Upper Campus Housing Project
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Structural
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Executive Summary

The following report is an examination into the design and analysis of an alternate structural system for the Upper Campus Housing Project. This building is a ten-story dormitory located on the campus of the University of Pittsburgh. The existing system is a one-way hollow-core concrete plank system with concrete masonry bearing and shear walls. The alternate design is a two-way flat plate system.

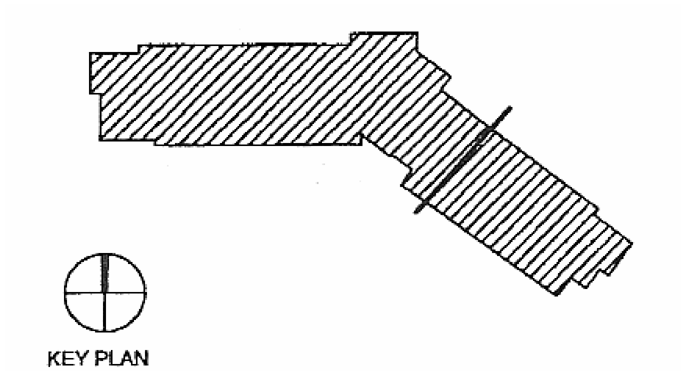
The two-way system design for the Upper Campus Housing Project will affect other buildings systems. The columns for this system were placed in areas to be used for HVAC. Therefore, the HVAC equipment will need to be placed in another location. The lateral system for this building is also greatly affected. The existing structure has reinforced concrete masonry bearing and shear walls, which are placed as all exterior walls and in the center of the structure. The alternate lateral system will be reinforced concrete shear walls placed only at various places along the exterior of the building.

Another system that will be affected by the alternate design is the exterior envelope. The shear walls for the original system make up the exterior for the building. In the alternate system, a light gauge metal stud curtain wall with a brick façade will be used.

The two-way design will allow for this building to be developed into another type of structure in the future if needed because of the flexibility of the floor plan and the ability to carry higher live loads. However, the schedule and the cost of the two-way system are higher than that of the one-way system. Therefore, the original system is a better design for this structure.

Project Background

The University of Pittsburgh is currently constructing a dormitory facility on its upper campus. This building is approximately 161,600sf and 9 stories above grade plus one ground level. The Upper Campus Housing Project will house approximately 512 students. It is located on Stadium Drive, not far from The Peterson Events Center. The main entrance to the building is on the South side. Here, a large staircase leads into the Lobby/Café area. The building façade consists of brick wall containing windows of tempered insulated spandrel and vision glass. The brick façade consists of different shades of light brown, complimenting the surrounding structures.



Construction on the Upper Campus Housing Project began in May of 2005 and is expected to end in July of 2006. The overall cost of the dormitory building is approximately 33 million dollars.

Project Team

Owner: The University of Pittsburgh

Construction Manager: P.J. Dick Incorporated

Architect: Perkins Eastman Architects PC

Civil/Site/Landscape Engineers: The Gateway Engineers, Inc.

Structural Engineer: Atlantic Engineering Services

MEP Engineer: Elwood S. Tower Corporation

Building Codes

International Building Code

ASTM

ACI 318 (Requirements for Structural Concrete)

ACI 530 (Requirements for Masonry Structures)

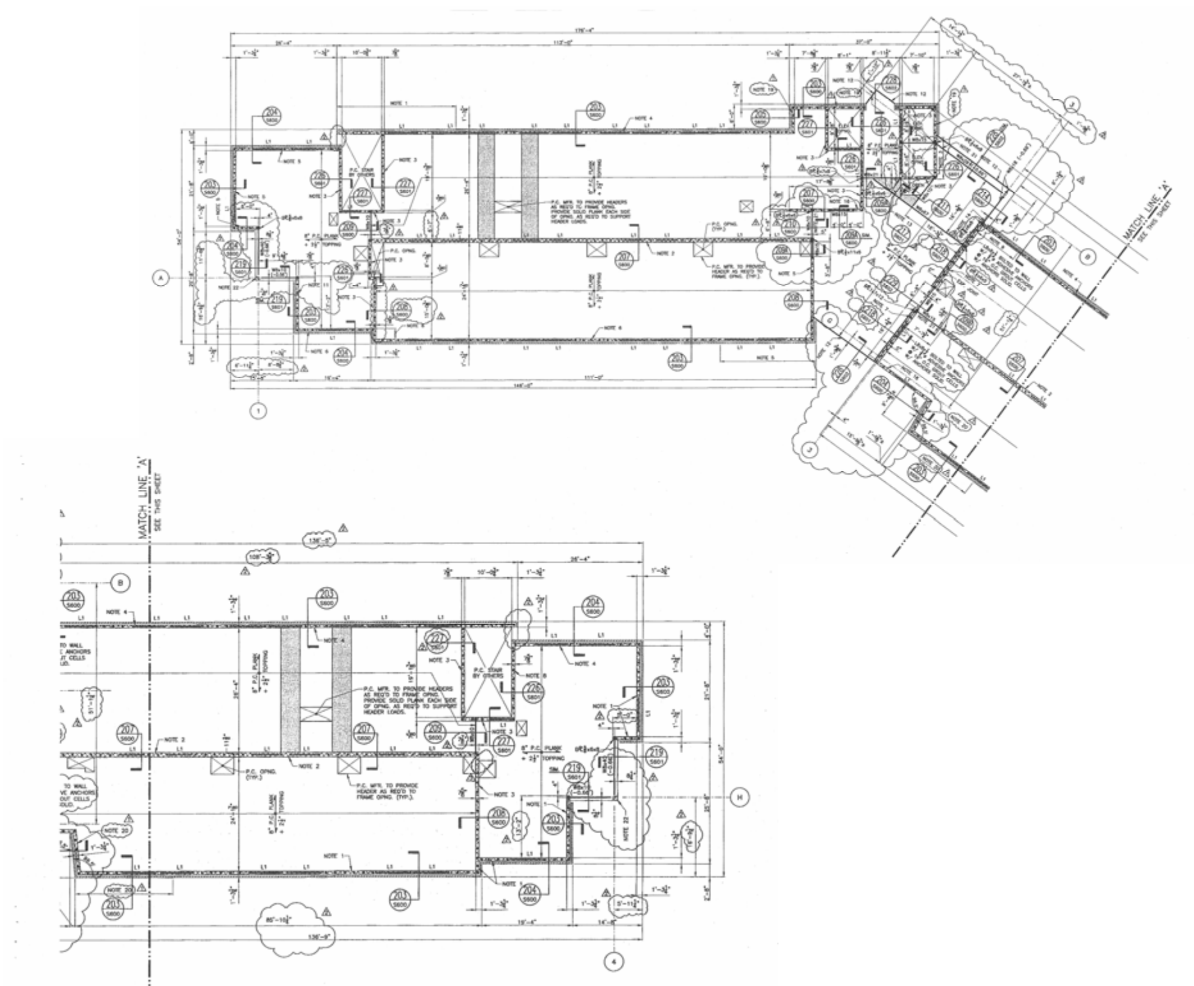
AISC (Specifications for Structural Steel Buildings)

ASCE7-02 (Lateral and Loading Code)

Existing Conditions

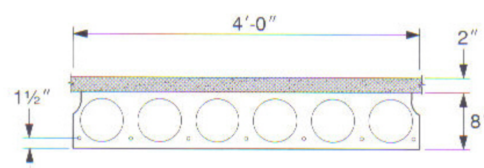
Structural

The existing structural system for the Upper Campus Housing Project is one-way 8" hollow-core concrete plank plus a 2 ½" topping with reinforced masonry bearing walls. The plank will be filled in solid where needed. Shown below is a typical framing layout for the existing system.



Framing Information		
Floor	**Typical Framing**	**Typical Span**
First	8" PC Plank + 2 1/2" Topping	24'-1 7/8" to 29'-4"
Second-Eight	8" PC Plank + 2 1/2" Topping	24'-1 7/8" to 29'-4"
Ninth	8" PC Plank + 2 1/2" Topping	24'-1 7/8" to 29'-4"
Roof	8" PC Plank w/o Topping	24'-1 7/8" to 29'-4"
	HSS6x6x3/8 Galv. Vert. Tube	Roof Column
	HSS6x6x1/4	10'
	Galv. 3 1/2" Dia. Std. Pipe	Roof Column
	Galv. W10x22	5' to 8'-7"

The hollow-core plank for this building is designed with a 15psf load added for topped members, a 25psf superimposed dead load, and the required live load.



There are also five steel columns in this building (1A, 2F, 2J, 3B, 4H). They are all HSS6.625x0.500. Two of these columns (2F and 2J) only span from the ground floor to the first floor (L=12'-6"). Two other columns (1A and 4H) span all the way to the ninth floor. Also, the last of the five columns (3B) spans the entire height of the building. Column 1A sits on a W8x31 transfer girder, which transfers the load from the column into the foundation. Columns 3B and 4H sit on concrete piers at the second floor level.

Also in this building there are four 20" dia. concrete piers located at column lines 3C, 3D, 3E, 3G. Each of these concrete piers span from SOG to the second floor level.

Minimum Design Compression Strength (f'c) at 28 days for Reinforced Concrete:

Foundations 3000psi

Walls 5000psi

Slab on Grade 4000psi

Interior Slabs 4000psi

Exterior Slabs 4000psi

Structural Slab and Elevated Slab (Ext.) 5000psi

Structural Slab and Elevated Slab (Int.) 4000psi

Foundation System

The foundation system of this building begins with 71-drilled concrete caissons. As stated above, each concrete caisson has a concrete strength (f'c) = 3000psi. The diameters of these caissons range from 36"-66". All caissons are designed to bear on either limestone/sandstone bedrock or shale/sandstone bedrock per geotechnical report dated December of 2004.

The foundation system also includes 78 concrete grade beams, which sit on the concrete caissons. The concrete strength of this concrete is also specified at 3000psi. All grade beams have a width = 24", except for GB 67 which has a width = 30". The depths of the grade beams range from 36"-60". The concrete masonry walls then sit directly on the grade beams. At each connection between a concrete masonry wall and a grade beam there is a key and waterstop. The key is provided to prevent sliding between members. Existing foundation details are located in the Appendix of this report on page 35.

Mechanical

Pitt Dormitory building is supplied by a CAV system. This system includes three types of units. The first unit (AHU-1) is a 5400cfm unit. This building also has rooftop units (RTU-1). These rooftop units are rated at 24,250cfm. In this building each resident director is supplied with his or her own electric furnace. Each of these furnaces (AHU-2) is 755cfm. AHU-2's have DX cooling and an electric heating coil.

Lighting/Electrical

There are many different types of lighting used in this building. The first floor lobby has indirect/direct, 120V, 160W pendant mounted lights. In other lounge and lobby areas of the building there are fluorescent downlights. In the dorm rooms there are ceiling mounted polycarbonate bowl fixtures. Other important areas to look at are the corridors. In the corridors there are recessed static fluorescent troffers with prismatic lenses.

This building's electrical system is supplied by 57 208Y/120V, 3PH, 4W panelboards. These panelboards are located on floors ground-ninth. There are also 2 480Y/277V, 3PH, 4W panelboards (1 for the roof and 1 for the penthouse).

Plumbing

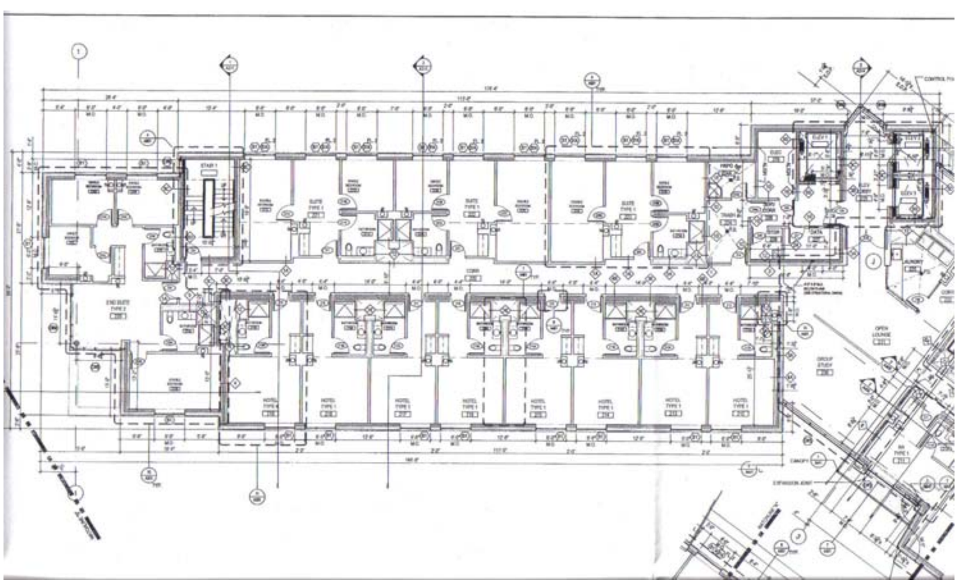
The Upper Campus Housing Project's domestic water supply is maintained by a domestic water booster system. 752gal domestic hot water tanks power this system. Located in the mechanical room is a 2" Diaphragm Compression Tank with a capacity of 211gal. There are also 2 140-degree water heaters located there. Each resident director room is supplied with a ¾" Diaphragm Compression Tank with a capacity of 2gal.

Fire Protection

This building is protected by a number of different sprinkler types. The hallways and common areas make use of the concealed pendent sprinklers. The corridor outside of the service areas has semi-recessed pendent sprinklers. Service areas are equipped with upright sprinklers. Dorm rooms have both concealed sidewall sprinklers and concealed pendent sprinklers. A 6" combined standpipe/sprinkler riser is located in the stairwells. The fire department connection and check valve with ball drip are located on the southeast side of the building (outside of the tenant locker room).

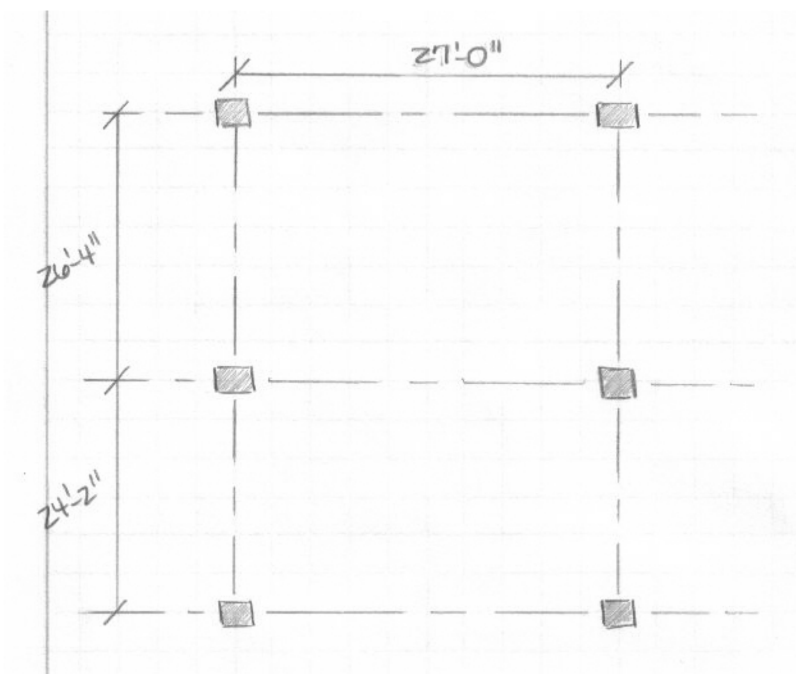
Problem Statement

Due to the nature of a one-way plank and bearing wall system, there is no flexibility to the architectural floor plan. For example, a hallway exists to one side of the center masonry wall running along approximately the centerline of the structure. This hallway must be designed at 100psf. The spaces to either side of this hallway are dorm rooms, which are designed to withstand only 40psf. Because of the nature of the plank, the main wall could not be moved if this building is ever converted for another use. The most common conversion that would be needed is office space. With office space loading equaling a minimum of 50psf, this would not be a possibility. On an ever-changing college campus, it is impossible to tell the university's needs for the structure down the road. Below is a typical architectural layout for the Upper Campus Housing Project.



Proposed Solution

The proposed solution to the above-mentioned design setback is a two-way system. A two-way flat-plate system was designed for the Upper Campus Housing Project to allow for higher floor loads. The use of this system will also allow for less shear walls, none of which will be located in the interior bays of the structure. Because the center shear wall can be removed, a more flexible floor plan will be possible for the future development of the structure. Shown to the right is a typical bay in the North/South direction of the building.



Designing the Upper Campus Housing Project as a two-way system will not only affect the structural system, but will also affect the lateral system and the exterior envelope. As mentioned above the lateral system will be 10" concrete shear walls placed only at the exterior and in the elevator shafts and stairs of the building. The exterior building envelope will become a light gauge metal stud curtain wall.

Depth Study

The two-way flat-plate system for the Upper Campus Housing Project was designed using ADOSS. The flat-plate system will be 10" with no drop panels of normal weight concrete with strength of 4000psi and a steel strength of 60,000psi. The original depth for the system was determined using ACI 318 Table 9.5(c) an exterior panel without edge beams or drop panels, $t_{min} = \ell n/30 = (27ft - 2ft)(12in/ft)/30 = 10"$. ACI 318 also specifies the minimum reinforcement in the slab as 0.0018Ag. Therefore, $As_{min} = 0.0018(10")(12") = 0.216\ in^2/ft$ (#5 at 12"). The columns for this system were designed by using interaction diagrams with a given moment and axial force. A starting size for the columns came from CRSI Handbook for shear requirements. This size is 26" x 26". The minimum reinforcement from ACI 10.16.8.6 for the columns is equal to 0.01Ag. Therefore, $Asmin = 0.01(26")(26") = 6.76in^2$ which is 12-#7. There is also a maximum reinforcement ratio for columns of 0.08Ag.

Loading

The gravity loads that were used to design the two-way flat-plate system were: dead, live, snow and roof live. For simplification of the design, the lateral loads were assumed to be taken by the shear walls.

Gravity Loads	
Dead	*Computed by ADOSS
Superimposed Dead	25psf
Live	80psf
Roof/Snow	30psf

Two-Way Slab Design

The following is part of the ADOSS output for a typical bay in the North/South direction. The program will design the reinforcement, but for the purpose of this design the following information was used to make a more consistent design based on 12" segments of slab.

NEGATIVE REINFORCEMENT

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1	4	|| R	229.4	6.15	13.5	2.92	13.5
2	4	L ||	-485.8	10.22	13.0	3.24	14.0
3	4	L ||	-197.2	5.26	13.0	3.02	14.0

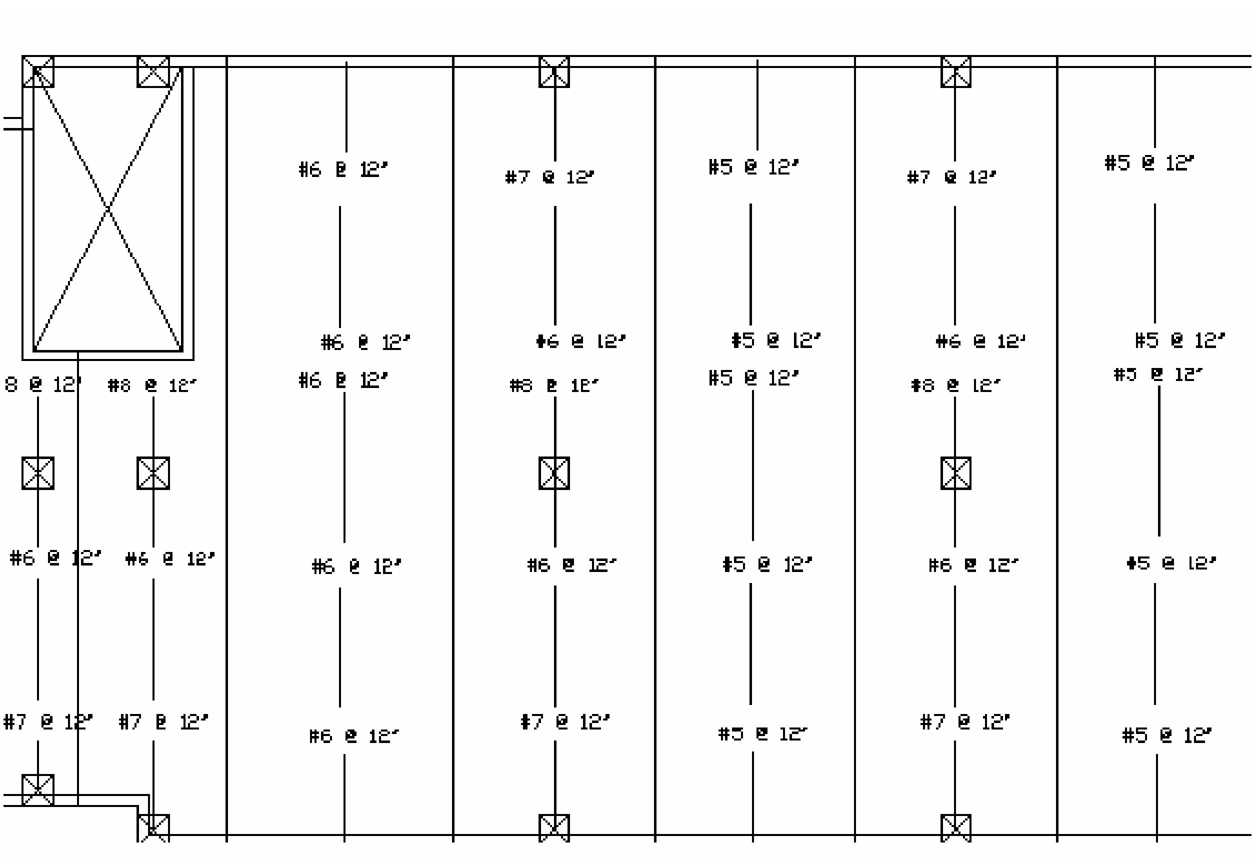
POSITIVE REINFORCEMENT

SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	4	12.8	333.4	5.42	13.5	3.57	13.5
3	4	14.9	304.4	4.94	13.0	3.25	14.0

An example calculation for the reinforcement is as follows for the column strip negative reinforcement at column #1:

As = 6.15in^2/13.5ft = 0.456 in2/ft (#7 at 12")

This calculation was done for each column strip and middle strip. The reinforcement was then distributed evenly throughout each strip. Below is an example of the floor reinforcement layout. All floors and directions are located in the Appendix page 75.


#6 @ 12"
#7 @ 12"
#5 @ 12"
#7 @ 12"
#5 @ 12"
#6 @ 12"
#6 @ 12"
#5 @ 12"
#6 @ 12"
#5 @ 12"
8 @ 12"
#8 @ 12"
#6 @ 12"
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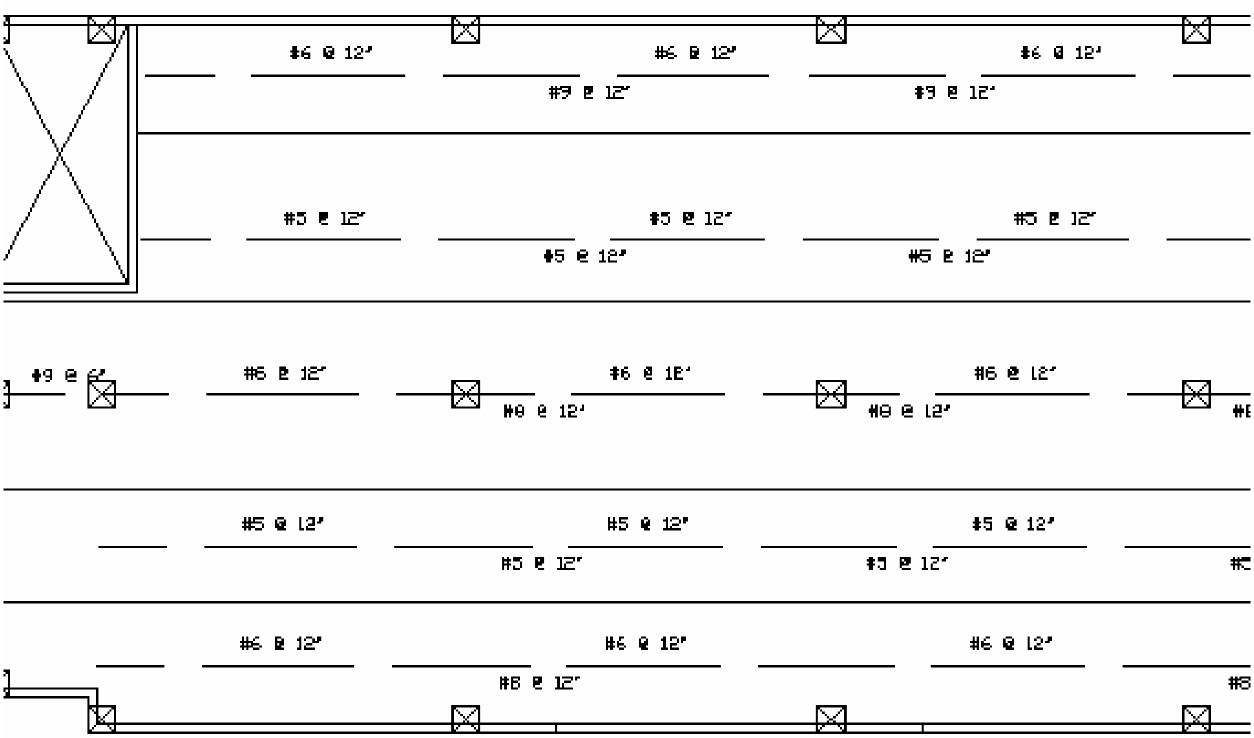


Long and short bar extensions were completed by ADOSS which complies with ACI Figure 13.3.8.

