October 26, 2007

LOCKWOOD PLACE
BALTIMORE, MD

[TECHNICAL ASSIGNMENT 2]

Monica Steckroth
Structural Option
Faculty Consultant: Dr. Linda Hanagan

Executive Summary

Lockwood Place in Baltimore, Maryland is a thirteen story mixed-use development building utilized predominately for retail and corporate businesses. The building enclosure is made primarily of steel with a glass curtain wall façade. Directly adjacent to the building sits a covered mall area and a parking garage. The parking garage connects to the second level of Lockwood Place through a corridor and lobby.

The goal of this report is to investigate alternative floor framing systems and determine their feasibility. Feasibility was determined based on constructability, cost, fire rating, aesthetics, vibration, and the overall impact on other structural components of the building. The systems investigated are: noncomposite steel; open-web steel joist; one-way slab with beams; and two-way flat slab with drop panels.

While the noncomposite steel system and one-way slab with beams system proved to be viable for further investigation, the two-way flat slab with drop panels and open-web steel joist systems did not. A two-way flat slab system with drop panels did not accommodate the existing column grid layout. An open-web steel joist system was very susceptible to vibration issues and required extensive fireproofing measures to achieve the required rating. A more detailed analysis of the systems found to be feasible will be made in the future to determine the optimum floor framing system.

TABLE OF CONTENTS

INTRODUCTION

As an expansion to the corporate/entertainment district of Baltimore's Inner Harbor, the Lockwood Place Office Building is located directly across from the National Aquarium. The building has a curved glass, curtain wall façade and abuts a covered mall area and an adjacent parking garage. It is comprised of thirteen floors and over 300,000 square feet of floor space.

At ground level, a visitor is welcomed by a grand lobby entrance. At the second level, a visitor has direct access to the adjacent parking garage. At the third level, tenants have the option to utilize two balcony spaces. Each floor is designed with large bay sizes, allowing for open floor plans. The spaces on the first two floors, occupied by retail tenants, rise to a combined height of 34 feet. The third through the twelfth floors are occupied by corporate tenants and each floor height is 13'-6". A penthouse is constructed on the thirteenth floor. The floor height is 18' and it sets back slightly from the rest of the building. Lockwood Place is designed to accommodate a range of tenants' needs, while providing a sleek exterior look with each story consisting of full height glass and large spans.

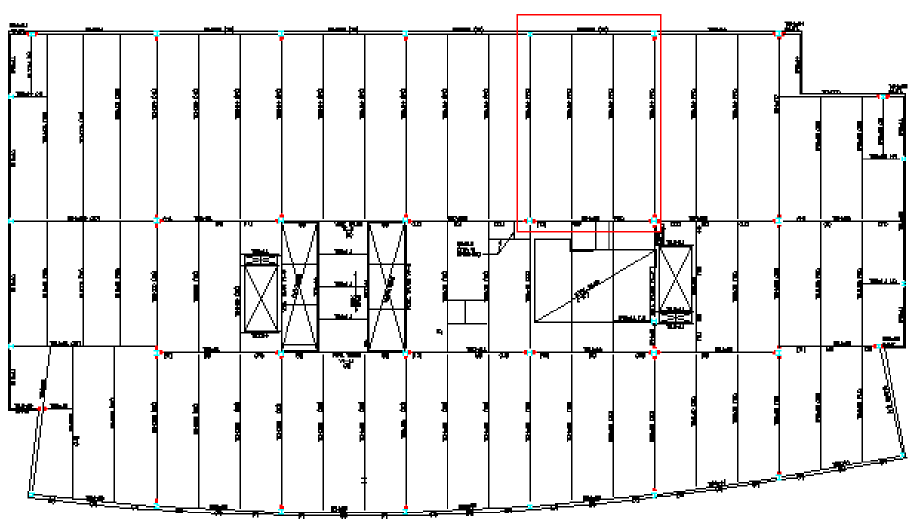
This report analyzes four different floor systems for a typical bay in comparison to the existing floor system. It discusses overall feasibility and impact the floor system has on other building components such as column grid and lateral system. Results are based on vibration criteria, constructability, and aesthetical impact among other factors. The typical bay used in analysis was taken from an office occupancy type floor and loading was determined accordingly.

STRUCTURAL SYSTEM OVERVIEW

Floor System

500 East Pratt Street has a typical superstructure floor framing system made of composite steel beams and girders. The slab is 3-1/4" light weight concrete topping on 3"x20gage galvanized metal deck. For composite beam action, ¾" diameter by 5-1/2" long headed shear studs are used, conforming to ASTM A108, Grades 1010 through 1020. Typical bay sizes are 30'-0" x 30'-0" and 45'-0" x 30'-0." Infill beams are spaced 10'-0" on center, framing into a typical girder size of W24x62. All steel conforms to ASTM A572, Grade 50, unless otherwise noted on the drawings. MEP systems are run through the structural framing system. Holes created in the beams and girders from the MEP systems are reinforced according to AISC Design Guide 2. A two hour fire rating is provided for all floor slabs, beams, girders, columns, roofs, and vertical trusses. For a more detailed description of atypical floor systems, please refer to Technical Assignment 1.

The typical framing plan (levels 5-11) involves long spans and open areas, providing space flexibility for tenants. The location of the 30'-0" x 45'-0" typical bay analyzed and redesigned throughout this report is at the fifth level and is highlighted below. Due to setbacks and balconies, the footprints and framing of the first through fourth floors, the twelfth floor, and the penthouse vary from what is shown below. Although this bay is considered an end span in the north/south direction, it proves to be the most common bay type.



Roof System

At the penthouse level of Lockwood Place, the building steps back creating a high roof and a low roof. A third roof, the highest point of the building, is created by an extended machine room ceiling located at the penthouse level. The roof on the penthouse is sloped slightly downward into the machine room wall. While the framing of the penthouse floor is consistent with the typical building superstructure system, infill beam sizes are reduced due to smaller bay widths. All three roof systems are 1-1/2"x20ga. galvanized type 'B' metal deck. Infill beams are located at 6' on center. Beam sizes range from W10x12 to W24x76 depending on their location.

Exterior slabs that are located at level twelve are 4-1/2" normal weight concrete topping on 3"x20gage galvanized composite metal deck. The slabs are reinforced with 6x6-W2.9xW2.9 W.W.F. Waterproofing is required for all exterior slabs.

A screen wall is located on level twelve to disguise mechanical equipment. A canopy extends over a balcony on the twelfth floor. The canopy is also made of 1-1/2"x20gage galvanized type 'B' metal deck.

Lateral System

Lockwood Place's lateral system is comprised of both moment frames and eccentric braced frames. Moment frames run both east/west and north/south directions. Eccentric braced frames are located around the elevators/elevator lobby. Sizes of the braces range from W14x19 at the base of the building to W8x31 at the top of the building and are pinned connections. Lateral loads were distributed based on the rigidity of each frame. Columns that have eccentric braces framed into them are designed to be fixed to their supports at the base of the building. All other columns are designed to have pinned bases.

Foundation

Located along Baltimore's Inner Harbor, Lockwood Place's soils consist of existing man-made fill. The maximum soil bearing pressure for spread footings is 1000psf. To accommodate for this bearing capacity, the foundation system is made of drilled caissons. Caisson shaft diameters range from 2'-6" to 6'-0." Typically, they extend a minimum if 1'-0" into Gneiss bedrock and have a minimum concrete compressive stress of 4500psi.

Grade beams travel between pile caps and have a minimum concrete compressive strength of 4000psi. Each grade beam ranges in size from 18"x24" to 24"x42" and is reinforced with top and bottom bars.

CODES & REFERENCES

Codes employed in this report:

- Design Standards
  American Society for Civil Engineers (ASCE-7-05)
  Design Code for Minimum Design Loads

- Structural Steel
  American Institute of Steel Construction (AISC)
  LRFD Specifications for Structural Steel Design – Unified Version, 2005

- Structural Concrete
  American Concrete Institute
  Specification for Reinforced Concrete and Masonry Structures, 2005

References employed in this report:

- CRSI Handbook (2002)
- Steel Joist Institute Standards
- United Steel Deck Manual (2002)
- RS Means Assemblies Cost Data (2008)
- Underwriters Laboratory Fire Resistance Vol.1 (2001)
- RAM Structural Systems
- PCA Slab

BUILDING LOAD SUMMARY

Gravity Loads

The loads for Lockwood Place are presented in an abbreviated form below. The loads are accumulated from The Maryland Building Code Performance Standard. Design loads from the engineer of record and those of the building code are shown in comparison.

Dead Load

DEAD LOAD (psf)							
Location/Loading	Office	Lobby/ Corridor	Machine Room	Retail	1st Floor Lobby	Balconies	Roof
Concrete Slab	46	46	46	63	63	63	-
Metal Deck	2	2	2	-	-	2	2
Pavers/ W.P.	-	-	-	-	-	2	2
M/E/C/L	8	8	8	-	-	8	8
Roofing	-	-	-	-	-	2	2
Insulation	-	-	-	-	-	2	2
Total Dead Load	56	56	56	63	88	115	14

Live Load

LIVE LOAD (psf)		
Location	Design Load	Minimum Required
Office	100	50 for offices only
Lobby/Corridor	100	100 first level, 80 above first level
Machine Room	125	125
Retail	100	100 first level, 75 above first level
1st Floor Lobby	100	100
Balconies	100	100 exterior
Roof	30	20 assuming no reduction

It is a conservative assumption to use an unreduced roof live load. Given that the front of the building is a curved radius, there is great variation in tributary areas among roof members. In many cases in the southern half of the building, the tributary area is too small to be reduced. To simplify the design, no live loads were reduced on the roof.

Wall Load

The building exterior is made of metal faced composite wall panels glazed into a glass curtain wall system. The wall estimated weight is 25psf. This weight is used to determine the building's seismic base shear.

SYSTEM 1: Composite Steel

Description:

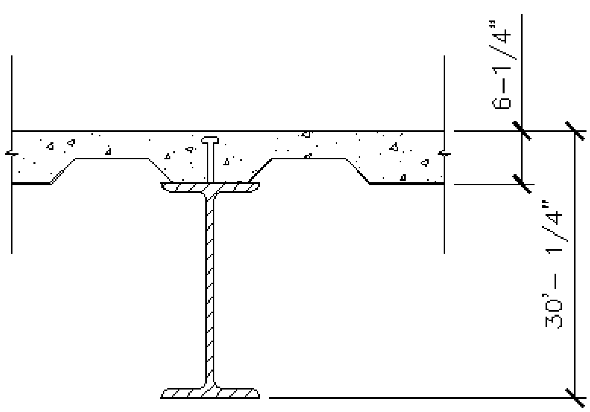
The existing floor construction is composite steel. The slab is made of 3" deck with 3-1/4" topping. In a typical bay size of 30'-0" x 45'-0, the typical girder size is W24x64 and infill beam sizes are W24x84 spaced 10' on center. Calculations were performed with a total dead load of 56psf and a live load of 100psf.

The existing framing members have a larger capacity for the given loads determined in Technical Assignment 1. This large capacity may be due to vibration criteria or consideration of holes throughout the beam for MEP systems. For the purpose of this report, detailed hole reinforcement details is omitted. The necessity of the holes and their reinforcement to maximize floor to ceiling height will need to be a consideration when determining other viable systems.

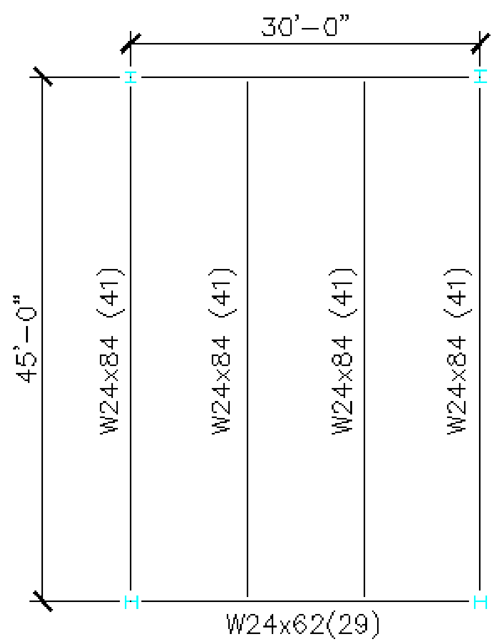
With the large increase in size and capacity of the members, composite action strength from the shear studs is not necessary. Please see the member size requirements for a noncomposite steel floor system on the following pages.

Layout & Materials:

f'c= 3500psi
fy= 60,000psi
6-1/4" total slab thickness, 3"
20 gage composite deck
Lightweight concrete
¾" diameter, 5-1/2" long shear studs



PLAN



SECTION

Constructability:

This system requires no formwork or shoring, allowing it to be easily constructed. Construction consists of setting the beams, laying the deck, and pouring the concrete. A fast erection time is possible and easy to sequence.

Aesthetics:

A composite steel floor allows for lighter steel members, yet higher strength. Large spans are possible, creating an open floor layout and flexible spaces. Floor to ceiling height can be maximized by allowing the MEP systems to run through reinforced holes in the beams.

Fire Rating:

A 3-1/4" thick concrete slab will automatically provide the two hour fire rating required for all floors in the building. Steel beams can easily be coated with spray-on fireproofing.

Cost:

Although calculations found smaller sized members to be acceptable, cost data was developed with sized specified on plan. Cost of materials and labor was taken from R.S. Means (2006). The cost data of a typical bay can be found in the table below. Costs include materials, labor, and equipment.

Components	Unit Cost	Quanity	Component Cost
Steel beams	106.71/ft.	180 ft.	4775.4
Steel girders	79.59/ft.	60 ft.	19207.8
Shear studs	0.835/lb.	2220 lb.	1853.7
Decking	2.36/ft.^{2}	1350 ft.^{2}	3186
Concrete	3.03/ ft.^{2}	1350 ft.^{2}	4090.5
Total			**$ 33,113.40**

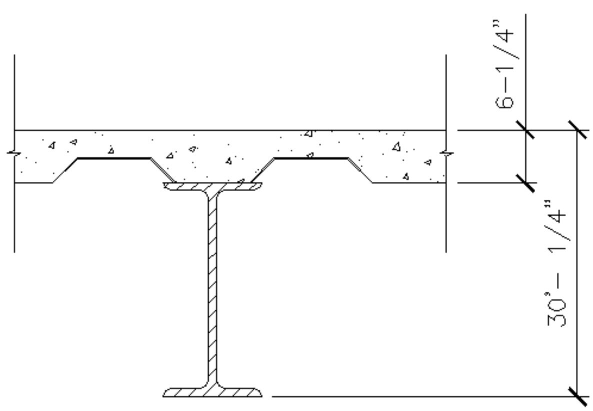
SYSTEM 2: NONCOMPOSITE STEEL

Description:

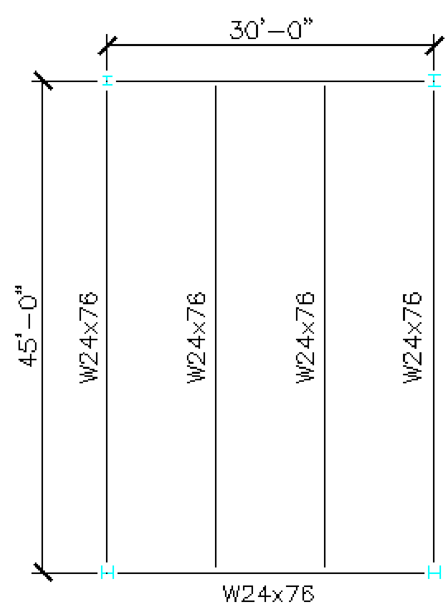
A noncomposite steel floor system was designed for a typical bay size of 30’-0” x 45’-0. The typical girder size was found to be W24x76 and infill beam sizes were W24x76 spaced 10’ on center. Deflection from total load is 2.10” and deflection from live load is 1.136.” To determine these sizes, a RAM model was assembled and compared to hand calculations. Calculations were performed with a total dead load of 56psf and a live load of 100psf. A thinner slab thickness would be sufficient for the design with absence of shear studs; however, slab thickness was designed as 3” deck with 3-1/4” topping to remain consistent with the composite steel floor system design. Detailed calculations can be found in Appendix A.

