University Academic Center

Eastern USA

Alexander Altemose | **Structural Option**

University Academic Center

- Introduction
  - General Information
  - Building Layout
  - Current Structure
- Proposed Goals
- Structural Depth
- Construction Breadth
- Conclusion

Project Team

Owner: (wishes to remain anonymous)

Architect / Engineer: Cannon Design

Construction Manager: Skanska USA Building Inc.

General Information

Height: 72 ft (5 floors)

Size: 192,000 sf

Function: Mixed use (A-3, B, S-1)

Construction: September 2005 – August 2007

Cost: $55.7 million

LEED Rating: Gold

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Ground Floor　Second Floor　Third Floor　Forth Floor　Fifth Floor

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Current Structure

- Brick, stone, and metal panel façade
- Spread footing foundation
- Composite metal deck floor system
  - 2" 20 gauge deck with 3.25" LWC topping (typical)
- Wide flange framing members
- Concentrically braced frames for lateral support
  - HSS members for diagonal bracing

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Proposed Goals

- Redesign office wing as separate concrete structure
- Minimize changes to current building form
- Strengthen foundations as needed
- Construction breadth
    - Cost and schedule reports of structures
- Lighting breadth (not included in this presentation)
    - Redesign lighting of computer lab space

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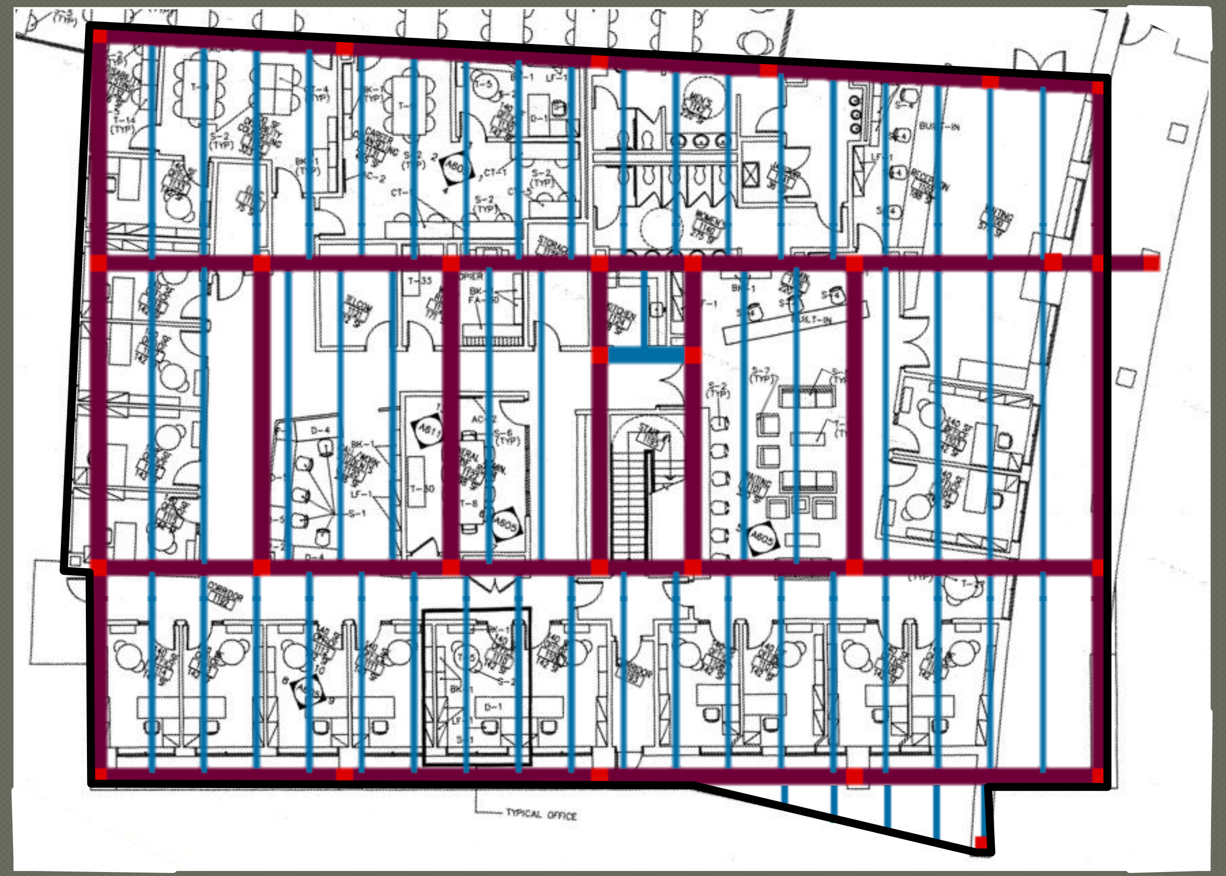

