.0	–0.1
		0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.3	0.2	0.1	–0.1	–0.3	–0.6	–0.9	–1.3
87-S		478	433	398	362	322	290	264	240	212	188	167	149	134	119	107	95	85	76	68	60
		0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.3
		0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.3	0.2	0.0	–0.3	–0.6
97-S		490	445	407	374	346	311	276	242	220	203	186	166	148	133	119	107	96	86	78	70
		0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.8	0.7	0.6
		0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.7	0.5	0.3	0.1	–0.2

4HC6 + 2

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

Strand Designation Code	Span, ft																		
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
66-S	470	396	335	285	244	210	182	158	136	113	93	75	59	46	34				
	0.2	0.2	0.2	0.2	0.2	02	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.2				
	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.1	–0.2	–0.3	–0.5	–0.7	–0.9	–1.2				
76-S		461	391	334	287	248	216	188	163	137	115	95	78	63	50	38	27		
		0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.1	–0.0	–0.1	–0.3		
		0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	–0.2	–0.3	–0.5	–0.7	–0.9	–1.2	–1.5		
96-S			473	424	367	319	279	245	216	186	160	137	116	98	82	68	55	43	33
			0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.1	0.0	–0.1
			0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.1	–0.1	–0.3	–0.5	–0.7	–1.0	–1.4	–1.7
87-S			485	446	415	377	331	292	258	224	195	169	147	127	109	94	80	67	55
			0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.3
			0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.2	0.1	–0.1	–0.3	–0.5	–0.8	–1.2
97-S			494	455	421	394	357	327	288	251	219	192	168	146	127	110	95	82	70
			0.5	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.8	0.7	0.6
			0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.2	0.0	–0.2	–0.5	–0.8

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

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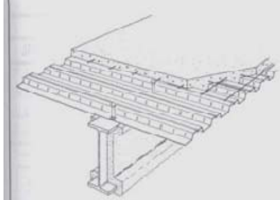
Figure 13: Hollow Core Slab

APPENDIX E

SUPERSTRUCTURES | **A3.5-540** | **Composite Beam, Deck & Slab**



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.

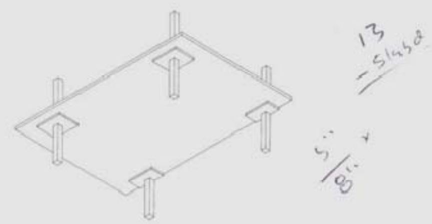
System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM 3.5-540-2400					
20X25 BAY, 40 PSF S. LOAD, 5-1/2" SLAB, 17-1/2" TOTAL THICKNESS					
Structural steel	4.320	Lb.	2.89	1.21	4.10
Welded shear connectors 3/4" diameter 4-7/8" long	.163	Ea.	.07	.24	.31
Metal decking, non-cellular composite, galv. 3" deep, 22 gauge	1.050	S.F.	1.06	.65	1.71
Sheet metal edge closure form, 12", w/2 bends, 18 ga	.045	L.F.	.07	.07	.14
Welded wire fabric rolls, 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf	1.000	S.F.	.08	.25	.33
Concrete ready mix, light weight, 3,000 PSI	.333	C.F.	1.37		1.37
Place and vibrate concrete, elevated slab less than 6", pumped	.333	C.F.		.36	.36
Finishing floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.59	.59
Curing with sprayed membrane curing compound	.010	C.S.F.	.04	.06	.10
Shores, erect and strip vertical to 10' high	.020	Ea.		.27	.27
Sprayed mineral fiber/cement for fireproof, 1" thick on beams	.483	S.F.	.22	.37	.59
TOTAL			5.80	4.07	9.87