Layout & Materials:

f’c= 3500psi
fy= 60,000psi
6-1/4” total slab thickness, 3” 20 gage composite deck
Lightweight concrete



SECTION



PLAN

Constructability:

This system requires no formwork or shoring, allowing it to be easily constructed. As with a composite steel floor, the construction process consists of setting the steel, laying the deck, and pouring the concrete. A fast erection time is possible and easy to sequences.

Aesthetics:

With a noncomposite steel floor system, large spans are still possible, creating an open floor plan and flexible spaces. Depths of members remain the same as the existing system. Floor to ceiling height can be maximized by allowing the MEP systems to run through reinforced holes in the beams.

Fire Rating:

A 3-1/4" thick concrete slab will automatically provide the two hour fire rating required for all floors in the building. Steel beams can easily be coated with spray-on fireproofing.

Other system effects:

Minimal changes will need to be made to adjust for a noncomposite steel system. Column grids and MEP systems will remain in place. Columns will remain approximately the same size, without affecting the lateral resisting system. Since the weight of the noncomposite steel system (63.4psf) is comparable to weight of the composite steel system (64.3), foundations will not be greatly affected. To meet vibration criteria for long spans and an office occupancy type, floor framing member sizes may need to be increased. If this system is determined to be the most viable floor system solution, a detailed vibration analysis will need to be completed to verify the controlling factors in the design of the members.

Cost:

Cost of materials and labor was taken from R.S. Means (year). The cost data of a typical bay can be found in the table below. Costs include materials, labor, and equipment.

Components	Unit Cost ($)	Quantity	Component Cost
Steel members	96.59	240ft	23181.60
Decking	2.36/ft^2	1350 ft^2	4090.50
Concrete	3.03/ ft^2	1350 ft^2	3186
Total		**$**	**30,458.1**

Summary:

Advantages	Disadvantages
2 hour fire rated	Heavy steel members
Likely meets vibration criteria	Long steel lead time
Fast erection time	
Easy to sequence	
Large spans	

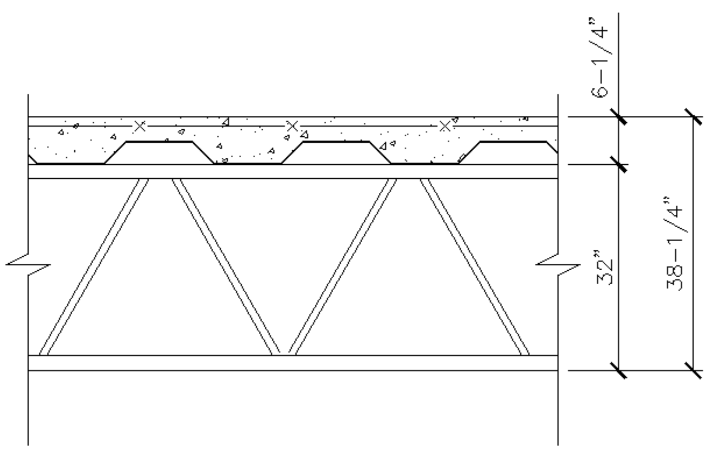
SYSTEM 3: OPEN-WEB STEEL JOIST

Description:

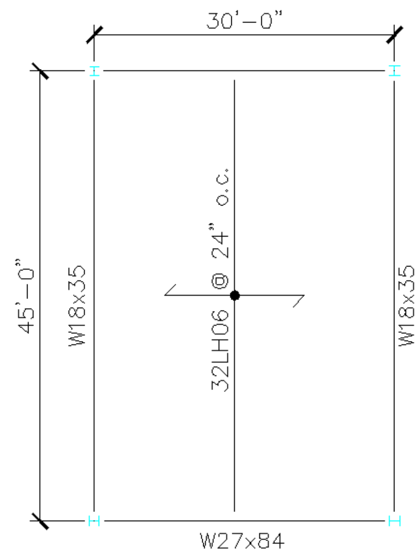
An open-web steel joist floor system was calculated for a typical bay size of 30'-0" x 45'-0". Joists span 45'-0" in the north/south direction. Joist sizes were to found as 32LH06, beam sizes were found as W18x35, and girder sizes were found as W27x84. The joists have a total deflection of 1.818" and a live load deflection of 1.166." Sizes were determined through comparison of a RAM model and hand calculations. Calculations were performed with a total dead load of 56psf and a live load of 100psf. Slab thickness was designed as 3" deck with 3-1/4" topping to remain consistent with the composite steel floor system design. A thinner slab thickness would be sufficient for the design. Calculations for this system can be found in Appendix B.

Layout & Materials:

f'c= 3500psi
fy= 60,000psi
6-1/4" total slab thickness, 3"
20 gage composite deck
Lightweight concrete



SECTION



PLAN

Constructability:

This system requires no formwork or shoring, allowing it to be easily constructed. The construction process consists of setting the steel, laying the deck, and pouring the concrete. A fast erection time is possible and easy to sequence. Cantilevered edges of the building require joists to be integrated with wide flange beams. It is not practical to assemble a joist to beam connection that is not orthogonal. The curved geometry of the south face of the building inhibits a standard layout of joists.

Aesthetics:

With an open-web steel joist floor system, large spans are possible, creating open floor plans and flexible spaces. Although, 32LH series joists have a depth of 32," floor to ceiling height can be maximized by running MEP systems through the open-webs of the joists.

Fire Rating:

A 3-1/4" thick concrete slab will automatically provide the two hour fire rating required for all floors in the building. Steel joists require a mesh encasement before applying spray-on fireproofing. This method is considered ineffective due to difficulty to properly cover the joists. A two hour fire rating could also be achieved by providing another layer with a two hour rating under the joists. MEP systems would need to be below the two hour rated layer to allow for accessible maintenance and in turn, floor to ceiling heights would be much lower.

Other system effects:

The existing column grid layout will remain in place for an open-web steel joist system and columns will remain approximately the same size, in turn the lateral system will not be affected. The weight of the structural system (63psf) is similar to the weight of the structural system (64.3psf), not affecting the foundations. MEP systems may require a drop in height, dependent upon the fireproofing method selected. Vibration is a serious concern of this type of system due to the lack of joist stiffness. Large amounts of vibration may cause this system to be an impractical alternative for floor construction.

Cost:

Cost of materials and labor was taken from R.S. Means (year). The cost data of a typical bay can be found in the table below. Costs include materials, labor, and equipment.

Components	Unit Cost	Quantity	Component Cost
Joists	17.10/ft.	630ft.	10773
Beams	47.80/ft.	180ft.	4302
Girders	106.28/ft.	60ft.	2376.80
Decking	2.36/ft^2	1350ft^2	3186
Concrete	3.03/ft^2	1350ft^2	4090
Total		**$**	**28,727.80**

Summary:

Advantages	Disadvantages
Fast erection time	Special fireproofing requirements
Easy to sequence	Susceptible to vibrations
Large spans	Difficult connections
Cost effective	Typical layouts may not be possible
	Long steel lead time

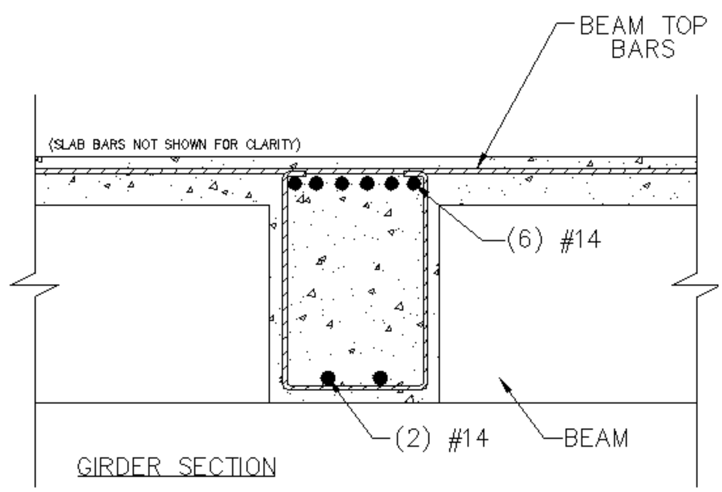
SYSTEM 4: ONE-WAY SLAB WITH BEAMS

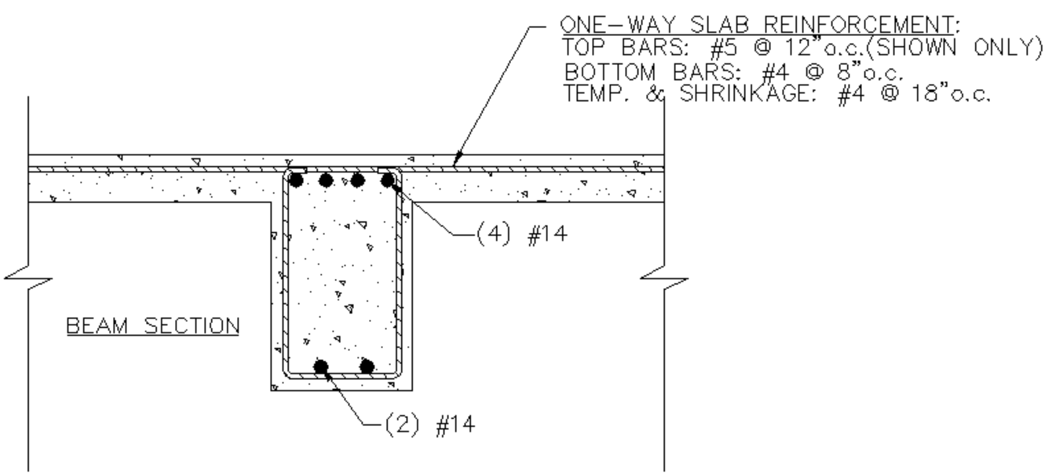
Description:

A concrete one-way slab with beams was calculated for a typical bay size of 30'-0"x 45'-0." The typical beam size was found to be 18"x32". To maximize floor height, girders depths were kept to 32" and sizes were found to be 24" x 32". A slab thickness of 6" is required for a 15'-0" slab span. Beam deflection from total load is 1.82". These members were sized using CRSI Handbook 2002. To accurately use the tables provided, load factors of 1.4*Dead +1.7*Live were applied. Calculations were performed with a total superimposed load of 10psf and a live load of 100psf. CRSI tables employed can be found in Appendix C. To view the full design, see figures below.

Layout & Materials:

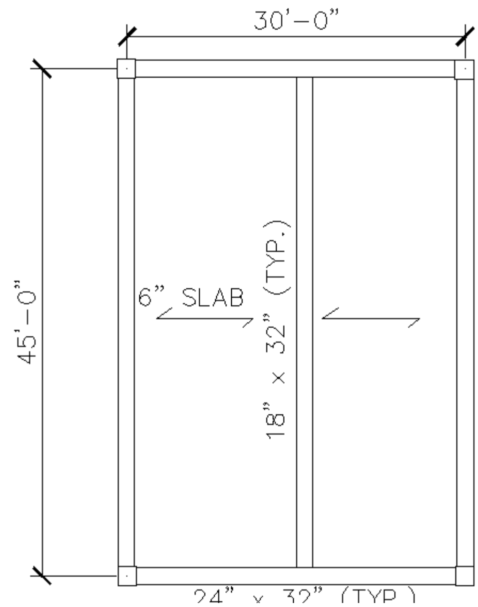
f'c= 4000psi
fy= 60,000psi
Slab pho= 0.005
6" total slab thickness
Normal weight concrete

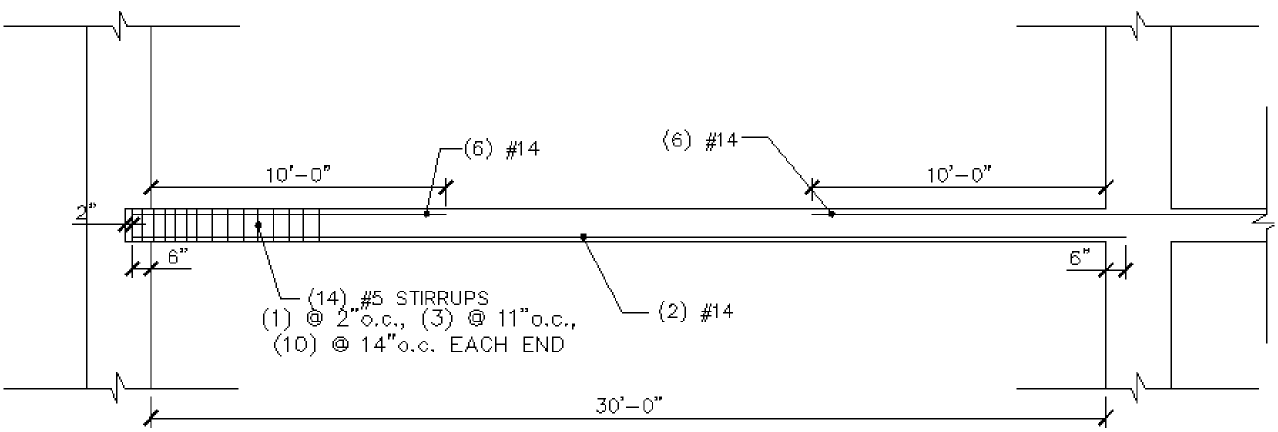




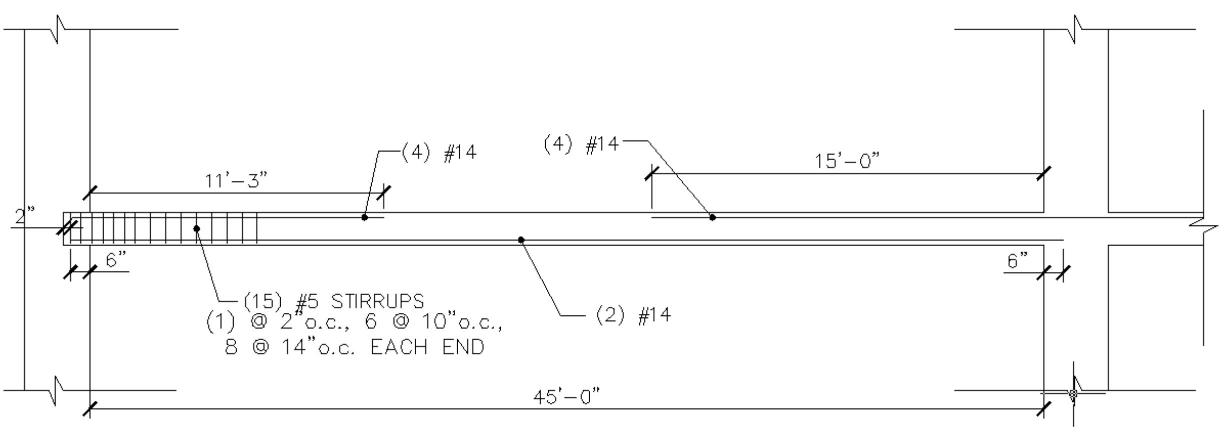
SECTION DETAILS

PLAN LAYOUT





GIRDER SECTION



BEAM SECTION

Constructability:

Formwork is required for the cast in place one-way slab with beam system. Workers need to allow appropriate shoring times before removing formwork. Formwork can be reused for the north half of the building, but will need to be constructed on a bay by bay bases for the south half of the building due to the curved exterior façade. Cast in place concrete will have a slower erection time than a steel system.