Redesign Overview

- 5” one-way slab
- One-way pan joists
- Ordinary moment frames

Material Properties

- Normal weight concrete
- f’c = 5,000psi
- fy = 60,000psi

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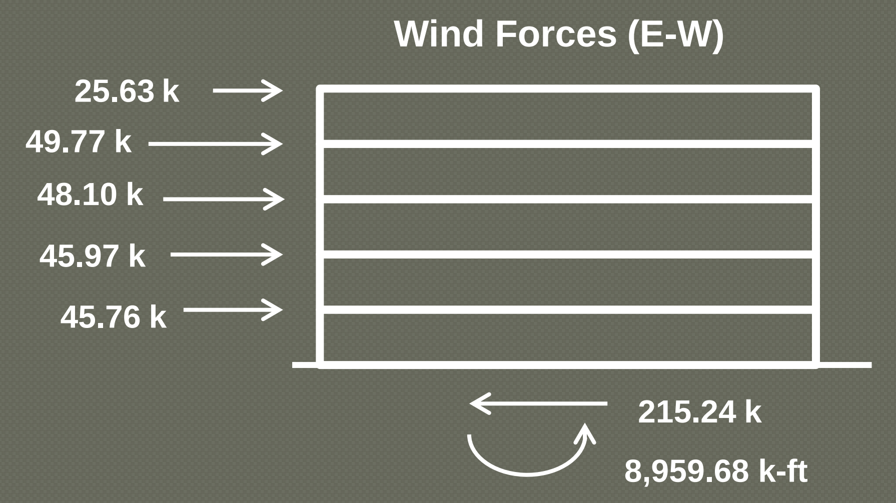
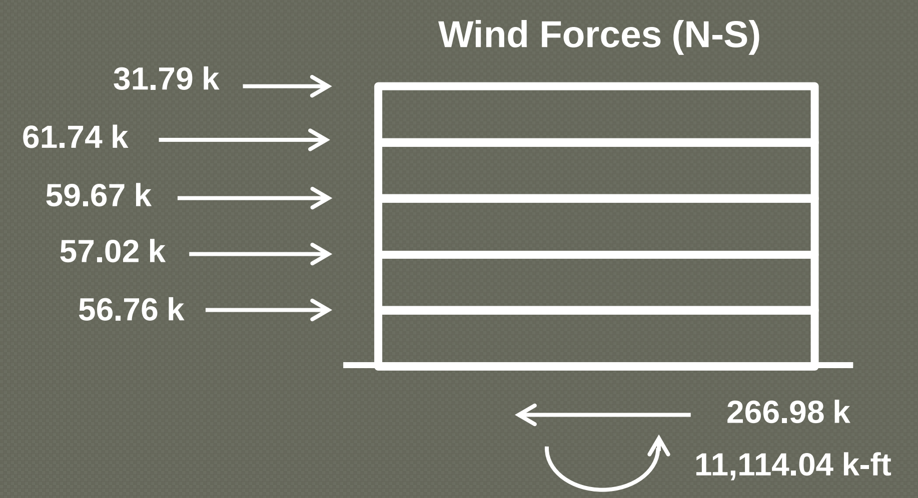
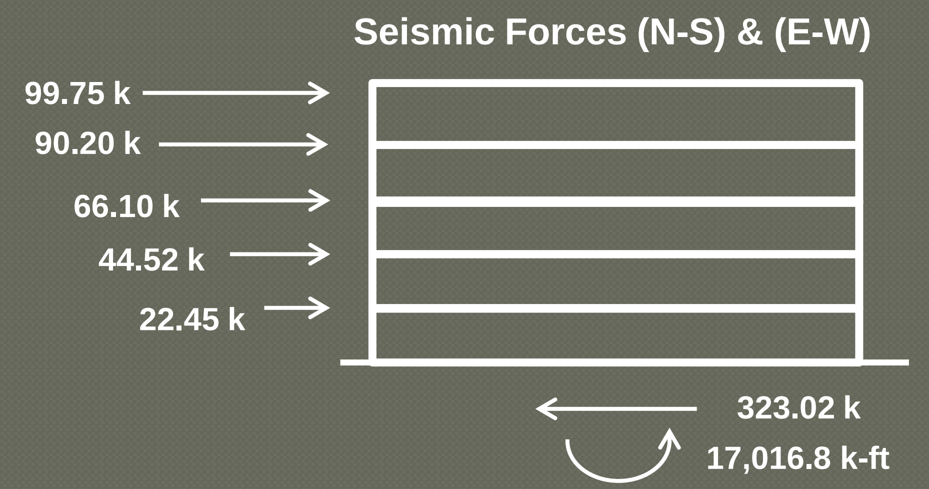
Live Loads		
Description	Designed Load (psf)	ASCE 7-10 Load (psf)
Slab on grade	100	100
Offices	50 + 20 (partitions)	50 + 15 (partitions)
Corridors (elevated floors)	80	80
Stairs	100	100
Roof	30	20

Design Loads

- Superimposed load for MEP designed for 20 psf
- All floors designed for 80 psf live load
- Roof designed for 30 psf live load
- Wind and seismic loads recalculated for new structure







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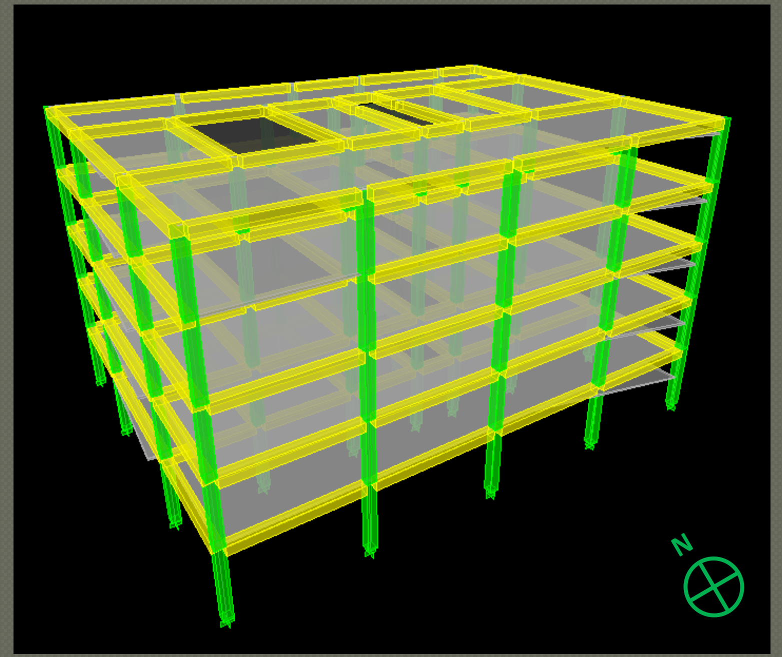
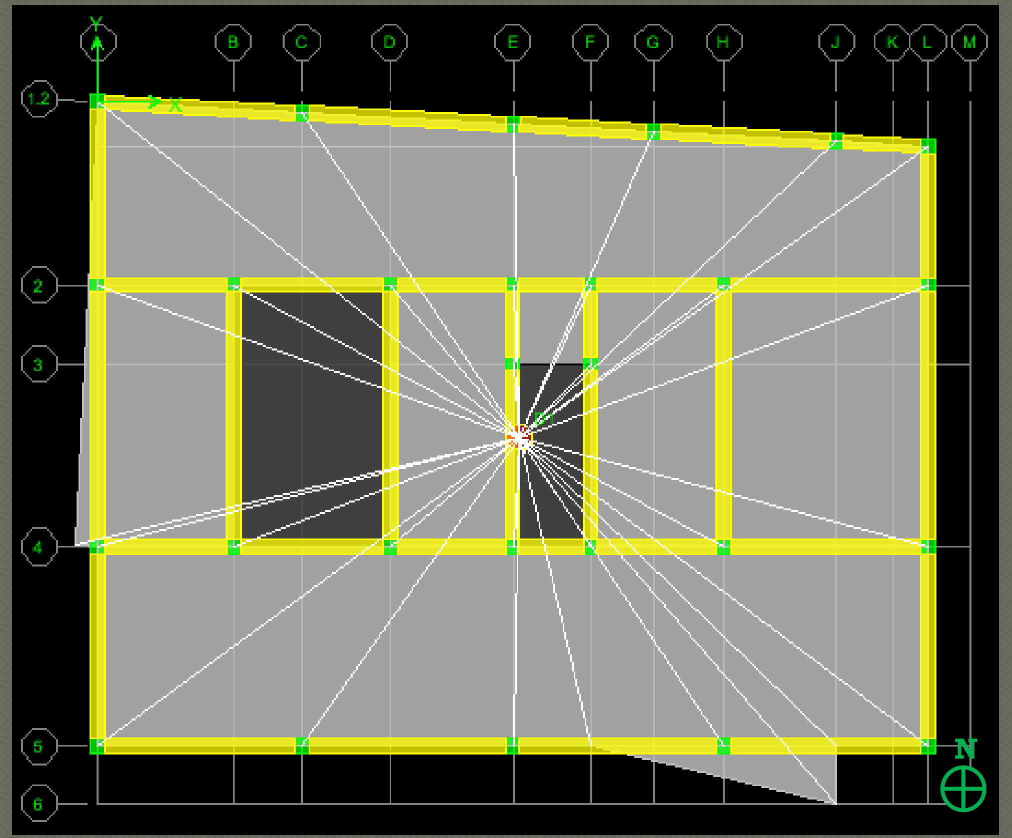
Drift Analysis using ETABS