The following design criterion was used in ADOSS to complete the design of the slabs:

Distance from reinforcement to tension face = 1.5"

Minimum Bar Size = #4

Minimum Clear Bar Spacing = 6"

100% Column Fixity

Column Design

The columns for the Upper Campus Housing Project were designed using interaction diagrams from the Design of Concrete Structures textbook. Using an excel spreadsheet an axial force and moment on each column was determined. Interaction diagrams were then used to find a reinforcement ratio. Each axial force was computed using the tributary area of the column and floor gravity loads. The axial force and the moment were then put into the following equations to get a reinforcement ratio needed for each column.

$$K_n = \frac{P_u}{\phi f'_c(A_g)} \qquad R_n = \frac{M_u}{\phi f'_c(A_g)h}$$

The interaction diagram used for this design is located in the Appendix on page 90. The lateral ties for each column were designed based on the following spacing requirements: 16 x diameter of the longitudinal bars (14"), 48 x diameter of the tie (48.375"), and the least dimension of the column (26"). Therefore, the lateral ties will be spaced at 14".

The following are design criteria for the design of the concrete columns for a two-way flat-plate system:

Minimum Concrete Cover = 1.5"

Strength Reduction Factor = 0.65

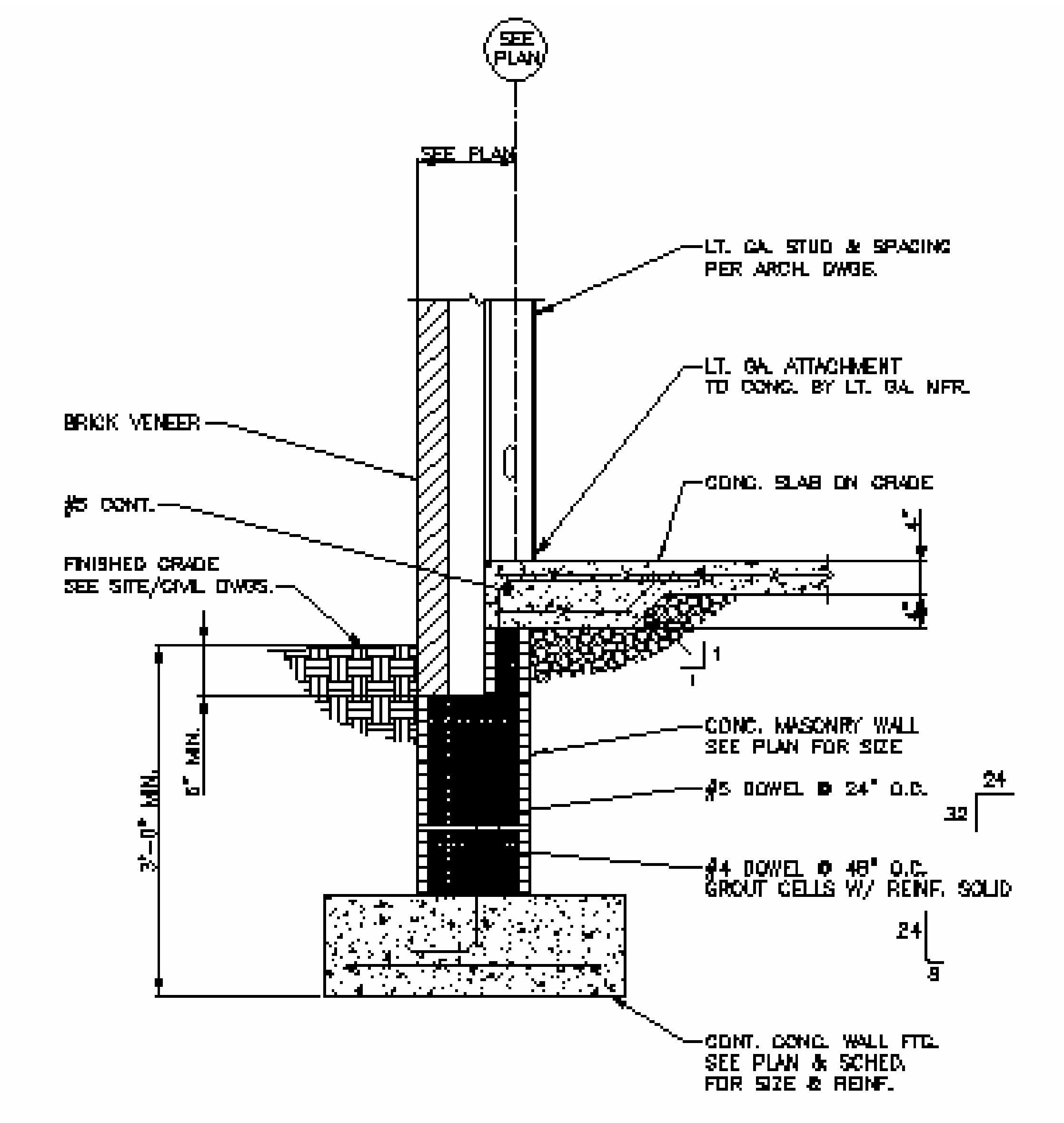
Lateral ties for <#10 bars = #3

Shown on the next page is the column schedule for the roof columns. Complete column schedules can be viewed in the Appendix page 91.

Column	A_{trib} (ft^2)	P (lb)	M_{max}	Size (in x in)	Reinfor.	Ties
A-6	378	72576	241.7	26 X 26	12-#7	#3 @ 14'
A-6.5	135	25920	365.2	26 X 26	12-#7	#3 @ 14'
B.3-0	0	0	0	26 X 26	-	-
B-1	75	14400	245.7	26 X 26	12-#7	#3 @ 14'
B-2	280	53760	245.7	26 X 26	12-#7	#3 @ 14'
B-3	405	77760	244.9	26 X 26	12-#7	#3 @ 14'
B-4	405	103680	238.5	26 X 26	12-#7	#3 @ 14'
B-5	405	103680	244.9	26 X 26	12-#7	#3 @ 14'
B.6-6.5	-	50000	365.2	26 X 26	12-#7	#3 @ 14'
B.7-6	168	32256	344	26 X 26	12-#7	#3 @ 14'
B.8-0	0	0	0	26 X 26	-	-
C.3-6.2	-	50000	365.2	26 X 26	12-#7	#3 @ 14'
C.4-0.3	0	0	0	26 X 26	-	#3 @ 14'
C-1	75	14400	344.4	26 X 26	12-#7	#3 @ 14'
C-2	680	130560	485.8	26 X 26	12-#7	#3 @ 14'
C-3	702	134784	485.8	26 X 26	12-#7	#3 @ 14'
C-4	702	179712	485.8	26 X 26	12-#7	#3 @ 14'
C-5	702	179712	485.8	26 X 26	12-#7	#3 @ 14'
C-6	304	58368	360.6	26 X 26	12-#7	#3 @ 14'
D-0.6	0	0	0	26 X 26	-	-
D-1	0	0	0	26 X 26	-	-
E-2	175.5	33696	197.2	26 X 26	12-#7	#3 @ 14'
E-3	336	64512	248.2	26 X 26	12-#7	#3 @ 14'
E-4	336	86016	228.2	26 X 26	12-#7	#3 @ 14'
E-5	336	86016	268.4	26 X 26	12-#7	#3 @ 14'
E-6	312	59904	197.2	26 X 26	12-#7	#3 @ 14'
E.5-6.8	84	16128	365.2	26 X 26	12-#7	#3 @ 14'
F-6.8	90	17280	365.8	26 X 26	12-#7	#3 @ 14'
F-7	67.5	12960	245.7	26 X 26	12-#7	#3 @ 14'
F-8	405	77760	244.5	26 X 26	12-#7	#3 @ 14'
F-9	405	77760	244.9	26 X 26	12-#7	#3 @ 14'
F-10	240	46080	241.7	26 X 26	12-#7	#3 @ 14'
F-11	285	54720	245.7	26 X 26	12-#7	#3 @ 14'
F.2-12	0	0	0	26 X 26	-	-
F.5-6.8	90	17280	365.2	26 X 26	12-#7	#3 @ 14'
F.6-12	0	0	0	26 X 26	-	-
G-7	81	15552	344.4	26 X 26	12-#7	#3 @ 14'
G-8	702	134784	485.8	26 X 26	12-#7	#3 @ 14'
G-9	702	134784	485.8	26 X 26	12-#7	#3 @ 14'
G-10	420	80640	485.8	26 X 26	12-#7	#3 @ 14'
G-11	280	53760	344.4	26 X 26	12-#7	#3 @ 14'
G.1-6.8	90	17280	365.2	26 X 26	12-#7	#3 @ 14'
G.3-11.7	0	0	0	26 X 26	-	-
G.6-6.8	84	16128	365.2	26 X 26	12-#7	#3 @ 14'
H-11	0	0	0	26 X 26	-	-
H-11.5	0	0	0	26 X 26	-	-
I-7	204	39168	220.4	26 X 26	12-#7	#3 @ 14'
I-8	336	64512	265	26 X 26	12-#7	#3 @ 14'
I-9	336	64512	246	26 X 26	12-#7	#3 @ 14'
I-10	97.5	18720	220.4	26 X 26	12-#7	#3 @ 14'

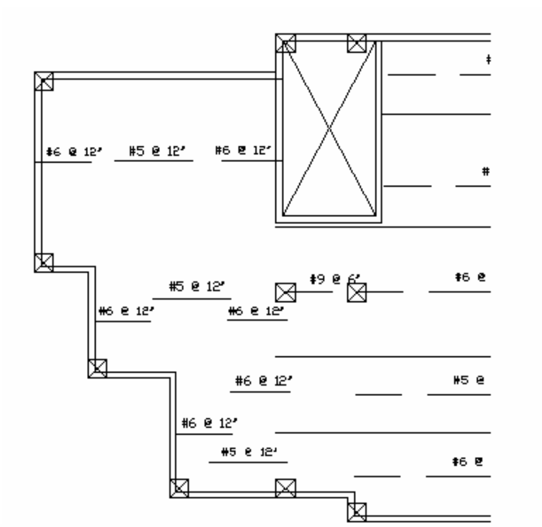
Foundations

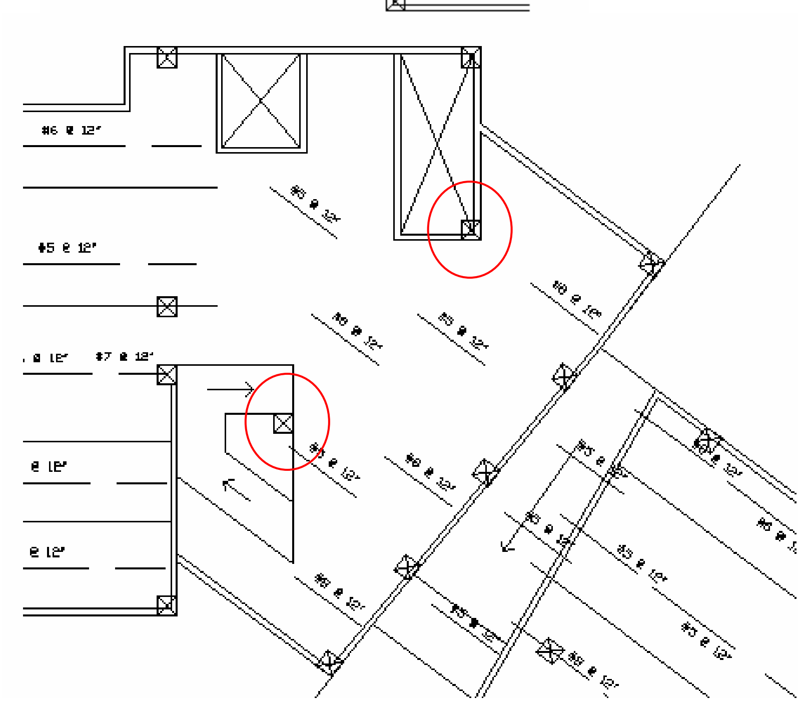
The new foundation system for the Upper Campus Housing Project will be square footings under each column. The foundation shown below is the curtain wall down to the wall footing.



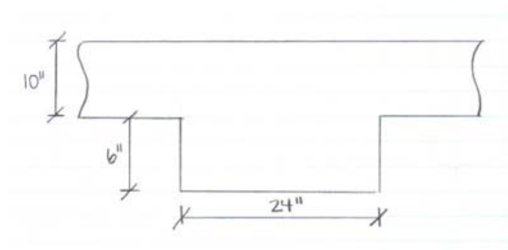
One-Way Design

The center section and the end sections of the floor plan (shown below) were designed as one-way systems. These one-way systems were also designed using ADOSS. They were checked with a manual calculation using a maximum moment of $wL^2/8$.





A beam was designed to span across the two columns circled below because the span was too high for the one-way system. The beam was designed by hand using a maximum moment of $wL^2/8$ also. It was designed as a T-beam for flexure and shear. The beam will have two rows of 5#8's for flexure and #3's for shear (1 at 2" and 18 at 9"). The beam calculations can be found in the Appendix on page 101. Also shown below is a picture of the beam designed.



Lateral Load Calculations (per ASCE7-02)

Seismic Use Group	I	Table 9.1.3
Site Classification	D	9.4.1.2.1
Ss	0.127	Figure 9.4.1.1a
S_1	0.054	Figure 9.4.1.1b
Fa	1.6	Table 9.4.1.2a
Fv	2.4	Table 9.4.1.2b
Seismic Design Category	A	
R	3	Table 9.5.2.2
I	1.0	Table 9.1.4

$Sms = FaSs = 1.6(0.127) = 0.203$

$Sm_1 = FvS_1 = 2.4(0.054) = 0.129$

$S_{DS} = (2/3)Sms = 0.135$

$S_{D1} = (2/3)\ Sm_1 = 0.086$

$T = Cthn^x = 0.02(100)^{0.75} = 0.632$

$Cs = S_{DS}/(R/I) = 0.045$

$Csmax = S_{D1}/(T(R/I)) = 0.045$

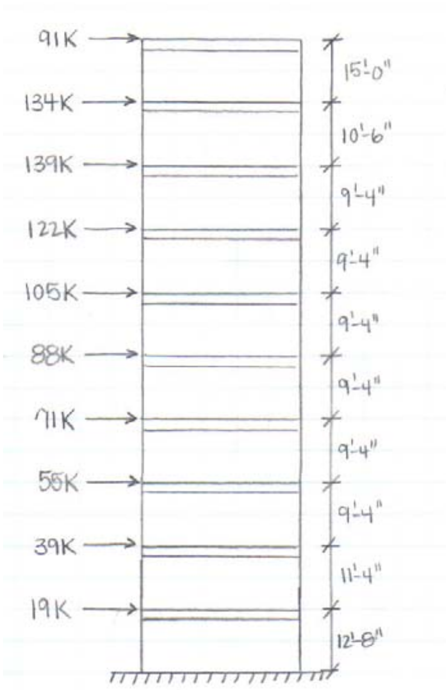
$Csmin = 0.044IS_{DS} = 0.006$

$V = CsW = 0.045(19875.5K) = 894.4K$

$K = 1 + ((0.632-0.5)/2) = 1.07$

Lateral Design

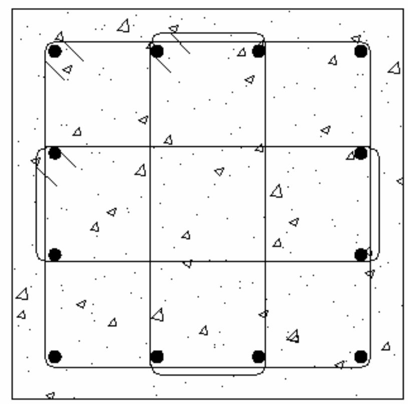
The lateral shear walls for this structure were designed using a stiffness analysis using a procedure described in Chapter 3 of the PCI Design Handbook. The forces on the building were distributed to each shear wall accordingly based on the stiffness of that wall. Each wall is 10" thick reinforced concrete. The seismic load case was used because it controls the design for these walls. The distribution of the seismic load to each floor is shown below. The corresponding wind loading diagram is located in the Appendix on page 37. Because there is an expansion joint located where the building angles, the lateral design can be complete assuming that the building works as two separate halves. The reinforcement can be summarized as follows:

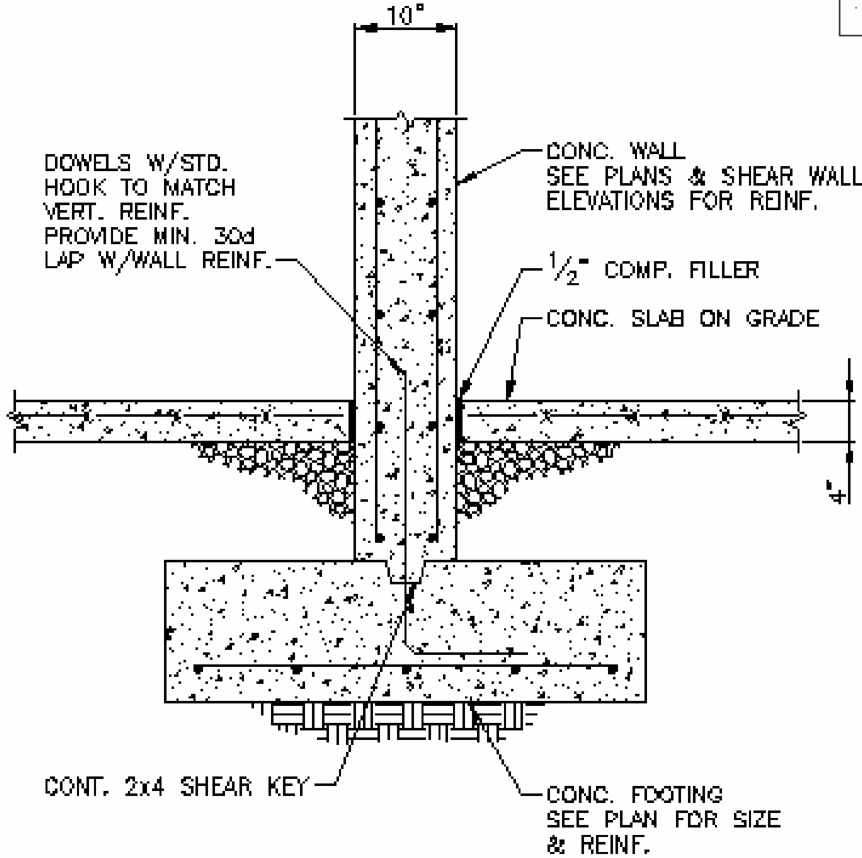


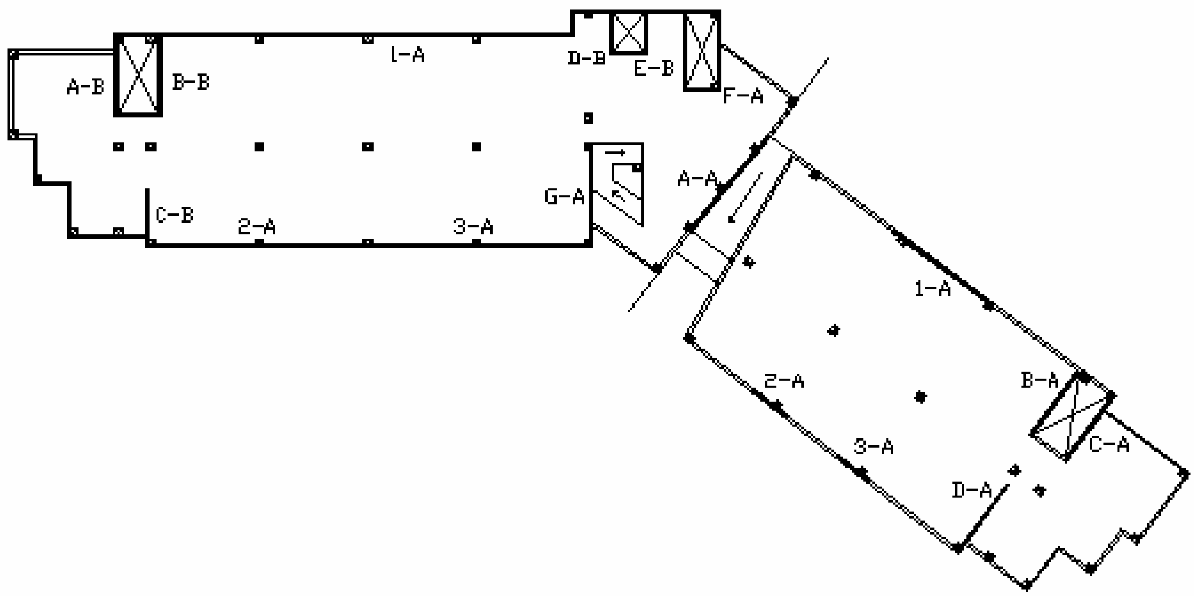
Shear Wall Design			
Type	Horizontal	Vertical (First and Last 12")	Vertical
A	#10 at 12"	20-#10's	#5 at 12"
B	#5 at 12"	20-#8's	#5 at 12"

The location and the types of shear walls are shown on the page 24. A complete design of the shear walls is located in the Appendix page 103.

The detail to the right is a column with 12 longitudinal bars and the required placement of lateral ties. The detail shown below is an example of how the shear wall will connect to the foundation.







Drift Check

$\Delta = (Ph^3/3EI)+(2.78Ph/AE)$

$E = 33(145pcf)^{1.5}(4000psi)^{0.5} = 3644ksi$

$\Delta_{allowable} = H/400 = 105.5ft(12in/ft)/400 = 3.165"$

Deflection calculations were done for each wall using an Excel spreadsheet. These calculations can be viewed on the next page. All deflections are less than the allowable limit. It is also important to note that the deflection at the expansion joint was considered for the two halves of the building hitting each other and is OK.

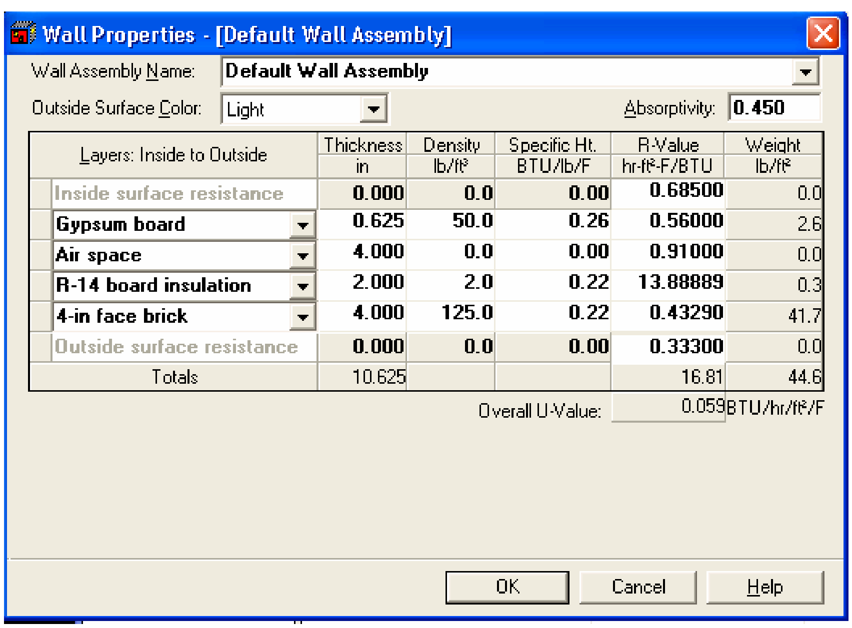
Left				
Wall	Length	Area	I	Deflection
A	237	2370	11093378	0.01883
B	237	2370	11093378	0.01883
C	171.96	1720	4237416	0.03113
D	60	600	180000	0.31538
E	60	600	180000	0.31538
F	216	2160	8398080	0.0216
G	312	3120	25309440	0.01296
1	336	3360	31610880	0.0118
2	120	1200	1440000	0.06113
3	120	1200	1440000	0.06113

Right				
Wall	Length	Area	I	Deflection
A	336	2370	31610880	0.01612
B	237	2370	11093378	0.01883
C	237	1720	11093378	0.02437
D	248.04	600	12716978	0.06153
1	216	3360	8398080	0.01586
2	120	1200	1440000	0.06113
3	120	1200	1440000	0.06113

Breadth Study

Thermal Gradient

Because the new design for the Upper Campus Housing Project will allow for less shear walls, a new exterior envelope will need to be constructed to fill in the voids between the remaining shear walls. This new curtain wall will consist of an exterior brick façade with a light gauge metal stud back up. For each material in the new wall construction a U-Factor and an R-Value were calculated. The R-Value, the thermal resistance, and the U-Factor, the solar heat gain coefficient, values were taken from the Carrier's Hourly Analysis Program. The following chart is the output from that program:



Wall Properties - [Default Wall Assembly]

Wall Assembly Name: Default Wall Assembly

Outside Surface Color: Light   Absorptivity: 0.450

Layers: Inside to Outside	Thickness in	Density lb/ft³	Specific Ht. BTU/lb/F	R-Value hr-ft²-F/BTU	Weight lb/ft²
Inside surface resistance	0.000	0.0	0.00	0.68500	0.0
Gypsum board	0.625	50.0	0.26	0.56000	2.6
Air space	4.000	0.0	0.00	0.91000	0.0
R-14 board insulation	2.000	2.0	0.22	13.88889	0.3
4-in face brick	4.000	125.0	0.22	0.43290	41.7
Outside surface resistance	0.000	0.0	0.00	0.33300	0.0
Totals	10.625			16.81	44.6

Overall U-Value: 0.059 BTU/hr/ft²/F

OK   Cancel   Help

From the information given from Carrier's Hourly Analysis Program the following Excel spreadsheet was constructed to calculate the change in temperature through each material:

Material	Thickness (in)	R-Value
Outside Air SR	0.00	0.33
4" Brick Veneer	4.00	0.43
Air Space	1.00	0.91
Board Insulation	2.00	13.89
Vapor Barrier	0.01	0.00
Air Space	3.50	0.91
GWB	0.63	0.56
Inside Air	0.00	0.69
Totals	11.14	17.72

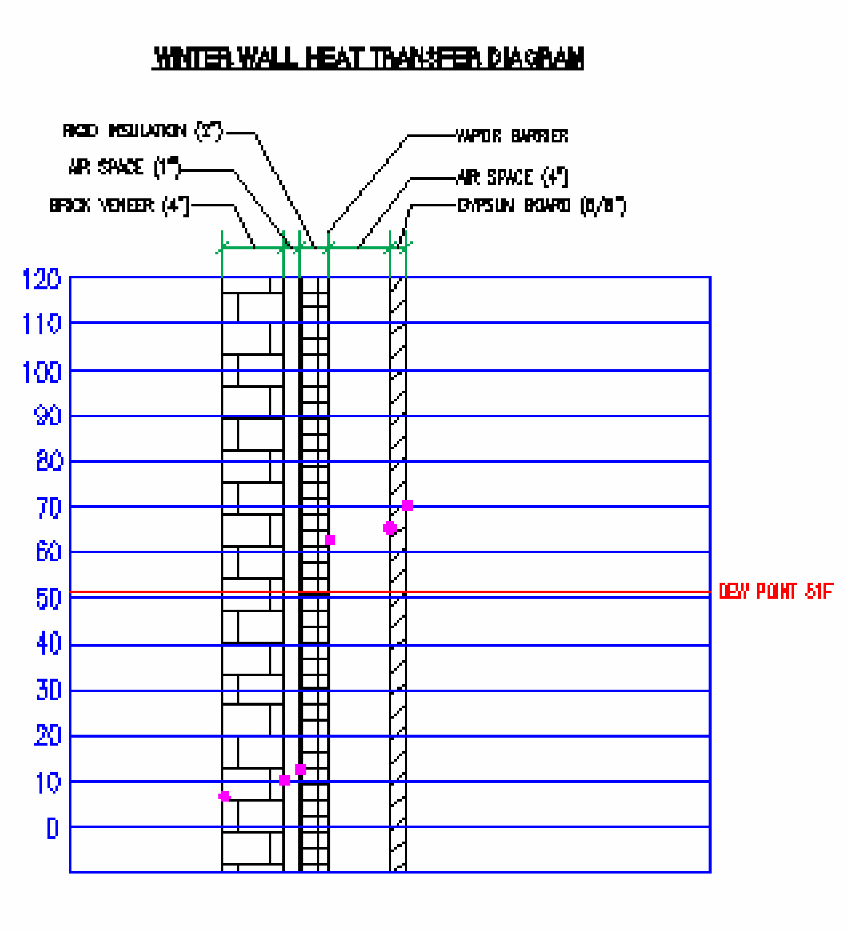
ΔT	
Winter	Summer
1.184	0.207
1.539	0.269
3.235	0.565
49.381	8.622
0.000	0.000
3.235	0.565
1.991	0.348
2.435	0.425

The entire spreadsheet can be viewed in Appendix page 105.