Aesthetics:

With a one-way slab with beams systems, large spans are still possible, creating open floor plans and flexible spaces. A total beam depth of 32” inhibits a large floor to ceiling height. Although in previous systems MEP equipment could be run through the structural system, this is not possible with concrete beams. With the use of a cast in place concrete floor system, the existing 1’8” slab overhangs can still be achieved.

Fire Rating:

A 6” thick concrete slab will automatically provide the two hour fire rating required for all floors in the building. No additional fireproofing is necessary.

Other System effects:

The existing column grid layout will remain in place for a one-way slab with beams system. Poured concrete columns will need to be sized to resist gravity and lateral loads. The existing moment frame/eccentric brace steel lateral system will need to be redesigned to accommodate the concrete floor system. A concrete moment frame or shear walls may be found more appropriate. Due to the increased weight of the building from the base floor system (77psf increase), lateral forces will need to be recalculated to ensure that seismic loads will not control over wind loads determined in Technical Assignment 1. Additionally, caisson foundation diameters will need to be resized to accommodate the increased load. It can be assumed that the concrete floor system has a relatively higher stiffness than that of the steel floor systems. Vibration criteria will not be a concern as compared to the other systems previously discussed.

Cost:

Cost of materials and labor was taken from R.S. Means (year). The cost data of a typical bay can be found in the table below. Relative to the previously discussed systems labor costs are high due to required formwork. The system costs include forms, reinforcing, concrete, placement and finishings. Unit costs are based on materials, labor, and equipment.

Components	Unit Cost	Quantity	Component Cost
System	553.50/ yd^3	74.4 yd^3	41,153.75
Total		**$**	**41,153.75**

Summary:

Advantages	Disadvantages
No additional fireproofing	Formwork needed
Vibration acceptable	Lower ceiling heights
Large spans	Concrete curing time
	Heavier than base system
	Expensive

SYSTEM 5: TWO WAY FLAT SLAB WITH DROP PANELS

Description:

A concrete one-way slab with beams was calculated for a typical bay size of 30'-0" x 30'-0". Although a two-way flat slab with drop panel system allows for larger spans than a two-two way flat plate system, it is not feasible to achieve the existing span of 45'-0." The design of the floor system can be found in the table below. To determine deflection of the design, a model consisting of three typical bays was set up in PCA Slab with the given load conditions, factors, and layout requirements. Although slab overhangs were considered for end spans, weight from the exterior wall was not. This model was simply to approximate deflections relative to other systems, not to determine exact calculations. A total deflection of 0.25" was found.

This design was determined through the use of CRSI Handbook 2002. To accurately use the tables provided, load factors of 1.4*Dead +1.7*Live were applied. Calculations were performed with a superimposed load of 10psf and a live load of 100psf. Due to the radius of the south edge of the building, individual bays will need to be normalized to determine sufficient reinforcement. Normalization of the bays allows the system to meet design criteria for a two-way slab system, but will need to be further investigated to insure this assumption is conservative. Each of the bays will vary in size. CRSI tables employed can be found in Appendix D.

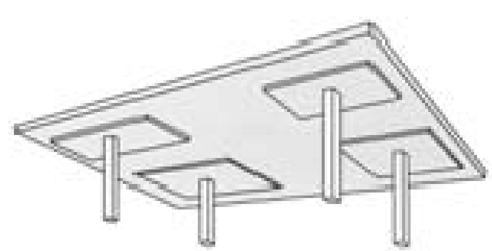
Span	30'-0"
Slab Depth	10"
Drop Panel Depth	8.5"
Drop Panel Size	10'-0"x 10'-0"
Column Strip	15'-0"
Middle Strip	15'-0"
Minimum Column Dimension	19"

Exterior Panel				
Column Strip			Middle Strip	
Top Ext.	Bottom	Top Int.	Bottom	Top Int.
14-#5	11-#9	14-#7	21-#5	10-#7

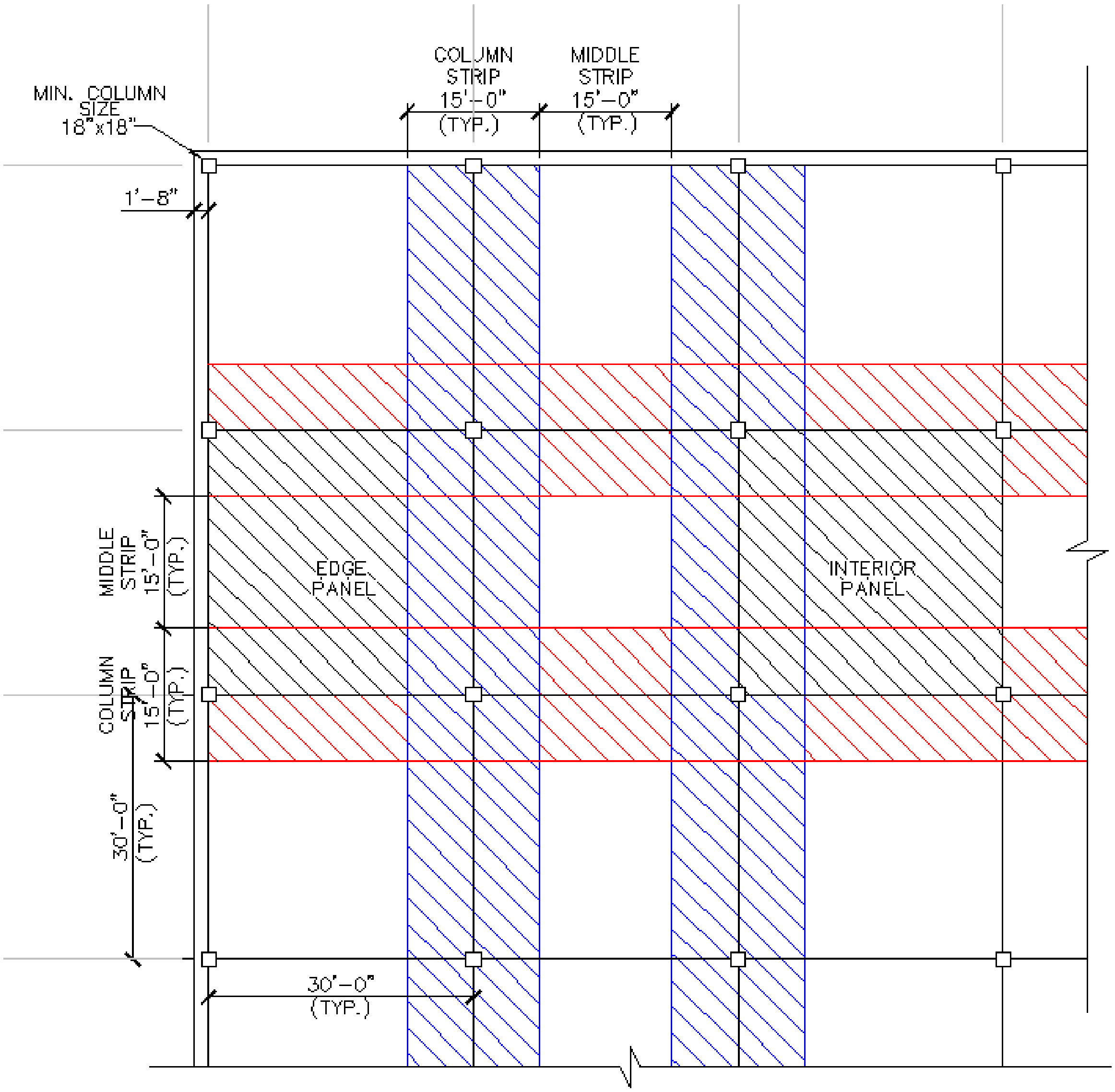
Interior Panel			
Column Strip		Middle Strip	
Top	Bottom	Top	Bottom
18-#6	22-#5	12-#6	10-#6

Layout & Materials:

f'c= 4000psi
fy= 60,000psi
10" slab thickness
8.5" drop panel depth
Normal weight concrete



3D Sketch



PLAN

Constructability:

Minimal formwork is needed for two-way flat slab construction. During construction it will be essential to ensure aggregate is thoroughly distributed between reinforcement bars.

Aesthetics:

Existing bay sizes need to be shorted with a two-way flat slab with drop panel system. A new grid layout can be achieved by creating three 30'-0" bays running in the north/south direction. A fourth bay at the south edge will vary slightly in length across the building with a maximum span of 28'-0." This grid layout will cause complications on lower floors that do not have typical layouts. Columns will extend through the middle of lobby spaces. Spaces become fairly small on the second level where a parking garage ramp cuts into the floor layout. Shorter bays and additional columns may restrict flexibility and marketability of the space.

A total floor depth of 18.5" is smaller than the existing system. Depending on the depth of the equipment, it may be possible to run MEP equipment below the slab without taking away from total existing floor to ceiling height. The existing 1'8" slab overhangs can still be achieved with the two-way flat stab floor system by extending the top bars at the exterior edge through the length of the overhang.

Fire Rating:

A 10" thick concrete slab will automatically provide the two hour fire rating required for all floors in the building. No additional fireproofing is necessary.

Other System effects:

The existing column grid layout will shift for a two-way flat slab with drop panel system. Poured concrete columns will need to be sized to resist gravity and lateral loads. A minimum column size of 18" is required. The existing moment frame/eccentric brace steel lateral system will need to be redesigned to accommodate the concrete floor system. A concrete moment frame or shear walls may be found more appropriate. Wind was the controlling lateral force determined from Technical Assignment 1. The substantial increase in weight of the floor system (105psf) will require a reevaluation to determine if wind forces will continue to control over seismic forces. The current caisson foundation system is drilled into bedrock, minimizing settlement issues. Caisson diameters may need to be increased to accommodate the additional load. It can be assumed that the concrete floor system has a relatively higher stiffness than that of the steel floor systems. Vibration criteria will not be as much of a concern as compared to the steel systems previously discussed.

Cost:

Cost of materials and labor was taken from R.S. Means (year). The cost data of a typical bay can be found in the table below. Equivalent costs were evaluated based on per square foot of the design and projected onto a 30'-0" x 45'-0" to allow for a direct comparison of floor systems. The system costs include forms, reinforcing, concrete, placement and finishings. Unit costs are based on materials, labor, and equipment.

Components	Unit Cost	Quantity	Component Cost
Beams	445.75/yd^3	45.6yd^3	20,327.10
Total		**$**	**20,327.10**

Summary:

Advantages	Disadvantages
No additional fireproofing	Formwork needed
Large floor to ceiling height	Larger minimum column size
Cost effective	Smaller spans, interrupted spaces
	Heavier than base system
	Variable construction results
	Concrete curing time necessary
	Larger minimum column size

COMPARISON

Comparisons between the existing floor system and the four new systems were made on the basis of a typical bay size. Fireproofing is based on a two hour minimum for floor systems. Deflection criteria are based on total load deflection of L/240 and live load deflection of L/360. Vibration analysis is based on relative stiffness of the systems. Results of the comparisons are shown in the table below. Large weight variations between the steel and concrete system can be attributed to the use of light weight verses normal weight concrete.

	System 1 Steel Composite	System 2 Steel Noncomposite	System 3 Open web steel joist	System 4 Two-way flat plate	System 5 One-way slab with beams
Total Depth	31"	29"	38-1/4"	18.5"	32"
Slab Depth	6-1/4"	6-1/4"	6-1/4"	10"	6"
Structure Weight	64.3psf	63.4psf	63psf	141psf	168psf
Cost /ft^2	$24.53	$22.56	$21.28	$15.06	$30.50
Fireproofing	Spray-on	Spray-on	Special required	Satisfied	Satisfied
Deflection	N/A	1.96"	2.24"	0.25"	1.18"
Vibration Concern	Moderate	Moderate	High	Low	Low
Lead Time	Long	Long	Long	Short	Short
Contractibility	No form work, easy to sequence	No form work, easy to sequence	No form work, easy to sequence	Formwork required, well distributed aggregate	Formwork required, curing time necessary
Durability	Steel fatigue Possible	Steel fatigue Possible	Steel fatigue Possible	Spawling concrete possible	Spawling concrete possible
Grid Changes	None	None	None	Yes	None
Foundation System Effects	None	None	None	larger caisson diameters needed	larger caisson diameters needed
Lateral System Effects	None	None	None	Yes	Yes
Viable Solution	Yes	Yes	No	No	Yes

CONCLUSION

Floor systems designed in this report are intended to give a relative comparison of the advantages and disadvantages of alternate construction possibilities at 500 East Pratt Street. The four systems investigated are: noncomposite steel; open-web steel joist; one-way flat slab with beams; and two-way flat plate with drop panels.

While the noncomposite steel and one-way slab with beam systems proved to be viable alternatives to the existing composite steel system, the two-way flat plate and open-web steel joist systems did not. Although the two-way flat slab system provided a larger floor to ceiling height, the necessary column grid adjustment was not accommodating to the architectural layout intended by the architect and decreases the space marketability. Open-web steel joists may be lighter in weight, but have major vibration potential with existing large spans. Extensive measures taken to provide proper fireproofing will greatly increase the cost of the system.

The noncomposite steel system designed in this report is lighter than the existing steel system, but has potential to increase in size due to vibration requirements. Following this report, a complete vibration analysis will need to be calculated to accurately determine the more economical system. One-way slab with beams may be heavier in weight and have lower floor to ceiling heights than the base system, but have little vibration concerns and can accommodate the building's existing grid layout. These factors prove the one-way slab with beam system worthy of further investigation.