- Input parameters
  - Diaphragms modeled as rigid
  - Mass lumped to diaphragms
  - Supports assumed fixed
- Icr = 0.35 Ig for beams
- Icr = 0.7 Ig for columns





Office Wing Story Drifts (Wind)

Floor	Story Height (ft)	Drift X (in.)	Drift Y (in.)	Allowable Drift (in.)	Pass?
Roof	14	0.002	0.098	0.42	YES
5	14	0.003	0.171	0.42	YES
4	14	0.055	0.250	0.42	YES
3	14	0.070	0.301	0.42	YES
2	16	0.052	0.237	0.48	YES
Total	72	0.24	1.06	2.16	YES

Office Wing Story Drifts (Seismic)

Floor	Story Height (ft)	Amplified Drift X (in.)	Amplified Drift Y (in.)	Allowable Drift (in.)	Pass?
Roof	14	0.051	0.598	2.52	YES
5	14	0.084	0.900	2.52	YES
4	14	0.110	1.144	2.52	YES
3	14	0.126	1.211	2.52	YES
2	16	0.088	0.860	2.88	YES
Total	72	0.475	4.725	12.96	YES

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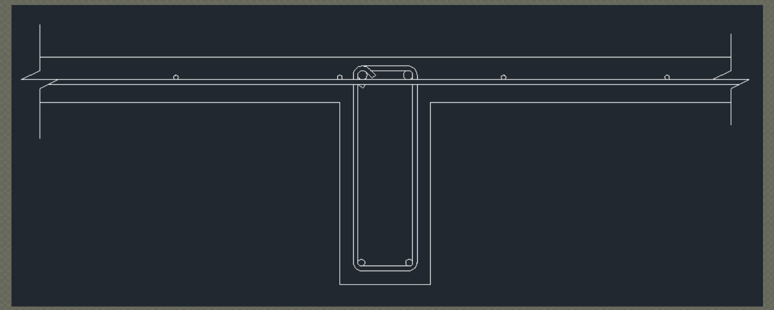
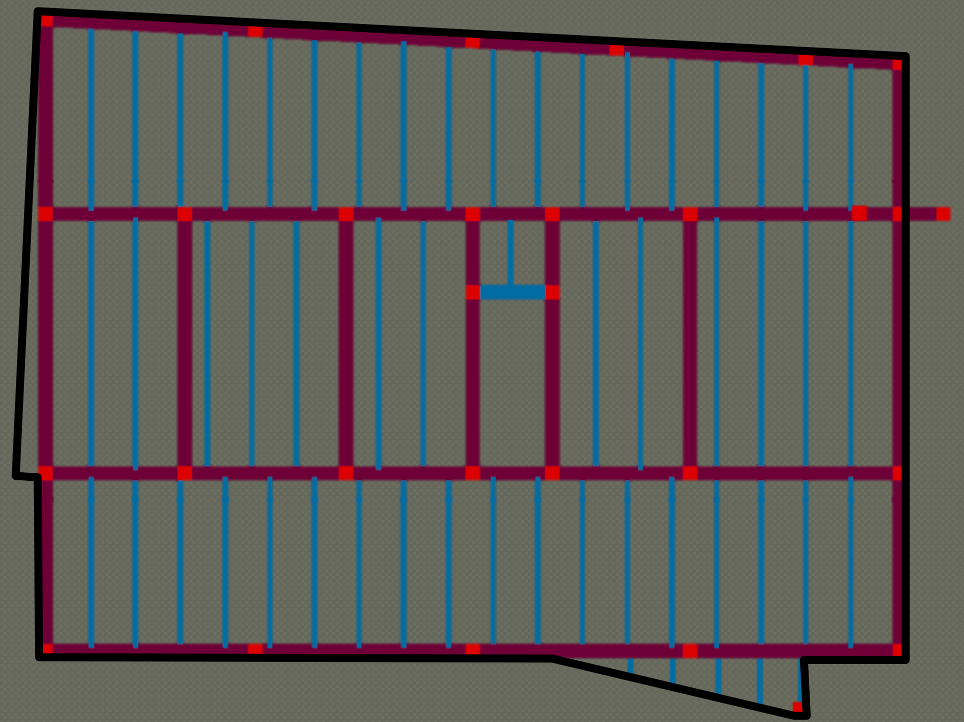
Slab Design