The information used to construct the spreadsheet came from various places. The dew point temperatures came from a psych chart based on 50% Relative Humidity and 75F for summer and 70F for winter. Therefore, the dew point temperatures are 55F for summer and 51F for winter. The maximum allowable U-Factor was determined from the ASHRAE std. 90.1-2004 (Appendix page 106). This maximum U-Factor is equal to 0.064. The outdoor design conditions came from the ASHRAE Design Handbook of Fundamentals 1993. This handbook states that for Pittsburgh, PA the summer outdoor condition is 86F and the winter outdoor condition is 7F.

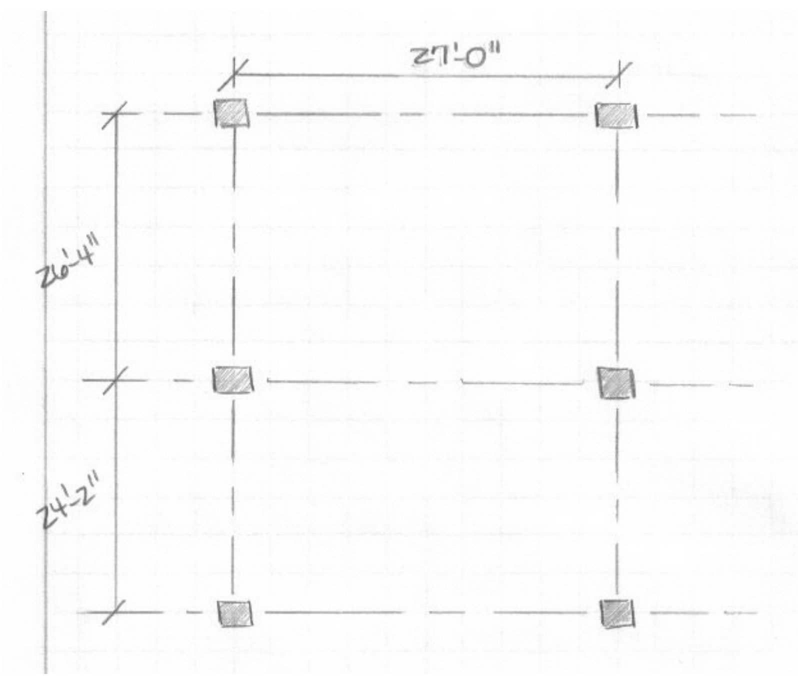
After the temperature changes were determined a wall section thermal gradient was constructed to determine where the water vapor would condense in each wall section.

In this case, the winter condition controls and tells us where to locate the vapor barrier in the wall section. Below is the thermal gradient for the winter condition. The summer condition can be viewed in the Appendix page 107.



Construction Management Issues

Construction management issues, such as cost and duration, are important to be considered when decided which type of structure is best for each project. For the purposes of this report each system the cost and duration of a typical bay was computed using the ICE 2000 program. An example of a typical bay for the flat-plate system is shown below. The typical bay for the one-way plank system is similar. However, it has walls along each horizontal column line instead of columns. Because of the complexity of the flat-plate system the cost and duration are about double of that of the one-way. The one-way system allows for much easier construction, which therefore allows for much less labor. The two-way system has much more labor because the slab and columns need to be formed and the reinforcement must be placed to the exact specifications of the engineer. A summary of the material and labor costs for each system is shown on the next page.



Cost and Duration System Summaries

Two-Way Flat-Plate System	
Material Cost	$11,967
Labor Cost	$7,305
Labor Fringes	$2,004
Equipment Cost	$837
Total	$22,113
Manhours	353

One-Way Plank System	
Material Cost	$8,091
Labor Cost	$1,815
Labor Fringes	$887
Equipment Cost	$265
Total	$11,058
Manhours	92

Summary and Conclusions

The Upper Campus Housing Project could be designed as either a one-way hollow-core plank system or a two-way flat-plate system. Designing the structure as a one-way system will allow for easier construction and less cost. However, the two-way system will allow for the conversion of the structure to another use if needed by the University of Pittsburgh in the future. This conversion would be possible because of a more flexible floor plan and the ability to carry higher floor loads.

The existing conditions for this building consist of one-way hollow-core concrete plank (8" + 2 ½" topping), filled in solid where needed. This system has reinforced concrete masonry bearing and shear walls located at every exterior wall and most interior walls. These shear walls are of varying thicknesses and reinforcement. The hollow-core plank system, because of its nature, allows for considerably easy and quick construction. This system however, causes the structure to be defined only as a dormitory structure. Dormitory structures can only withstand a 40psf live load. Also, because the interior walls are also bearing and shear walls they cannot be moved to accommodate a new floor layout.

The proposed two-way flat-plate system consists of 10" slab with 26" x 26" reinforced columns. This system will have 10" reinforced concrete shear walls located at various places along the exterior of the building. The new system will also have a new building envelope consisting of light gauge metal stud walls with a brick façade. This system will allow for a flexible floor plan because all interior walls will only be partitions and can be moved if needed for future development of the structure.

This system also provides large bays (approximately 27' x 27') and higher floor loads (80psf).

Overall it is more important for developers to consider lower cost and not worry about the possible future development of the building. Therefore, the one-way hollow-core plank system is a better system overall for the structure of the Upper Campus Housing Project. This makes sense because it is unlikely that the professional engineers and developers would choose a system that was not the best choice. Below is a summary of the cost and duration of a typical bay for each system, proving that the one-way system is a better choice. However, the two-way system is a possibility for the structure and could be used in a similar design.

System	Cost/Typical Bay	Manhours/Typical Bay
Two-Way	$22,113	353
One-Way	$11,058	92

Acknowledgements

I would like to say thank you to everyone who has helped me during my time in Senior Thesis. First and foremost, Dr. Hanagan has been a wonderful advisor. She has helped me not only with senior thesis, but along the way during my time here as a Penn State AE. She has been a steady and consistent source of knowledge and experience. The knowledge I have gained from her will help me greatly in my path to success as a professional engineer. Second, I would like to thank my fellow AE students. We were all going through this together and managed to help each other along the way. Third, I would like to thank the entire AE faculty. The teachers in this department care a lot about their students and are truly interested in helping us succeed. Last, but certainly not least, I would like to thank everyone from Atlantic Engineering Services. My work there last summer provided me with a vast knowledge of information that will help me throughout my career and has helped me greatly during thesis.

References

Design of Concrete Structures 13th Edition

ACI318-02

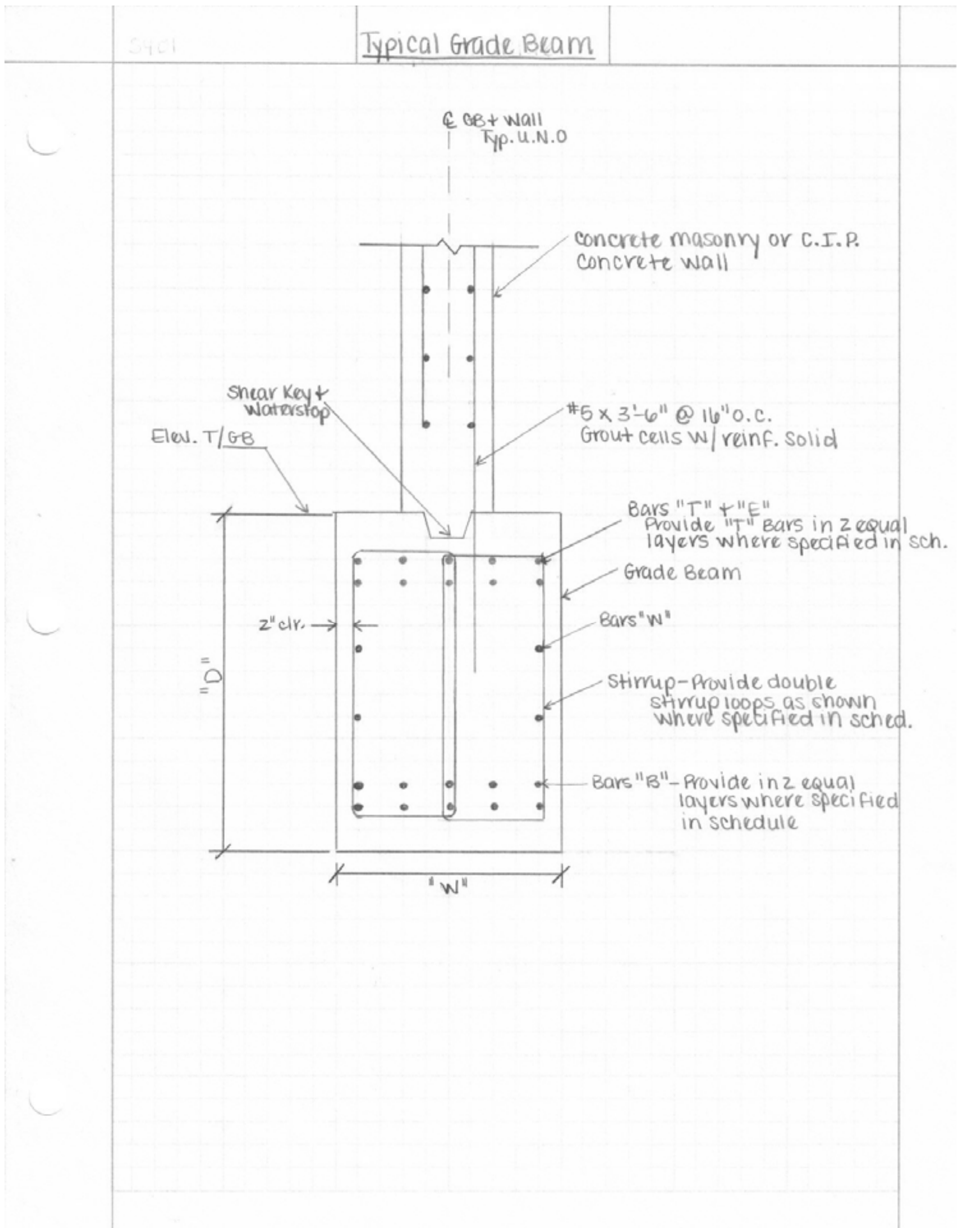
AISC Manual of Steel Construction

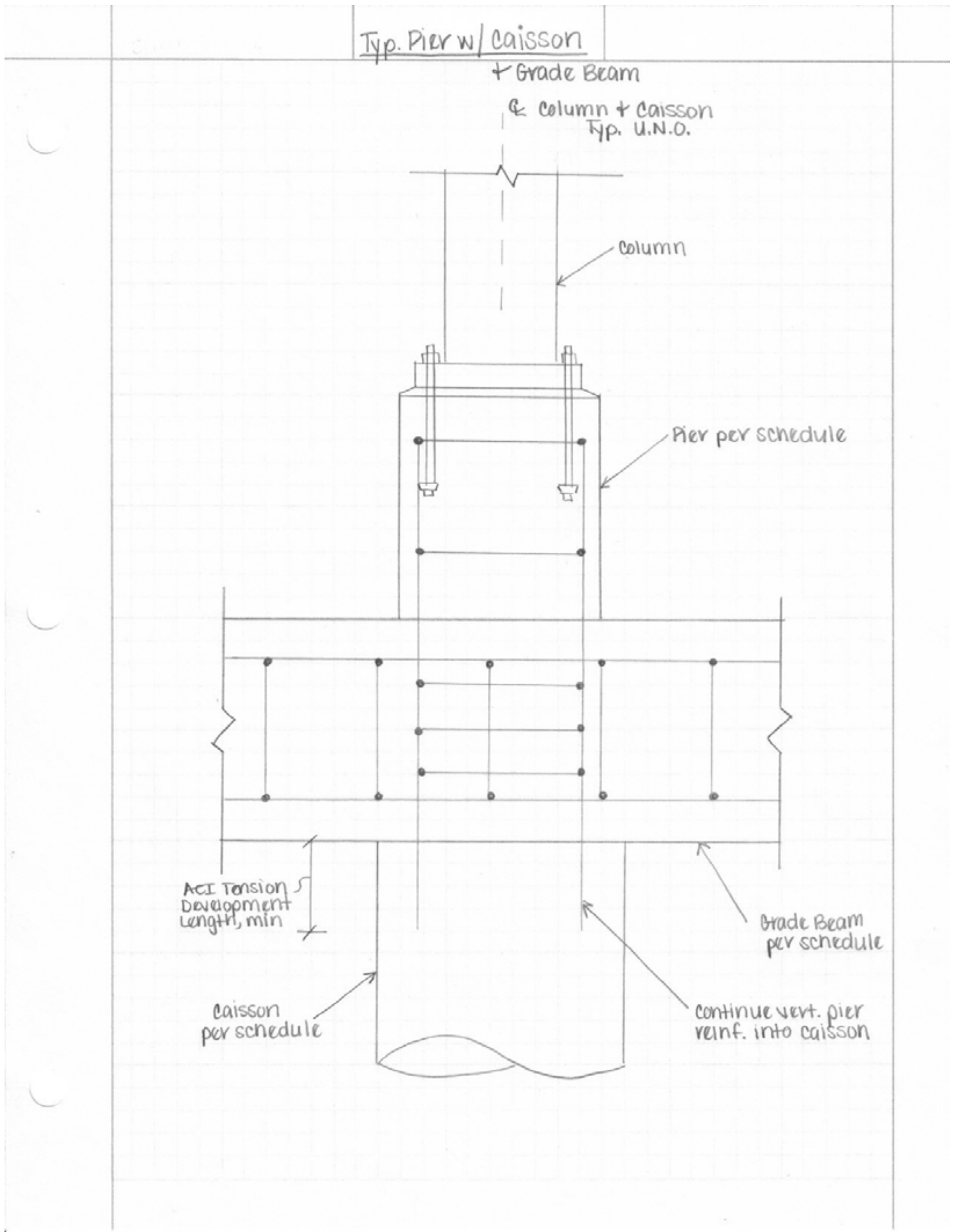
PCI Design Handbook

CRSI Design Handbook

Appendix

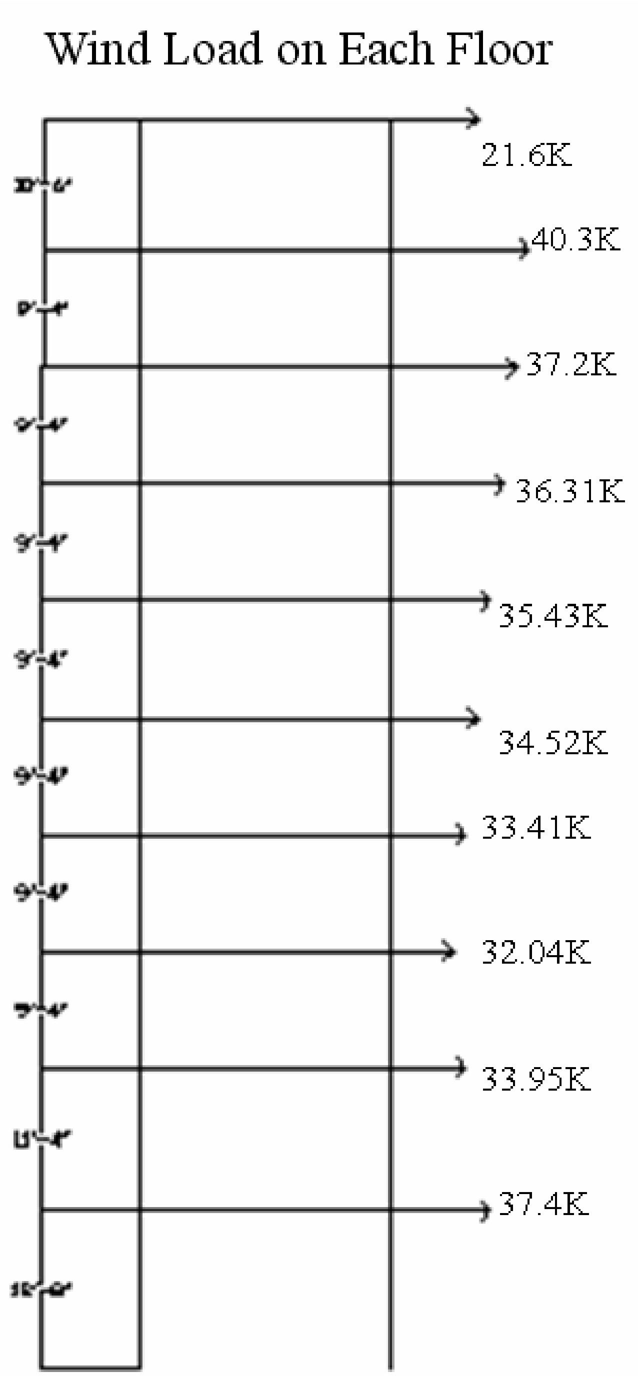
Existing Foundation Details





Typ. Pier w/ Caisson
+ Grade Beam
℄ Column + Caisson
Typ. U.N.O.
Column
Pier per schedule
ACI Tension Development Length, min
Grade Beam per schedule
Caisson per schedule
Continue vert. pier reinf. into caisson

Wind Load Distribution



ADOSS Output

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1
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                pppppp    ccccc    aaaaa
                p     p  c     c  a     a
                p     p  c     c        a
                p     p  c         aaaaaa
                p     p  c     c  a     a
                p     p  c     c  a     a
                pppppp    ccccc    aaaaaa
                p
                p


         AAA    DDDDD      OOO     SSSSS    SSSSS
        A   A   D    D    O   O   S     S  S     S
       A     A  D     D  O     O  S        S
       AAAAAAA  D     D  O     O   SSSSS    SSSSS
       A     A  D     D  O     O        S        S    ( ttttt mm   mm  )
       A     A  D    D    O   O   S     S  S     S   (    t   m m m m   )
       A     A  DDDDD      OOO     SSSSS    SSSSS     (   t   m   m  m  )



*********************************************************

 Computer program for ANALYSIS AND DESIGN OF SLAB SYSTEMS

*********************************************************




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```
FILE NAME            UNTITLED.ADS

PROJECT ID.          Thesis
                     -----------------------------------
SPAN ID.             LeftEW
                     -------------------

ENGINEER             Nikki Hazy

DATE                 03/27/06
TIME                 12:46:10

UNITS                U.S. in-lb
CODE                 ACI 318-89

SLAB SYSTEM          FLAT PLATE
FRAME LOCATION       INTERIOR

DESIGN METHOD        STRENGTH DESIGN
MOMENTS AND SHEARS   NOT PROPORTIONED

NUMBER OF SPANS  7
```

CONCRETE FACTORS	SLABS	BEAMS	COLUMNS
DENSITY(pcf)	150.0	150.0	150.0
TYPE	NORMAL WGT	NORMAL WGT	NORMAL WGT
f'c (ksi)	4.0	4.0	4.0
fct (psi)	423.7	423.7	423.7
fr (psi)	474.3	474.3	474.3

```
REINFORCEMENT DETAILS: NON-PRESTRESSED
  YIELD STRENGTH Fy  =  60.00 ksi
  DISTANCE TO RF CENTER FROM TENSION FACE:
       AT SLAB TOP    =   1.50 in  OUTER LAYER
       AT SLAB BOTTOM =   1.50 in  OUTER LAYER
  MINIMUM FLEXURAL BAR SIZE:
       AT SLAB TOP    =  # 4
       AT SLAB BOTTOM =  # 4
  MINIMUM SPACING:
       IN SLAB =   6.00 in

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```

SPAN/LOADING DATA
****

SPAN NUMBER	LENGTH L1 (ft)	Tslab (in)	WIDTH L2*** LEFT (ft)	RIGHT (ft)	SLAB SYSTEM	DESIGN STRIP (ft)	COLUMN STRIP** (ft)	UNIFORM LOADS S. DL (psf)	LIVE (psf)
1*	1.1+	10.0	13.5	13.0	1	26.5	.0	25.0	80.0
2	8.0	10.0	13.5	13.0	1	26.5	4.0	25.0	80.0
3	27.0	10.0	13.5	13.0	1	26.5	13.3	25.0	80.0
4	27.0	10.0	13.5	13.0	1	26.5	13.3	25.0	80.0
5	27.0	10.0	13.5	13.0	1	26.5	13.3	25.0	80.0
6	27.0	10.0	13.5	13.0	1	26.5	13.3	25.0	80.0
7*	1.1+	10.0	13.5	13.0	1	26.5	.0	25.0	80.0

* -Indicates cantilever span information.
** -Strip width used for positive flexure.
***-L2 widths are 1/2 dist. to transverse column.
"E"-Indicates exterior strip.
\+ -Indicates change in dimension due to support conditions.

PARTIAL LOADING DATA
****

PARTIAL LOADINGS ARE NOT SPECIFIED

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COLUMN/TORSIONAL DATA
****

COLUMN NUMBER	COLUMN ABOVE SLAB C1 (in)	C2 (in)	HGT (ft)	COLUMN BELOW SLAB C1 (in)	C2 (in)	HGT (ft)	CAPITAL** EXTEN. (in)	DEPTH (in)	COLUMN STRIP* (ft)	MIDDLE STRIP* (ft)
1	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	4.0	22.5
2	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	4.0	22.5
3	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.3	13.3
4	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.3	13.3
5	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.3	13.3
6	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.3	13.3

Columns with zero "C2" are round columns.
* -Strip width used for negative flexure.