Although a fifth alternative system was not in the scope of this report, a post tensioned floor system may provide the advantages of a thinner slab allowing for a large floor to ceiling height, fast construction time, and accommodation of large spans and radial grid lines. This system will be further investigated in the future to determine the optimum choice for Lockwood Place's floor system.

APPENDIX A
SYSTEM 2

APPENDIX A

Beam Spot Check:

$w = 1.2(56) + 1.6(100) = (2272)(10)/1000) = 2.272$ klf

$M_u = \frac{(2.272)(45)^2}{8} = 575.1^k$

$\Delta_T = \frac{L}{240} = \frac{45(12)}{240} = 2.25''$; $\Delta_L = \frac{L}{360} = \frac{45(12)}{360} = 1.5''$

$2.25 = \frac{1.56(45)^4(1728)}{(29000)(I)} \cdot \frac{5}{384}$ $I = 2206\ in^4$

(from unfactored loads)

$1.5 = \frac{1.0(45)^4(1728)}{(29000)(I)} \cdot \frac{5}{384}$ $I = 2121.0\ in^4$

W 24x76 = $\phi M_n = 750$ $\Delta_L = 1.136''$
$I_x = 2100$ $\Delta_T = 2.10''$
* RAM model reduced liveloads

Weight of system:

concrete: $(3.5 + 3/2) = \frac{5''}{12}(115pcf) = 47.9$ psf

deck: 2psf

steel: $76(45(4) + 2(30)) = 18240/30(45) = 13.5$psf

Total: 63.4 psf

Weight of Existing System:

concrete = 48 psf

deck: 2psf

steel: $84(4)(45) + 62(2)(30) = \frac{18840}{30(45)} = 14$psf

studs: estimate 2^{lbs}/stud $(222) = 444^{lb}/30(45) = 0.33$psf

Total weight = 64.3psf

APPENDIX A

Cost Data:

steel Decking - $2.36/SF (30)(45) = 3186

concrete - 3.03 /SF (30)(45) = 4090.5
- assume 6" slab
- includes forms, reinforcing, concrete, placement & finishing

steel - W24x76 = 96.59 /LF (45(4) + 2(30)) = 23181.6

Total Bay cost = $ 30,458.1

Unit Cost - $22.56 / ft²

Total Depth = 6.25 + 22.4 = 28.65 ≈ 29"
Total Depth existing = 6.25 + 24.1 = 30.35"

Cost for existing system:

steel Deck - 3186

concrete - 4090.5

steel - W24x62 = 79.59 (2)(30) = 4775.4
W24x84 = 106.71 (4)(45) = 19207.8

studs - equivalent stud cost to 10 lb of steel
222(10) (0.835) = 1853.7
(average cost/lb)

Total Cost = $ 33113.46
Unit Cost: $24.53 / S.F

Gravity Beam Design

RAM Steel v11.0
DataBase: Floor System 2
Building Code: IBC

10/24/07 20:38:4
Steel Code: AISC LRF

Floor Type: typical **Beam Number = 51**

SPAN INFORMATION (ft): I-End (65.00,45.00) J-End (95.00,45.00)

Beam Size (Optimum) = W24X76 Fy = 50.0 ksi
Total Beam Length (ft) = 30.00
Mp (kip-ft) = 833.33

POINT LOADS (kips):

Dist	DL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%
10.000	14.31	22.50	36.7	0.00	0.00	0.0	0.00	Snow
10.000	9.52	15.75	36.7	0.00	0.00	0.0	0.00	Snow
20.000	14.31	22.50	36.7	0.00	0.00	0.0	0.00	Snow
20.000	9.52	15.75	36.7	0.00	0.00	0.0	0.00	Snow

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.076	0.000	---	NonR
	30.000	0.076	0.000		

SHEAR (Ultimate): Max Vu (1.2DL+1.6LL) = 68.74 kips 0.90Vn = 283.93 kips

MOMENTS (Ultimate):

Span	Cond	LoadCombo	Mu kip-ft	@ ft	Lb ft	Cb	Phi	Phi*Mn kip-ft
Center	Max +	1.2DL+1.6LL	683.9	15.0	10.0	1.00	0.90	686.47
Controlling		1.2DL+1.6LL	683.9	15.0	10.0	1.00	0.90	686.47

REACTIONS (kips):

	Left	Right
DL reaction	24.97	24.97
Max +LL reaction	24.23	24.23
Max +total reaction (factored)	68.74	68.74

DEFLECTIONS:

Dead load (in)	at	15.00 ft	= -0.671	L/D =	537
Live load (in)	at	15.00 ft	= -0.659	L/D =	546
Net Total load (in)	at	15.00 ft	= -1.330	L/D =	271

Gravity Beam Design

RAM Steel v11.0
DataBase: Floor System 2
Building Code: IBC

10/24/07 20:38:4
Steel Code: AISC LRF

Floor Type: typical **Beam Number = 35**

SPAN INFORMATION (ft): I-End (115.00,45.00) J-End (115.00,90.00)

Beam Size (Optimum) = W24X76 Fy = 50.0 ksi
Total Beam Length (ft) = 45.00
Mp (kip-ft) = 833.33

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.560	1.000	25.0%	Red
	45.000	0.560	1.000		
2	0.000	0.076	0.000	---	NonR
	45.000	0.076	0.000		

SHEAR (Ultimate): Max Vu (1.2DL+1.6LL) = 44.18 kips 0.90Vn = 283.93 kips

MOMENTS (Ultimate):

Span	Cond	LoadCombo	Mu kip-ft	@ ft	Lb ft	Cb	Phi	Phi*Mn kip-ft
Center	Max +	1.2DL+1.6LL	497.0	22.5	0.0	1.00	0.90	750.00
Controlling		1.2DL+1.6LL	497.0	22.5	0.0	1.00	0.90	750.00

REACTIONS (kips):

	Left	**Right**
DL reaction	14.31	14.31
Max +LL reaction	16.87	16.87
Max +total reaction (factored)	44.18	44.18

DEFLECTIONS:

Dead load (in)	at	22.50 ft =	-0.964	L/D =	560
Live load (in)	at	22.50 ft =	-1.136	L/D =	475
Net Total load (in)	at	22.50 ft =	-2.100	L/D =	257

03 30 Cast-In-Place Concrete

03 30 53 – Miscellaneous Cast-In-Place Concrete

03 30 53.40	Concrete In Place	Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	Equipment	Total	Total Incl O&P
1240	Maximum reinforcing	C-14A	13.77	14.524	C.Y.	695	555	55	1,305	1,700
1300	20" diameter, minimum reinforcing		41.04	4.873		265	187	18.35	470.35	605
1320	Average reinforcing		24.05	8.316		445	320	31.50	796.50	1,025
1340	Maximum reinforcing		17.01	11.758		695	450	44.50	1,189.50	1,525
1400	24" diameter, minimum reinforcing		51.85	3.857		251	148	14.55	413.55	525
1420	Average reinforcing		27.06	7.391		445	284	28	757	965
1440	Maximum reinforcing		18.29	10.935		685	420	41	1,146	1,450
1500	36" diameter, minimum reinforcing		75.04	2.665		254	102	10.05	366.05	450
1520	Average reinforcing		37.49	5.335		425	205	20	650	810
1540	Maximum reinforcing		22.84	8.757		665	335	33	1,033	1,300
1900	Elevated slabs, flat slab with drops, 125 psf Sup. Load, 20' span	C-14B	38.45	5.410		263	207	19.60	489.60	635
1950	→ 30' span		50.99	4.079		275	156	14.75	445.75	560
2100	Flat plate, 125 psf Sup. Load, 15' span		30.24	6.878		242	264	25	531	705
2150	25' span		49.60	4.194		249	161	15.20	425.20	540
2300	Waffle const., 30" domes, 125 psf Sup. Load, 20' span		37.07	5.611		375	215	20.50	610.50	770
2350	30' span		44.07	4.720		335	181	17.10	533.10	665
2500	One way joists, 30" pans, 125 psf Sup. Load, 15' span		27.38	7.597		450	291	27.50	768.50	980
2550	25' span		31.15	6.677		410	256	24	690	880
2700	One way beam & slab, 125 psf Sup. Load, 15' span		20.59	10.102		264	385	36.50	685.50	935
2750	→ 25' span		28.36	7.334		246	281	26.50	553.50	740
2900	Two way beam & slab, 125 psf Sup. Load, 15' span		24.04	8.652		253	330	31.50	614.50	835
2950	25' span		35.87	5.799		216	222	21	459	605
3100	Elevated slabs including finish, not									
3110	including forms or reinforcing									
3150	Regular concrete, 4" slab	C-8	2613	.021	S.F.	1.36	.73	.28	2.37	2.91
3200	6" slab		2585	.022		2.02	.73	.28	3.03	3.64
3250	2-1/2" thick floor fill		2685	.021		.67	.71	.27	1.65	2.33
3300	Lightweight, 110# per C.F., 2-1/2" thick floor fill		2585	.022		1.19	.73	.28	2.20	2.73
3400	Cellular concrete, 1-5/8" fill, under 5000 S.F.		2000	.028		.79	.95	.36	2.10	2.71
3450	Over 10,000 S.F.		2200	.025		:76	.86	.33	1.95	2.50
3500	Add per floor for 3 to 6 stories high		31800	.002			.06	.02	.08	.12
3520	For 7 to 20 stories high									

05 31 Steel Decking

05 31 13 – Steel Floor Decking

05 31 13.50 Floor Decking

0010	**FLOOR DECKING** R053100-10									
3200	Open decking, 3" deep, wide rib, 22 gauge, galvanized, under 50 squares	E-4	3600	.009	S.F.	2.21	.39	.04	2.64	3.18
3250	50-500 squares		3800	.008		1.77	.37	.03	2.17	2.65
3260	over 500 squares		4000	.008		1.59	.35	.03	1.97	2.42
3300	20 gauge, under 50 squares		3400	.009		2.58	.41	.04	3.03	3.61
3350	50-500 squares		3600	.009		2.06	.39	.04	2.49	3.01
3360	over 500 squares		3800	.008		1.85	.37	.03	2.25	2.74
3400	18 gauge, under 50 squares		3200	.010		3.32	.44	.04	3.80	4.48
3450	50-500 squares		3400	.009		2.66	.41	.04	3.11	3.70
3460	over 500 squares		3600	.009		2.39	.39	.04	2.82	3.37
3500	16 gauge, under 50 squares		3000	.011		4.39	.46	.04	4.89	5.70
3550	50-500 squares		3200	.010		3.51	.44	.04	3.99	4.69
3560	over 500 squares		3400	.009		3.16	.41	.04	3.61	4.26
3700	4-1/2" deep, long span roof, over 50 squares, 20 gauge		2700	.012		4.13	.52	.05	4.70	5.50
3800	18 gauge		2460	.013		5.30	.57	.05	5.92	6.95
3900	16 gauge		2350	.014		3.98	.59	.06	4.63	5.50
4100	6" deep, long span, 18 gauge		2000	.016		7.60	.70	.07	8.37	9.70
4200	16 gauge		1930	.017		5.70	.72	.07	6.49	7.65
4300	14 gauge		1860	.017		7.30	.75	.07	8.12	9.50
4500	7-1/2" deep, long span, 18 gauge		1690	.019		8.35	.82	.08	9.25	10.80
4600	16 gauge		1590	.020		6.25	.88	.08	7.21	8.50
4700	14 gauge		1490	.021		8.05	.93	.09	9.07	10.65
4800	For painted instead of galvanized, deduct					2%				
5000	For acoustical perforated, with fiberglass, add				S.F.	1.09			1.09	1.20
5200	Non-cellular composite deck, galv., 2" deep, 22 gauge	E-4	3860	.008		1.53	.36	.03	1.92	2.37
5300	20 gauge		3600	.009		1.69	.39	.04	2.12	2.60
5400	18 gauge		3380	.009		2.15	.41	.04	2.60	3.15
5500	16 gauge		3200	.010		2.69	.44	.04	3.17	3.79
5700	3" deep, galv., 22 gauge		3200	.010		1.67	.44	.04	2.15	2.66
5800	20 gauge		3000	.011		1.86	.46	.04	2.36	2.93
5900	18 gauge CN		2850	.011		2.29	.49	.05	2.83	3.45
6000	16 gauge		2700	.012		3.06	.52	.05	3.63	4.35

4740	x 93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4760	x 101	1000	.080	113	3.39	1.70	118.09	132
4780	x 122	1000	.080	122	3.39	1.70	127.09	142
4900	W 24 x 55	1000	.080	148	3.39	1.70	153.09	170
5100	x 62	1110	.072	66.50	3.06	1.53	71.09	80
5300	x 68	1110	.072	75	3.06	1.53	79.59	89.50
5500	x 76	1110	.072	82.50	3.06	1.53	87.09	97.50
5700	x 84	1110	.072	92	3.06	1.53	96.59	108
5720	x 94	1080	.074	102	3.14	1.57	106.71	119
5740	x 104	1080	.074	114	3.14	1.57	118.71	132
		1050	.076	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX B
SYSTEM 3

APPENDIX B

JOIST SPOT CHECK:

$w = 100 + 56 = 156(2) = 312$ lb/ft
$w_L = 200$ lb/ft

32LH06 : 371.4 > 312 OK
257.4 > 200

$\Delta_T = 1.818$
$\Delta_L = 1.166$

Total Depth = 32 + 6 1/4 = 38.25"

Weight: concrete = 47.9
slab = 2
joists = 7 ← 15 lb/ft (45)(14) = 9450 # / 30(45)
steel = 6.1 ← 35(45)(2) + 84(30)(2) / 30(45)
Total = 63 psf

Cost: Decking = 3186
concrete = 4090
joists = 17.10(45)(14) = 10773
beams = 47.80(2)(45) = 4302
Girders = 106.28(30)(2) = 6376.8
Total = 28727.8

unit = $21.28/S.F.