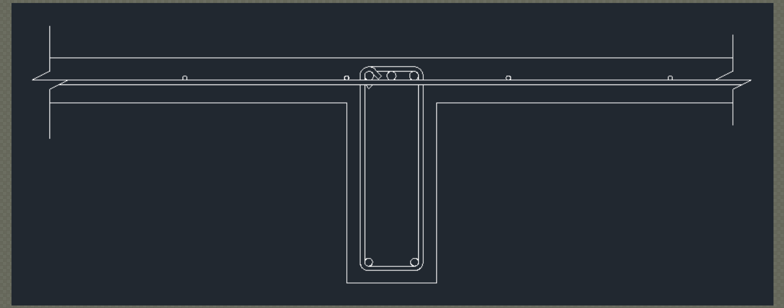
- Minimum thickness for deflections: 2.4”
- Minimum thickness for 2hr fire rating: 5”
- Minimum cover: ¾”
  - ➢ Use 5” slab with: #4s @ 8” o.c. for flexure
    #4s @ 18” o.c. for shrinkage & temperature

Joist Design

- Minimum depth for deflections: 19.75”
- Minimum cover: 1.5”
  - ➢ Use pan joists: 20” pan depth, 10” rib width, 66” pan width
    with: 3-#8s top (interior span)
    2-#7s bottom (interior span)
    2-#8s top (exterior spans)
    2-#6s bottom (exterior spans)


Exterior span




Interior span

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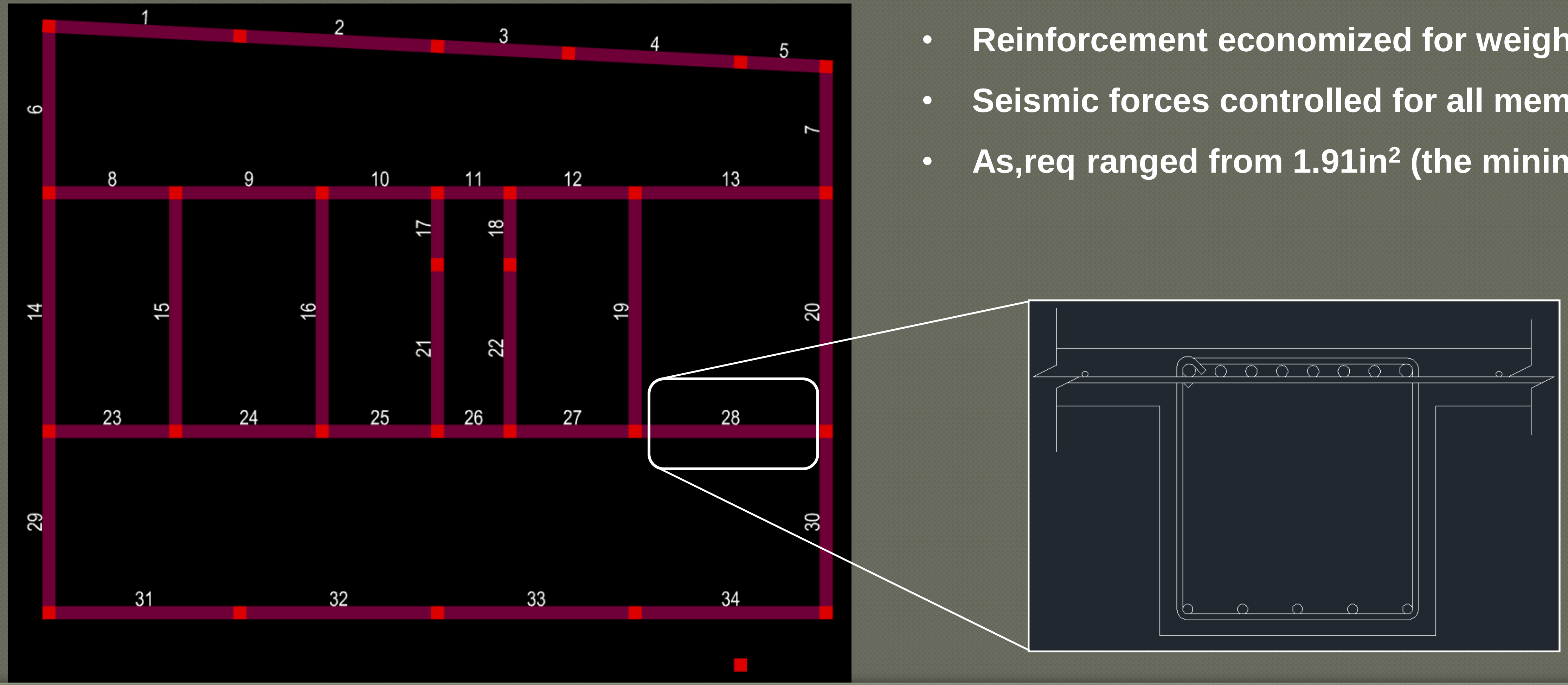
Seismic Design Category B

- Ordinary concrete moment frames
- Two continuous bars both top and bottom reinforcement



Top:

6-#8s & 2-#9s (2 bars continuous)

Bottom:

5-#7s (2 bars continuous)

Lateral Beam Design

- All beams are 25”x24” to match joist depth and column width for constructability
- Reinforcement done for 2nd floor and repeated on other floors
- Reinforcement economized for weight
- Seismic forces controlled for all members except beams 13 and 28
- As,req ranged from 1.91in^2 (the minimum required steel) to 6.65in^2