**-Capital extension distance measured from face of column.

COLUMN NUMBER	TRANSVERSE BEAM WIDTH (in)	TRANSVERSE BEAM DEPTH (in)	TRANSVERSE BEAM ECCEN (in)	DROP PANEL/SOLID HEAD LEFT (ft)	DROP PANEL/SOLID HEAD RIGHT (ft)	DROP PANEL/SOLID HEAD WIDTH (ft)	DROP PANEL/SOLID HEAD THICK (in)	SUPPORT FIXITY* %
1	.0	.0	.0	.0	.0	.0	.0	100%
2	.0	.0	.0	.0	.0	.0	.0	100%
3	.0	.0	.0	.0	.0	.0	.0	100%
4	.0	.0	.0	.0	.0	.0	.0	100%
5	.0	.0	.0	.0	.0	.0	.0	100%
6	.0	.0	.0	.0	.0	.0	.0	100%

* -Support fixity of 0% denotes pinned condition.
Support fixity of 999% denotes fixed end condition.

```
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                           LATERAL LOAD/OUTPUT DATA
                           ************************

LATERAL LOADS ARE NOT SPECIFIED



OUTPUT DATA
PATTERN LOADINGS:                 1 THRU 4
PATTERN LIVE LOAD FACTOR (1-3)  =    75%

LOAD FACTORS:
  U = 1.40*D + 1.70*L
  U =  .75( 1.40*D + 1.70*L + 1.70*W)
  U =  .90*D + 1.30*W


OUTPUT OPTION(S):
  Input Echo
  Centerline Moments and Shears
  Column Strip Distribution Fac
  Shear Table
  Reinforcing Required
  Bar Sizing
  Additional Information
  Deflections
  Material Quantities

 THE CAPITAL AT COLUMN  1 HAS BEEN MODIFIED TO FALL WITHIN THE SPECIFIED
 SLAB, DROP OR BEAM DIMENSIONS
** NEW CAPITAL EXTENSION =    .00 in. AT LEFT OF COLUMN.

 THE CAPITAL AT COLUMN  6 HAS BEEN MODIFIED TO FALL WITHIN THE SPECIFIED
 SLAB, DROP OR BEAM DIMENSIONS
** NEW CAPITAL EXTENSION =    .00 in. AT RIGHT OF COLUMN.

**SLAB SPAN  2 IS NOT A TWO WAY SYSTEM.
THE SLAB DESIGN MUST BE PERFORMED MANUALLY.

**TOTAL UNFACTORED DEAD LOAD =         466.192 kips
                   LIVE LOAD =         250.513 kips
```

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---- STATICS PRINT-OUT FOR GRAVITY LOAD ANALYSIS ----

J O I N T   M O M E N T S (ft - kips)

JOINT	PATTERN-1				PATTERN-2			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-4.6	-12.3	8.4	8.4	-4.6	-39.7	22.2	22.2
2	-299.5	462.3	-81.4	-81.4	-290.5	461.7	-85.6	-85.6
3	-550.7	541.6	4.5	4.5	-498.7	377.7	60.5	60.5
4	-531.8	529.3	1.3	1.3	-369.2	478.5	-54.7	-54.7
5	-554.6	593.7	-19.6	-19.6	-508.8	440.6	34.1	34.1
6	-350.5	4.6	172.9	172.9	-210.6	4.6	103.0	103.0

JOINT	PATTERN-3				PATTERN-4			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-3.0	-10.6	6.8	6.8	-5.2	-33.3	19.2	19.2
2	-191.7	280.7	-44.5	-44.5	-319.7	492.2	-86.2	-86.2
3	-411.8	500.5	-44.4	-44.4	-603.6	582.2	10.7	10.7
4	-480.5	364.5	58.0	58.0	-563.3	558.9	2.2	2.2
5	-391.4	543.9	-76.2	-76.2	-596.8	652.6	-27.9	-27.9
6	-352.0	3.0	174.5	174.5	-373.0	5.2	183.9	183.9

J O I N T   S H E A R S (kips)

JOINT	PATTERN-1		PATTERN-2		PATTERN-3		PATTERN-4	
NUMBER	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
1	-8.5	5.6	-8.5	-19.4	-5.6	7.4	-9.5	-7.9
2	-74.3	109.7	-63.1	109.8	-58.0	69.9	-80.4	119.2
3	-115.4	113.9	-112.6	75.0	-79.6	112.0	-127.5	124.1
4	-113.1	112.7	-74.4	110.1	-110.5	73.7	-122.7	122.0
5	-114.6	120.8	-112.3	83.2	-75.7	118.3	-124.8	133.7
6	-103.8	8.5	-66.2	8.5	-104.1	5.6	-113.0	9.5

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DESIGN MOMENT ENVELOPES AT CRITICAL SECTIONS FROM SUPPORTS
****

COL NUM	LOAD TYPE	CROSS SECTN		DESIGN MOMENT (ft-k)	DISTANCE CR.SECTN (ft)	LOAD PTRN	MAX.I.P. DISTANCE (ft)	LOAD PTRN
1	TOTL	LEFT	TOP	-3.5	.190	4	1.083	1
			BOT	.0	.000	0	.000	0
		RGHT	TOP	.0	.000	0	2.800	3
			BOT	-15.8	1.292	4	.000	0
2	TOTL	LEFT	TOP	-215.6	1.400	4	.000	0
			BOT	.0	.000	0	.000	0
		RGHT	TOP	323.3	1.500	4	5.400	2
			BOT	.0	.000	0	.000	0
3	TOTL	LEFT	TOP	-422.3	1.500	4	6.750	3
			BOT	.0	.000	0	.000	0
		RGHT	TOP	406.1	1.500	4	6.750	2
			BOT	.0	.000	0	.000	0
4	TOTL	LEFT	TOP	-389.2	1.500	4	6.750	2
			BOT	.0	.000	0	.000	0
		RGHT	TOP	385.9	1.500	4	6.750	3
			BOT	.0	.000	0	.000	0
5	TOTL	LEFT	TOP	-419.6	1.500	4	6.750	3
			BOT	.0	.000	0	.000	0
		RGHT	TOP	462.0	1.500	4	6.750	2
			BOT	.0	.000	0	.000	0


```
6     TOTL LEFT  TOP     -234.4       1.292       4        4.050       2
                     BOT          .0        .000       0         .000       0

                RGHT  TOP         3.5        .190       4        1.083       1
                     BOT          .0        .000       0         .000       0

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            DESIGN MOMENT ENVELOPES AT CRITICAL SECTIONS ALONG SPANS
            ********************************************************
 -----------------------------------------------------------------------------
--
  SPAN   LOAD       CRITICAL   DESIGN   LOAD  MAX. I.P.  LOAD  MAX. I.P.
LOAD
  NUM    TYPE       SECTION    MOMENT   PTRN  DIST LEFT  PTRN  DIST RGHT
PTRN
                      (ft)     (ft-k)          (ft)             (ft)
 -----------------------------------------------------------------------------
--
    2    TOTL      .600  TOP        .0    0       .000    0        .000    0
                         BOT      14.4    1     -1.000    2       -.600    0

    3    TOTL    12.825  TOP        .0    0       .000    0        .000    0
                         BOT     290.1    4      7.425    1       8.775    1

    4    TOTL    14.175  TOP        .0    0       .000    0        .000    0
                         BOT     263.2    3      8.775    1       7.425    1

    5    TOTL    12.825  TOP        .0    0       .000    0        .000    0
                         BOT     260.2    2      7.425    1       8.775    2

    6    TOTL    14.175  TOP        .0    0       .000    0        .000    0
                         BOT     329.4    4      8.775    3       8.775    1

 -----------------------------------------------------------------------------
--
```

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DISTRIBUTION OF DESIGN MOMENTS AT SUPPORTS
****

COL NUM	CROSS SECTN		TOTAL MOMENT (ft-k)	TOTAL-VERT DIFFERENCE (ft-k) (%)	COLUMN STRIP MOMENT (ft-k) (%)	BEAM MOMENT (ft-k) (%)	MIDDLE STRIP MOMENT (ft-k) (%)
1	LEFT	TOP	-3.5	.0 (0)	-3.5 (98)	.0 (0)	-.1 (1)
		BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	-15.8	.0 (0)	-15.6 (98)	.0 (0)	-.2 (1)
2	LEFT	TOP	-215.6	.0 (0)	-161.7 (75)	.0 (0)	-53.9 (25)
		BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT	TOP	323.3	.0 (0)	242.5 (75)	.0 (0)	80.8 (25)
		BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
3	LEFT	TOP	-422.3	.0 (0)	-316.7 (75)	.0 (0)	-105.6 (25)
		BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT	TOP	406.1	.0 (0)	304.6 (75)	.0 (0)	101.5 (25)
		BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)

```
4  LEFT TOP  -389.2       .0 (   0)  -291.9 ( 75)       .0 (   0)   -97.3 ( 25)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

      RGHT TOP   385.9       .0 (   0)   289.4 ( 75)       .0 (   0)    96.5 (
25)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

   5  LEFT TOP  -419.6       .0 (   0)  -314.7 ( 75)       .0 (   0)  -104.9 (
25)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

      RGHT TOP   462.0       .0 (   0)   346.5 ( 75)       .0 (   0)   115.5 (
25)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

   6  LEFT TOP  -234.4       .0 (   0)  -230.8 ( 98)       .0 (   0)    -3.6 (
1)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

      RGHT TOP     3.5       .0 (   0)     3.5 ( 98)       .0 (   0)      .1 (
1)
           BOT      .0       .0 (   0)      .0 (   0)       .0 (   0)      .0 (
0)

-----------------------------------------------------------------------------
---
```

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DISTRIBUTION OF DESIGN MOMENTS IN SPANS
****

SPAN NUM	CROSS SECTN		TOTAL MOMENT (ft-k)	TOTAL-VERT DIFFERENCE (ft-k) (%)	COLUMN STRIP MOMENT (ft-k) (%)	BEAM MOMENT (ft-k) (%)	MIDDLE STRIP MOMENT (ft-k) (%)
2	.60	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	14.4	.0 (0)	8.6 (60)	.0 (0)	5.8 (39)
3	12.82	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	290.1	.0 (0)	174.1 (60)	.0 (0)	116.1 (39)
4	14.18	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	263.2	.0 (0)	157.9 (60)	.0 (0)	105.3 (40)
5	12.82	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	260.2	.0 (0)	156.1 (60)	.0 (0)	104.1 (39)
6	14.18	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	329.4	.0 (0)	197.6 (60)	.0 (0)	131.8 (40)

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S H E A R   A N A L Y S I S

NOTE--Allowable shear stress in slabs = 252.96 psi when ratio of col. dim. (long/short) is less than 2.0.

--Wide beam shear (see "CODE") is not computed, check manually.

--After the column numbers, C = Corner, E = Exterior, I = Interior.

D I R E C T   S H E A R   W I T H   T R A N S F E R   O F   M O M E N T

		A R O U N D			C O L U M N				
COL. NO.	ALLOW. STRESS (psi)	PATT NO.	REACTION (kips)	SHEAR STRESS (psi)	PATT NO.	REACTION (kips)	UNBAL. MOMENT (ft-k)	SHEAR TRANSFR (ft-k)	SHEAR STRESS (psi)
1E	252.96	1	11.6	13.97	2	.0	-54.7	-20.4	51.09
2I	247.27	4	195.7	152.17	4	195.7	172.5	69.0	195.18
3I	247.27	4	247.6	192.55	4	247.6	-21.4	-8.5	197.88
4I	247.27	4	240.7	187.16	4	240.7	-4.4	-1.8	188.25
5I	247.27	4	254.6	197.94	4	254.6	55.8	22.3	211.86
6E	252.96	4	119.6	143.93	4	119.6	-251.0	-93.5	247.48

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N E G A T I V E   R E I N F O R C E M E N T
****

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1**	4	L ||	-3.5	.86	4.0	4.86	22.5
2	4	|| R	323.3	7.58	4.0	4.86	22.5
3	4	L ||	-422.3	8.78	13.3	2.86	13.3
4	4	L ||	-389.2	8.06	13.3	2.86	13.3
5	4	|| R	462.0	9.67	13.3	3.08	13.3
6	4	L ||	-234.4	6.29	13.3	2.86	13.3

** - Positive reinforcement required, compute manually.

P O S I T I V E   R E I N F O R C E M E N T
****

SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	1	.6	14.4	.86	4.0	4.86	22.5
3	4	12.8	290.1	4.70	13.3	3.10	13.3
4	3	14.2	263.2	4.25	13.3	2.86	13.3
5	2	12.8	260.2	4.20	13.3	2.86	13.3
6	4	14.2	329.4	5.35	13.3	3.53	13.3

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D E S I G N R E S U L T S

NOTE--The schedule given below is a guide for proper reinforcement placement and is based on reasonable engineering judgement. Unusual boundary and/or loading conditions may require modification of this schedule.

N E G A T I V E R E I N F O R C E M E N T

COLUMN	COLUMN STRIP								MIDDLE STRIP			
	LONG BARS				SHORT BARS				LONG BARS			
	-BAR-LENGTH-				-BAR-LENGTH-				-BAR-LENGTH-			
NUMBER	NO	SIZE	LEFT (ft)	RIGHT (ft)	NO	SIZE	LEFT (ft)	RIGHT (ft)	NO	SIZE	LEFT (ft)	RIGHT (ft)
1**	3	# 4	1.08	3.51	2	# 4	1.08	2.25	25	# 4	1.08	3.51
2	3	#10	8.53	8.53	3	#10	7.00	7.10	25	# 4	6.55	6.95
3	10	# 6	8.53	8.53	10	# 6	6.05	6.05	15	# 4	8.30	8.30
4	10	# 6	8.53	8.53	9	# 6	6.05	6.05	15	# 4	8.30	8.30
5	11	# 6	8.53	8.53	11	# 6	6.05	6.05	16	# 4	8.30	8.30
6	11	# 5	8.53	1.08	10	# 5	6.05	1.08	15	# 4	6.55	1.08

** - Positive reinforcement required, design manually.

P O S I T I V E R E I N F O R C E M E N T

* C O L U M N S T R I P * M I D D L E S T R I P

SPAN	LONG BARS			SHORT BARS			LONG BARS			SHORT BARS		
	---- B A R ----			---- B A R ----			---- B A R ----			---- B A R ----		
NUMBER	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)
2	3	# 4	7.17	2	# 4	6.42	13	# 4	7.67	12	# 4	6.22
3	12	# 4	26.50	12	# 4	20.25	8	# 4	27.50	8	# 4	18.90
4	11	# 4	26.50	11	# 4	20.25	8	# 4	27.50	7	# 4	18.90
5	11	# 4	26.50	10	# 4	20.25	8	# 4	27.50	7	# 4	18.90
6	9	# 5	26.17	9	# 5	23.04	9	# 4	26.67	9	# 4	22.37

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A D D I T I O N A L   I N F O R M A T I O N   A T   S U P P O R T S

COLUMN NUMBER	REINF. SUMMARY W/O U. MOMENT REQ'D (sq.in)	REINF. SUMMARY W/O U. MOMENT PROV'D (sq.in)	ADD'L R/F REQ'D DUE TO UNBALANCED (U.) MOMENT TRANSFER: MAX.U. MOMENT (ft-k)	GAMMA -f	FLEXURAL TRANSFER (ft-k)	PATT NO.	CRITICAL SLABW (ft)	SECTION AREA (sq.in)	R/F
1	5.72	6.00	-44.4	.63	-27.8	2	5.5	.74	0 #4
2	12.44	12.62	172.5	.60	103.5	4	5.5	2.83	0 #10
3	11.65	11.80	-121.0	.60	-72.6	2	5.5	1.96	0 #6
4	10.92	11.36	-116.0	.60	-69.6	3	5.5	1.87	0 #6
5	12.75	12.88	152.5	.60	91.5	3	5.5	2.49	0 #6
6	9.15	9.51	-367.8	.63	-230.9	4	5.5	6.75	14 #5

NOTE: Zero transfer "CRITICAL SLABW" indicates no support dimensions given for transfer.
If beam(s) are present, transfer mode may be due to beam shear and/or torsion, check manually.

A D D I T I O N A L   I N F O R M A T I O N   F O R   I N - S P A N   C O N D I T I O N S

SPAN NUMBER	REINF. SUMMARY AT MIDSPAN REQ'D. (sq.in)	REINF. SUMMARY AT MIDSPAN PROV'D. (sq.in)	TOTAL FACTORED SPAN STATIC DESIGN MOMENT (W/O PARTIAL LOADS) (ft-k)
2	5.72	6.00	28.7

3	7.79	8.00	660.2
4	7.11	7.40	660.2
5	7.06	7.20	660.2
6	8.88	9.18	660.2

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D E F L E C T I O N   A N A L Y S I S
****

NOTES--The deflections below must be combined with those of the analysis in the perpendicular direction. Consult users manual for method of combination and limitations.

--Spans 1 and 7 are cantilevers.

--Time-dependent deflections are in addition to those shown and must be computed as a multiplier of the dead load(DL) deflection. See "CODE" for range of multipliers.

--Deflections due to concentrated or partialloads may be larger at the point of application than those shown at the centerline. Deflections are computed as from an average uniform loading derived from the sum of all loads applied to the span.

--Modulus of elasticity of concrete, Ec = 3834. ksi

SPAN NUMBER	DEAD LOAD Ieff. (in^4)	COLUMN STRIP DEFLECTION DUE TO: DEAD (in)	COLUMN STRIP LIVE (in)	COLUMN STRIP TOTAL (in)	MIDDLE STRIP DEFLECTION DUE TO: DEAD (in)	MIDDLE STRIP LIVE (in)	MIDDLE STRIP TOTAL (in)
1	26500.	.001	.001	.002	.001	.001	.002
2	26500.	-.002	-.001	-.002	-.005	-.003	-.007
3	23806.	.155	.143	.298	.082	.073	.155
4	22484.	.147	.134	.281	.070	.064	.134
5	22416.	.144	.131	.274	.067	.062	.128
6	23605.	.191	.151	.342	.094	.068	.161
7	26500.	-.011	-.006	-.016	-.011	-.006	-.017

```
          Q U A N T I T Y   E S T I M A T E S
           ***********************************

 TOTAL QUANTITIES
 ----------------
 CONCRETE         ....       96.6 cu.yd
 FORMWORK         ....     3131.  sq.ft
 REINFORCEMENT (IN THE DIRECTION OF ANALYSIS)
  (NEGATIVE)      ....     2829.  lbs
  (POSITIVE)      ....     2663.  lbs

 SUMMARY OF QUANTITIES
 ---------------------
 CONCRETE         ....        .83  cu.ft/sq.ft
 FORMWORK         ....       1.00  sq.ft/sq.ft
 REINFORCEMENT** ....       1.75  lbs / sq.ft

   **(IN THE DIRECTION OF ANALYSIS)

                * Program completed as requested *
```

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```
                pppppp    ccccc    aaaaa
                p     p  c     c  a     a
                p     p  c     c        a
                p     p  c         aaaaaa
                p     p  c     c  a     a
                p     p  c     c  a     a
                pppppp    ccccc    aaaaaa
                p
                p


         AAA    DDDDD      OOO     SSSSS    SSSSS
        A   A   D    D    O   O   S     S  S     S
       A     A  D     D  O     O  S        S
       AAAAAAA  D     D  O     O   SSSSS    SSSSS
       A     A  D     D  O     O        S        S    ( ttttt mm   mm  )
       A     A  D    D    O   O   S     S  S     S   (    t   m m m m   )
       A     A  DDDDD      OOO     SSSSS    SSSSS     (   t   m  m  m  )
```

****

Computer program for ANALYSIS AND DESIGN OF SLAB SYSTEMS

****

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FILE NAME P:\THESIS\ADOSS\TYPICAL1.ADS

PROJECT ID. Thesis

SPAN ID. Typical First

ENGINEER Nikki Hazy

DATE 03/19/06
TIME 22:52:01

UNITS U.S. in-lb
CODE ACI 318-89

SLAB SYSTEM FLAT PLATE
FRAME LOCATION INTERIOR

DESIGN METHOD STRENGTH DESIGN
MOMENTS AND SHEARS NOT PROPORTIONED

NUMBER OF SPANS 4

CONCRETE FACTORS	SLABS	BEAMS	COLUMNS
DENSITY(pcf)	150.0	150.0	150.0
TYPE	NORMAL WGT	NORMAL WGT	NORMAL WGT
f'c (ksi)	4.0	4.0	4.0
fct (psi)	423.7	423.7	423.7
fr (psi)	474.3	474.3	474.3

REINFORCEMENT DETAILS: NON-PRESTRESSED
YIELD STRENGTH Fy = 60.00 ksi
DISTANCE TO RF CENTER FROM TENSION FACE:

```
AT SLAB TOP    =   1.50 in  OUTER LAYER
       AT SLAB BOTTOM =   1.50 in  OUTER LAYER
  MINIMUM FLEXURAL BAR SIZE:
       AT SLAB TOP    =  # 4
       AT SLAB BOTTOM =  # 4
  MINIMUM SPACING:
       IN SLAB =   6.00 in
```

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SPAN/LOADING DATA
****

SPAN NUMBER	LENGTH L1 (ft)	Tslab (in)	WIDTH LEFT (ft)	L2*** RIGHT (ft)	SLAB SYSTEM	DESIGN STRIP (ft)	COLUMN STRIP** (ft)	UNIFORM LOADS S. DL (psf)	LIVE (psf)
1*	1.1+	10.0	13.5	13.5	1	27.0	.0	25.0	80.0
2	27.0	10.0	13.5	13.5	1	27.0	13.5	25.0	80.0
3	26.0	10.0	13.5	13.5	1	27.0	13.0	25.0	80.0
4*	1.1+	10.0	13.5	13.5	1	27.0	.0	25.0	80.0

* -Indicates cantilever span information.
** -Strip width used for positive flexure.
***-L2 widths are 1/2 dist. to transverse column.
"E"-Indicates exterior strip.
\+ -Indicates change in dimension due to support conditions.

PARTIAL LOADING DATA
****

03-21-** ADOSS(tm) 6.01 Proprietary Software of PORTLAND CEMENT ASSN. Page 4
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COLUMN/TORSIONAL DATA
****

COLUMN	COLUMN ABOVE SLAB			COLUMN BELOW SLAB			CAPITAL**		COLUMN	MIDDLE
NUMBER	C1	C2	HGT	C1	C2	HGT	EXTEN.	DEPTH	STRIP*	STRIP*
	(in)	(in)	(ft)	(in)	(in)	(ft)	(in)	(in)	(ft)	(ft)
1	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.5	13.5
2	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.0	14.0
3	26.0	26.0	6.0	26.0	26.0	6.0	5.0	5.0	13.0	14.0

Columns with zero "C2" are round columns.
* -Strip width used for negative flexure.
**-Capital extension distance measured from face of column.

COLUMN	TRANSVERSE BEAM			DROP PANEL/SOLID HEAD				SUPPORT
NUMBER	WIDTH	DEPTH	ECCEN	LEFT	RIGHT	WIDTH	THICK	FIXITY*
	(in)	(in)	(in)	(ft)	(ft)	(ft)	(in)	%
1	.0	.0	.0	.0	.0	.0	.0	100%
2	.0	.0	.0	.0	.0	.0	.0	100%