05 21 Steel Joist Framing

05 21 16 – Longspan Steel Joist Framing

05 21 16.50	Longspan Joists	Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	Equipment	Total	Total incl O&P
2040	Average	E-7	13	6.154	Ton	1,675	261	141	2,077	2,45
2080	Maximum		11	7.273		1,975	310	166	2,451	2,90
2200	18LH04, 12 Lb/LF		1400	.057	L.F.	10.05	2.42	1.31	13.78	
2220	18LH08, 19 Lb/LF		1400	.057		15.90	2.42	1.31	19.63	
2240	20LH04, 12 Lb/LF		1400	.057		10.05	2.42	1.31	13.78	
2260	20LH08, 19 Lb/LF		1400	.057		15.90	2.42	1.31	19.63	
2280	24LH05, 13 Lb/LF		1400	.057		10.85	2.42	1.31	14.58	
2300	24LH10, 23 Lb/LF		1400	.057		19.25	2.42	1.31	22.98	
2320	28LH06, 16 Lb/LF		1800	.044		13.40	1.88	1.02	16.30	
2340	28LH11, 25 Lb/LF		1800	.044		21	1.88	1.02	23.90	
2360	32LH08, 17 Lb/LF		1800	.044		14.20	1.88	1.02	17.10	
2380	32LH13, 30 Lb/LF		1800	.044		25	1.88	1.02	27.90	
2400	36LH09, 21 Lb/LF		1800	.044		17.55	1.88	1.02	20.45	
2420	36LH14, 36 Lb/LF		1800	.044		30	1.88	1.02	32.90	
2440	40LH10, 21 Lb/LF		2200	.036		17.55	1.54	.83	19.92	
2460	40LH15, 36 Lb/LF		2200	.036		30	1.54	.83	32.37	
2480	44LH11, 22 Lb/LF		2200	.036		18.40	1.54	.83	20.77	
2500	44LH16, 42 Lb/LF		2200	.036		35	1.54	.83	37.37	
2520	48LH11, 22 Lb/LF		2200	.036		18.40	1.54	.83	20.77	
2540	48LH16, 42 Lb/LF		2200	.036		35	1.54	.83	37.37	

05 12 Structural Steel Framing

05 12 23 – Structural Steel for Buildings

05 12 23.75 Structural Steel Members		Crew	Daily Output	Labor-Hours	Unit	2008 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
0720	x 26	E-2	600	.093	L.F.	31.50	3.91	2.61	38.02	44
0740	x 33		550	.102		40	4.26	2.85	47.11	54.50
0900	x 49		550	.102		59.50	4.26	2.85	66.61	75.50
1100	W 12 x 14		880	.064		16.95	2.66	1.78	21.39	25
1300	x 22		880	.064		26.50	2.66	1.78	30.94	36
1500	x 26		880	.064		31.50	2.66	1.78	35.94	41
1520	x 35		810	.069		42.50	2.89	1.93	47.32	53.50
1560	x 50		750	.075		60.50	3.13	2.09	65.72	74
1580	x 58		750	.075		70	3.13	2.09	75.22	84.50
1700	x 72		640	.088		87	3.66	2.45	93.11	105
1740	x 87		640	.088		105	3.66	2.45	111.11	125
1900	W 14 x 26		990	.057		31.50	2.37	1.58	35.45	40.50
2100	x 30		900	.062		36.50	2.60	1.74	40.84	46.50
2300	x 34		810	.069		41	2.89	1.93	45.82	52.50
2320	x 43		810	.069		52	2.89	1.93	56.82	64
2340	x 53		800	.070		64	2.93	1.96	68.89	77.50
2360	x 74		760	.074		89.50	3.08	2.06	94.64	106
2380	x 90		740	.076		109	3.17	2.12	114.29	128
2500	x 120		720	.078		145	3.26	2.18	150.44	168
2700	W 16 x 26		1000	.056		31.50	2.34	1.57	35.41	40.50
2900	x 31		900	.062		37.50	2.60	1.74	41.84	48
3100	x 40		800	.070		48.50	2.93	1.96	53.39	60
3120	x 50		800	.070		60.50	2.93	1.96	65.39	73.50
3140	x 67		760	.074		81	3.08	2.06	86.14	96.50
3300	W 18 x 35	E-5	960	.083		42.50	3.53	1.77	47.80	54.50
3500	x 40		960	.083		48.50	3.53	1.77	53.80	61
3520	x 46		960	.083		55.50	3.53	1.77	60.80	69
3700	x 50		912	.088		60.50	3.72	1.86	66.08	75
3900	x 55		912	.088		66.50	3.72	1.86	72.08	81.50
3920	x 65		900	.089		78.50	3.77	1.89	84.16	95
3940	x 76		900	.089		92	3.77	1.89	97.66	110
3960	x 86		900	.089		104	3.77	1.89	109.66	123
3980	x 106		900	.089		128	3.77	1.89	133.66	150
4100	W 21 x 44		1064	.075		53	3.19	1.60	57.79	66
4300	x 50		1064	.075		60.50	3.19	1.60	65.29	74
4500	x 62		1036	.077		75	3.27	1.64	79.91	90
4700	x 68		1036	.077		82.50	3.27	1.64	87.41	98
4720	x 83		1000	.080		100	3.39	1.70	105.09	118
4740	x 93		1000	.080		113	3.39	1.70	118.09	132
4760	x 101		1000	.080		122	3.39	1.70	127.09	142
4780	x 122		1000	.080		148	3.39	1.70	153.09	170
4900	W 24 x 55		1110	.072		66.50	3.06	1.53	71.09	80
5100	x 62		1110	.072		75	3.06	1.53	79.59	89.50
5300	x 68		1110	.072		82.50	3.06	1.53	87.09	97.50
5500	x 76		1110	.072		92	3.06	1.53	96.59	108
5700	x 84		1080	.074		102	3.14	1.57	106.71	119
5720	x 94		1080	.074		114	3.14	1.57	118.71	132
5740	x 104		1050	.076		126	3.23	1.62	130.85	145
5760	x 117		1050	.076		142	3.23	1.62	146.85	163
5780	x 146		1050	.076		177	3.23	1.62	181.85	201
5800	W 27 x 84		1190	.067		102	2.85	1.43	106.28	119
5900	x 94		1190	.067		114	2.85	1.43	118.28	132
5920	x 114		1150	.070		138	2.95	1.48	142.43	159

114

05 31 Steel Decking

05 31 13 – Steel Floor Decking

05 31 13.50 Floor Decking

		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**FLOOR DECKING** R053100-10									
3200	Open decking, 3" deep, wide rib, 22 gauge, galvanized, under 50 squares	E-4	3600	.009	S.F.	2.21	.39	.04	2.64	3.18
3250	50-500 squares		3800	.008		1.77	.37	.03	2.17	2.65
3260	over 500 squares		4000	.008		1.59	.35	.03	1.97	2.42
3300	20 gauge, under 50 squares		3400	.009		2.58	.41	.04	3.03	3.61
3350	50-500 squares		3600	.009		2.06	.39	.04	2.49	3.01
3360	over 500 squares		3800	.008		1.85	.37	.03	2.25	2.74
3400	18 gauge, under 50 squares		3200	.010		3.32	.44	.04	3.80	4.48
3450	50-500 squares		3400	.009		2.66	.41	.04	3.11	3.70
3460	over 500 squares		3600	.009		2.39	.39	.04	2.82	3.37
3500	16 gauge, under 50 squares		3000	.011		4.39	.46	.04	4.89	5.70
3550	50-500 squares		3200	.010		3.51	.44	.04	3.99	4.69
3560	over 500 squares		3400	.009		3.16	.41	.04	3.61	4.26
3700	4-1/2" deep, long span roof, over 50 squares, 20 gauge		2700	.012		4.13	.52	.05	4.70	5.50
3800	18 gauge		2460	.013		5.30	.57	.05	5.92	6.95
3900	16 gauge		2350	.014		3.98	.59	.06	4.63	5.50
4100	6" deep, long span, 18 gauge		2000	.016		7.60	.70	.07	8.37	9.70
4200	16 gauge		1930	.017		5.70	.72	.07	6.49	7.65
4300	14 gauge		1860	.017		7.30	.75	.07	8.12	9.50
4500	7-1/2" deep, long span, 18 gauge		1690	.019		8.35	.82	.08	9.25	10.80
4600	16 gauge		1590	.020		6.25	.88	.08	7.21	8.50
4700	14 gauge		1490	.021		8.05	.93	.09	9.07	10.65
4800	For painted instead of galvanized, deduct					2%				
5000	For acoustical perforated, with fiberglass, add				S.F.	1.09			1.09	1.20
5200	Non-cellular composite deck, galv., 2" deep, 22 gauge	E-4	3860	.008		1.53	.36	.03	1.92	2.37
5300	20 gauge		3600	.009		1.69	.39	.04	2.12	2.60
5400	18 gauge		3380	.009		2.15	.41	.04	2.60	3.15
5500	16 gauge		3200	.010		2.69	.44	.04	3.17	3.79
5700	3" deep, galv., 22 gauge		3200	.010		1.67	.44	.04	2.15	2.66
5800	20 gauge		3000	.011		1.86	.46	.04	2.36	2.93
5900	18 gauge CN		2850	.011		2.29	.49	.05	2.83	3.45

03 30 Cast-In-Place Concrete

03 30 53 – Miscellaneous Cast-In-Place Concrete

03 30 53.40 Concrete In Place		Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	Equipment	Total	Total Incl O&P
1240	Maximum reinforcing	C-14A	13.77	14.524	C.Y.	695	555	55	1,305	1,700
1300	20" diameter, minimum reinforcing		41.04	4.873		265	187	18.35	470.35	605
1320	Average reinforcing		24.05	8.316		445	320	31.50	796.50	1,025
1340	Maximum reinforcing		17.01	11.758		695	450	44.50	1,189.50	1,525
1400	24" diameter, minimum reinforcing		51.85	3.857		251	148	14.55	413.55	525
1420	Average reinforcing		27.06	7.391		445	284	28	757	965
1440	Maximum reinforcing		18.29	10.935		685	420	41	1,146	1,450
1500	36" diameter, minimum reinforcing		75.04	2.665		254	102	10.05	366.05	450
1520	Average reinforcing		37.49	5.335		425	205	20	650	810
1540	Maximum reinforcing		22.84	8.757		665	335	33	1,033	1,300
1900	Elevated slabs, flat slab with drops, 125 psf Sup. Load, 20' span	C-14B	38.45	5.410		263	207	19.60	489.60	635
1950	→ 30' span		50.99	4.079		275	156	14.75	445.75	560
2100	Flat plate, 125 psf Sup. Load, 15' span		30.24	6.878		242	264	25	531	705
2150	25' span		49.60	4.194		249	161	15.20	425.20	540
2300	Waffle const., 30" domes, 125 psf Sup. Load, 20' span		37.07	5.611		375	215	20.50	610.50	770
2350	30' span		44.07	4.720		335	181	17.10	533.10	665
2500	One way joists, 30" pans, 125 psf Sup. Load, 15' span		27.38	7.597		450	291	27.50	768.50	980
2550	25' span		31.15	6.677		410	256	24	690	880
2700	One way beam & slab, 125 psf Sup. Load, 15' span		20.59	10.102		264	385	36.50	685.50	935
2750	→ 25' span		28.36	7.334		246	281	26.50	553.50	740
2900	Two way beam & slab, 125 psf Sup. Load, 15' span		24.04	8.652		253	330	31.50	614.50	835
2950	25' span		35.87	5.799		216	222	21	459	605
3100	Elevated slabs including finish, not									
3110	including forms or reinforcing									
3150	Regular concrete, 4" slab	C-8	2613	.021	S.F.	1.36	.73	.28	2.37	2.91
3200	6" slab		2585	.022		2.02	.73	.28	3.03	3.64
3250	2-1/2" thick floor fill		[illegible]	[illegible]		[illegible]	[illegible]			

Standard Joist Selection

RAM Steel v11.0
floor system 1
DataBase: Floor System 3
Building Code: IBC

1

Floor Type: typical **Beam Number = 160**

SPAN INFORMATION (ft): I-End (105.00,45.00) J-End (105.00,90.00)

Joist Size (Optimum) = 32LH06
Total Beam Length (ft) = 45.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.112	0.200	0.0%	Red
	45.000	0.112	0.200		
2	0.000	0.000	0.000	---	NonR
	45.000	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 312.0

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	112.0	
Live:	200.0	257.4
Total:	312.0	371.4

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	79.0	22.5

REACTIONS (kips):

	Left	**Right**
DL reaction	2.52	2.52
Max +LL reaction	4.50	4.50
Max +total reaction	7.02	7.02

DEFLECTIONS:

Dead load (in)	=	0.653	L/D	=	827
Live load (in)	=	1.166	L/D	=	463
Total load (in)	=	1.818	L/D	=	297

Gravity Beam Design

RAM Steel v11.0
floor system 1
DataBase: Floor System 3
Building Code: IBC

10/24/07 20:30:
Steel Code: ASD 9th E

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

SPAN INFORMATION (ft): I-End (125.00,45.00) J-End (125.00,90.00)
Beam Size (Optimum) = W18X35 Fy = 50.0 ksi
Total Beam Length (ft) = 45.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.112	0.200	0.0%	Red
	45.000	0.112	0.200		
2	0.000	0.035	0.000	---	NonR
	45.000	0.035	0.000		

SHEAR: Max V (DL+LL) = 7.81 kips fv = 1.54 ksi Fv = 19.13 ksi

MOMENTS:

Span	Cond	Moment	@	Lb	Cb	Tension Flange		Compr Flange	
		kip-ft	ft	ft		fb	Fb	fb	Fb
Center	Max +	87.8	22.5	0.0	1.00	18.30	33.00	18.30	33.00
Controlling		87.8	22.5	0.0	1.00	18.30	33.00	---	---

REACTIONS (kips):

	Left	**Right**
DL reaction	3.31	3.31
Max +LL reaction	4.50	4.50
Max +total reaction	7.81	7.81

DEFLECTIONS:

Dead load (in)	at	22.50 ft	=	-0.917	L/D	=	589
Live load (in)	at	22.50 ft	=	-1.248	L/D	=	433
Net Total load (in)	at	22.50 ft	=	-2.165	L/D	=	249

Gravity Beam Design

RAM Steel v11.0
floor system 1
DataBase: Floor System 3
Building Code: IBC

10/24/07 20:30:5
Steel Code: ASD 9th E(

Floor Type: typical **Beam Number = 51**

SPAN INFORMATION (ft): I-End (65.00,45.00) J-End (95.00,45.00)
Beam Size (Optimum) = W27X84 Fy = 50.0 ksi
Total Beam Length (ft) = 30.00

POINT LOADS (kips):

Dist	DL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%
2.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
2.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
4.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
4.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
6.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
6.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
8.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
8.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
10.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
10.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
12.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
12.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
14.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
14.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
16.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
16.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
18.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
18.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
20.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
20.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
22.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
22.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
24.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
24.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
26.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
26.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow
28.000	2.52	4.50	42.6	0.00	0.00	0.0	0.00	Snow
28.000	1.76	3.15	42.6	0.00	0.00	0.0	0.00	Snow

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.084	0.000	---	NonR
	30.000	0.084	0.000		

SHEAR: Max V (DL+LL) = 62.00 kips fv = 5.30 ksi Fv = 19.44 ksi

MOMENTS:

Span	Cond	Moment	@	Lb	Cb	Tension Flange		Compr Flange	
		kip-ft	ft	ft		fb	Fb	fb	Fb
Center	Max +	495.3	15.0	2.0	1.00	27.91	33.00	27.91	33.00
Controlling		495.3	15.0	2.0	1.00	27.91	33.00	---	---

Gravity Beam Design

RAM Steel v11.0
floor system 1
DataBase: Floor System 3
Building Code: IBC

Page 2
10/24/07 20:30::
Steel Code: ASD 9th E

REACTIONS (kips):

	Left	Right
DL reaction	31.25	31.25
Max +LL reaction	30.74	30.74
Max +total reaction	62.00	62.00

DEFLECTIONS:

Dead load (in)	at	15.00 ft =	-0.489	L/D =	736
Live load (in)	at	15.00 ft =	-0.482	L/D =	746
Net Total load (in)	at	15.00 ft =	-0.972	L/D =	370

STANDARD LOAD TABLE/LONG SPAN STEEL JOISTS, LH-SERIES
Based on a Maximum Allowable Tensile Stress of 30 ksi

Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists only)	Depth in inches	SAFELOAD* in Lbs. Between		CLEAR SPAN IN FEET															
			28-32		33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24LH03	11	24	11500		342 235	339 226	336 218	323 204	307 188	293 175	279 162	267 152	255 141	244 132	234 124	224 116	215 109	207 102	199 96	191 90
24LH04	12	24	14100		419 288	398 265	379 246	360 227	343 210	327 195	312 182	298 169	285 158	273 148	262 138	251 130	241 122	231 114	222 107	214 101
24LH05	13	24	15100		449 308	446 297	440 285	419 264	399 244	380 226	363 210	347 196	331 182	317 171	304 160	291 150	280 141	269 132	258 124	248 117
24LH06	16	24	20300		604 411	579 382	555 356	530 331	504 306	480 284	457 263	437 245	417 228	399 211	381 197	364 184	348 172	334 161	320 152	307 142
24LH07	17	24	22300		665 452	638 421	613 393	588 367	565 343	541 320	516 297	491 276	468 257	446 239	426 223	407 208	389 195	373 182	357 171	343 161
24LH08	18	24	23800		707 480	677 447	649 416	622 388	597 362	572 338	545 314	520 292	497 272	475 254	455 238	435 222	417 208	400 196	384 184	369 173
24LH09	21	24	28000		832 562	808 530	785 501	764 460	731 424	696 393	663 363	632 337	602 313	574 292	548 272	524 254	501 238	480 223	460 209	441 196
24LH10	23	24	29600		882 596	856 559	832 528	809 500	788 474	768 439	737 406	702 378	668 351	637 326	608 304	582 285	556 266	533 249	511 234	490 220
24LH11	25	24	31200		927 624	900 588	875 555	851 525	829 498	807 472	787 449	768 418	734 388	701 361	671 337	642 315	616 294	590 276	567 259	544 243
			33-39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
28LH05	13	28	14000	14000	337 219	323 205	310 192	297 180	286 169	275 159	265 150	255 142	245 133	237 126	228 119	220 113	213 107	206 102	199 97	193 92
28LH06	16	28	18600	18600	448 289	429 270	412 253	395 238	379 223	364 209	350 197	337 186	324 175	313 166	301 156	291 148	281 140	271 133	262 126	253 120
28LH07	17	28	21000	21000	505 326	484 305	464 285	445 267	427 251	410 236	394 222	379 209	365 197	352 186	339 176	327 166	316 158	305 150	295 142	285 135
28LH08	18	28	22500	22500	540 348	517 325	496 305	475 285	456 268	438 252	420 236	403 222	387 209	371 196	357 185	344 175	331 165	319 156	308 148	297 140
28LH09	21	28	27700	27700	667 428	639 400	612 375	586 351	563 329	540 309	519 291	499 274	481 258	463 243	446 228	430 216	415 204	401 193	387 183	374 173
28LH10	23	28	30300	30300	729 466	704 439	679 414	651 388	625 364	600 342	576 322	554 303	533 285	513 269	495 255	477 241	460 228	444 215	429 204	415 193
28LH11	25	28	32500	32500	780 498	762 475	736 448	711 423	682 397	655 373	629 351	605 331	582 312	561 294	540 278	521 263	502 249	485 236	468 223	453 212
28LH12	27	28	35700	35700	857 545	837 520	818 496	800 476	782 454	766 435	737 408	709 383	682 361	656 340	632 321	609 303	587 285	566 270	546 256	527 243
28LH13	30	28	37200	37200	895 569	874 543	854 518	835 495	816 472	799 452	782 433	766 415	751 396	722 373	694 352	668 332	643 314	620 297	598 281	577 266
			38-46	47-48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
32LH06	14	32	16700	16700	338 211	326 199	315 189	304 179	294 169	284 161	275 153	266 145	257 138	249 131	242 125	234 119	227 114	220 108	214 104	208 99
32LH07	[illegible]	32	[illegible]	[illegible]	[illegible] 235	[illegible] 223	[illegible] 211	[illegible] 200	[illegible] 189	[illegible] 179	[illegible] 170	[illegible] 162	[illegible] 154	[illegible] 146	[illegible] 140	[illegible] 133	[illegible] 127	[illegible] 121	[illegible] 116	[illegible] 111
32LH08	17	32	20400	20400	411 255	397 242	383 229	369 216	357 205	345 194	333 184	322 175	312 167	302 159	293 151	284 144	275 137	267 131	259 125	252 120
32LH09	21	32	25600	25600	516 319	498 302	480 285	463 270	447 256	432 243	418 230	404 219	391 208	379 198	367 189	356 180	345 172	335 164	325 157	315 149
32LH10	21	32	28300	28300	571 352	550 332	531 315	512 297	495 282	478 267	462 254	445 240	430 228	416 217	402 206	389 196	376 186	364 178	353 169	342 162
32LH11	24	32	31000	31000	625 385	602 363	580 343	560 325	541 308	522 292	505 277	488 263	473 251	458 239	443 227	429 216	416 206	403 196	390 187	378 179
32LH12	27	32	36400	36400	734 450	712 428	688 406	664 384	641 364	619 345	598 327	578 311	559 295	541 281	524 267	508 255	492 243	477 232	463 221	449 211
32LH13	30	32	40600	40600	817 500	801 480	785 461	771 444	742 420	715 397	690 376	666 354	643 336	621 319	600 304	581 288	562 275	544 262	527 249	511 238
32LH14	33	32	41800	41800	843 515	826 495	810 476	795 458	780 440	766 417	738 395	713 374	688 355	665 337	643 321	622 304	602 290	583 276	564 264	547 251
32LH15	35	32	43200	43200	870 532	853 511	837 492	821 473	805 454	791 438	776 422	763 407	750 393	725 374	701 355	678 338	656 322	635 306	616 292	597 279
			42-46	47-56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
36LH07	16	36	16800	16800	292 177	283 168	274 160	266 153	258 146	251 140	244 134	237 128	230 122	224 117	218 112	212 107	207 103	201 99	196 95	191 91
36LH08	18	36	18500	18500	321 194	311 185	302 176	293 168	284 160	276 153	268 146	260 140	253 134	246 128	239 123	233 118	227 113	221 109	215 104	209 100
36LH09	21	36	23700	23700	411 247	398 235	386 224	374 214	363 204	352 195	342 186	333 179	323 171	314 163	306 157	297 150	289 144	282 138	275 133	267 127
36LH10	21	36	26100	26100	454 273	440 260	426 248	413 236	401 225	389 215	378 206	367 197	357 188	347 180	338 173	328 165	320 159	311 152	303 146	295 140
36LH11	23	36	28500	28500	495 297	480 283	465 269	451 257	438 246	425 234	412 224	401 214	389 205	378 196	368 188	358 180	348 173	339 166	330 159	322 153
36LH12	25	36	34100	34100	593 354	575 338	557 322	540 307	523 292	508 279	493 267	478 255	464 243	450 232	437 222	424 213	412 204	400 195	389 187	378 179
36LH13	30	36	40100	40100	697 415	675 395	654 376	634 359	615 342	596 327	579 312	562 298	546 285	531 273	516 262	502 251	488 240	475 231	463 222	451 213
36LH14	36	36	44200	44200	768 456	755 434	729 412	706 392	683 373	661 356	641 339	621 323	602 309	584 295	567 283	551 270	535 259	520 247	505 237	492 228
36LH15	36	36	46600	46600	809 480	795 464	781 448	769 434	744 413	721 394	698 375	677 358	656 342	637 327	618 312	600 299	583 286	567 274	551 263	536 252

STEEL JOIST INSTITUTE

53

APPENDIX C
SYSTEM 4

APPENDIX C

ONE WAY SLAB:

$f'_c = 4000$
$f_y = 60,000$

$w = 1.4(10) + 1.7(100) = 184$

· End span will control $182 > 163.4$

- select $h = 6''$ $\rho = 0.005$

· Interior Span $210 > 163.4$ OK

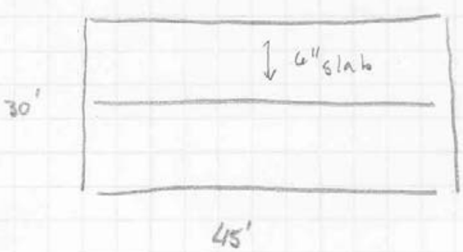
slabweight = 75psf

Serviceability Check:

1. deflection - $\frac{100}{182}\left(\frac{15(12)}{360}\right) = 0.274 < l/360 = 0.5''$

2. crack control - 3/4" cover assumed
max spacing is 12" OK

BEAMS



· Estimate beam size =
$30(18)\left(\frac{150}{144}\right)(1.4) = 787.5$ plf

Factored loads → $[10(1.4) + 1.7(100) + 4/12(150)(1.4)]\,15$
$+ 787.5$
$= 5083.5$ plf
$= 5.1$ klf

Choose 30x18 in
End span beam table

$\Delta_T = .139\left(\frac{5.1}{1.6}\right)(30)^4 = 1.82''$

GIRDER

· assume clear span = 30' for conservative

1. convert uniform loads − $5.08\left(\frac{45}{2} + \frac{31.5}{2}\right) = 194.31^K$

stem = $\left(\frac{18(30)}{144}\right)(150)(1.4) = 787.5$

· concentrated load factored moment $M = \frac{194.31(30)}{8}$

$M = 728.66^{'k}$

$w = \frac{11(728.66)}{30^2} = 8.9^{K/ft}$

· total factored uniform load (−M_u)
$= 8.9 + .79 = 9.696^{K/ft}$

· factored positive moment = $728.66 + \frac{.79(30)^2}{16} = 773.1$

· equivalent uniform load for (+M)
$\frac{16(787.5)}{30^2} + .79 = 14.79^{K/ft}$

2. choose design for beam from interior beam tables
⇒ 32 × 24 15.8 > 14.79
→ selfweight changed

· Estimate T_u w/ live load on one side only

$w = .170(45/2) = 3.825^{K/ft}$

$t_u = 1/11\,(3.825)(30)^2 = 312.95$

$Z_u = \frac{66}{1820}(312.95) = 10.32^{K/ft} < 15^{K/ft}$ OK

∴ closed stirrups & additional longitudinal bars for torsion are not needed

· Shear max $V = 194.31/2 + .79(15) = 76.62^K$

· equivalent w_u − $76.62/15 = 5.108 < 15.8$ OK
initial stirrup spacing

Weight:

concrete slab – $6/12\,(150)\,[(30)(45) - 3(45)(18/12)] = 86062.5^{lb}$

beams – $3(45)(18/12)(32/12)(150) = 81000$

girders – $2(30)(24/12)(32/12)(150) = 48000$

steel – $2299(2) + 3(2163) = 11087$

Total weight $= 226149.5^{lb}$, unit $= 167.5$ psf

Cost: one way beam & slab, span 25' : 553.50/cy

$CY = [1147.5 + 320 + 540]/3^3 = 74.4\ yd^3$

Total cost $\$41153.75$

Unit cost $= \$30.5$/sf.

SOLID ONE-WAY SLABS—END SPAN — $f'_c = 3{,}000$ psi — Grade 60 Bars — Top Steel for $-M_u$, $\rho \approx 0.0050$

Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Top Bars	#4	#4	#4	#4	#5	#5	#5	#5	#5	#6	#6	#6	#6
Spacing (in.)	12	12	11	9	12	11	10	10	9	12	11	10	10
Bottom Bars	#4	#4	#4	#4	#4	#5	#5	#5	#5	#5	#6	#6	#6
Spacing (in.)	12	11	10	8	8	12	11	11	10	9	12	11	11
Top Bars Free End	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4	#4
Spacing (in.)	12	12	12	12	12	12	12	12	12	12	12	12	12
T-S Bars	#3	#3	#3	#3	#4	#4	#4	#4	#4	#4	#4	#5	#5
Spacing (in.)	15	13	12	11	18	17	15	14	13	13	12	18	17
Areas of Steel (in.^{2}/ft) Top Interior	.200	.200	.218	.267	.310	.338	.372	.377	.413	.440	.480	.528	.528
Bottom	.200	.218	.240	.300	.300	.310	.338	.338	.372	.413	.440	.480	.480
Slab Wt. (psf)	50	56	63	69	75	81	88	94	100	106	113	119	125
CLEAR SPAN	**FACTORED USABLE SUPERIMPOSED LOAD (psf)**												
6′-0″	700	906											
6′-6″	586	761	967										
7′-0″	496	645	821										
7′-6″	423	552	704	988									
8′-0″	363	475	608	856	986								
8′-6″	314	412	528	747	861	976							
9′-0″	272	359	462	656	757	858							
9′-6″	237	314	405	579	669	759	916						
10′-0″	207	276	357	513	593	674	814	890					
10′-6″	158	191	248	364	481	591	722	790	957				
11′-0″	138	167	218	323	429	528	647	708	859	987			
11′-6″	120	146	192	287	383	473	582	636	774	890			
12′-0″	105	127	169	256	343	426	524	574	700	806	952		
12′-6″	91	111	149	228	308	383	473	518	634	731	865		
13′-0″	79	97	131	204	277	346	428	469	575	664	787	937	999
13′-6″	68	84	115	182	249	312	388	426	523	605	719	857	914
14′-0″	58	73	101	162	224	282	352	386	477	552	657	785	837
14′-6″	49	62	88	145	202	256	320	351	435	505	602	721	769
15′-0″	42	53	76	129	182	231	291	320	397	462	552	662	707
15′-6″		45	66	115	163	209	264	291	363	423	507	610	651
16′-0″			56	102	147	190	241	265	332	388	466	562	600
16′-6″			48	90	132	171	219	241	304	356	429	519	554
17′-0″			40	79	118	155	199	220	278	327	395	479	511
17′-6″				69	105	140	181	200	255	300	363	442	473
18′-0″				60	94	126	164	182	233	275	335	409	437
18′-6″				51	83	113	149	165	213	253	309	378	405
19′-0″				44	73	101	135	149	195	232	284	350	374
19′-6″					64	90	122	135	178	213	262	324	347
20′-0″					56	80	109	122	162	195	241	300	321

Note: See Fig. 7-1 for reinforcing bar details.