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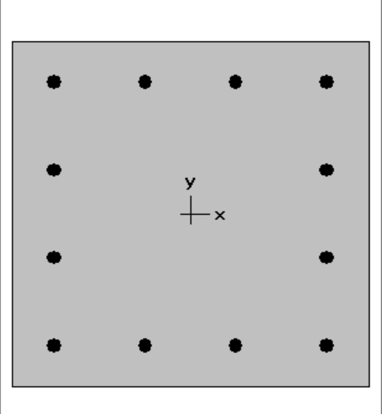
Column Design

- All columns designed the same
- 24”x24” to minimize impact of interior spaces
- 12-#8s reinforcement

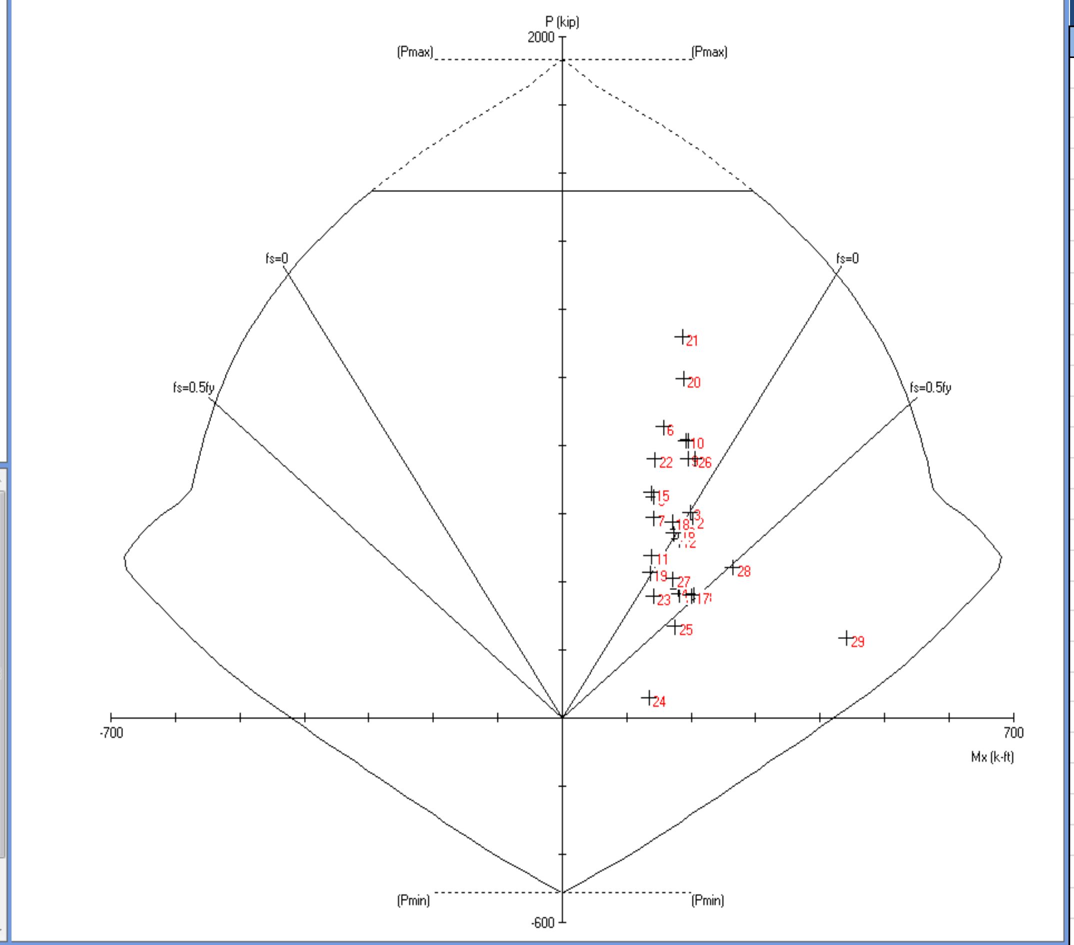


24 x 24 in
1.65% reinf.

MATERIAL:
=========
f'c = 5 ksi
Ec = 4030.51 ksi
fc = 4.25 ksi
Beta1 = 0.8
fy = 60 ksi
Es = 29000 ksi

SECTION:
========
Ag = 576 in^2
Ix = 27648 in^4
Iy = 27648 in^4
Xo = 0 in
Yo = 0 in

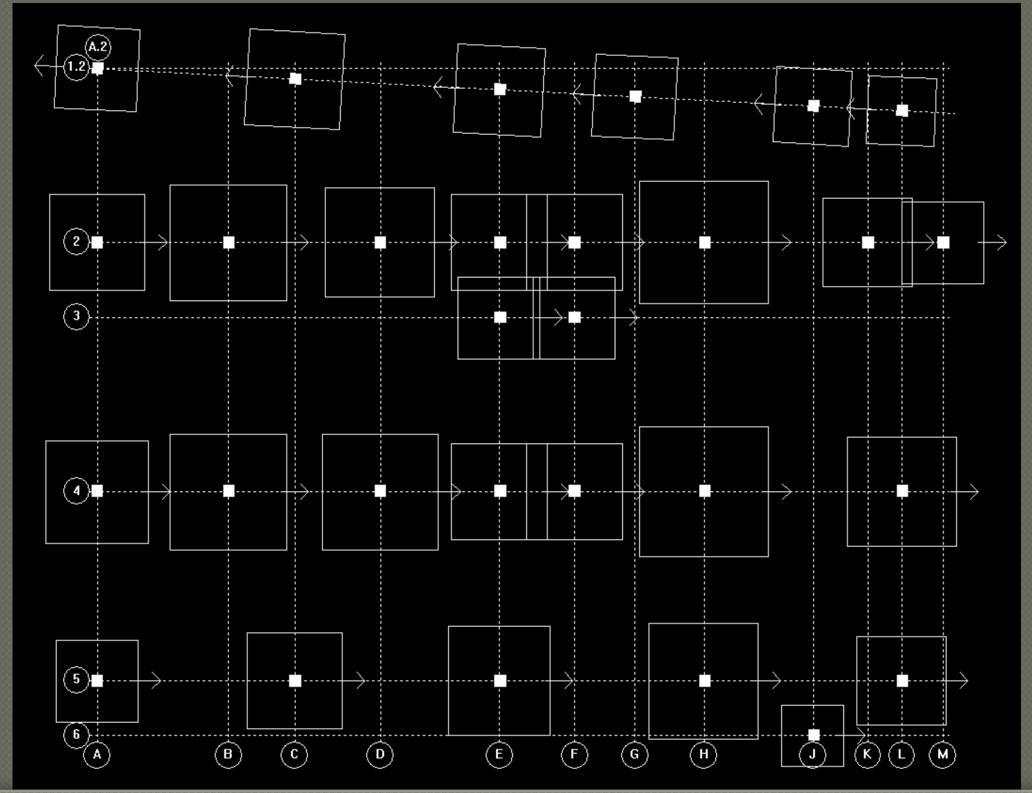
REINFORCEMENT:
===============
12 #8 bars @ 1.646%
As = 9.48 in^2
Confinement: Tied
Clear Cover = 2.38 in
Min Clear Spacing = 5.08 in