3.5-540 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	5.80	4.07	9.87
2500	R3.5 -100	75	5-1/2	1 - 9-1/2	115	6.05	4.08	10.13
2750		125	5-1/2	1 - 9-1/2	167	7.45	4.82	12.27
2900		200	6-1/4	1 - 11-1/2	251	8.35	5.20	13.55
3000	25x25	40	5-1/2	1 - 9-1/2	82	5.75	3.89	9.64
3100		75	5-1/2	1 - 11-1/2	118	6.40	3.94	10.34
3200		125	5-1/2	2 - 2-1/2	169	6.70	4.28	10.98
3300		200	6-1/4	2 - 6-1/4	252	9.05	4.99	14.04
3400	25x30	40	5-1/2	1 - 11-1/2	83	5.85	3.86	9.71
3600		75	5-1/2	1 - 11-1/2	119	6.30	3.90	10.20
3900		125	5-1/2	1 - 11-1/2	170	7.30	4.40	11.70
4000		200	6-1/4	2 - 6-1/4	252	9.10	5	14.10
4200	30x30	40	5-1/2	1 - 11-1/2	81	5.85	3.99	9.84
4400		75	5-1/2	2 - 2-1/2	116	6.40	4.15	10.55
4500		125	5-1/2	2 - 5-1/2	168	7.70	4.67	12.37
4700		200	6-1/4	2 - 9-1/4	252	9.25	5.40	14.65
4900	30x35	40	5-1/2	2 - 2-1/2	82	6.15	4.12	10.27
5100		75	5-1/2	2 - 5-1/2	117	6.70	4.22	10.92
5300		125	5-1/2	2 - 5-1/2	169	7.95	4.75	12.70
5500		200	6-1/4	2 - 9-1/4	254	9.30	5.40	14.70
5750	35x35	40	5-1/2	2 - 5-1/2	84	6.55	4.14	10.69
6000		75	5-1/2	2 - 5-1/2	121	7.50	4.41	11.91
7000		125	5-1/2	2 - 8-1/2	170	8.75	5.05	13.80
7200		200	5-1/2	2 - 11-1/2	254	10.15	5.60	15.75

3 SUPERSTRUCTURES

SUPERSTRUCTURES | A3.5-140 | C.I.P. Flat Slab w/Drop Panels



General: Flat Slab: Solid uniform depth concrete two-way slabs with drop panels at columns and no column capitals.

Design and Pricing Assumptions:
Concrete f'c = 3 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.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM 3.5-140-1700 **15'X15' BAY 40 PSF S. LOAD, 12" MIN. COL. 6" SLAB, 1-1/2" DROP, 117 PSF**					
Forms in place, flat slab with drop panels, to 15' high, 4 uses	.993	S.F.	1.33	3.79	5.12
Forms in place, exterior spandrel, 12" wide, 4 uses	.034	SFCA	.03	.23	.26
Reinforcing in place, elevated slabs #4 to #7	1.588	Lb.	.51	.48	.99
Concrete ready mix, regular weight, 3000 psi	.513	C.F.	1.31		1.31
Place and vibrate concrete, elevated slab, 6" to 10" pump	.513	C.F.		.47	.47
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.59	.59
Cure with sprayed membrane curing compound	.010	C.S.F.	.04	.06	.10
TOTAL			3.22	5.62	8.84

3.5-140 Cast in Place Flat Slab with Drop Panels

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB & DROP (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1700	15 x 15	40	12	6 - 1-1/2	117	3.22	5.60	8.82
1720	R3.5 -010	75	12	6 - 2-1/2	153	3.29	5.65	8.94
1760		125	14	6 - 3-1/2	205	3.42	5.75	9.17
1780		200	16	6 - 4-1/2	281	3.58	5.90	9.48
1840	15 x 20	40	12	6-1/2 - 2	124	3.42	5.70	9.12
1860	R3.5 -100	75	14	6-1/2 - 4	162	3.56	5.85	9.41
1880		125	16	6-1/2 - 5	213	3.76	6	9.76
1900		200	18	6-1/2 - 6	293	3.85	6.05	9.90
1960	20 x 20	40	12	7 - 3	132	3.59	5.80	9.39
1980		75	16	7 - 4	168	3.78	5.95	9.73
2000		125	18	7 - 6	221	4.17	6.15	10.32
2100		200	20	8 - 6-1/2	309	4.23	6.25	10.48
2300	20 x 25	40	12	8 - 5	147	3.99	6	9.99
2400		75	18	8 - 6-1/2	184	4.26	6.25	10.51
2600		125	20	8 - 8	236	4.59	6.55	11.14
2800		200	22	8-1/2 - 8-1/2	323	4.78	6.70	11.48
3200	25 x 25	40	12	8-1/2 - 5-1/2	154	4.17	6.10	10.27
3400		75	18	8-1/2 - 7	191	4.37	6.30	10.67
4000		125	20	8-1/2 - 8-1/2	243	4.65	6.60	11.25
4400		200	24	9 - 8-1/2	329	4.87	6.70	11.57
5000	25 x 30	40	14	9-1/2 - 7	168	4.50	6.35	10.85
5200		75	18	9-1/2 - 7	203	4.77	6.55	11.32
5600		125	22	9-1/2 - 8	256	4.97	6.75	11.72
5800		200	24	10 - 10	342	5.30	6.95	12.25

For expanded coverage of these items see *Means Concrete & Masonry Cost Data 2000*

3 SUPERSTRUCTURES

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SUPERSTRUCTURES | **A3.5-140** | **C.I.P. Flat Slab w/Drop Panels**