```
|    3   |     .0    .0    .0 |      .0         .0         .0     .0 |    100%
|
|________|___________________|____________________________________|__________
|
```

* -Support fixity of 0% denotes pinned condition.
Support fixity of 999% denotes fixed end condition.

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LATERAL LOAD/OUTPUT DATA
****

LATERAL LOADS ARE SPECIFIED AS BEING CAUSED BY WIND

LATERAL LOAD FROM FLOORS ABOVE (Pa) = .00 kips

LATERAL LOAD AT THIS FLOOR (Pb) = .00 kips

NOTE: The analysis procedure adopted by the program is approximate.

LATERAL LOADS DISTRIBUTED TO THE COLUMN AND MIDDLE STRIPS ACCORDING TO CODE DISTRIBUTION FACTORS.

OUTPUT DATA
PATTERN LOADINGS: 1 THRU 8
PATTERN LIVE LOAD FACTOR (1-3) = 75%

LOAD FACTORS:
U = 1.40*D + 1.70*L
U = .75(1.40*D + 1.70*L + 1.70*W)
U = .90*D + 1.30*W

OUTPUT OPTION(S):
Input Echo
Centerline Moments and Shears
Column Strip Distribution Fac
Shear Table
Reinforcing Required
Bar Sizing

Additional Information
  Deflections
  Material Quantities

THE CAPITAL AT COLUMN 1 HAS BEEN MODIFIED TO FALL WITHIN THE SPECIFIED SLAB, DROP OR BEAM DIMENSIONS
** NEW CAPITAL EXTENSION = .00 in. AT LEFT OF COLUMN.

THE CAPITAL AT COLUMN 3 HAS BEEN MODIFIED TO FALL WITHIN THE SPECIFIED SLAB, DROP OR BEAM DIMENSIONS
** NEW CAPITAL EXTENSION = .00 in. AT RIGHT OF COLUMN.

**TOTAL UNFACTORED DEAD LOAD = 221.665 kips
LIVE LOAD = 119.160 kips

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---- STATICS PRINT-OUT FOR GRAVITY LOAD ANALYSIS ----
****

J O I N T   M O M E N T S (ft - kips)

JOINT	PATTERN-1				PATTERN-2			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-4.7	349.0	-172.2	-172.2	-4.7	208.5	-101.9	-101.9
2	-614.8	593.1	10.8	10.8	-458.4	542.8	-42.2	-42.2
3	-315.0	4.7	155.1	155.1	-314.4	3.1	155.7	155.7

JOINT	PATTERN-3				PATTERN-4			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-3.1	348.5	-172.7	-172.7	-5.3	369.3	-182.0	-182.0
2	-569.6	449.0	60.3	60.3	-681.5	657.5	12.0	12.0
3	-182.9	4.7	89.1	89.1	-329.7	5.3	162.2	162.2

J O I N T   S H E A R S (kips)

JOINT	PATTERN-1		PATTERN-2		PATTERN-3		PATTERN-4	
NUMBER	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
1	-8.7	105.1	-8.7	66.9	-5.7	105.1	-9.7	114.1
2	-123.8	120.5	-85.4	117.9	-121.5	83.5	-137.3	133.6

3	-100.3	8.7	-100.3	5.7	-63.1	8.7	-108.4	9.7

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---- STATICS PRINT-OUT FOR GRAVITY/LATERAL LOAD ANALYSIS ----
****

J O I N T   M O M E N T S (ft - kips)

JOINT	PATTERN-5				PATTERN-6			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-2.0	144.0	-71.0	-71.0	-2.0	144.0	-71.0	-71.0
2	-265.8	256.5	4.7	4.7	-265.8	256.5	4.7	4.7
3	-128.6	2.0	63.3	63.3	-128.6	2.0	63.3	63.3

JOINT	PATTERN-7				PATTERN-8			
NUMBER	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM
1	-3.9	276.9	-136.5	-136.5	-3.9	276.9	-136.5	-136.5
2	-511.1	493.1	9.0	9.0	-511.1	493.1	9.0	9.0
3	-247.3	3.9	121.7	121.7	-247.3	3.9	121.7	121.7

J O I N T   S H E A R S (kips)

JOINT	PATTERN-5		PATTERN-6		PATTERN-7		PATTERN-8	
NUMBER	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
1	-3.7	44.4	-3.7	44.4	-7.3	85.6	-7.3	85.6
2	-53.5	52.0	-53.5	52.0	-103.0	100.2	-103.0	100.2
3	-42.2	3.7	-42.2	3.7	-81.3	7.3	-81.3	7.3

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DESIGN MOMENT ENVELOPES AT CRITICAL SECTIONS FROM SUPPORTS
****

COL NUM	LOAD TYPE		CROSS SECTN	DESIGN MOMENT (ft-k)	DISTANCE CR.SECTN (ft)	LOAD PTRN	MAX.I.P. DISTANCE (ft)	LOAD PTRN
1	TOTL	LEFT	TOP	-3.6	.190	4	1.083	1
			BOT	.0	.000	0	.000	0
		RGHT	TOP	229.4	1.292	4	4.050	2
			BOT	.0	.000	0	4.050	5
	VERT	LEFT	TOP	-3.6	.190	4	1.083	1
			BOT	.0	.000	0	.000	0
		RGHT	TOP	229.4	1.292	4	4.050	2
			BOT	.0	.000	0	.000	0
2	TOTL	LEFT	TOP	-485.8	1.500	4	6.750	2
			BOT	.0	.000	0	6.750	6
		RGHT	TOP	467.2	1.500	4	6.500	3
			BOT	.0	.000	0	6.500	5
	VERT	LEFT	TOP	-485.8	1.500	4	6.750	2
			BOT	.0	.000	0	.000	0
		RGHT	TOP	467.2	1.500	4	6.500	3
			BOT	.0	.000	0	.000	0
3	TOTL	LEFT	TOP	-197.2	1.292	4	3.900	2
			BOT	.0	.000	0	3.900	6
		RGHT	TOP	3.6	.190	4	1.083	1
			BOT	.0	.000	0	.000	0
	VERT	LEFT	TOP	-197.2	1.292	4	3.900	2

	BOT	.0	.000	0	.000	0
RGHT	TOP	3.6	.190	4	1.083	1
	BOT	.0	.000	0	.000	0

--

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DESIGN MOMENT ENVELOPES AT CRITICAL SECTIONS ALONG SPANS
****

SPAN NUM	LOAD TYPE	CRITICAL SECTION (ft)		DESIGN MOMENT (ft-k)	LOAD PTRN	MAX. I.P. DIST LEFT (ft)	LOAD PTRN	MAX. I.P. DIST RGHT (ft)	LOAD PTRN
2	TOTL	12.825	TOP	.0	0	.000	0	.000	0
			BOT	333.4	4	8.775	1	8.775	3
	VERT	12.825	TOP	.0	0	.000	0	.000	0
			BOT	333.4	4	8.775	1	8.775	3
3	TOTL	14.950	TOP	.0	0	.000	0	.000	0
			BOT	304.4	4	9.750	2	7.150	1
	VERT	14.950	TOP	.0	0	.000	0	.000	0
			BOT	304.4	4	9.750	2	7.150	1

--

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DISTRIBUTION OF DESIGN MOMENTS AT SUPPORTS
****

COL NUM	CROSS SECTN	TOTAL MOMENT (ft-k)	TOTAL-VERT DIFFERENCE (ft-k) (%)	COLUMN STRIP MOMENT (ft-k) (%)	BEAM MOMENT (ft-k) (%)	MIDDLE STRIP MOMENT (ft-k) (%)
1	LEFT TOP	-3.6	.0 (0)	-3.5 (98)	.0 (0)	-.1 (1)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT TOP	229.4	.0 (0)	225.9 (98)	.0 (0)	3.5 (1)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
2	LEFT TOP	-485.8	.0 (0)	-364.3 (75)	.0 (0)	-121.4 (25)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT TOP	467.2	.0 (0)	350.4 (75)	.0 (0)	116.8 (25)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
3	LEFT TOP	-197.2	.0 (0)	-194.2 (98)	.0 (0)	-3.0 (1)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	RGHT TOP	3.6	.0 (0)	3.5 (98)	.0 (0)	.1 (1)
	BOT	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)

DISTRIBUTION OF DESIGN MOMENTS IN SPANS
****

SPAN NUM	CROSS SECTN		TOTAL MOMENT (ft-k)	TOTAL-VERT DIFFERENCE (ft-k) (%)	COLUMN STRIP MOMENT (ft-k) (%)	BEAM MOMENT (ft-k) (%)	MIDDLE STRIP MOMENT (ft-k) (%)
2	12.82	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	333.4	.0 (0)	200.1 (60)	.0 (0)	133.4 (40)
	12.82	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	333.4	.0 (0)	200.1 (60)	.0 (0)	133.4 (40)
3	14.95	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
		BOT	304.4	.0 (0)	182.6 (60)	.0 (0)	121.7 (39)

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DISTRIBUTION OF DESIGN MOMENTS IN SPANS
****

SPAN NUM	CROSS SECTN	TOTAL MOMENT (ft-k)	TOTAL-VERT DIFFERENCE (ft-k) (%)	COLUMN STRIP MOMENT (ft-k) (%)	BEAM MOMENT (ft-k) (%)	MIDDLE STRIP MOMENT (ft-k) (%)
14.95	TOP	.0	.0 (0)	.0 (0)	.0 (0)	.0 (0)
	BOT	304.4	.0 (0)	182.6 (60)	.0 (0)	121.7 (40)

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S H E A R   A N A L Y S I S
****

NOTE--Allowable shear stress in slabs = 252.96 psi when ratio of col. dim. (long/short) is less than 2.0.

--Wide beam shear (see "CODE") is not computed, check manually.

--After the column numbers, C = Corner, E = Exterior, I = Interior.

D I R E C T   S H E A R   W I T H   T R A N S F E R   O F   M O M E N T
A R O U N D   C O L U M N

COL. NO.	ALLOW. STRESS (psi)	PATT NO.	REACTION (kips)	SHEAR STRESS (psi)	PATT NO.	REACTION (kips)	UNBAL. MOMENT (ft-k)	SHEAR TRANSFR (ft-k)	SHEAR STRESS (psi)
1E	252.96	4	120.9	145.51	4	120.9	245.9	91.6	246.95
2I	247.27	4	267.0	207.59	4	267.0	-24.1	-9.6	213.59
3E	252.96	4	115.2	138.64	4	115.2	-211.7	-78.9	226.00

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N E G A T I V E   R E I N F O R C E M E N T
****

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1	4	|| R	229.4	6.15	13.5	2.92	13.5
2	4	L ||	-485.8	10.22	13.0	3.24	14.0
3	4	L ||	-197.2	5.26	13.0	3.02	14.0

P O S I T I V E   R E I N F O R C E M E N T
****

SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	4	12.8	333.4	5.42	13.5	3.57	13.5
3	4	14.9	304.4	4.94	13.0	3.25	14.0

```
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                         D E S I G N   R E S U L T S
                         ***************************


    NOTE--The schedule given below is a guide for proper reinforcement
          placement and is based on reasonable engineering judgement.
          Unusual boundary and/or loading conditions may require
          modification of this schedule.


                   N E G A T I V E   R E I N F O R C E M E N T
                   ********************************************

        *          C O L U M N    S T R I P          *M I D D L E   S T R
I P
        *     LONG   BARS      *     SHORT   BARS      *     LONG   BARS
 COLUMN * -B A R - L E N G T H- * -B A R - L E N G T H- * -B A R - L E N G T
H-
 NUMBER * NO  SIZE LEFT   RIGHT * NO  SIZE LEFT   RIGHT * NO  SIZE LEFT
RIGHT
        *          (ft)   (ft)  *          (ft)   (ft)  *          (ft)
(ft)
 -----------------------------------------------------------------------------
---
    1     10   # 5  1.08   8.53   10   # 5  1.08   6.05   15   # 4  1.08
6.55
    2      9   # 7  8.53   8.53    8   # 7  6.05   6.05   16   # 4  8.30
8.05
    3      9   # 5  8.23   1.08    8   # 5  5.85   1.08   15   # 4  6.33
1.08


                  P O S I T I V E   R E I N F O R C E M E N T
                  ********************************************

        *   C O L U M N     S T R I P   *   M I D  D L E     S T R I P
        *   LONG   BARS   *   SHORT  BARS   *   LONG   BARS   *   SHORT  BARS
 SPAN   * ---- B A R ---- * ---- B A R ---- * ---- B A R ---- * ---- B A R --
--
 NUMBER * NO  SIZE LENGTH * NO  SIZE LENGTH * NO  SIZE LENGTH * NO  SIZE
LENGTH
        *           (ft)  *           (ft)  *           (ft)  *
(ft)
```

```
 -----------------------------------------------------------------------------
---
    2      9   # 5  26.17    9   # 5  23.04    9   # 4  26.67    9   # 4
22.37
    3      8   # 5  25.17    8   # 5  22.17    9   # 4  25.67    8   # 4
21.52



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       A D D I T I O N A L   I N F O R M A T I O N   A T  S U P P O R T S
       ******************************************************************

        * REINF. SUMMARY* ADD'L R/F REQ'D DUE TO UNBALANCED (U.) MOMENT
TRANSFER
 COLUMN * --------------* -----------------------------------------------------
---
 NUMBER * W/O U. MOMENT * MAX.U. *GAMMA* FLEXURAL  *PATT* CRITICAL    SECTION
        * REQ'D - PROV'D* MOMENT * -f  * TRANSFER  *NO. * SLABW  - AREA -
R/F
        *(sq.in) (sq.in)* (ft-k) *     *  (ft-k) *    * (ft)   (sq.in)
-----------------------------------------------------------------------------
--
   1       9.06     9.20   364.0    .63    228.4      4     5.5    6.67 14  #
5
   2      13.46*   13.40  -120.7    .60    -72.4      3     5.5    1.95  0  #
7
   3       8.28*    8.27  -324.4    .63   -203.6      4     5.5    5.86 12  #
5

 NOTE: Zero transfer "CRITICAL SLABW" indicates no support dimensions
       given for transfer.
       If beam(s) are present, transfer mode may be due to beam shear
       and/or torsion, check manually.

 * - Indicates REQ'D reinforcement is greater than PROV'D (check bar
selection)
```

A D D I T I O N A L   I N F O R M A T I O N   F O R
I N - S P A N   C O N D I T I O N S
****

SPAN NUMBER	REINF. SUMMARY AT MIDSPAN REQ'D. (sq.in)	PROV'D. (sq.in)	TOTAL FACTORED SPAN STATIC DESIGN MOMENT (W/O PARTIAL LOADS) (ft-k)
2	8.99	9.18	672.6
3	8.18	8.36	617.7

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D E F L E C T I O N   A N A L Y S I S
****

NOTES--The deflections below must be combined with those of the analysis in the perpendicular direction. Consult users manual for method of combination and limitations.

--Spans 1 and 4 are cantilevers.

--Time-dependent deflections are in addition to those shown and must be computed as a multiplier of the dead load(DL) deflection. See "CODE" for range of multipliers.

--Deflections due to concentrated or partialloads may be larger at the point of application than those shown at the centerline. Deflections are computed as from an average uniform loading derived from the sum of all loads applied to the span.

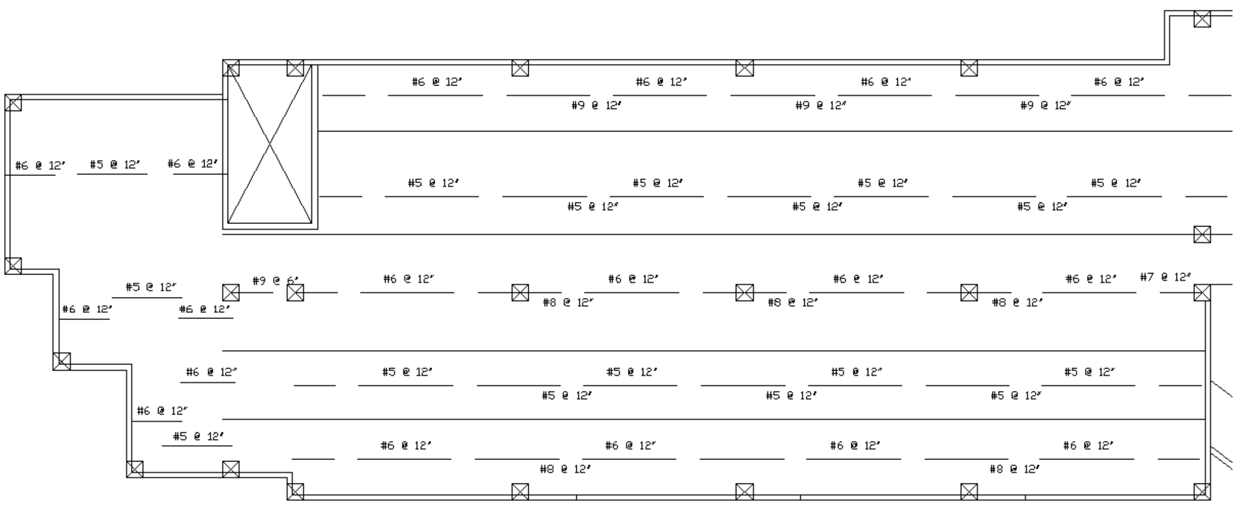
--Modulus of elasticity of concrete, Ec = 3834. ksi

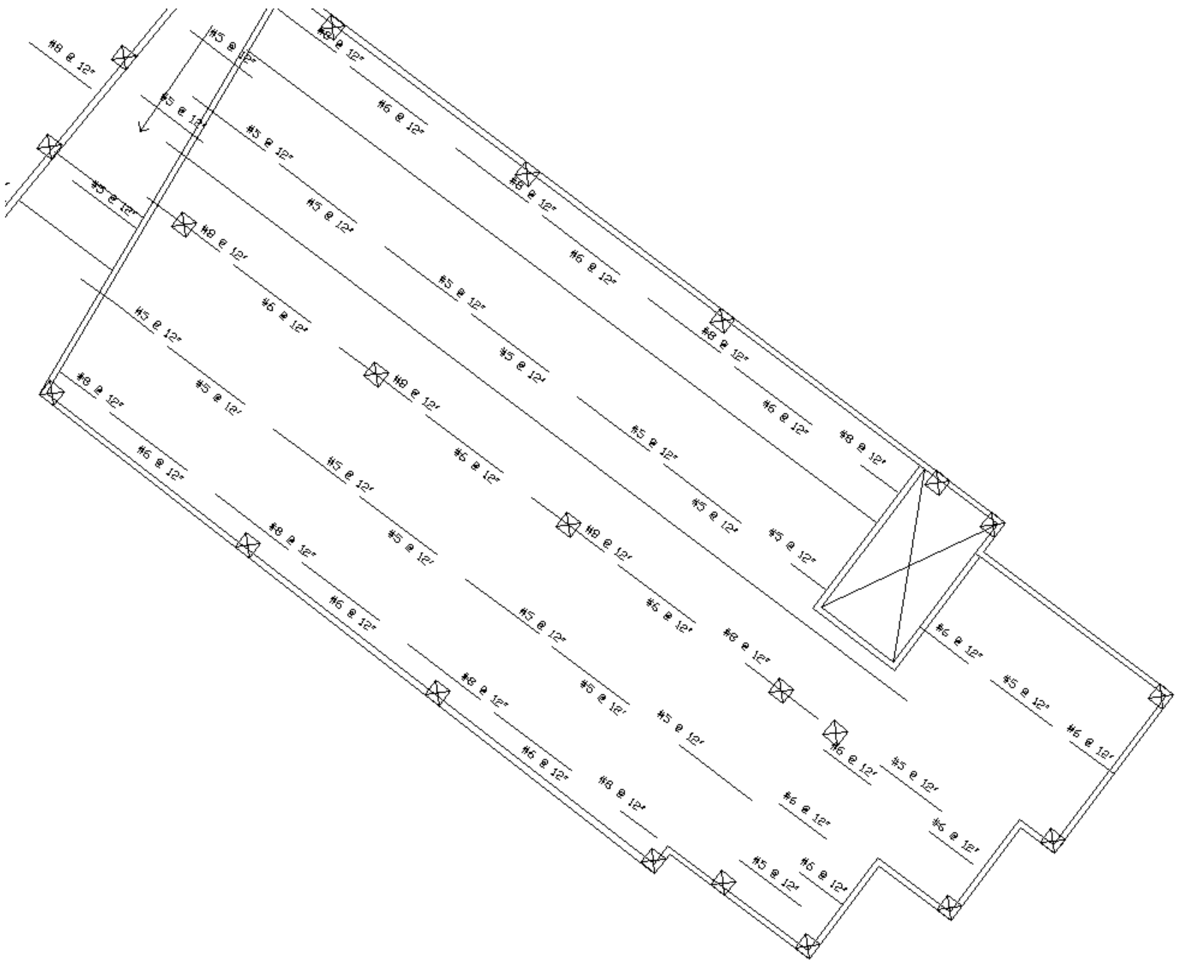
SPAN NUMBER	DEAD LOAD Ieff. (in^4)	COLUMN STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)	MIDDLE STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)
1	27000.	-.011	-.006	-.017	-.011	-.006	-.017
2	23940.	.190	.141	.331	.092	.063	.155
3	24151.	.164	.106	.269	.073	.045	.119


```
  4       27000.    -.010    -.005    -.015     -.010    -.005    -.015


                    Q U A N T I T Y   E S T I M A T E S
                    ***********************************

          TOTAL QUANTITIES
          ----------------
          CONCRETE        ....       46.0 cu.yd
          FORMWORK        ....     1490.  sq.ft
          REINFORCEMENT (IN THE DIRECTION OF ANALYSIS)
           (NEGATIVE)     ....     1157.  lbs
           (POSITIVE)     ....     1421.  lbs

          SUMMARY OF QUANTITIES
          ---------------------
          CONCRETE        ....        .83  cu.ft/sq.ft
          FORMWORK        ....       1.00  sq.ft/sq.ft
          REINFORCEMENT** ....       1.73  lbs / sq.ft