Ground Floor Column Design Forces			
Reference #	Column	Pu (kips)	Mu (k-ft)
1	A1	365	182
2	A2	582	203
3	A4	605	198
4	A5	380	179
5	B2	817	196
6	B4	855	157
7	C1.2	588	142
8	C5	650	142
9	D2	763	195
10	D4	816	192
11	E1.2	477	139
12	E2	526	181
13	E3	364	204
14	E4	543	173
15	E5	662	139
16	F2	554	179
17	F3	361	201
18	F4	577	171
19	G1.2	428	136
20	H2	997	188
21	H4	1120	186
22	H5	761	144
23	J1.2	359	141
24	J6	61	134
25	L1.2	269	175
26	L4	762	205
27	L5	409	172
28	K2	443	265
29	M2	236	441

Foundation Impact

- RAM foundation was used to design new foundations
- Soil bearing capacity of 3,000 psf
- Sizes increased as expected
- New footings still reasonably sized
- Combined footings needed under stairwell



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  - Steel vs. Concrete Structure Schedules
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Steel vs. Concrete Cost Summary

- **Cost summary only includes areas of design that were changed as part of the concrete redesign**
- **Cost based off unit costs in RSMeans 2012**
- **Steel is $361,969.52 more expensive than concrete**

New Office Wing Design Costs

	Material	Labor	Equipment	Total	Total with O&P
Formwork	$172,235.55	$407,588.51	$0.00	$579,824.06	$815,942.64
Rebar	$153,558.67	$108,194.27	$0.00	$261,752.94	$342,390.60
Concrete	$252,822.92	$53,140.34	$15,985.59	$321,948.85	$376,821.90
Finishing	$0.00	$11,722.32	$0.00	$11,722.32	$17,583.48
Total	$578,617.14	$580,645.43	$15,985.59	$1,175,248.16	$1,552,738.62

Original Office Wing Design Costs

	Material	Labor	Equipment	Total	Total with O&P
Formwork	$1,670.70	$8,703.78	$0.00	$10,374.48	$15,224.89
Reinforcing	$24,621.93	$19,828.88	$0.00	$44,450.81	$58,945.93
Concrete	$146,751.02	$18,422.33	$5,011.77	$170,185.12	$194,658.14
Finishing	$0.00	$11,722.32	$0.00	$11,722.32	$17,583.48
Shear Studs	$4,189.50	$6,247.50	$3,013.50	$13,450.50	$19,110.00
Steel Framing	$1,010,429.31	$173,036.06	$49,631.94	$1,233,097.31	$1,467,798.24
Metal Deck	$1,511.39	$21,970.86	$1,608.43	$114,473.37	$141,387.47
Total	$1,189,173.85	$259,931.72	$59,265.64	$1,597,753.90	$1,914,708.14

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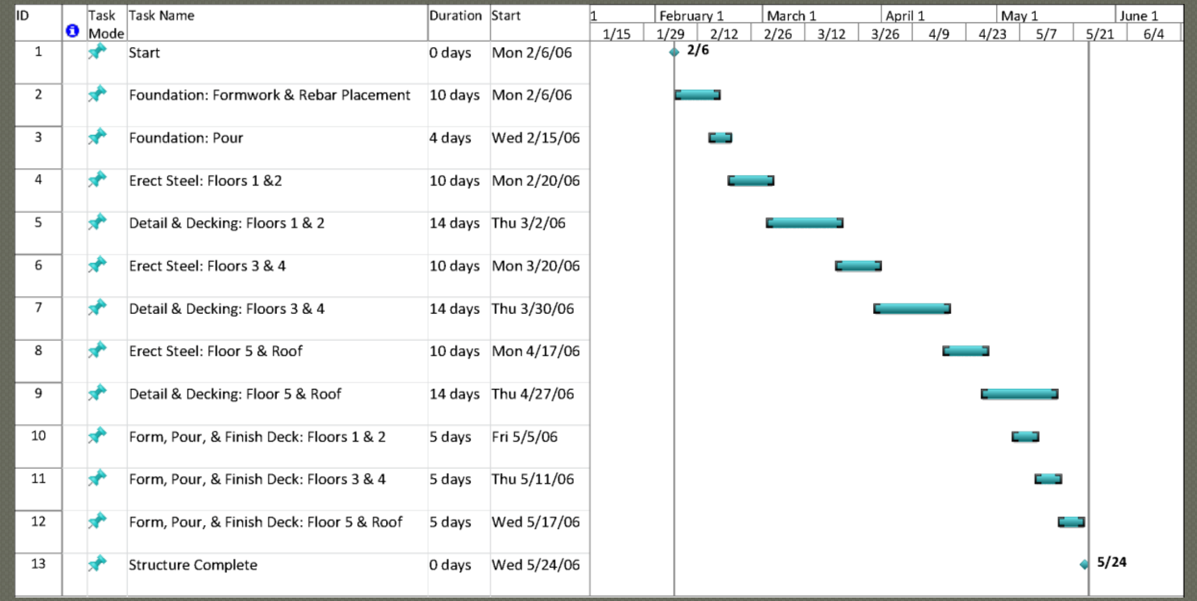
Steel vs. Concrete Schedule Summary