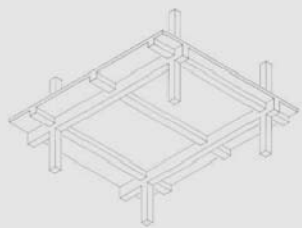
3.5-140 **Cast in Place Flat Slab with Drop Panels**

	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	MINIMUM COL. SIZE (IN.)	SLAB & DROP (IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
6400	30 x 30	40	14	10-1/2 - 7-1/2	182	4.85	6.50	11.3
6600		75	18	10-1/2 - 7-1/2	217	5.15	6.75	11.9
6800		125	22	10-1/2 - 9	269	5.35	6.95	12.3
7000		200	26	11 - 11	359	5.70	7.25	12.9
7400	30 x 35	40	16	11-1/2 - 9	196	5.25	6.80	12.0
7900		75	20	11-1/2 - 9	231	5.55	7.10	12.6
8000		125	24	11-1/2 - 11	284	5.80	7.25	13.0
9000	35 x 35	40	16	12 - 9	202	5.40	6.85	12.2
9400		75	20	12 - 11	240	5.75	7.15	12.9
9600		125	24	12 - 11	290	5.95	7.30	13.2

3 SUPERSTRUCTURES

70 **Important: See the Reference Section for critical supporting data - Reference Numbers and City Cost Indexe**

SUPERSTRUCTURES | **A3.5-120** | **C.I.P. Beam & Slab, One Way**



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.

SUPERSTRUCTURES 3

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM 3.5-120-3000					
BM. & SLAB ONE WAY 15'X15' BAY, 40 PSF S.LOAD,12" MIN. COL.					
Forms in place, flat plate to 15' high, 4 uses	.858	S.F.	.80	3.18	3.98
Forms in place, exterior spandrel, 12" wide, 4 uses	.142	SFCA	.12	.95	1.07
Forms in place, interior beam. 12" wide, 4 uses	.306	SFCA	.25	1.68	1.93
Reinforcing in place, elevated slabs #4 to #7	1.600	Lb.	.51	.48	.99
Concrete ready mix, regular weight, 3000 psi	.410	C.F.	1.05		1.05
Place and vibrate concrete, elevated slab less than 6", pump	.410	C.F.		.44	.44
Finish floor, monolithic steel trowel finish for finish floor	1.000	S.F.		.59	.59
Cure with sprayed membrane curing compound	.010	C.S.F.	.04	.06	.10
TOTAL			2.77	7.38	10.15

3.5-120 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.	COST PER S.F. INST.	COST PER S.F. TOTAL
3000	15x15	40	12	4	120	2.77	7.35	10.12
3100	R3.5 -010	75	12	4	138	2.83	7.40	10.23
3200		125	12	4	188	2.89	7.50	10.39
3300		200	14	4	266	3.06	7.75	10.81
3600	15x20	40	12	4	102	2.83	7.30	10.13
3700	R3.5 -100	75	12	4	140	2.96	7.55	10.51
3800		125	14	4	192	3.12	7.80	10.92
3900		200	16	4	272	3.44	8.35	11.79
4200	20x20	40	12	5	115	3.09	7.20	10.29
4300		75	14	5	154	3.33	7.70	11.03
4400		125	16	5	206	3.49	8.10	11.59
4500		200	18	5	287	3.89	8.70	12.59
5000	20x25	40	12	5-1/2	121	3.22	7.20	10.42
5100		75	14	5-1/2	160	3.53	7.80	11.33
5200		125	16	5-1/2	215	3.78	8.25	12.03
5300		200	18	5-1/2	294	4.09	8.85	12.94
5500	25x25	40	12	6	129	3.40	7.05	10.45
5600		75	16	6	171	3.70	7.60	11.30
5700		125	18	6	227	4.29	8.70	12.99
5800		200	2	6	300	4.72	9.30	14.02
6500	25x30	40	14	6-1/2	132	3.45	7.20	10.65
6600		75	16	6-1/2	172	3.75	7.65	11.40
6700		125	18	6-1/2	231	4.38	8.65	13.03
6800		200	20	6-1/2	312	4.77	9.40	14.17

For expanded coverage of these items see *Means Concrete & Masonry Cost Data 2000*

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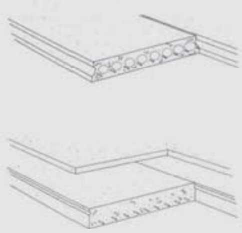
3 SUPERSTRUCTURES