            **(IN THE DIRECTION OF ANALYSIS)

                       * Program completed as requested *
```

Reinforcement Layouts

First Floor EW

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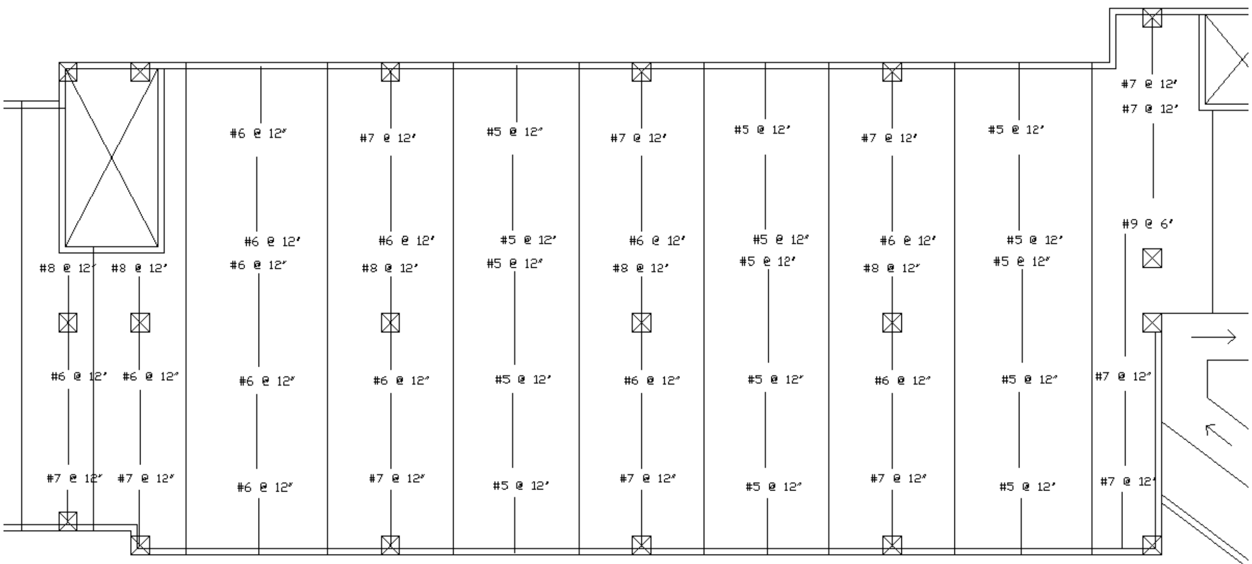
First Floor NS



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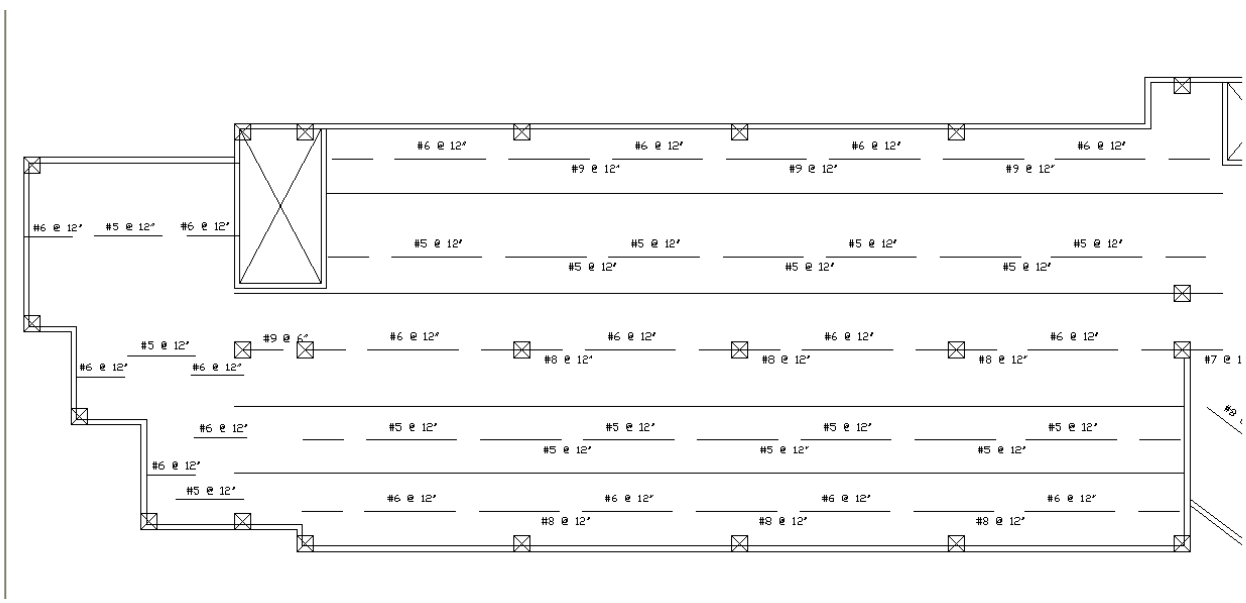
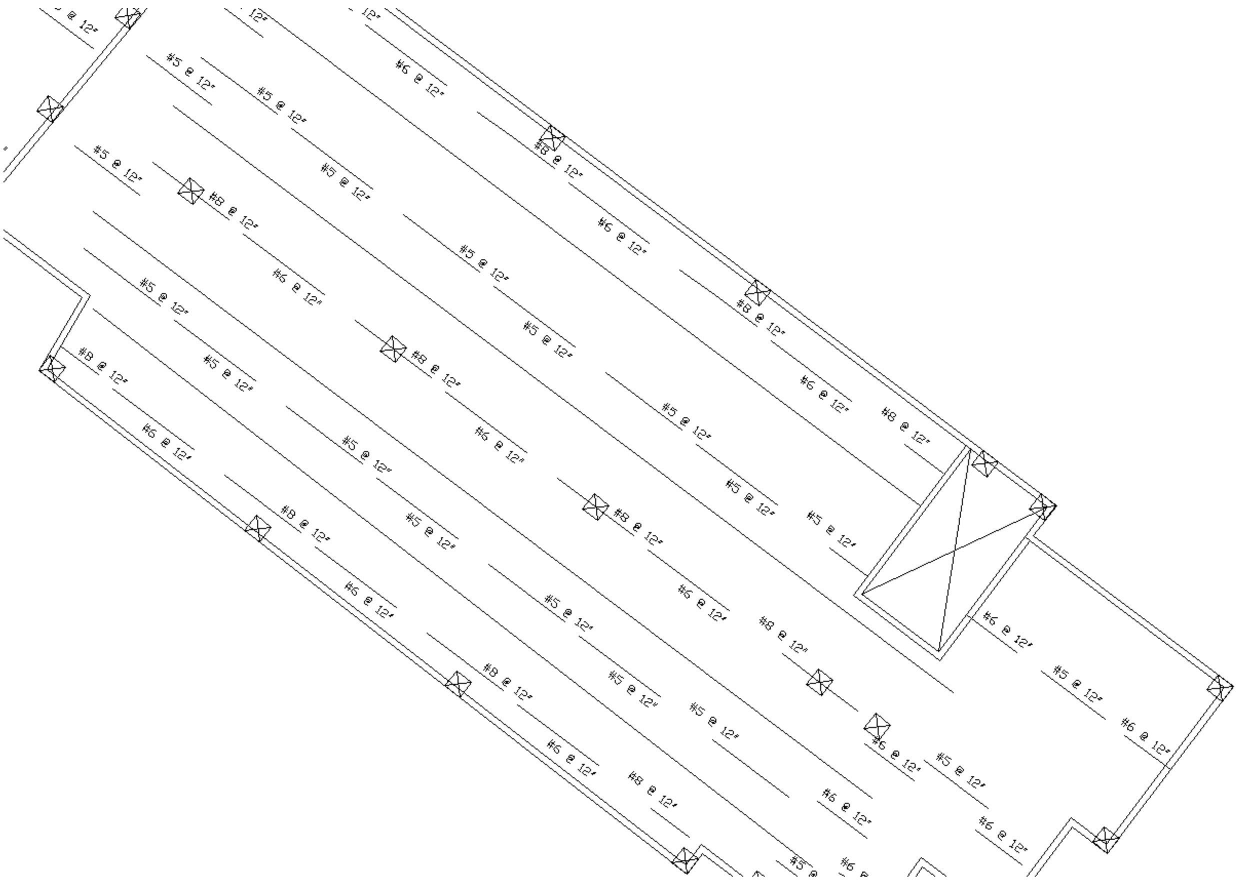
Second-Eighth Floors EW





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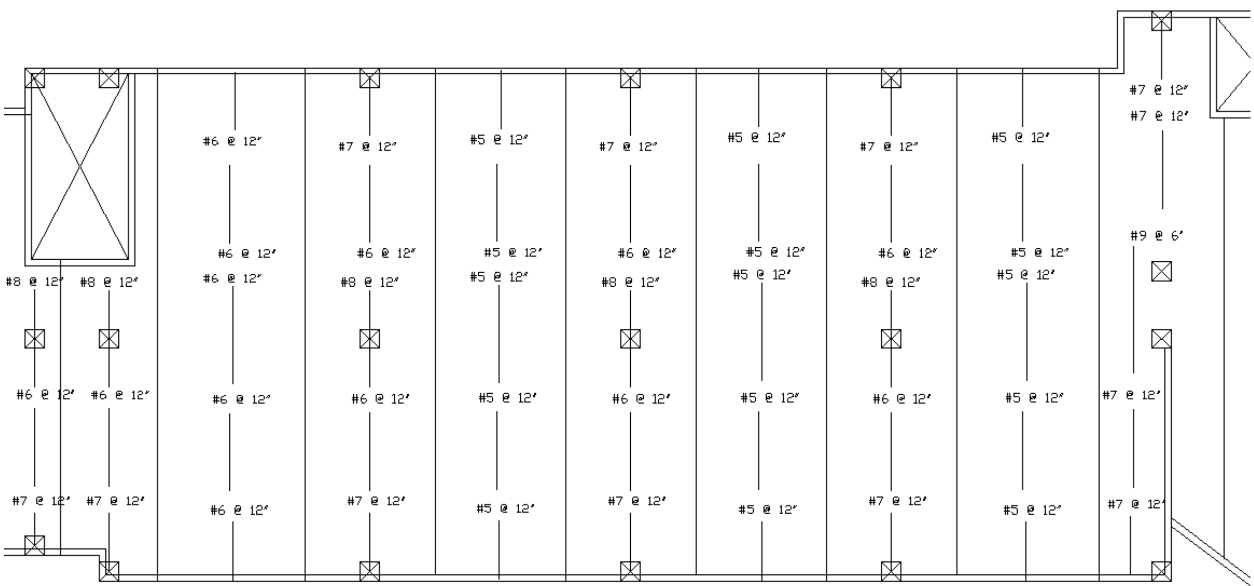
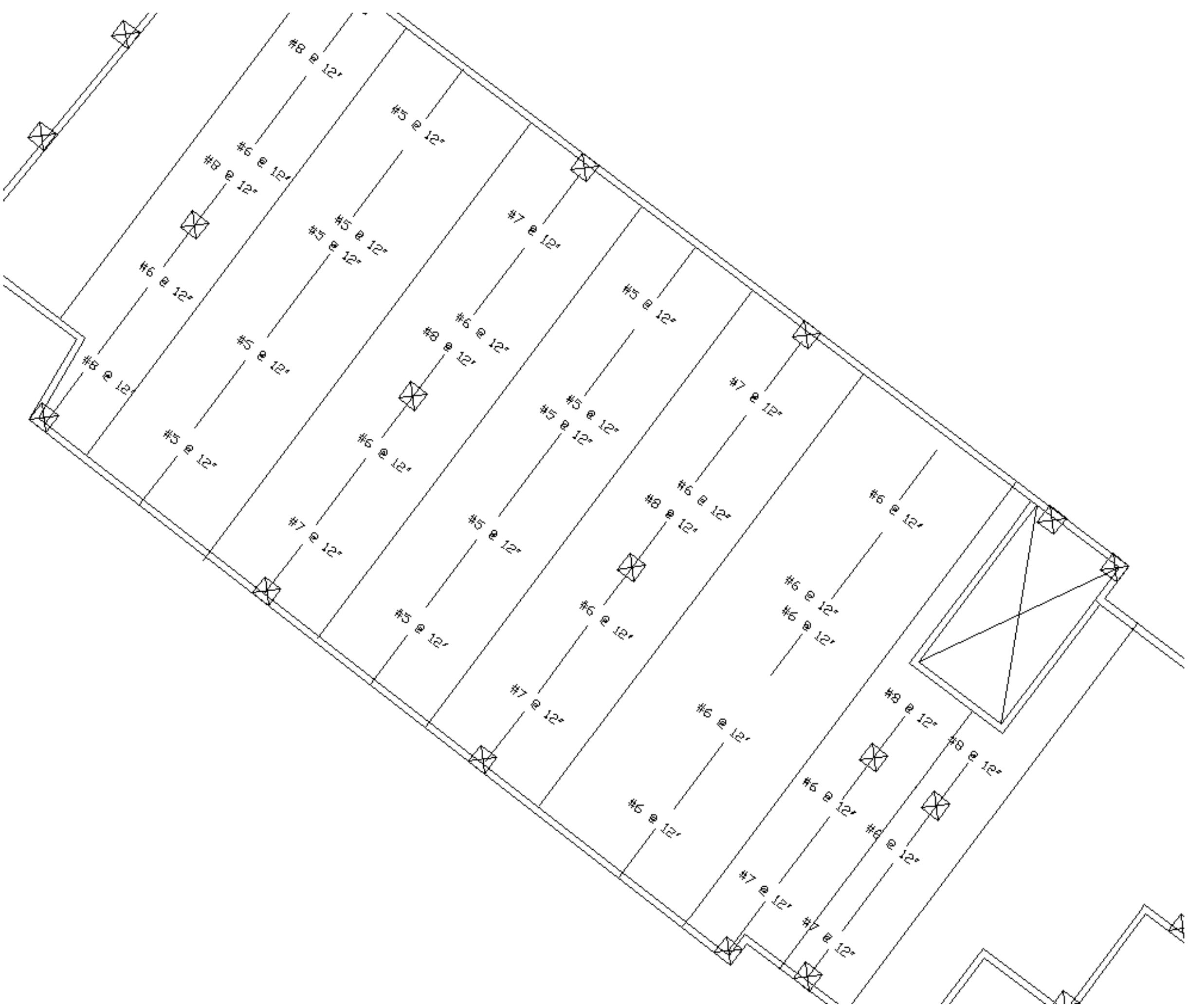
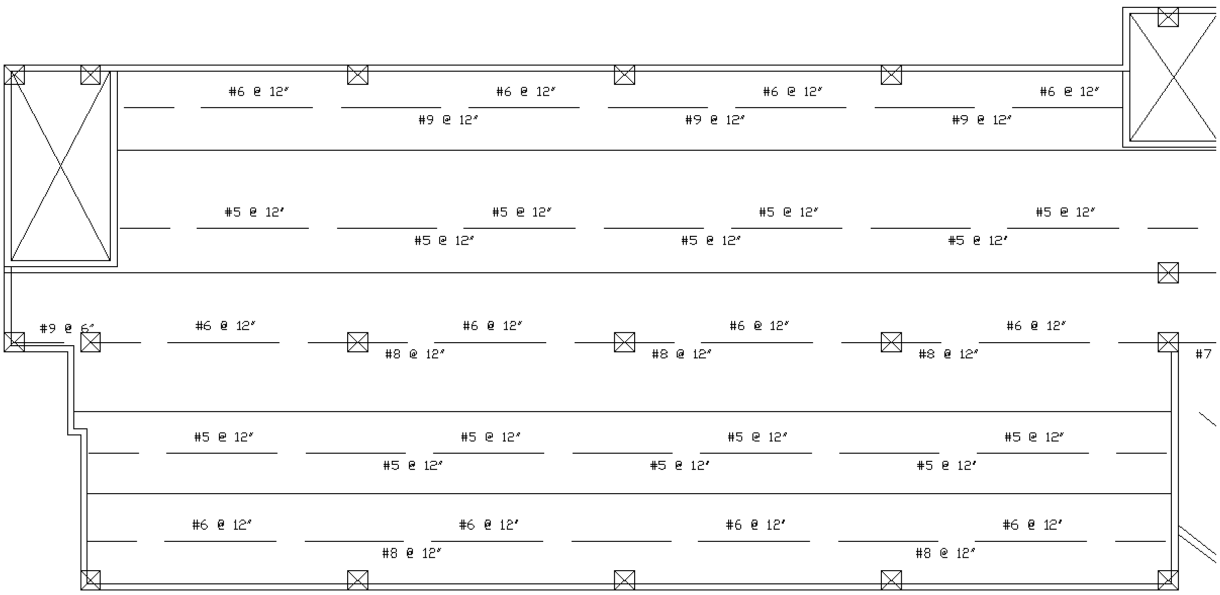
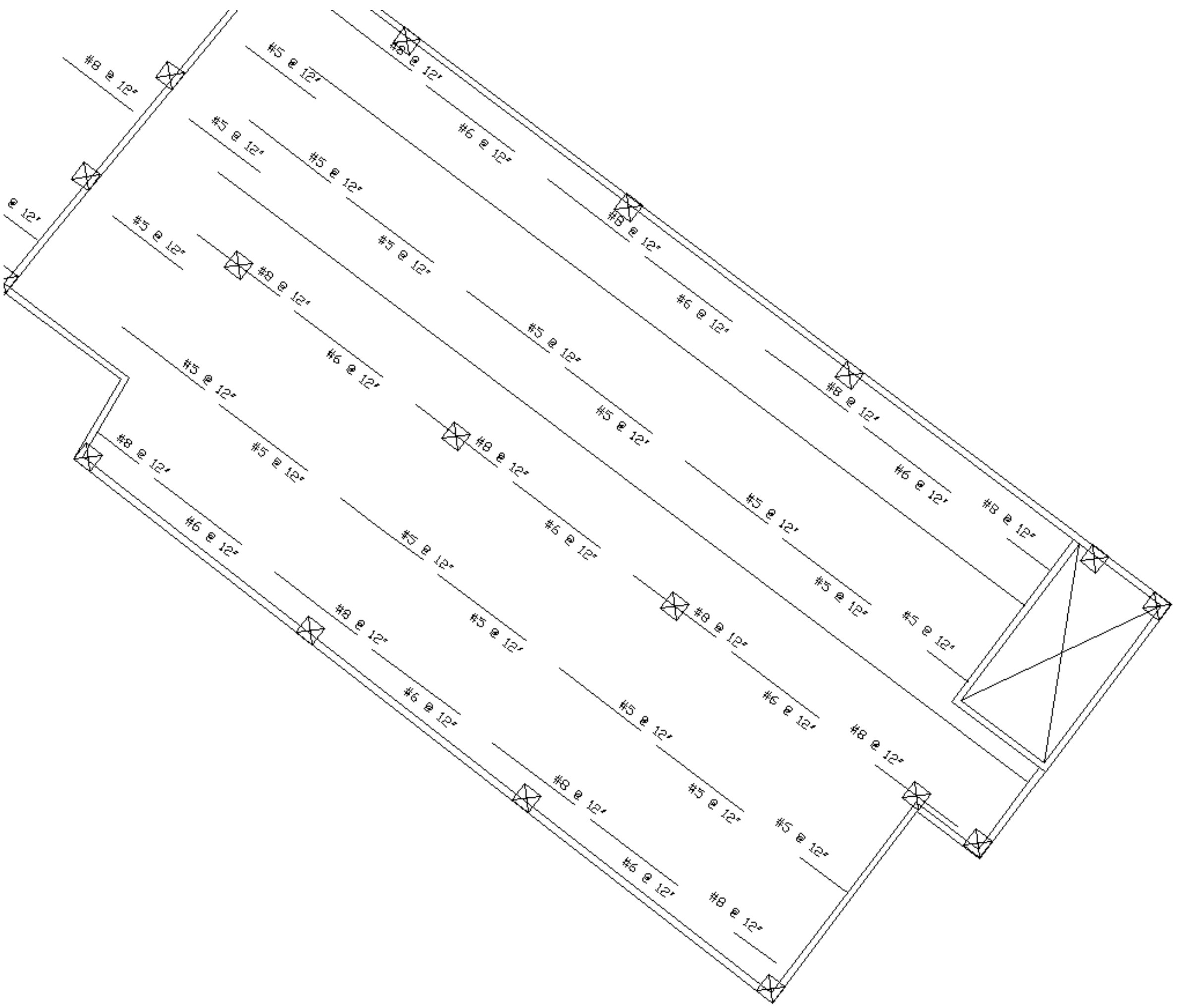
Second-Eighth Floors NS





Ninth Floor EW





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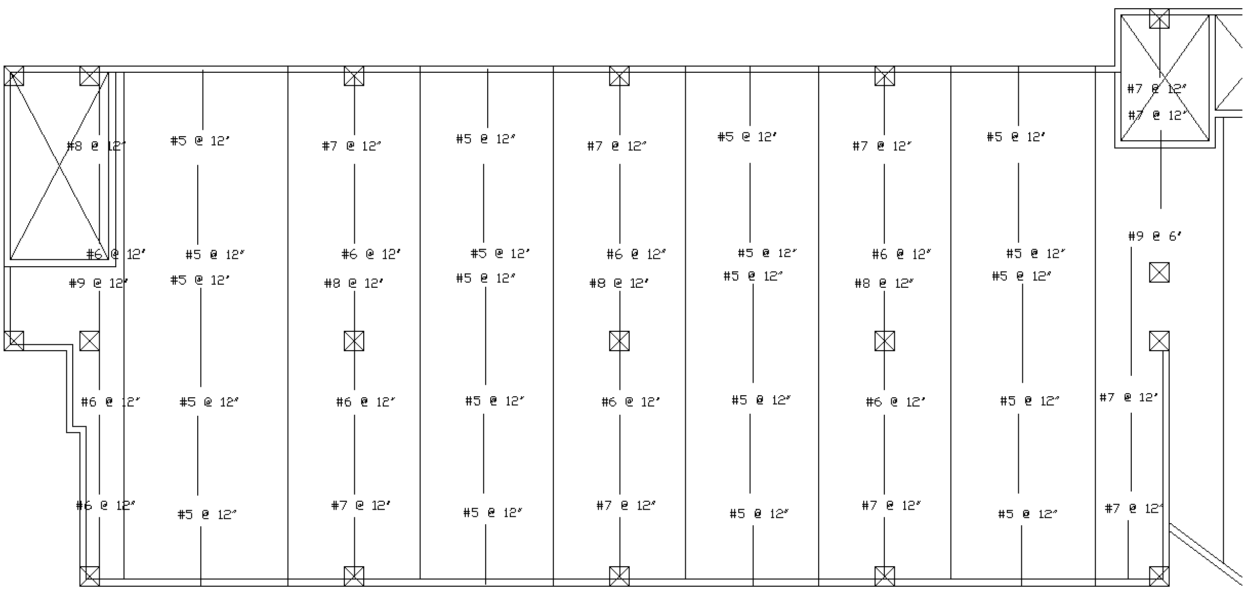
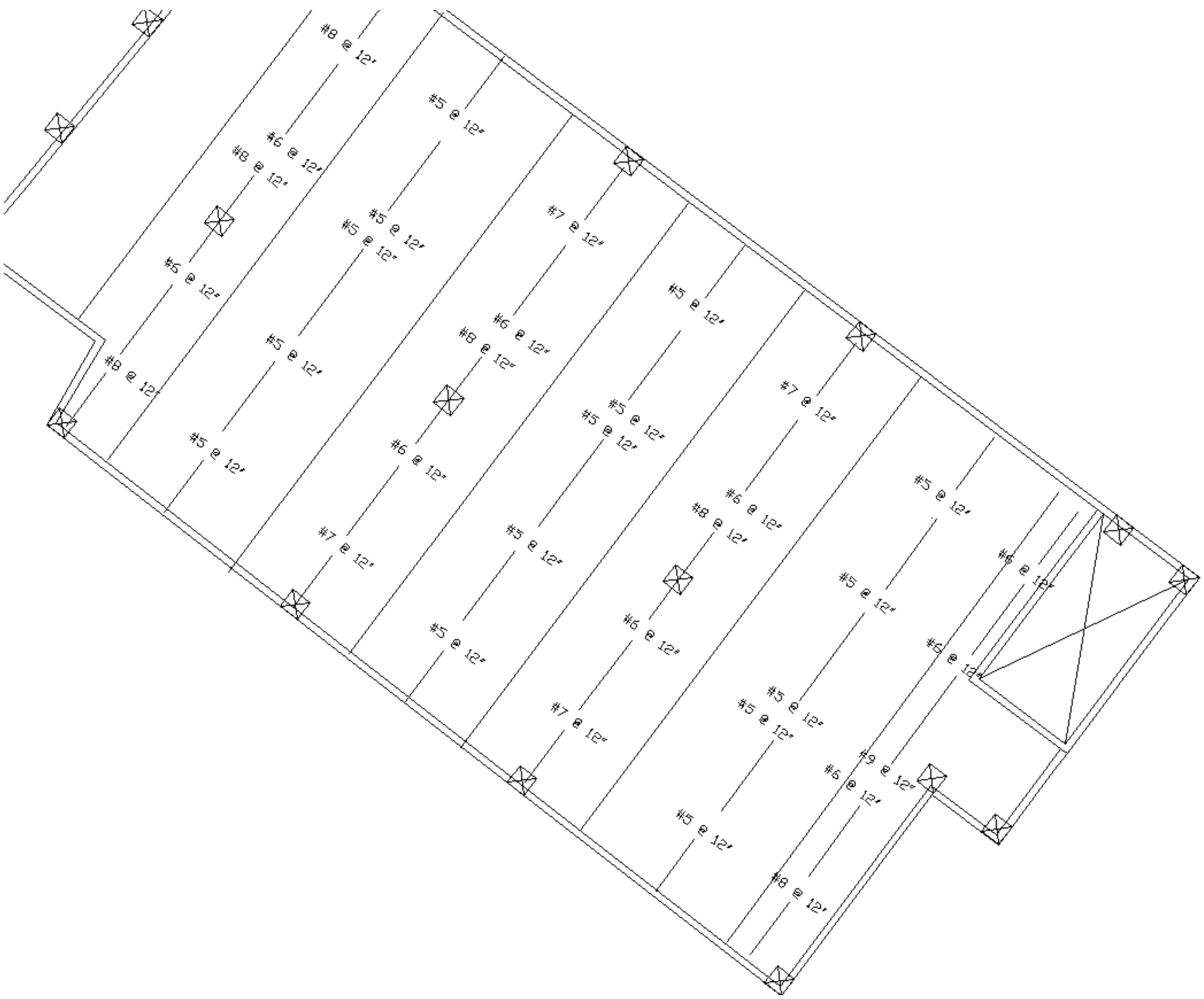
Ninth Floor NS





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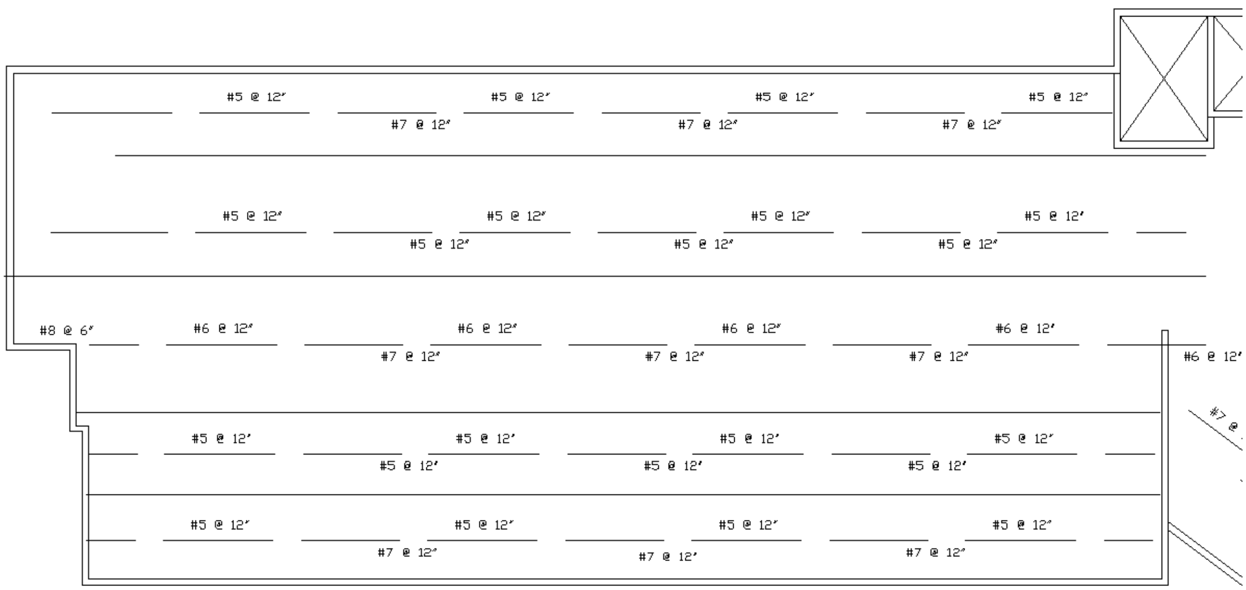
Roof EW



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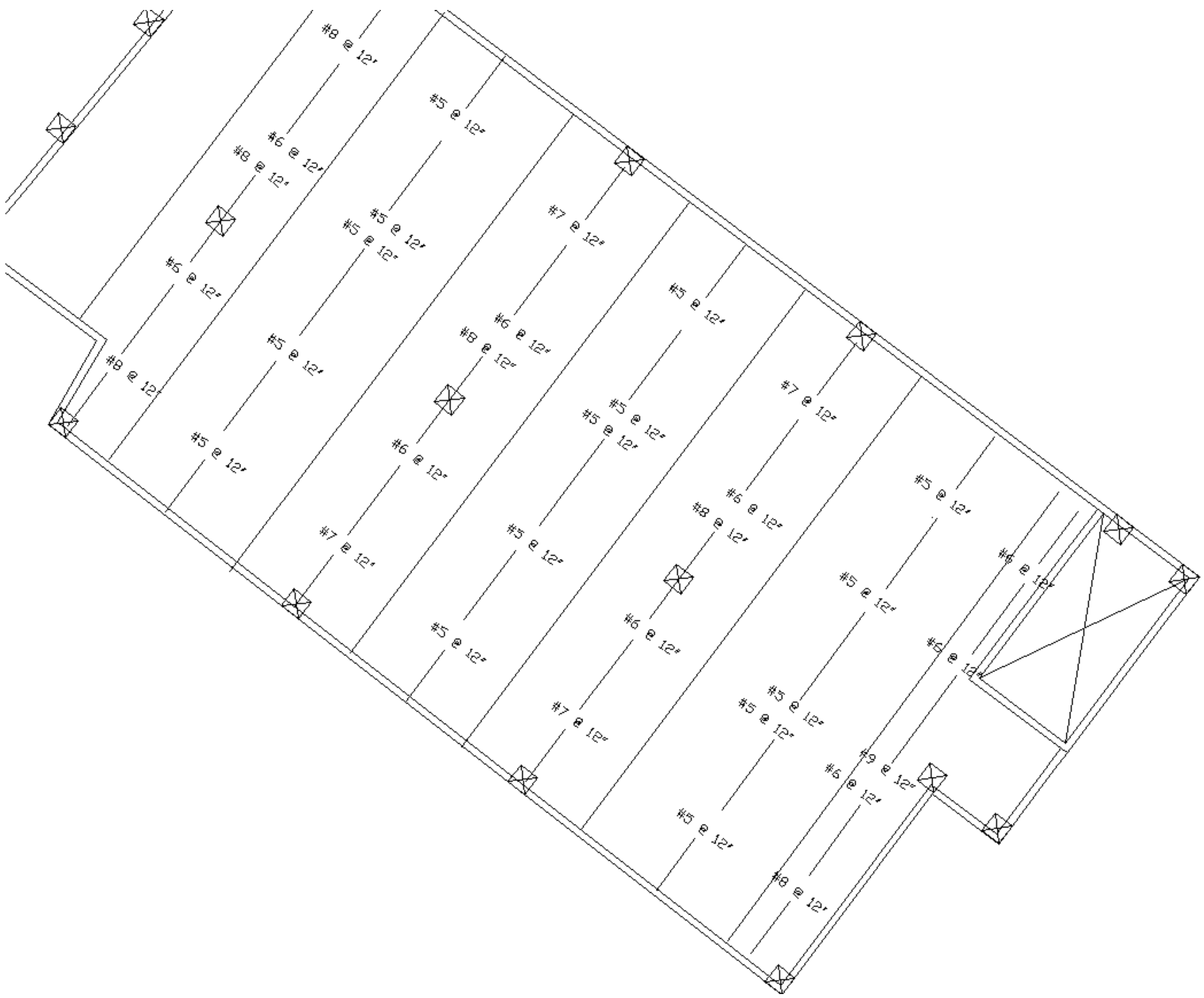
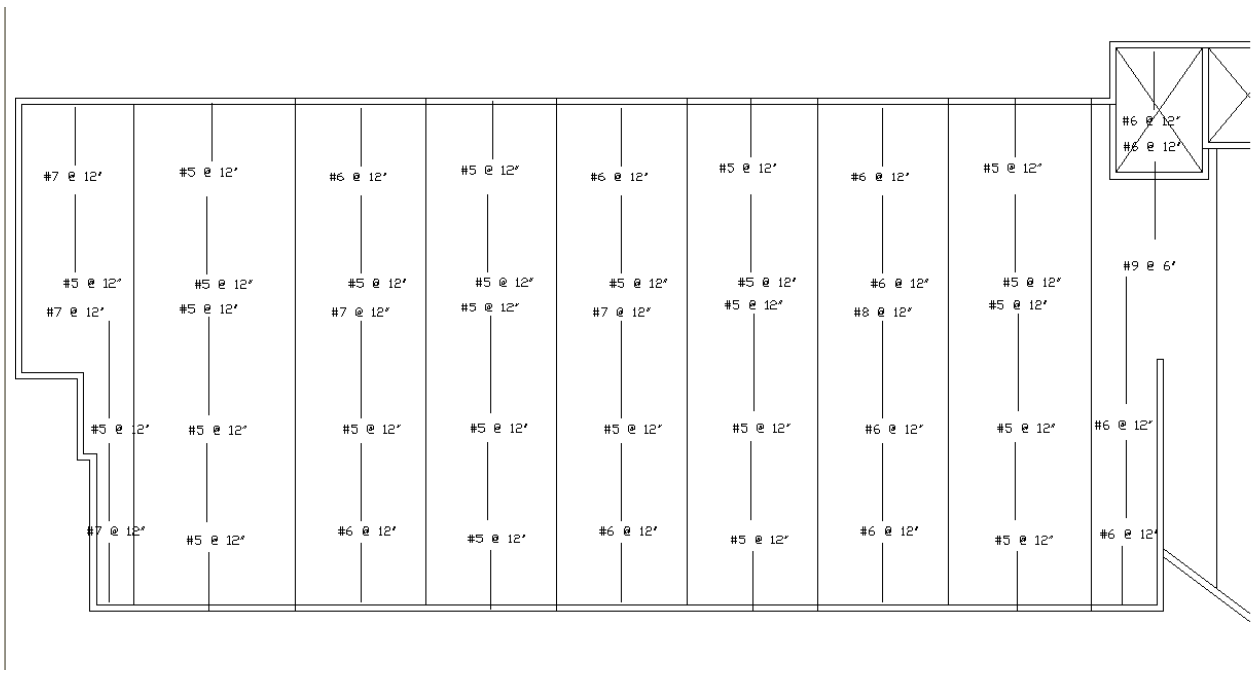


Roof NS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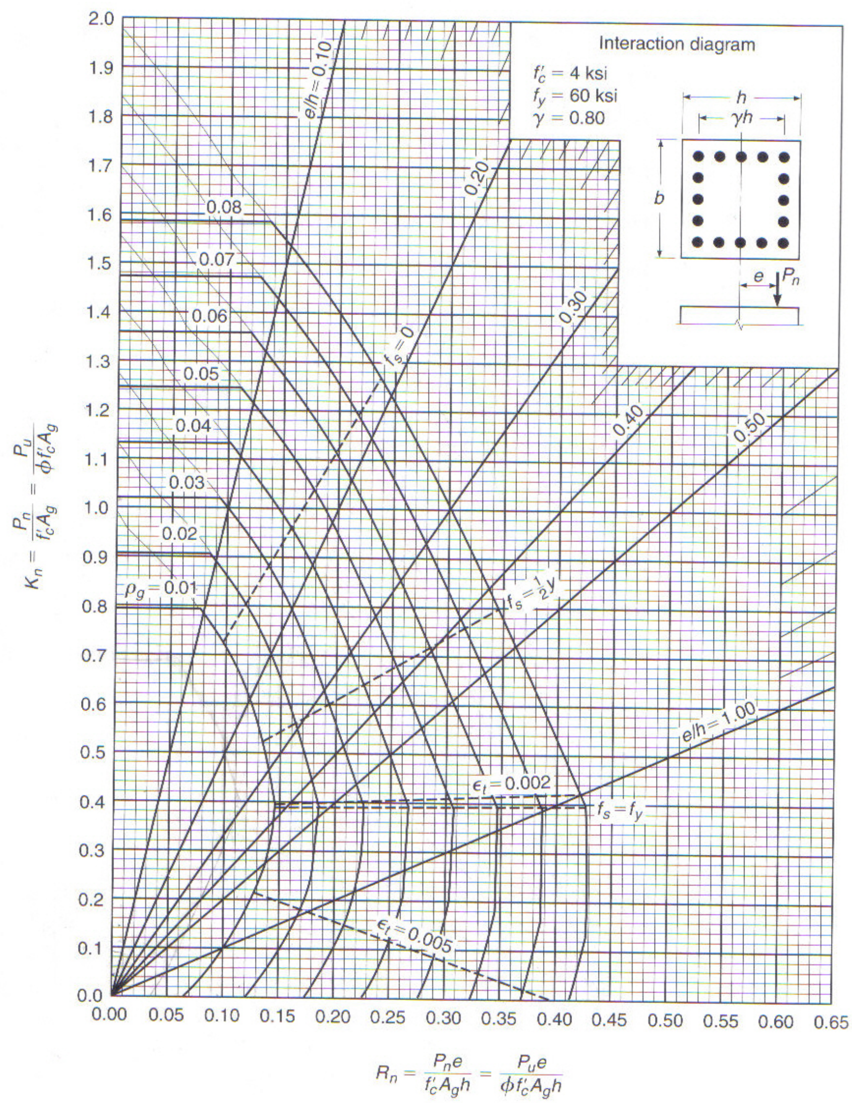
Interaction Diagram



GRAPH A.7
Column strength interaction diagram for rectangular section with bars on four faces and $\gamma = 0.80$ (for instructional use only).

Roof Column Schedule

Column	A_{trib} (ft^2)	P (lb)	M_{Unbal}	Size (in x in)	Reinfor.	Ties
A-6	378	72576	241.7	26 X 26	12-#7	#3@14"
A-6.5	135	25920	355.2	26 X 26	12-#7	#3@14"
B.3-0	0	0	0	26 X 26	-	-
B-1	75	14400	245.7	26 X 26	12-#7	#3@14"
B-2	280	53760	245.7	26 X 26	12-#7	#3@14"
B-3	405	77760	244.9	26 X 26	12-#7	#3@14"
B-4	405	103680	239.5	26 X 26	12-#7	#3@14"
B-5	405	103680	244.9	26 X 26	12-#7	#3@14"
B.6-6.5	-	50000	355.2	26 X 26	12-#7	#3@14"
B.7-6	168	32256	344	26 X 26	12-#7	#3@14"
B.8-0	0	0	0	26 X 26	-	-
C.3-6.2	-	50000	355.2	26 X 26	12-#7	#3@14"
C.4-0.3	0	0	0	26 X 26	-	#3@14"
C-1	75	14400	344.4	26 X 26	12-#7	#3@14"
C-2	680	130560	485.8	26 X 26	12-#7	#3@14"
C-3	702	134784	485.8	26 X 26	12-#7	#3@14"
C-4	702	179712	485.8	26 X 26	12-#7	#3@14"
C-5	702	179712	485.8	26 X 26	12-#7	#3@14"
C-6	304	58368	350.6	26 X 26	12-#7	#3@14"
D-0.6	0	0	0	26 X 26	-	-
D-1	0	0	0	26 X 26	-	-
E-2	175.5	33696	197.2	26 X 26	12-#7	#3@14"
E-3	336	64512	248.2	26 X 26	12-#7	#3@14"
E-4	336	86016	228.2	26 X 26	12-#7	#3@14"
E-5	336	86016	268.4	26 X 26	12-#7	#3@14"
E-6	312	59904	197.2	26 X 26	12-#7	#3@14"
E.5-6.8	84	16128	355.2	26 X 26	12-#7	#3@14"
F-6.8	90	17280	355.8	26 X 26	12-#7	#3@14"
F-7	67.5	12960	245.7	26 X 26	12-#7	#3@14"
F-8	405	77760	244.5	26 X 26	12-#7	#3@14"
F-9	405	77760	244.9	26 X 26	12-#7	#3@14"
F-10	240	46080	241.7	26 X 26	12-#7	#3@14"
F-11	285	54720	245.7	26 X 26	12-#7	#3@14"
F.2-12	0	0	0	26 X 26	-	-
F.5-6.8	90	17280	355.2	26 X 26	12-#7	#3@14"
F.6-12	0	0	0	26 X 26	-	-
G-7	81	15552	344.4	26 X 26	12-#7	#3@14"
G-8	702	134784	485.8	26 X 26	12-#7	#3@14"
G-9	702	134784	485.8	26 X 26	12-#7	#3@14"
G-10	420	80640	485.8	26 X 26	12-#7	#3@14"
G-11	280	53760	344.4	26 X 26	12-#7	#3@14"
G.1-6.8	90	17280	355.2	26 X 26	12-#7	#3@14"
G.3-11.7	0	0	0	26 X 26	-	-
G.6-6.8	84	16128	355.2	26 X 26	12-#7	#3@14"
H-11	0	0	0	26 X 26	-	-
H-11.5	0	0	0	26 X 26	-	-
I-7	204	39168	220.4	26 X 26	12-#7	#3@14"
I-8	336	64512	265	26 X 26	12-#7	#3@14"
I-9	336	64512	246	26 X 26	12-#7	#3@14"
I-10	97.5	18720	220.4	26 X 26	12-#7	#3@14"

Ninth Floor Column Schedule

A-6	378	175392	241.7	26X26	12-#7	#3@14"
A-6.5	135	62640	355.2	26X26	12-#7	#3@14"
B.3-0	0	0	0	26X26	-	-
B-1	75	34800	245.7	26X26	12-#7	#3@14"
B-2	280	129920	245.7	26X26	12-#7	#3@14"
B-3	405	187920	244.9	26X26	12-#7	#3@14"
B-4	405	213840	239.5	26X26	12-#7	#3@14"
B-5	405	213840	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	100000	355.2	26X26	12-#7	#3@14"
B.7-6	168	77952	344	26X26	12-#7	#3@14"
B.8-0	0	0	0	26X26	-	-
C.3-6.2	-	100000	355.2	26X26	12-#7	#3@14"
C.4-0.3	0	0	0	26X26	-	-
C-1	75	34800	344.4	26X26	12-#7	#3@14"
C-2	680	315520	485.8	26X26	12-#7	#3@14"
C-3	702	325728	485.8	26X26	12-#7	#3@14"
C-4	702	370656	485.8	26X26	12-#7	#3@14"
C-5	702	370656	485.8	26X26	12-#7	#3@14"
C-6	304	141056	350.6	26X26	12-#7	#3@14"
D-0.6	0	0	0	26X26	-	-
D-1	0	0	0	26X26	-	-
E-2	175.5	81432	197.2	26X26	12-#7	#3@14"
E-3	336	155904	248.2	26X26	12-#7	#3@14"
E-4	336	177408	228.2	26X26	12-#7	#3@14"
E-5	336	177408	268.4	26X26	12-#7	#3@14"
E-6	312	144768	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	38976	355.2	26X26	12-#7	#3@14"
F-6.8	90	41760	355.8	26X26	12-#7	#3@14"
F-7	67.5	31320	245.7	26X26	12-#7	#3@14"
F-8	405	187920	244.5	26X26	12-#7	#3@14"
F-9	405	187920	244.9	26X26	12-#7	#3@14"
F-10	240	111360	241.7	26X26	12-#7	#3@14"
F-11	285	132240	245.7	26X26	12-#7	#3@14"
F.2-12	0	0	0	26X26	-	-
F.5-6.8	90	41760	355.2	26X26	12-#7	#3@14"
F.6-12	0	0	0	26X26	-	-
G-7	81	37584	344.4	26X26	12-#7	#3@14"
G-8	702	325728	485.8	26X26	12-#7	#3@14"
G-9	702	325728	485.8	26X26	12-#7	#3@14"
G-10	420	194880	485.8	26X26	12-#7	#3@14"
G-11	280	129920	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	41760	355.2	26X26	12-#7	#3@14"
G.3-11.7	0	0	0	26X26	-	-
G.6-6.8	84	38976	355.2	26X26	12-#7	#3@14"
H-11	0	0	0	26X26	-	-
H-11.5	0	0	0	26X26	-	-
I-7	204	94656	220.4	26X26	12-#7	#3@14"
I-8	336	155904	265	26X26	12-#7	#3@14"
I-9	336	155904	246	26X26	12-#7	#3@14"
I-10	97.5	45240	220.4	26X26	12-#7	#3@14"

Eight Floor Column Schedule

A-6	378	278208	241.7	26X26	12-#7	#3@14"
A-6.5	135	99360	355.2	26X26	12-#7	#3@14"
B.3-0	130	35360	114.9	26X26	12-#7	#3@14"
B-1	255	104160	245.7	26X26	12-#7	#3@14"
B-2	280	206080	245.7	26X26	12-#7	#3@14"
B-3	405	298080	244.9	26X26	12-#7	#3@14"
B-4	405	324000	239.5	26X26	12-#7	#3@14"
B-5	405	324000	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	150000	355.2	26X26	12-#7	#3@14"
B.7-6	168	123648	344	26X26	12-#7	#3@14"
B.8-0	78	21216	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	150000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	16320	114.9	26X26	12-#7	#3@14"
C-1	205	90560	344.4	26X26	12-#7	#3@14"
C-2	680	500480	485.8	26X26	12-#7	#3@14"
C-3	702	516672	485.8	26X26	12-#7	#3@14"
C-4	702	561600	485.8	26X26	12-#7	#3@14"
C-5	702	561600	485.8	26X26	12-#7	#3@14"
C-6	304	223744	350.6	26X26	12-#7	#3@14"
D-0.6	91	24752	114.9	26X26	12-#7	#3@14"
D-1	130	35360	220.4	26X26	12-#7	#3@14"
E-2	180	130392	197.2	26X26	12-#7	#3@14"
E-3	336	247296	248.2	26X26	12-#7	#3@14"
E-4	336	268800	228.2	26X26	12-#7	#3@14"
E-5	336	268800	268.4	26X26	12-#7	#3@14"
E-6	312	229632	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	61824	355.2	26X26	12-#7	#3@14"
F-6.8	90	66240	355.8	26X26	12-#7	#3@14"
F-7	67.5	49680	245.7	26X26	12-#7	#3@14"
F-8	405	298080	244.5	26X26	12-#7	#3@14"
F-9	405	298080	244.9	26X26	12-#7	#3@14"
F-10	240	176640	241.7	26X26	12-#7	#3@14"
F-11	285	209760	245.7	26X26	12-#7	#3@14"
F.2-12	210	57120	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	66240	355.2	26X26	12-#7	#3@14"
F.6-12	78	21216	114.2	26X26	12-#7	#3@14"
G-7	81	59616	344.4	26X26	12-#7	#3@14"
G-8	702	516672	485.8	26X26	12-#7	#3@14"
G-9	702	516672	485.8	26X26	12-#7	#3@14"
G-10	420	309120	485.8	26X26	12-#7	#3@14"
G-11	280	206080	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	66240	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	55760	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	61824	355.2	26X26	12-#7	#3@14"
H-11	132	35904	220.4	26X26	12-#7	#3@14"
H-11.5	84	22848	114.9	26X26	12-#7	#3@14"
I-7	204	150144	220.4	26X26	12-#7	#3@14"
I-8	336	247296	265	26X26	12-#7	#3@14"
I-9	336	247296	246	26X26	12-#7	#3@14"
I-10	144	84408	220.4	26X26	12-#7	#3@14"

Seventh Floor Column Schedule

A-6	378	381024	241.7	26X26	12-#7	#3@14"
A-6.5	135	136080	355.2	26X26	12-#7	#3@14"
B.3-0	130	70720	114.9	26X26	12-#7	#3@14"
B-1	255	173520	245.7	26X26	12-#7	#3@14"
B-2	280	282240	245.7	26X26	12-#7	#3@14"
B-3	405	408240	244.9	26X26	12-#7	#3@14"
B-4	405	434160	239.5	26X26	12-#7	#3@14"
B-5	405	434160	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	200000	355.2	26X26	12-#7	#3@14"
B.7-6	168	169344	344	26X26	12-#7	#3@14"
B.8-0	78	42432	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	200000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	32640	114.9	26X26	12-#7	#3@14"
C-1	205	146320	344.4	26X26	12-#7	#3@14"
C-2	680	685440	485.8	26X26	12-#7	#3@14"
C-3	702	707616	485.8	26X26	12-#7	#3@14"
C-4	702	752544	485.8	26X26	12-#7	#3@14"
C-5	702	752544	485.8	26X26	12-#7	#3@14"
C-6	304	306432	350.6	26X26	12-#7	#3@14"
D-0.6	91	49504	114.9	26X26	12-#7	#3@14"
D-1	130	70720	220.4	26X26	12-#7	#3@14"
E-2	180	179352	197.2	26X26	12-#7	#3@14"
E-3	336	338688	248.2	26X26	12-#7	#3@14"
E-4	336	360192	228.2	26X26	12-#7	#3@14"
E-5	336	360192	268.4	26X26	12-#7	#3@14"
E-6	312	314496	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	84672	355.2	26X26	12-#7	#3@14"
F-6.8	90	90720	355.8	26X26	12-#7	#3@14"
F-7	67.5	68040	245.7	26X26	12-#7	#3@14"
F-8	405	408240	244.5	26X26	12-#7	#3@14"
F-9	405	408240	244.9	26X26	12-#7	#3@14"
F-10	240	241920	241.7	26X26	12-#7	#3@14"
F-11	285	287280	245.7	26X26	12-#7	#3@14"
F.2-12	210	114240	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	90720	355.2	26X26	12-#7	#3@14"
F.6-12	78	42432	114.2	26X26	12-#7	#3@14"
G-7	81	81648	344.4	26X26	12-#7	#3@14"
G-8	702	707616	485.8	26X26	12-#7	#3@14"
G-9	702	707616	485.8	26X26	12-#7	#3@14"
G-10	420	423360	485.8	26X26	12-#7	#3@14"
G-11	280	282240	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	90720	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	111520	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	84672	355.2	26X26	12-#7	#3@14"
H-11	132	71808	220.4	26X26	12-#7	#3@14"
H-11.5	84	45696	114.9	26X26	12-#7	#3@14"
I-7	204	205632	220.4	26X26	12-#7	#3@14"
I-8	336	338688	265	26X26	12-#7	#3@14"
I-9	336	338688	246	26X26	12-#7	#3@14"
I-10	144	123576	220.4	26X26	12-#7	#3@14"

Sixth Floor Column Schedule

A-6	378	483840	241.7	26 X 26	12-#7	#3@14"
A-6.5	135	172800	355.2	26 X 26	12-#7	#3@14"
B.3-0	130	106080	114.9	26 X 26	12-#7	#3@14"
B-1	255	242880	245.7	26 X 26	12-#7	#3@14"
B-2	280	358400	245.7	26 X 26	12-#7	#3@14"
B-3	405	518400	244.9	26 X 26	12-#7	#3@14"
B-4	405	544320	239.5	26 X 26	12-#7	#3@14"
B-5	405	544320	244.9	26 X 26	12-#7	#3@14"
B.6-6.5	-	250000	355.2	26 X 26	12-#7	#3@14"
B.7-6	168	215040	344	26 X 26	12-#7	#3@14"