SOLID ONE-WAY SLABS—INTERIOR SPAN — Top Steel for $-M_u$

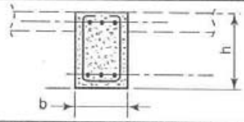
$f_c' = 3{,}000$ psi — Grade 60 Bars — $\rho \approx 0.0050$

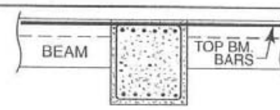
Thickness (in.)	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Top Bars	#4	#4	#4	#4	#5	#5	#5	#5	#5	#6	#6	#6	#6
Spacing (in.)	12	11	10	9	12	11	10	10	9	12	11	10	10
Bottom Bars	#3	#3	#3	#4	#4	#4	#4	#4	#4	#5	#5	#5	#5
Spacing (in.)	10	9	7	12	11	10	10	9	8	12	11	10	10
T-S Bars	#3	#3	#3	#3	#4	#4	#4	#4	#4	#4	#4	#5	#5
Spacing (in.)	15	13	12	11	18	17	15	14	13	13	12	18	17
Areas of Steel (in.^{2}/ft) Top Interior	.200	.218	.240	.267	.310	.338	.372	.372	.413	.440	.480	.528	.528
Bottom	.132	.147	.189	.200	.218	.240	.240	.267	.300	.310	.338	.372	.372
Slab Wt. (psf)	50	56	63	69	75	81	88	94	100	106	113	119	125
CLEAR SPAN	**FACTORED USABLE SUPERIMPOSED LOAD (psf)**												
6′-0″	703	923											
6′-6″	589	775											
7′-0″	498	657	907										
7′-6″	425	562	778	988									
8′-0″	365	485	673	856									
8′-6″	315	420	586	747	935								
9′-0″	273	367	513	656	822								
9′-6″	238	321	452	579	727	894	980						
10′-0″	208	282	399	513	646	795	872						
10′-6″	181	243	317	410	539	661	779	882					
11′-0″	159	214	281	365	482	592	699	792	964				
11′-6″	139	189	249	326	432	532	629	713	870	994			
12′-0″	122	167	222	291	388	479	568	644	787	901			
12′-6″	107	148	197	261	349	433	514	583	715	819	967		
13′-0″	94	131	176	234	315	392	465	529	650	746	882		
13′-6″	82	116	157	210	285	355	423	481	593	681	806	959	
14′-0″	71	102	139	188	257	322	384	438	541	623	739	880	939
14′-6″	61	90	124	169	233	293	350	400	495	570	678	809	863
15′-0″	53	79	110	151	210	266	319	365	453	523	623	745	795
15′-6″	45	69	97	136	190	242	291	333	416	480	573	688	733
16′-0″		60	86	121	172	220	265	305	381	442	528	635	678
16′-6″		51	76	108	156	200	242	279	350	406	487	587	627
17′-0″		44	66	96	140	182	221	255	322	374	450	543	580
17′-6″			57	86	127	165	201	233	296	345	416	503	538
18′-0″			49	76	114	150	184	213	272	318	384	467	499
18′-6″			42	66	102	136	167	195	250	293	355	433	463
19′-0″				58	91	123	152	178	230	270	329	402	429
19′-6″				50	81	111	138	162	211	249	304	373	399
20′-0″				43	72	100	125	147	194	229	281	346	370

Note: See Fig. 7-1 for reinforcing bar details.

$f'_c = 4{,}000$ psi
$f_y = 60{,}000$ psi

RECTANGULAR BEAMS, END SPANS





TOTAL CAPACITY $U = 1.4D + 1.7L$[8]

STEM h in.	STEM b in.	BARS[1] BOTTOM ℓ_n + 12 in.	BARS[1] BOTTOM 0.875 ℓ_n	Layers (2)	TOP	SPAN ℓ_n = 40 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 42 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 44 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 46 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	$+\phi M_n$ / $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\times 10^{-9}$ in.
		2#11		1	3#10	2.7	133M	14	-	839	2.4	133M	14	-	876	2.2	133M	14	-	912	2.0	133M	13	-	948	387	227
				1			245H	55	1.6	1289		254H	54	1.6	1140		274H	54	1.6	1203		354F	54	1.6	1346	467	
		2#14		1	3#11	3.5	153M	14	-	1123	3.2	153M	14	-	1172	2.9	163M	14	-	1227	2.7	163M	13	-	1276	540	203
				1			245H	55	1.6	1562		255H	54	1.6	1633		275H	54	1.6	1725		285H	54	1.6	1796	562	
	16	2#14	1#14	1	3#14	4.8	175M	14	-	1778	4.4	175M	14	-	1849	4.0*	184M	14	-	1830	3.7*	184M	13	-	1901	772	160
				1			345E	55	1.6	2242		365E	54	1.6	2356		385E	54	1.6	2470		405E	54	1.6	2584	772	
		2#14	2#14	2	4#14	5.7*	205HdK	14	-	2301	5.2*	195K	14	-	2378	4.7*	205K	13	-	2487	4.3*	215K	13	-	2596	911	152
				2			345E	54	1.6	2717		365E	54	1.6	2853		385E	54	1.6	2989		405E	54	1.6	3126	911	
		2#10	1#10	1	3#10	2.9	133M	17	-	911	2.7	133M	17	-	951	2.4	133M	16	-	990	2.2	133M	16	-	1030	471	202
				1			225I	67	1.8	1331		235I	66	1.8	1393		245I	66	1.8	1455		255I	66	1.8	1517	471	
		2#11	1#11	1	3#11	3.6	143M	17	-	1117	3.2	153M	17	-	1171	2.9	153M	16	-	1220	2.7	153M	16	-	1269	568	189
				1			225I	67	1.8	1532		235I	66	1.8	1603		245I	66	1.8	1674		255I	65	1.8	1746	568	
	18	2#14	1#14	1	4#14	5.4	175M	17	-	1987	4.9	175M	17	-	2067	4.5	185M	16	-	2163	4.1*	184M	16	-	2135	785	139
				1			305F	66	1.8	2380		325F	66	1.8	2504		335F	66	1.8	2606		355F	65	1.8	2730	1002	
		2#14	2#14	1	5#14	6.9*	195HgM	17	-	2495	6.2*	195IeM	17	-	2597	5.7*	205IdM	16	-	2715	5.2*	205IdM	16	-	2817	1002	125
32				2			405D	66	1.8	3078		425D	66	1.8	3224		445D	66	1.8	3371		405E	65	1.8	3384	1128	
		2#10	1#10	1	3#11	3.3	134M	20	-	1059	3.0	134M	20	-	1102	2.7	134M	20	-	1146	2.5	134M	19	-	1189	474	182
				1			225I	79	2.0	1428		235I	79	2.0	1495		245I	78	2.0	1561		255I	78	2.0	1627	573	
		2#11	1#11	1	3#14	3.9	144M	20	-	1381	3.6	154M	20	-	1448	3.3	154M	20	-	1506	3.0	154M	19	-	1563	573	161
				1			225I	79	2.0	1739		235I	79	2.0	1820		245I	78	2.0	1900		255I	78	2.0	1980	795	
	20	2#14	2#14	1	4#14	6.4	175IcM	20	-	2265	5.8	175M	20	-	2358	5.3*	185M	20	-	2468	4.8*	185M	19	-	2561	1019	123
				1			345E	79	2.0	2764		365E	78	2.0	2903		385E	78	2.0	3042		355F	78	1.9	3066	1019	
		3#14	2#14	1	5#14	7.7	215GiM	20	-	2848	6.9*	205HgM	20	-	2949	6.3*	205IfM	20	-	3066	5.8*	205IeM	19	-	3183	1224	106
				1			485C	79	2.0	3603		425D	78	2.0	3582		445D	78	2.0	3745		465D	78	1.9	3909	1224	
		2#11	1#11	1	4#10	3.9	133M	26	-	1209	3.6	133M	26	-	1260	3.2	133M	26	-	1310	3.0	133M	26	-	1361	580	156
				1			245H	106	2.3	2011		255H	105	2.3	2101		275H	104	2.3	2230		285H	104	2.3	2319	628	
		2#14	1#14	1	4#11	4.7	143M	26	-	1603	4.3	153M	26	-	1683	3.9	153M	26	-	1751	3.6	153M	26	-	1820	810	138
				1			275G	106	2.3	2512		215J	105	2.3	2346		225J	104	2.3	2454		235J	104	2.3	2562	758	
	24	2#14	2#14	1	5#14	7.2	174M	26	-	2531	6.5	174M	26	-	2633	5.9*	184M	26	-	2755	5.4*	184M	26	-	2857	1046	107
				1			305F	106	2.3	3361		285G	105	2.3	3385		305G	104	2.3	3565		315G	104	2.3	3706	1266	
		3#14	2#14	1	6#14	8.7	175M	26	-	3248	7.9*	185M	26	-	3407	7.2*	195M	26	-	3565	6.6*	194M	26	-	3467	1266	93
				1			345E	106	2.3	4034		365E	105	2.3	4239		335F	104	2.3	4248		355F	104	2.3	4452	1469	

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ 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, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

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

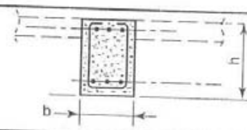
(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C × (w/1.6) × ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft.
"Average service load" is taken as w/1.6.

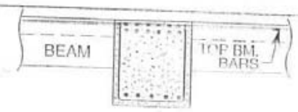
CONCRETE REINFORCING STEEL INSTITUTE

12-41

$f'_c = 4{,}000$ psi
$f_y = 60{,}000$ psi

RECTANGULAR BEAMS, INTERIOR SPANS





TOTAL CAPACITY $U = 1.4D + 1.7L$ (3)

STEM h in.	STEM b in.	BOTTOM ℓ_n + 12 in.	BOTTOM 0.875 ℓ_n	Lay-ers (2)	TOP	SPAN ℓ_n = 32 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 34 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 36 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	SPAN ℓ_n = 38 ft LOAD (4) k/ft	STIR. TIES (5)	ϕT_n ft-kips	$A\ell$ sq. in.	STEEL WGT lb.	$+\phi M_n$ / $-\phi M_n$ (6) ft-kip	DEFL (C) (7) $\div 10^9$ in.
32	16	2#10		1 1	3#10	5.0	113M 195H	14 58	- 1.7	617 969	4.4	113M 215H	14 57	- 1.7	651 1046	3.9	113M 225H	14 57	- 1.7	685 1102	3.5	123M 235H	14 56	- 1.7	725 1153	319 467	131
		2#11		1 1	3#11	6.0	114M 195H	14 58	- 1.7	800 1100	5.4	124M 215H	14 57	- 1.7	853 1186	4.8	124M 225H	14 57	- 1.7	895 1250	4.3	133M 235H	14 56	- 1.7	866 1311	387 562	130
		2#14		1 2	4#14	8.4	135M 285E	14 58	- 1.7	1363 1761	7.5	135M 295E	14 57	- 1.7	1435 1854	6.7	145M 315E	14 57	- 1.7	1522 1969	6.0	145M 335E	14 56	- 1.7	1593 2083	510 911	107
		2#14	1#14	1 2	4#14	9.8	145IeM 325D	14 58	- 1.7	1563 2031	8.7	145IdM 345D	14 57	- 1.7	1646 2157	7.7	155IdM 315E	14 57	- 1.7	1744 2175	6.9	155M 335E	14 56	- 1.7	1827 2301	772 911	95
	18	2#9	1#9	1 1	3#11	5.9	113M 245F	18 70	- 1.9	705 1180	5.2	113M 195I	17 69	- 1.9	745 1109	4.7	123M 205I	17 69	- 1.9	790 1171	4.2	123M 215I	17 68	- 1.9	830 1233	377 568	116
		2#10	1#10	1 1	3#14	7.4	125M 245F	18 70	- 1.9	1071 1411	6.5	124M 265F	17 69	- 1.9	1054 1510	5.8	134M 275F	17 69	- 1.9	1118 1586	5.2	134M 295F	17 68	- 1.8	1172 1685	471 785	106
		2#11	2#11	1 1	4#14	10.8	155HfM 325D	18 70	- 1.9	1501 1971	9.5	145IeM 345D	17 69	- 1.9	1563 2093	8.5	155IdM 365D	17 69	- 1.9	1657 2215	7.6	155IcM 335E	17 68	- 1.8	1735 2227	736 1002	87
		2#14	1#14	1 2	5#14	12.1	175FiM 385C	18 70	- 1.9	1779 2350	10.7	175GhM 415C	17 69	- 1.9	1872 2510	9.6	175GgM 435C	17 69	- 1.9	1965 2647	8.6	175HfM 385D	17 68	- 1.8	2059 2629	785 1128	84
	20	2#9	1#9	1 1	3#11	5.9	104M 185I	21 83	- 2.1	750 1059	5.3	114M 195I	21 82	- 2.1	801 1122	4.7	114M 205I	20 82	- 2.1	841 1185	4.2	114M 215I	20 81	- 2.0	881 1248	379 573	102
		2#11	1#11	1 1	3#14	8.5	125M 285E	21 83	- 2.1	1166 1610	7.6	125M 265F	21 82	- 2.1	1226 1624	6.7	134M 275F	20 82	- 2.0	1223 1707	6.1	134M 295F	20 81	- 2.0	1283 1813	573 795	98
		2#14	1#14	1 1	4#14	11.0	145HeM 325D	21 83	- 2.1	1572 2076	9.7	145IdM 345D	21 82	- 2.1	1655 2204	8.7	155IdM 365D	20 82	- 2.0	1755 2333	7.8	155IcM 335E	20 81	- 2.0	1838 2347	795 1019	82
		3#11	2#11	1 1	5#14	13.2	175FjM 385C	21 83	- 2.1	1878 2469	11.7	175FiM 415C	21 82	- 2.1	1977 2637	10.4	175GhM 435C	20 82	- 2.0	2075 2781	9.3	165HfM 465C	20 81	- 2.0	2158 2919	907 1221	72
	24	2#10	1#10	1 1	4#11	7.5	113M 225G	28 111	- 2.5	956 1701	6.6	113M 235G	28 110	- 2.4	1008 1792	5.9	113M 245G	27 109	- 2.4	1060 1883	5.3	123M 195J	27 108	- 2.4	1123 1710	479 758	85
		2#11	1#11	1 -1	4#14	9.1	124M 225G	28 111	- 2.5	1373 1991	8.0	123M 235G	28 110	- 2.4	1327 2101	7.2	123M 245G	27 109	- 2.4	1397 2210	6.4	133M 265G	27 108	- 2.4	1478 2358	680 1016	80
		2#14	1#14	1 1	5#14	12.7	135M 285E	28 111	- 2.5	1920 2600	11.2	135M 265F	28 110	- 2.4	2013 2614	10.0	144M 275F	27 109	- 2.4	1973 2747	9.0	144M 295F	27 108	- 2.4	2096 2918	810 1266	71
		2#14	2#14	1 1	6#14	15.8	145IcM 325D	28 111	- 2.5	2299 3103	14.0	145M 345D	28 110	- 2.4	2414 3296	12.5	145M 315E	27 109	- 2.4	2529 3293	11.2	155M 335E	27 108	- 2.4	2675 3486	1046 1469	61

(1) See "Recommended Bar Details", Fig. 12-1. For girders, use tabulated beam depth — 2 inches (b — 2").
(2) In "Layers" column, first line is number of layers for bottom bars, second line is for number of layers for top bars.
(3) For superimposed factored load capacity, deduct 1.4 x stem weight.
(4) Total capacities tabulated causing deflection in excess of $\ell_n/360$ 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, secondline is for closed ties. See Fig. 12-4. At free ends, use stirrups tabulated for "Interior Spans". For b > 24 in., provide 4 legs (two stirrups) of size and spacing tabulated. For stirrup nomenclature, see page 12-13.