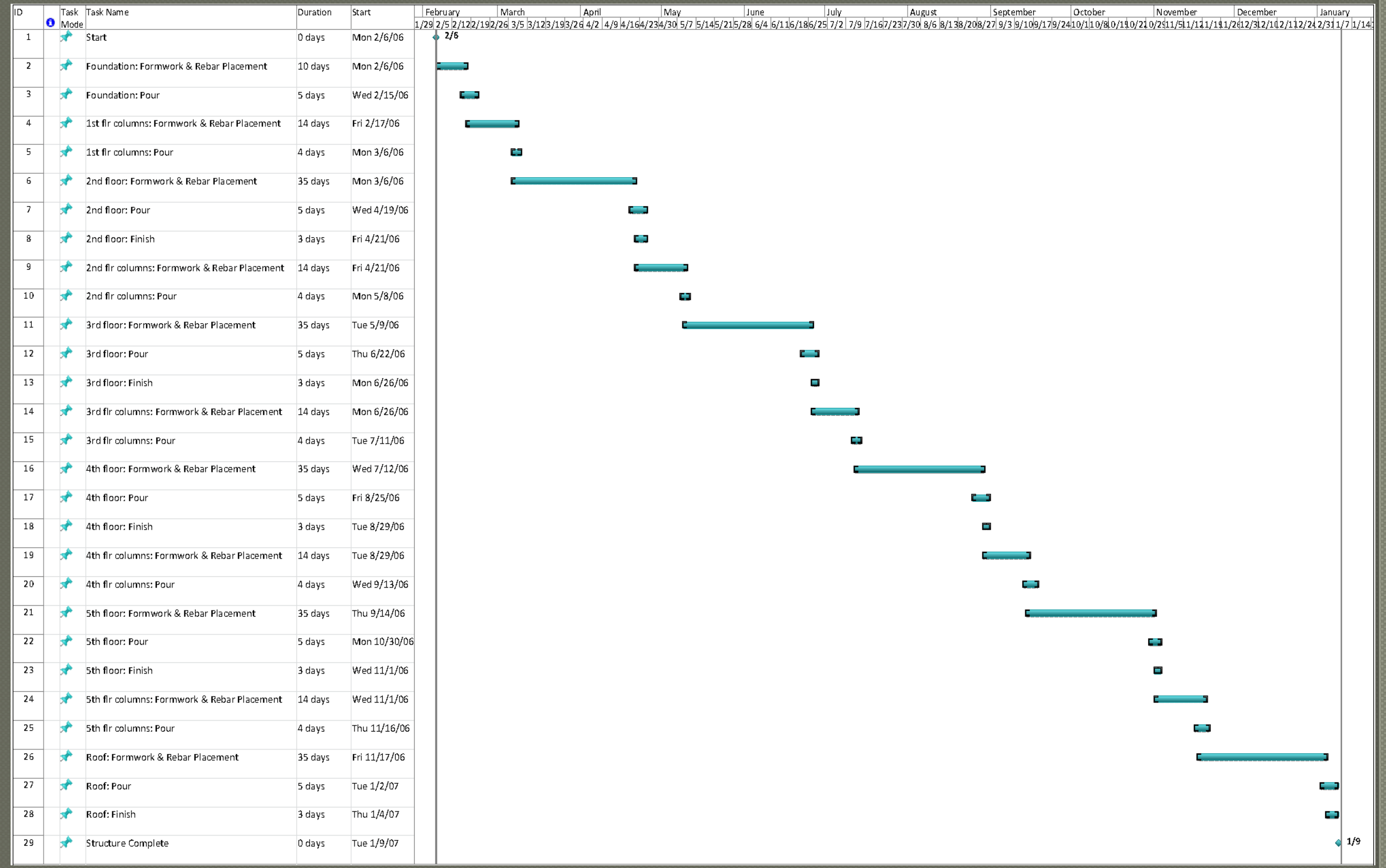
- Durations also calculated using RSMeans 2012
- Concrete design is scheduled to take 230 days longer than original steel



ID	Task Name	Duration	Start
1	Start	0 days	Mon 2/6/06
2	Foundation: Formwork & Rebar Placement	10 days	Mon 2/6/06
3	Foundation: Pour	4 days	Wed 2/15/06
4	Erect Steel: Floors 1 &2	10 days	Mon 2/20/06
5	Detail & Decking: Floors 1 & 2	14 days	Thu 3/2/06
6	Erect Steel: Floors 3 & 4	10 days	Mon 3/20/06
7	Detail & Decking: Floors 3 & 4	14 days	Thu 3/30/06
8	Erect Steel: Floor 5 & Roof	10 days	Mon 4/17/06
9	Detail & Decking: Floor 5 & Roof	14 days	Thu 4/27/06
10	Form, Pour, & Finish Deck: Floors 1 & 2	5 days	Fri 5/5/06
11	Form, Pour, & Finish Deck: Floors 3 & 4	5 days	Thu 5/11/06
12	Form, Pour, & Finish Deck: Floor 5 & Roof	5 days	Wed 5/17/06
13	Structure Complete	0 days	Wed 5/24/06