B.8-0	78	63648	114.9	26 X 26	12-#7	#3@14"
C.3-6.2	-	250000	355.2	26 X 26	12-#7	#3@14"
C.4-0.3	60	48960	114.9	26 X 26	12-#7	#3@14"
C-1	205	202080	344.4	26 X 26	12-#7	#3@14"
C-2	680	870400	485.8	26 X 26	12-#7	#3@14"
C-3	702	898560	485.8	26 X 26	12-#7	#3@14"
C-4	702	943488	485.8	26 X 26	12-#7	#3@14"
C-5	702	943488	485.8	26 X 26	12-#7	#3@14"
C-6	304	389120	350.6	26 X 26	12-#7	#3@14"
D-0.6	91	74256	114.9	26 X 26	12-#7	#3@14"
D-1	130	106080	220.4	26 X 26	12-#7	#3@14"
E-2	180	228312	197.2	26 X 26	12-#7	#3@14"
E-3	336	430080	248.2	26 X 26	12-#7	#3@14"
E-4	336	451584	228.2	26 X 26	12-#7	#3@14"
E-5	336	451584	268.4	26 X 26	12-#7	#3@14"
E-6	312	399360	197.2	26 X 26	12-#7	#3@14"
E.5-6.8	84	107520	355.2	26 X 26	12-#7	#3@14"
F-6.8	90	115200	355.8	26 X 26	12-#7	#3@14"
F-7	67.5	86400	245.7	26 X 26	12-#7	#3@14"
F-8	405	518400	244.5	26 X 26	12-#7	#3@14"
F-9	405	518400	244.9	26 X 26	12-#7	#3@14"
F-10	240	307200	241.7	26 X 26	12-#7	#3@14"
F-11	285	364800	245.7	26 X 26	12-#7	#3@14"
F.2-12	210	171360	114.2	26 X 26	12-#7	#3@14"
F.5-6.8	90	115200	355.2	26 X 26	12-#7	#3@14"
F.6-12	78	63648	114.2	26 X 26	12-#7	#3@14"
G-7	81	103680	344.4	26 X 26	12-#7	#3@14"
G-8	702	898560	485.8	26 X 26	12-#7	#3@14"
G-9	702	898560	485.8	26 X 26	12-#7	#3@14"
G-10	420	537600	485.8	26 X 26	12-#7	#3@14"
G-11	280	358400	344.4	26 X 26	12-#7	#3@14"
G.1-6.8	90	115200	355.2	26 X 26	12-#7	#3@14"
G.3-11.7	205	167280	114.9	26 X 26	12-#7	#3@14"
G.6-6.8	84	107520	355.2	26 X 26	12-#7	#3@14"
H-11	132	107712	220.4	26 X 26	12-#7	#3@14"
H-11.5	84	68544	114.9	26 X 26	12-#7	#3@14"
I-7	204	261120	220.4	26 X 26	12-#7	#3@14"
I-8	336	430080	265	26 X 26	12-#7	#3@14"
I-9	336	430080	246	26 X 26	12-#7	#3@14"
I-10	144	162744	220.4	26 X 26	12-#7	#3@14"

Fifth Floor Column Schedule

A-6	378	586656	241.7	26X26	12-#7	#3@14"
A-6.5	135	209520	355.2	26X26	12-#7	#3@14"
B.3-0	130	141440	114.9	26X26	12-#7	#3@14"
B-1	255	312240	245.7	26X26	12-#7	#3@14"
B-2	280	434560	245.7	26X26	12-#7	#3@14"
B-3	405	628560	244.9	26X26	12-#7	#3@14"
B-4	405	654480	239.5	26X26	12-#7	#3@14"
B-5	405	654480	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	300000	355.2	26X26	12-#7	#3@14"
B.7-6	168	260736	344	26X26	12-#7	#3@14"
B.8-0	78	84864	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	300000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	65280	114.9	26X26	12-#7	#3@14"
C-1	205	257840	344.4	26X26	12-#7	#3@14"
C-2	680	1055360	485.8	26X26	12-#11	#4@22"
C-3	702	1089504	485.8	26X26	12-#11	#4@22"
C-4	702	1134432	485.8	26X26	12-#11	#4@22"
C-5	702	1134432	485.8	26X26	12-#11	#4@22"
C-6	304	471808	350.6	26X26	12-#7	#3@14"
D-0.6	91	99008	114.9	26X26	12-#7	#3@14"
D-1	130	141440	220.4	26X26	12-#7	#3@14"
E-2	180	277272	197.2	26X26	12-#7	#3@14"
E-3	336	521472	248.2	26X26	12-#7	#3@14"
E-4	336	542976	228.2	26X26	12-#7	#3@14"
E-5	336	542976	268.4	26X26	12-#7	#3@14"
E-6	312	484224	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	130368	355.2	26X26	12-#7	#3@14"
F-6.8	90	139680	355.8	26X26	12-#7	#3@14"
F-7	67.5	104760	245.7	26X26	12-#7	#3@14"
F-8	405	628560	244.5	26X26	12-#7	#3@14"
F-9	405	628560	244.9	26X26	12-#7	#3@14"
F-10	240	372480	241.7	26X26	12-#7	#3@14"
F-11	285	442320	245.7	26X26	12-#7	#3@14"
F.2-12	210	228480	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	139680	355.2	26X26	12-#7	#3@14"
F.6-12	78	84864	114.2	26X26	12-#7	#3@14"
G-7	81	125712	344.4	26X26	12-#7	#3@14"
G-8	702	1089504	485.8	26X26	12-#11	#4@22"
G-9	702	1089504	485.8	26X26	12-#11	#4@22"
G-10	420	651840	485.8	26X26	12-#7	#3@14"
G-11	280	434560	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	139680	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	223040	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	130368	355.2	26X26	12-#7	#3@14"
H-11	132	143616	220.4	26X26	12-#7	#3@14"
H-11.5	84	91392	114.9	26X26	12-#7	#3@14"
I-7	204	316608	220.4	26X26	12-#7	#3@14"
I-8	336	521472	265	26X26	12-#7	#3@14"
I-9	336	521472	246	26X26	12-#7	#3@14"
I-10	144	201912	220.4	26X26	12-#7	#3@14"

Fourth Floor Column Schedule

A-6	378	689472	241.7	26X26	12-#7	#3@14"
A-6.5	135	246240	355.2	26X26	12-#7	#3@14"
B.3-0	130	176800	114.9	26X26	12-#7	#3@14"
B-1	255	381600	245.7	26X26	12-#7	#3@14"
B-2	280	510720	245.7	26X26	12-#7	#3@14"
B-3	405	738720	244.9	26X26	12-#7	#3@14"
B-4	405	764640	239.5	26X26	12-#7	#3@14"
B-5	405	764640	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	350000	355.2	26X26	12-#7	#3@14"
B.7-6	168	306432	344	26X26	12-#7	#3@14"
B.8-0	78	106080	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	350000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	81600	114.9	26X26	12-#7	#3@14"
C-1	205	313600	344.4	26X26	12-#7	#3@14"
C-2	680	1240320	485.8	26X26	12-#11	#4@22"
C-3	702	1280448	485.8	26X26	12-#11	#4@22"
C-4	702	1325376	485.8	26X26	12-#11	#4@22"
C-5	702	1325376	485.8	26X26	12-#11	#4@22"
C-6	304	554496	350.6	26X26	12-#7	#3@14"
D-0.6	91	123760	114.9	26X26	12-#7	#3@14"
D-1	130	176800	220.4	26X26	12-#7	#3@14"
E-2	180	326232	197.2	26X26	12-#7	#3@14"
E-3	336	612864	248.2	26X26	12-#7	#3@14"
E-4	336	634368	228.2	26X26	12-#7	#3@14"
E-5	336	634368	268.4	26X26	12-#7	#3@14"
E-6	312	569088	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	153216	355.2	26X26	12-#7	#3@14"
F-6.8	90	164160	355.8	26X26	12-#7	#3@14"
F-7	67.5	123120	245.7	26X26	12-#7	#3@14"
F-8	405	738720	244.5	26X26	12-#7	#3@14"
F-9	405	738720	244.9	26X26	12-#7	#3@14"
F-10	240	437760	241.7	26X26	12-#7	#3@14"
F-11	285	519840	245.7	26X26	12-#7	#3@14"
F.2-12	210	285600	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	164160	355.2	26X26	12-#7	#3@14"
F.6-12	78	106080	114.2	26X26	12-#7	#3@14"
G-7	81	147744	344.4	26X26	12-#7	#3@14"
G-8	702	1280448	485.8	26X26	12-#11	#4@22"
G-9	702	1280448	485.8	26X26	12-#11	#4@22"
G-10	420	766080	485.8	26X26	12-#7	#3@14"
G-11	280	510720	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	164160	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	278800	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	153216	355.2	26X26	12-#7	#3@14"
H-11	132	179520	220.4	26X26	12-#7	#3@14"
H-11.5	84	114240	114.9	26X26	12-#7	#3@14"
I-7	204	372096	220.4	26X26	12-#7	#3@14"
I-8	336	612864	265	26X26	12-#7	#3@14"
I-9	336	612864	246	26X26	12-#7	#3@14"
I-10	144	241080	220.4	26X26	12-#7	#3@14"

Third Floor Column Schedule

A-6	378	792288	241.7	26X26	12-#7	#3@14"
A-6.5	135	282960	355.2	26X26	12-#7	#3@14"
B.3-0	130	212160	114.9	26X26	12-#7	#3@14"
B-1	255	450960	245.7	26X26	12-#7	#3@14"
B-2	280	586880	245.7	26X26	12-#7	#3@14"
B-3	405	848880	244.9	26X26	12-#7	#3@14"
B-4	405	874800	239.5	26X26	12-#7	#3@14"
B-5	405	874800	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	400000	355.2	26X26	12-#7	#3@14"
B.7-6	168	352128	344	26X26	12-#7	#3@14"
B.8-0	78	127296	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	400000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	97920	114.9	26X26	12-#7	#3@14"
C-1	205	369360	344.4	26X26	12-#7	#3@14"
C-2	680	1425280	485.8	26X26	12-#11	#4@22"
C-3	702	1471392	485.8	26X26	12-#11	#4@22"
C-4	702	1516320	485.8	26X26	12-#11	#4@22"
C-5	702	1516320	485.8	26X26	12-#11	#4@22"
C-6	304	637184	350.6	26X26	12-#7	#3@14"
D-0.6	91	148512	114.9	26X26	12-#7	#3@14"
D-1	130	212160	220.4	26X26	12-#7	#3@14"
E-2	180	375192	197.2	26X26	12-#7	#3@14"
E-3	336	704256	248.2	26X26	12-#7	#3@14"
E-4	336	725760	228.2	26X26	12-#7	#3@14"
E-5	336	725760	268.4	26X26	12-#7	#3@14"
E-6	312	653952	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	176064	355.2	26X26	12-#7	#3@14"
F-6.8	90	188640	355.8	26X26	12-#7	#3@14"
F-7	67.5	141480	245.7	26X26	12-#7	#3@14"
F-8	405	848880	244.5	26X26	12-#7	#3@14"
F-9	405	848880	244.9	26X26	12-#7	#3@14"
F-10	240	503040	241.7	26X26	12-#7	#3@14"
F-11	285	597360	245.7	26X26	12-#7	#3@14"
F.2-12	210	342720	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	188640	355.2	26X26	12-#7	#3@14"
F.6-12	78	127296	114.2	26X26	12-#7	#3@14"
G-7	81	169776	344.4	26X26	12-#7	#3@14"
G-8	702	1471392	485.8	26X26	12-#11	#4@22"
G-9	702	1471392	485.8	26X26	12-#11	#4@22"
G-10	420	880320	485.8	26X26	12-#7	#3@14"
G-11	280	586880	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	188640	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	334560	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	176064	355.2	26X26	12-#7	#3@14"
H-11	132	215424	220.4	26X26	12-#7	#3@14"
H-11.5	84	137088	114.9	26X26	12-#7	#3@14"
I-7	204	427584	220.4	26X26	12-#7	#3@14"
I-8	336	704256	265	26X26	12-#7	#3@14"
I-9	336	704256	246	26X26	12-#7	#3@14"
I-10	144	280248	220.4	26X26	12-#7	#3@14"

Second Floor Column Schedule

A-6	378	895104	241.7	26X26	12-#7	#3@14"
A-6.5	135	319680	355.2	26X26	12-#7	#3@14"
B.3-0	130	247520	114.9	26X26	12-#7	#3@14"
B-1	255	520320	245.7	26X26	12-#7	#3@14"
B-2	280	663040	245.7	26X26	12-#7	#3@14"
B-3	405	959040	244.9	26X26	12-#7	#3@14"
B-4	405	984960	239.5	26X26	12-#7	#3@14"
B-5	405	984960	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	450000	355.2	26X26	12-#7	#3@14"
B.7-6	168	397824	344	26X26	12-#7	#3@14"
B.8-0	78	148512	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	450000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	114240	114.9	26X26	12-#7	#3@14"
C-1	205	425120	344.4	26X26	12-#7	#3@14"
C-2	680	1610240	485.8	26X26	16-#11	#4@22"
C-3	702	1662336	485.8	26X26	16-#11	#4@22"
C-4	702	1707264	485.8	26X26	16-#11	#4@22"
C-5	702	1707264	485.8	26X26	16-#11	#4@22"
C-6	304	719872	350.6	26X26	12-#7	#3@14"
D-0.6	91	173264	114.9	26X26	12-#7	#3@14"
D-1	130	247520	220.4	26X26	12-#7	#3@14"
E-2	180	424152	197.2	26X26	12-#7	#3@14"
E-3	336	795648	248.2	26X26	12-#7	#3@14"
E-4	336	817152	228.2	26X26	12-#7	#3@14"
E-5	336	817152	268.4	26X26	12-#7	#3@14"
E-6	312	738816	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	198912	355.2	26X26	12-#7	#3@14"
F-6.8	90	213120	355.8	26X26	12-#7	#3@14"
F-7	67.5	159840	245.7	26X26	12-#7	#3@14"
F-8	405	959040	244.5	26X26	12-#7	#3@14"
F-9	405	959040	244.9	26X26	12-#7	#3@14"
F-10	240	568320	241.7	26X26	12-#7	#3@14"
F-11	285	674880	245.7	26X26	12-#7	#3@14"
F.2-12	210	399840	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	213120	355.2	26X26	12-#7	#3@14"
F.6-12	78	148512	114.2	26X26	12-#7	#3@14"
G-7	81	191808	344.4	26X26	12-#7	#3@14"
G-8	702	1662336	485.8	26X26	16-#11	#4@22"
G-9	702	1662336	485.8	26X26	16-#11	#4@22"
G-10	420	994560	485.8	26X26	12-#7	#3@14"