SUPERSTRUCTURES | **A3.5-120** | **C.I.P. Beam & Slab, One Way**

3.5-120	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	3.99	7.75	11.74
7100		75	18	7-1/2	191	4.40	8.20	12.6[illegible]
7300		125	20	7-1/2	245	4.68	8.70	13.3[illegible]
7400		200	24	7-1/2	328	5.20	9.65	14.8[illegible]
7500	30x35	40	16	8	158	4.22	8	12.2[illegible]
7600		75	18	8	196	4.49	8.30	12.7[illegible]
7700		125	22	8	254	5	9.20	14.2[illegible]
7800		200	26	8	332	5.45	9.55	15
8000	35x35	40	16	9	169	4.69	8.25	12.94
8200		75	20	9	213	5.10	9	14.1[illegible]
8400		125	24	9	272	5.55	9.40	14.9[illegible]
8600		200	26	9	355	6.10	10.05	16.1[illegible]
9000	35x40	40	18	9	174	4.81	8.40	13.2[illegible]
9300		75	22	9	214	5.20	9.10	14.3[illegible]
9400		125	26	9	273	5.65	9.45	15.1[illegible]
9600		200	30	9	355	6.20	10.10	16.3[illegible]

3 SUPERSTRUCTURES

SUPERSTRUCTURES | A3.5-210 | Precast Plank



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 3.5-210-2000					
10' SPAN, 40 LBS S.F. WORKING LOAD, 2" TOPPING					
Precast prestressed concrete roof/floor slabs 4" thick, grouted	1.000	S.F.	5.10	1.58	6.6
Edge forms to 6" high on elevated slab, 4 uses	.100	L.F.	.04	.27	[illegible]
Welded wire fabric 6 x 6 - W1.4 x W1.4 (10 x 10), 21 lb/csf, 10% lap	.010	C.S.F.	.08	.25	[illegible]
Concrete ready mix, regular weight, 3000 psi	.170	C.F.	.44		[illegible]
Place and vibrate concrete, elevated slab less than 6", pumped	.170	C.F.		.19	[illegible]
Finishing floor, monolithic steel trowel finish for resilient tile	1.000	S.F.		.54	[illegible]
Curing with sprayed membrane curing compound	.010	C.S.F.	.04	.06	[illegible]
TOTAL			5.70	2.89	8.5

3.5-210 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	5.10	1.58	6.6
0750	R3.5 -010	75	6	50	125	4.93	1.26	6.1
0770		100	6	50	150	4.93	1.26	6.1
0800	15	40	6	50	90	4.93	1.26	6.1
0820	R3.5 -100	75	6	50	125	4.93	1.26	6.1
0850		100	6	50	150	4.93	1.26	6.1
0875	20	40	6	50	90	4.93	1.26	6.1
0900		75	6	50	125	4.93	1.26	6.1
0920		100	6	50	150	4.93	1.26	6.1
0950	25	40	6	50	90	4.93	1.26	6.1
0970		75	8	55	130	5.50	1.01	6.5
1000		100	8	55	155	5.50	1.01	6.5
1200	30	40	8	55	95	5.50	1.01	6.5
1300		75	8	55	130	5.50	1.01	6.5
1400		100	10	70	170	6.25	.65	6.9
1500	40	40	10	70	110	6.25	.65	6.9
1600		75	12	70	145	5.25	.70	5.9
1700	45	40	12	70	110	5.25	.70	5.9

76 **Important: See the Reference Section for critical supporting data - Reference Numbers and City Cost Index**

SUPERSTRUCTURES | A3.5-210 | Precast Plank

3 SUPERSTRUCTURES

3.5-210 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.	INST.	TOTAL
2000	10	40	6	75	115	5.70	2.89	8.59
2100		75	8	75	150	5.55	2.57	8.12
2200		100	8	75	175	5.55	2.57	8.12
2500	15	40	8	75	115	5.55	2.57	8.12
2600		75	8	75	150	5.55	2.57	8.12
2700		100	8	75	175	5.55	2.57	8.12
2800	20	40	8	75	115	5.55	2.57	8.12
2900		75	8	75	150	5.55	2.57	8.12
3000		100	8	75	175	5.55	2.57	8.12
3100	25	40	8	75	115	5.55	2.57	8.12
3200		75	8	75	150	5.55	2.57	8.12
3300		100	10	80	180	6.10	2.32	8.42
3400	30	40	10	80	120	6.10	2.32	8.42
3500		75	10	80	155	6.10	2.32	8.42
3600		100	10	80	180	6.10	2.32	8.42
3700	35	40	12	95	135	6.85	1.96	8.81
3800		75	12	95	170	6.85	1.96	8.81
3900		100	14	95	195	5.85	2.01	7.86
4000	40	40	12	95	135	6.85	1.96	8.81
4500		75	14	95	170	5.85	2.01	7.86
5000	45	40	14	95	135	5.85	2.01	7.86

For expanded coverage of these items see *Means Concrete & Masonry Cost Data 2000*