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

(6) $+\phi M_n$ and $-\phi M_n$ are design moment strength capacities for rectangular section b × h.
(7) Midspan elastic deflection (in.) = C x (w/1.6) x ℓ_n^4, where w = tabulated load (k/ft.), ℓ_n in ft.
"Average service load" is taken as w/1.6.

CONCRETE REINFORCING STEEL INSTITUTE

*Assumed column is a minimum of 12" squ

03 30 Cast-In-Place Concrete

03 30 53 – Miscellaneous Cast-In-Place Concrete

03 30 53.40 Concrete In Place		Crew	Daily Output	Labor-Hours	Unit	2008 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
1240	Maximum reinforcing	C-14A	13.77	14.524	C.Y.	695	555	55	1,305	1,700
1300	20" diameter, minimum reinforcing		41.04	4.873		265	187	18.35	470.35	605
1320	Average reinforcing		24.05	8.316		445	320	31.50	796.50	1,025
1340	Maximum reinforcing		17.01	11.758		695	450	44.50	1,189.50	1,525
1400	24" diameter, minimum reinforcing		51.85	3.857		251	148	14.55	413.55	525
1420	Average reinforcing		27.06	7.391		445	284	28	757	965
1440	Maximum reinforcing		18.29	10.935		685	420	41	1,146	1,450
1500	36" diameter, minimum reinforcing		75.04	2.665		254	102	10.05	366.05	450
1520	Average reinforcing		37.49	5.335		425	205	20	650	810
1540	Maximum reinforcing		22.84	8.757		665	335	33	1,033	1,300
1900	Elevated slabs, flat slab with drops, 125 psf Sup. Load, 20' span	C-14B	38.45	5.410		263	207	19.60	489.60	635
1950	→ 30' span		50.99	4.079		275	156	14.75	445.75	560
2100	Flat plate, 125 psf Sup. Load, 15' span		30.24	6.878		242	264	25	531	705
2150	25' span		49.60	4.194		249	161	15.20	425.20	540
2300	Waffle const., 30" domes, 125 psf Sup. Load, 20' span		37.07	5.611		375	215	20.50	610.50	770
2350	30' span		44.07	4.720		335	181	17.10	533.10	665
2500	One way joists, 30" pans, 125 psf Sup. Load, 15' span		27.38	7.597		450	291	27.50	768.50	980
2550	25' span		31.15	6.677		410	256	24	690	880
2700	One way beam & slab, 125 psf Sup. Load, 15' span		20.59	10.102		264	385	36.50	685.50	935
2750	→ 25' span		28.36	7.334		246	281	26.50	553.50	740
2900	Two way beam & slab, 125 psf Sup. Load, 15' span		24.04	8.652		253	330	31.50	614.50	835
2950	25' span		35.87	5.799		216	222	21	459	605
3100	Elevated slabs including finish									

APPENDIX D
SYSTEM 5

APPENDIX D

·Limitations:

1 square column size
2 square panels
3. min 3 panels continuous
4. Equal spans
5. edge flush w/ alter face of column
small 1'8" cantilever to consider
6. Live load 50 ≤ 2(56)
7. slab f'c = 4000, normal weight
8. no edge beams
9. design for gravity load

superimposed dead

Factored Live loads = 1.4(10) + 1.7(100) = 184 psf

· adjust column grid to 30' x 30'
45' span is not feasible

Weight: concrete – (10/12)(150) = 125 psf = 112500 lb

drop panels – (10×10)/4 (4) (8.5/12)(150) = 10625 lb

reinforcement – (4.16 psf)(30)(30) = 3744 lb

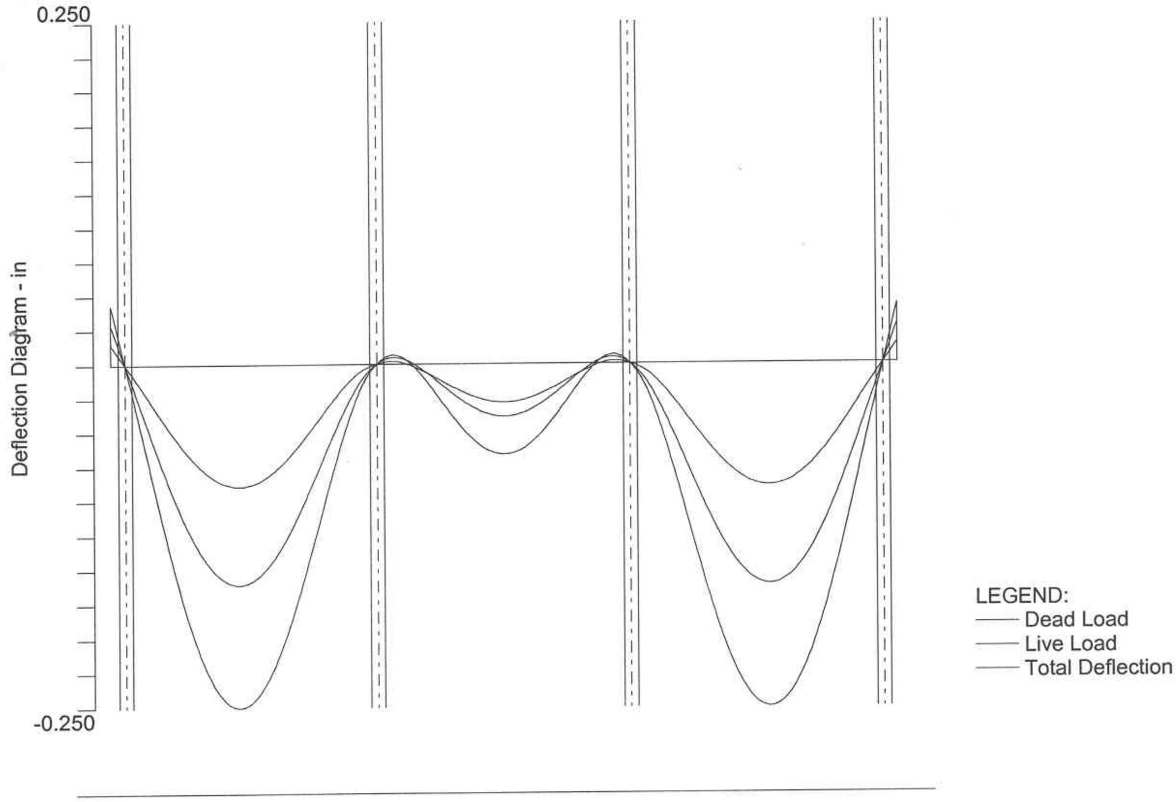
Total weight → 126869

Unit weight → 141 psf (45/30)

Cost: total system ~ elevated slab w/ drop panels 445.75/cy

((10/12)(30)(30) + (8.5/12)(10)(10)) / 3³ = 30.4 yd³ (45/30) = 45.6

Total cost = $ 13551.4 (45/30) =
Unit cost : $ 15.06 /ft²



PCA Slab deflection output

f'_c = 4,000 psi
Grade 60 Bars

FLAT SLAB SYSTEM
SQUARE EDGE PANEL With Drop Panels
No Beams

h = 10 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS

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)
25	100	5.50	8.33	12	0.776	12-#5 2	10-#6	14-#5	9-#5	9-#5	2.39	130.1	260.2	350.3
25	200	5.50	8.33	15	0.809	12-#5 4	13-#6	13-#6	12-#5	10-#5	2.95	171.3	342.6	461.2
25	300	7.00	8.33	18	0.664	12-#5 1	17-#6	15-#6	15-#5	9-#6	3.59	212.4	424.7	571.8
25	400	8.50	8.33	19	0.632	12-#5 1	15-#7	12-#7	10-#7	15-#5	4.25	254.3	508.6	684.6
25	500	8.50	10.00	21	0.744	13-#5 3	11-#9	26-#5	15-#6	10-#7	4.97	295.4	590.8	795.3
26	100	5.50	8.67	12	0.810	12-#5 3	11-#6	16-#5	11-#5	10-#5	2.60	146.8	293.7	395.3
26	200	7.00	8.67	15	0.704	12-#5 1	11-#7	14-#6	10-#6	12-#5	3.17	194.0	388.0	522.3
26	300	8.50	8.67	18	0.633	12-#5 1	11-#8	15-#6	9-#7	15-#5	3.88	240.6	481.1	647.6
26	400	8.50	8.67	19	0.745	13-#5 3	13-#8	18-#6	11-#7	9-#7	4.73	287.7	575.5	774.7
26	500	8.50	10.40	24	0.745	15-#5 4	13-#9	12-#8	10-#8	14-#6	5.49	330.9	661.8	890.9
27	100	7.00	9.00	12	0.746	12-#5 2	18-#5	16-#5	12-#5	10-#5	2.63	165.4	330.8	445.4
27	200	7.00	9.00	15	0.804	12-#5 5	17-#6	15-#6	11-#6	13-#5	3.37	218.2	436.3	587.4
27	300	8.50	9.00	18	0.674	12-#5 2	16-#7	13-#7	19-#5	16-#5	4.12	270.7	541.5	728.9
27	400	8.50	10.80	22	0.756	14-#5 5	12-#9	12-#8	10-#8	19-#5	5.09	321.6	643.2	865.8
27	500	8.50	10.80	27	0.682	16-#5 3	17-#8	13-#8	9-#9	9-#8	5.78	366.6	733.3	987.1
28	100	7.00	9.33	12	0.784	13-#5 2	14-#6	18-#5	13-#5	11-#5	2.76	185.0	370.0	498.1
28	200	8.50	9.33	16	0.714	13-#5 3	11-#8	15-#6	17-#5	15-#5	3.56	243.2	486.4	654.8
28	300	8.50	9.33	19	0.757	13-#5 5	11-#9	14-#7	12-#7	10-#7	4.56	302.4	604.8	814.1
28	400	8.50	11.20	25	0.692	16-#5 3	17-#8	13-#8	11-#8	12-#7	5.47	357.1	714.3	961.5
29	100	8.50	9.67	12	0.737	13-#5 2	22-#5	18-#5	15-#5	12-#5	2.91	206.7	413.4	556.5
29	200	8.50	9.67	16	0.758	13-#5 4	12-#8	13-#7	19-#5	16-#5	3.81	271.2	542.5	730.3
29	300	8.50	9.67	22	0.718	15-#5 4	20-#7	16-#7	10-#8	20-#5	4.92	334.3	668.6	900.1
29	400	8.50	11.60	28	0.639	17-#5 2	15-#9	14-#8	12-#8	10-#8	5.83	392.7	785.4	1057.3
30	100	8.50	10.00	12	0.774	14-#5 2	10-#8	20-#5	16-#5	10-#6	3.16	229.4	458.8	617.6
30	200	8.50	10.00	18	0.744	14-#5 4	11-#9	14-#7	21-#5	10-#7	4.16	299.6	599.1	806.5
30	300	8.50	10.00	24	0.675	16-#5 3	17-#8	14-#8	11-#8	12-#7	5.24	369.5	739.1	994.9

SQUARE INTERIOR PANEL
With Drop Panels(2)
No Beams

h = 10 in. = TOTAL SLAB DEPTH BETWEEN DROP PANELS

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)
100	12	13-#5	9-#5	9-#5	9-#5	2.19	0.884
200	18	12-#6	12-#5	10-#5	9-#5	2.63	0.884
300	21	14-#6	15-#5	12-#5	10-#5	3.10	0.898
400	23	15-#6	18-#5	10-#6	12-#5	3.63	0.912
500	25	13-#7	15-#6	16-#5	10-#6	4.26	0.947
100	12	15-#5	11-#5	10-#5	10-#5	2.40	0.884
200	18	17-#5	14-#5	11-#5	10-#5	2.73	0.898
300	21	14-#6	9-#7	13-#5	11-#5	3.31	0.912
400	23	13-#7	11-#7	16-#5	10-#6	4.17	0.912
500	25	27-#5	10-#8	10-#7	16-#5	4.65	0.947
100	12	15-#5	12-#5	10-#5	10-#5	2.37	0.898
200	18	14-#6	11-#6	12-#5	10-#5	2.92	0.898
300	21	12-#7	19-#5	15-#5	9-#6	3.56	0.912
400	24	26-#5	10-#8	10-#7	15-#5	4.35	0.947
500	27	16-#7	11-#8	11-#7	18-#5	5.02	0.947
100	12	17-#5	13-#5	10-#5	10-#5	2.42	0.898
200	19	14-#6	17-#5	13-#5	12-#5	3.02	0.912
300	21	13-#7	22-#5	12-#6	10-#6	3.85	0.912
400	24	16-#7	11-#8	20-#5	12-#6	4.71	0.947
100	12	17-#5	15-#5	12-#5	11-#5	2.58	0.912
200	19	16-#6	19-#5	15-#5	13-#5	3.27	0.912
300	21	15-#7	10-#8	10-#7	16-#5	4.34	0.912
400	26	13-#8	12-#8	12-#7	10-#7	5.06	0.947
100	12	14-#6	12-#6	13-#5	11-#5	2.77	0.912
200	19	18-#6	22-#5	12-#6	10-#6	3.57	0.912
300	21	16-#7	11-#8	11-#7	18-#5	4.56	0.912

CONCRETE REINFORCING STEEL INSTITUTE

03 30 Cast-In-Place Concrete
03 30 53 – Miscellaneous Cast-In-Place Concrete

03 30 53.40 Concrete In Place	Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	Equipment	Total	Total Incl
1240 Maximum reinforcing	C-14A	13.77	14.524	C.Y.	695	555	55	1,305	
1300 20" diameter, minimum reinforcing		41.04	4.873		265	187	18.35	470.35	
1320 Average reinforcing		24.05	8.316		445	320	31.50	796.50	
1340 Maximum reinforcing		17.01	11.758		695	450	44.50	1,189.50	
1400 24" diameter, minimum reinforcing		51.85	3.857		251	148	14.55	413.55	
1420 Average reinforcing		27.06	7.391		445	284	28	757	
1440 Maximum reinforcing		18.29	10.935		685	420	41	1,146	
1500 36" diameter, minimum reinforcing		75.04	2.665		254	102	10.05	366.05	
1520 Average reinforcing		37.49	5.335		425	205	20	650	
1540 Maximum reinforcing		22.84	8.757		665	335	33	1,033	
1900 Elevated slabs, flat slab with drops, 125 psf Sup. Load, 20' span	C-14B	38.45	5.410		263	207	19.60	489.60	
1950 30' span		50.99	4.079		275	156	14.75	445.75	
2100 Flat plate, 125 psf Sup. Load, 15' span		30.24	6.878		242	264	25	531	
2150 25' span		49.60	4.194		249	161	15.20	425.20	
2300 Waffle const., 30" domes, 125 psf Sup. Load, 20' span									