G-11	280	663040	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	213120	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	390320	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	198912	355.2	26X26	12-#7	#3@14"
H-11	132	251328	220.4	26X26	12-#7	#3@14"
H-11.5	84	159936	114.9	26X26	12-#7	#3@14"
I-7	204	483072	220.4	26X26	12-#7	#3@14"
I-8	336	795648	265	26X26	12-#7	#3@14"
I-9	336	795648	246	26X26	12-#7	#3@14"
I-10	144	319416	220.4	26X26	12-#7	#3@14"

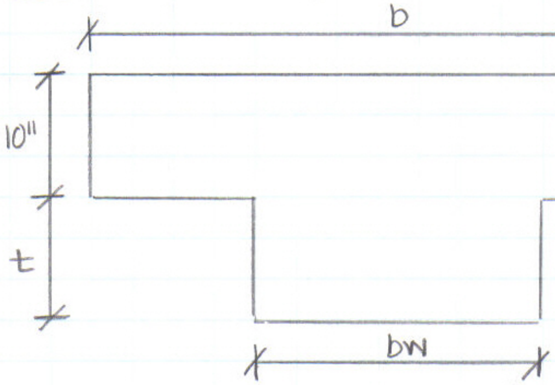
First Floor Column Schedule

A-6	378	997920	241.7	26X26	12-#7	#3@14"
A-6.5	135	356400	355.2	26X26	12-#7	#3@14"
B.3-0	130	282880	114.9	26X26	12-#7	#3@14"
B-1	255	589680	245.7	26X26	12-#7	#3@14"
B-2	280	739200	245.7	26X26	12-#7	#3@14"
B-3	405	1069200	244.9	26X26	12-#7	#3@14"
B-4	405	1095120	239.5	26X26	12-#7	#3@14"
B-5	405	1095120	244.9	26X26	12-#7	#3@14"
B.6-6.5	-	500000	355.2	26X26	12-#7	#3@14"
B.7-6	168	443520	344	26X26	12-#7	#3@14"
B.8-0	78	169728	114.9	26X26	12-#7	#3@14"
C.3-6.2	-	500000	355.2	26X26	12-#7	#3@14"
C.4-0.3	60	130560	114.9	26X26	12-#7	#3@14"
C-1	205	480880	344.4	26X26	12-#7	#3@14"
C-2	680	1795200	485.8	26X26	16-#11	#4@22"
C-3	702	1853280	485.8	26X26	16-#11	#4@22"
C-4	702	1898208	485.8	26X26	16-#11	#4@22"
C-5	702	1898208	485.8	26X26	16-#11	#4@22"
C-6	304	802560	350.6	26X26	12-#7	#3@14"
D-0.6	91	198016	114.9	26X26	12-#7	#3@14"
D-1	130	282880	220.4	26X26	12-#7	#3@14"
E-2	180	473112	197.2	26X26	12-#7	#3@14"
E-3	336	887040	248.2	26X26	12-#7	#3@14"
E-4	336	908544	228.2	26X26	12-#7	#3@14"
E-5	336	908544	268.4	26X26	12-#7	#3@14"
E-6	312	823680	197.2	26X26	12-#7	#3@14"
E.5-6.8	84	221760	355.2	26X26	12-#7	#3@14"
F-6.8	90	237600	355.8	26X26	12-#7	#3@14"
F-7	67.5	178200	245.7	26X26	12-#7	#3@14"
F-8	405	1069200	244.5	26X26	12-#7	#3@14"
F-9	405	1069200	244.9	26X26	12-#7	#3@14"
F-10	240	633600	241.7	26X26	12-#7	#3@14"
F-11	285	752400	245.7	26X26	12-#7	#3@14"
F.2-12	210	456960	114.2	26X26	12-#7	#3@14"
F.5-6.8	90	237600	355.2	26X26	12-#7	#3@14"
F.6-12	78	169728	114.2	26X26	12-#7	#3@14"
G-7	81	213840	344.4	26X26	12-#7	#3@14"
G-8	702	1853280	485.8	26X26	16-#11	#4@22"
G-9	702	1853280	485.8	26X26	16-#11	#4@22"
G-10	420	1108800	485.8	26X26	12-#7	#3@14"
G-11	280	739200	344.4	26X26	12-#7	#3@14"
G.1-6.8	90	237600	355.2	26X26	12-#7	#3@14"
G.3-11.7	205	446080	114.9	26X26	12-#7	#3@14"
G.6-6.8	84	221760	355.2	26X26	12-#7	#3@14"
H-11	132	287232	220.4	26X26	12-#7	#3@14"
H-11.5	84	182784	114.9	26X26	12-#7	#3@14"
I-7	204	538560	220.4	26X26	12-#7	#3@14"
I-8	336	887040	265	26X26	12-#7	#3@14"
I-9	336	887040	246	26X26	12-#7	#3@14"
I-10	144	358584	220.4	26X26	12-#7	#3@14"

Beam Design

Beam #1 (Floors 1→9)

Flexure



Try: $t = 6''$

$b_w = 24''$

$W_u = [1.2(25psf) + 1.6(80psf) + 1.2(150pcf)16''/12]\ 90''/12 = 2985plf$

$M_u = WL^2/8 = 2985^{lb}/ft(30ft)^2/8$

$= 335.8^{lK} = 4029.8^{llK}$

$d = 16'' - 1.5'' = 14.5''$

$$b = \begin{bmatrix} 8h_{f\,left} \\ 1/2\,Ln_{left} \end{bmatrix}_{min} + bw + \begin{bmatrix} 8h_{f\,right} \\ 1/2\,Ln_{right} \end{bmatrix}_{min} = \begin{bmatrix} 8(10'') = 80'' \\ 1/2(20ft)(12in/ft) = 120'' \end{bmatrix}_{min} + 24'' + \begin{bmatrix} 80'' \\ 120'' \end{bmatrix}_{min}$$

$$= 184'' \leq L/4 = 1/4(30ft)(12in/ft) = 90''$$

Assume $a \leq h_f$

$M_n = M_u/\phi = 4029.8^{llK}/0.9 = 4478^{llK}$ Assume $(d - a/2) = 0.9d = 13.05''$

$$A_s = \frac{M_n}{f_y(0.9d)} = \frac{4478^{llK}}{60Ksi(13.05'')} = 5.72in^2$$

Try 2 Rows of 4#8 ($A_s = 6.32in^2$) → $d = 16'' - 3.5'' = 12.5''$

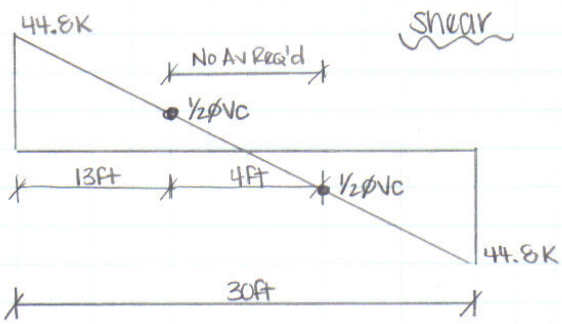
$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{6.32in^2(60Ksi)}{0.85(4Ksi)90''} = 1.24'' < 10''$$

$$A_{s\,min} = \frac{3\sqrt{f'_c}\,b_w d}{f_y} = \frac{3\sqrt{4000}(24'')12.5''}{60000Ksi} = 0.95in^2 \quad \text{OK}$$

$$= \frac{200\,b_w d}{f_y} = \frac{200(24'')12.5''}{60000Ksi} = 1in^2 \quad \text{OK}$$

$$\phi M_n = \phi A_s f_y(d - a/2) = 0.9(6.32in^2)(60Ksi)(12.5'' - 1.24''/2) = 4054.4^{llK} \quad \text{OK}$$

Shear



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

$= 2\sqrt{4000}\,(24")\,12.5" = 37.95K$

$\tfrac{1}{2}\phi V_c = \tfrac{1}{2}(0.75)\,37.95K$

$= 14.23K$

slope = 2.99

$V_{u\,at\,d} = 44.8K - 3(12.5"/12) = 41.68K = V_{u\,max}$

$V_s = \dfrac{V_u - \phi V_c}{\phi} = \dfrac{41.68K - 0.75(37.95K)}{0.75} = 17.62K$

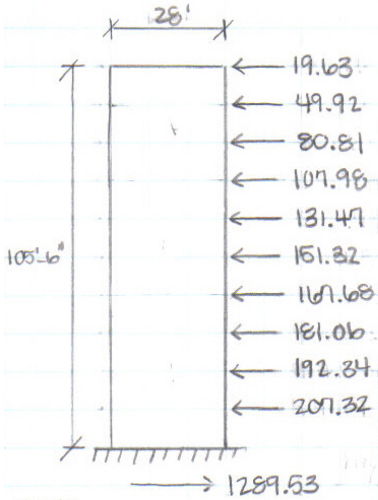
$s = \dfrac{A_v f_y d}{V_s} = \dfrac{0.22in^2(60ksi)12.5"}{17.62K} = 9.36" \rightarrow 9"$

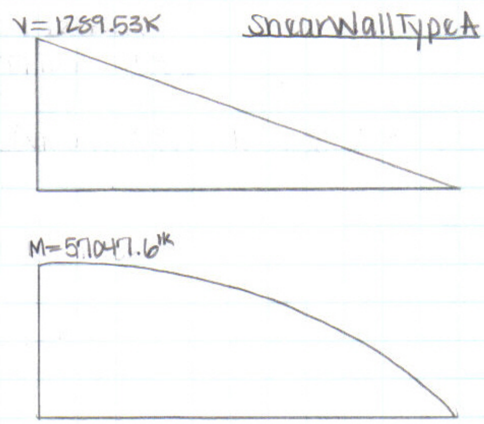
$\phi V_n = \phi V_c + \phi V_s = 0.75\left(37.95K + \dfrac{0.22in^2(60ksi)12.5"}{9"}\right) = 42.21K$

$l_v = \dfrac{(44.8K - 42.21K)12}{3} = 10.36"$

1 at 2"
18 at 9"

Shear Wall Type A





Horiz

$V_c = 2\sqrt{f'_c}\,hd = 2\sqrt{4000\text{psi}}\,(10")(0.8)(28')12 = 340K$

$V_u \le \phi V_n = \phi(V_c + V_s) \rightarrow V_u/\phi = 1289.5K/0.75 \le 340K + V_s \rightarrow V_s \ge 1379.3K$

$A_v = \dfrac{V_s(s_2)}{f_y d} = \dfrac{1379.3K(12")}{60ksi(0.8)28(12)} = 1.03in^2$

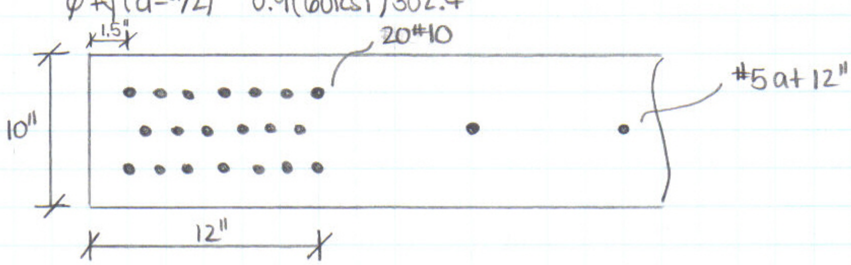
use #10 at 12"

Vert

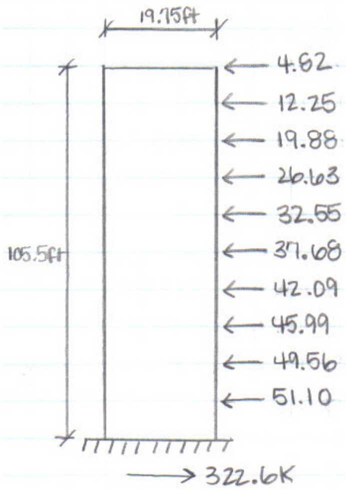
$M_n = M_u/\phi = 57048'K/0.9 = 63386'K = A_s f_y(d - a/2)$

Assume $(d - a/2) = 0.9d = 0.9(28ft)(12) = 302.4"$

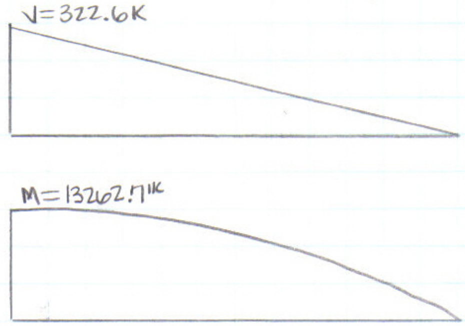
$A_s = \dfrac{M_n}{\phi f_y (d - a/2)} = \dfrac{63386.7'K(12)}{0.9(60ksi)302.4"} = 46.6in^2$



Shear Wall Type B



Shear Wall Type B



Horiz

$V_c = 2\sqrt{f_c'}\,h\,d = 2\sqrt{4000\text{psi}}\,(10'')(0.8)(19.57')12 = 239.8K$

$V_u \le \phi V_n = \phi(V_c + V_s) \rightarrow V_u/\phi = 322.6K/0.75 \le 240K + V_s \rightarrow V_s = 191K$

$A_v = \dfrac{V_s(S_2)}{f_y d} = \dfrac{191K\,(12'')}{60ksi(0.8)(19.75)12} = 0.20\,in^2$

$A_{v,min} = 0.0025(12'')(10'') = 0.30\,in^2$

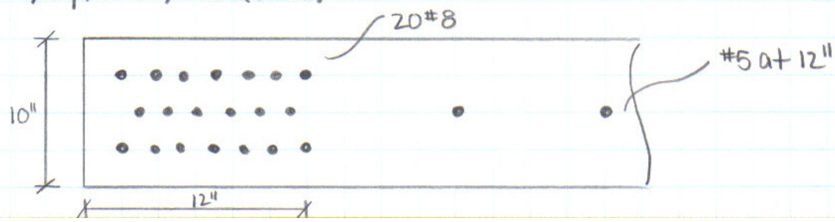
use #5 at 12"

Vert

$M_n = M_u/\phi = 13262.7'K/0.9 = 14736.3'K = A_s f_y (d - a/2)$

Assume $(d - a/2) = 0.9d = 0.9(19.25')12 = 207.9''$

$A_s = \dfrac{M_n}{\phi f_y (d - a/2)} = \dfrac{14736.3'K(12)}{0.9(60ksi)207.9''} = 15.8\,in^2$



Thermal Gradient Calculations

U-Values	Source	
Maximum Allowable U-Value	ASHRAE std. 90.1-2004	0.064
Wall Construction U-Value	Carrier's Hourly Analysis	0.059

Temperatures (F)	
Winter Outdoor Temp	7
Summer Outdoor Temp	86
Winter Indoor Temp	70
Summer Indoor Temp	75

Q-Value	(Outdoor-Indoor)/R_{Total}
Q-Winter (Man. Wall)	3.555
Q-Summer (Man. Wall)	0.621

Dew Point Tempeatures (F)	Based on:	
Winter	75F, 50%RH	55
Summer	70F, 50%RH	51

Material	Thickness (in)	R-Value	ΔT Winter	ΔT Summer	Temp (F) Winter	Temp (F) Summer
Outside Air SR	0.00	0.33	1.184	0.207	7	86
4" Brick Veneer	4.00	0.43	1.539	0.269	8.18	85.79
Air Space	1.00	0.91	3.235	0.565	9.72	85.52
Board Insulation	2.00	13.89	49.381	8.622	12.96	84.96
Vapor Barrior	0.01	0.00	0.000	0.000	62.34	76.34
Air Space	3.50	0.91	3.235	0.565	62.34	76.34
GWB	0.63	0.56	1.991	0.348	65.57	75.77
Inside Air	0.00	0.69	2.435	0.425	67.56	75.43
Totals	11.14	17.72			70.00	75.00

ASHRAE std. 90.1-2004

TABLE 5.5-5
Building Envelope Requirements For Climate Zone 5 (A,B,C)

	Nonresidential		Residential		Semiheated	
Opaque Elements	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**	**Assembly Maximum**	**Insulation Min. R-Value**
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.173	R-5.0 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above Grade						
Mass	U-0.123	R-7.6 ci	U-0.090	R-11.4 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel Framed	U-0.084	R-13.0 + R-3.8 ci	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 ci	U-0.074	R-10.4 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.840	R-10 for 36 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**	**Assembly Max. U (Fixed/ Operable)**	**Assembly Max. SHGC (All Orientations/ North-Oriented)**
Vertical Glazing,% of Wall						
0-10.0%	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{fixed}^{-1.22}$	$^{SHGC}\text{all}^{-NR}$
	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-1.27}$	$^{SHGC}\text{north}^{NR}$
10.1-20.0%	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-1.22}$	$^{SHGC}\text{all}^{-NR}$
	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-1.27}$	$^{SHGC}\text{north}^{NR}$
20.1-30.0%	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-1.22}$	$^{SHGC}\text{all}^{-NR}$
	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-1.27}$	$^{SHGC}\text{north}^{NR}$
30.1-40.0%	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-0.57}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{fixed}^{-1.22}$	$^{SHGC}\text{all}^{-NR}$
	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-0.67}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-1.27}$	$^{SHGC}\text{north}^{NR}$
40.1-50.0%	$^{U}\text{fixed}^{-0.46}$	$^{SHGC}\text{all}^{-0.26}$	$^{U}\text{fixed}^{-0.46}$	$^{SHGC}\text{all}^{-0.26}$	$^{U}\text{fixed}^{-0.98}$	$^{SHGC}\text{all}^{-NR}$
	$^{U}\text{oper}^{-0.47}$	$^{SHGC}\text{north}^{-0.36}$	$^{U}\text{oper}^{-0.47}$	$^{SHGC}\text{north}^{-0.49}$	$^{U}\text{oper}^{-1.02}$	$^{SHGC}\text{north}^{NR}$
Skylight with Curb, Glass,% of Roof						
0-2.0%	$^{U}\text{all}^{-1.17}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{all}^{-1.17}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{all}^{-1.98}$	$^{SHGC}\text{all}^{-NR}$
2.1-5.0%	$^{U}\text{all}^{-1.17}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{all}^{-1.17}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{all}^{-1.98}$	$^{SHGC}\text{all}^{-NR}$
Skylight with Curb, Plastic,% of Roof						
0-2.0%	$^{U}\text{all}^{-1.10}$	$^{SHGC}\text{all}^{-0.77}$	$^{U}\text{all}^{-1.10}$	$^{SHGC}\text{all}^{-0.77}$	$^{U}\text{all}^{-1.90}$	$^{SHGC}\text{all}^{-NR}$
2.1-5.0%	$^{U}\text{all}^{-1.10}$	$^{SHGC}\text{all}^{-0.62}$	$^{U}\text{all}^{-1.10}$	$^{SHGC}\text{all}^{-0.62}$	$^{U}\text{all}^{-1.90}$	$^{SHGC}\text{all}^{-NR}$
Skylight without Curb, All,% of Roof						
0-2.0%	$^{U}\text{all}^{-0.69}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{all}^{-0.69}$	$^{SHGC}\text{all}^{-0.49}$	$^{U}\text{all}^{-1.36}$	$^{SHGC}\text{all}^{-NR}$
2.1-5.0%	$^{U}\text{all}^{-0.69}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{all}^{-0.69}$	$^{SHGC}\text{all}^{-0.39}$	$^{U}\text{all}^{-1.36}$	$^{SHGC}\text{all}^{-NR}$

Summer Gradient

SUMMER WALL HEAT TRANSFER DIAGRAM