Steel Schedule: 2/6/06 – 5/24/06

Total duration: 107 days



ID	Task Name	Duration	Start
1	Start	0 days	Mon 2/6/06
2	Foundation: Formwork & Rebar Placement	10 days	Mon 2/6/06
3	Foundation: Pour	5 days	Wed 2/15/06
4	1st flr columns: Formwork & Rebar Placement	14 days	Fri 2/17/06
5	1st flr columns: Pour	4 days	Mon 3/6/06
6	2nd floor: Formwork & Rebar Placement	35 days	Mon 3/6/06
7	2nd floor: Pour	5 days	Wed 4/19/06
8	2nd floor: Finish	3 days	Fri 4/21/06
9	2nd flr columns: Formwork & Rebar Placement	14 days	Fri 4/21/06
10	2nd flr columns: Pour	4 days	Mon 5/8/06
11	3rd floor: Formwork & Rebar Placement	35 days	Tue 5/9/06
12	3rd floor: Pour	5 days	Thu 6/22/06
13	3rd floor: Finish	3 days	Mon 6/26/06
14	3rd flr columns: Formwork & Rebar Placement	14 days	Mon 6/26/06
15	3rd flr columns: Pour	4 days	Tue 7/11/06
16	4th floor: Formwork & Rebar Placement	35 days	Wed 7/12/06
17	4th floor: Pour	5 days	Fri 8/25/06
18	4th floor: Finish	3 days	Tue 8/29/06
19	4th flr columns: Formwork & Rebar Placement	14 days	Tue 8/29/06
20	4th flr columns: Pour	4 days	Wed 9/13/06
21	5th floor: Formwork & Rebar Placement	35 days	Thu 9/14/06
22	5th floor: Pour	5 days	Mon 10/30/06
23	5th floor: Finish	3 days	Wed 11/1/06
24	5th flr columns: Formwork & Rebar Placement	14 days	Wed 11/1/06
25	5th flr columns: Pour	4 days	Thu 11/16/06
26	Roof: Formwork & Rebar Placement	35 days	Fri 11/17/06
27	Roof: Pour	5 days	Tue 1/2/07
28	Roof: Finish	3 days	Thu 1/4/07
29	Structure Complete	0 days	Tue 1/9/07

Concrete Schedule: 2/6/06 – 1/9/07

Total duration: 337 days

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  - Questions?

Review

- Concrete redesign of office wing
  - One-way pan joist floor system
  - Ordinary concrete moment frame lateral system
- Seismic forces controlled lateral design
- No disrupting of spaces due to new column layout
- Floor-to-floor heights remain unchanged

Conclusions

- Concrete moment frames offer a “free” lateral system with minimal additions as opposed to a steel braced frame system

Recommendations

- Further analysis to minimize member sizes on upper floors
- Redesign the original structure without the office wing

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Acknowledgements

Thank you to the following groups and individuals for their continued support in completing this thesis report:

- The Owner (who wished to remain anonymous)
- Skanska USA Building Inc.
- The entire AE faculty
- The entire AE student body (especially fellow 5th years)
- My friends and family

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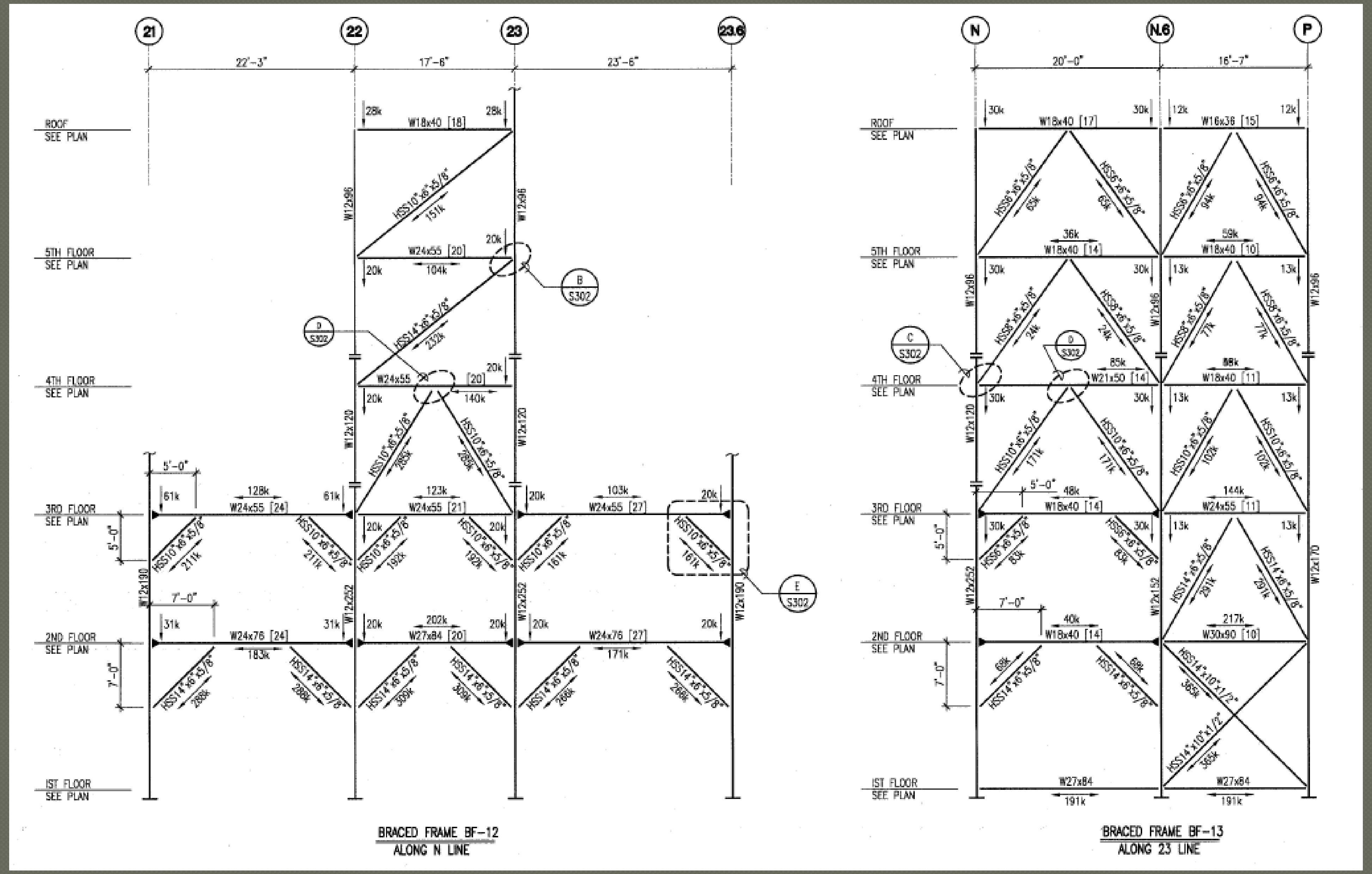
- **Additional slides**



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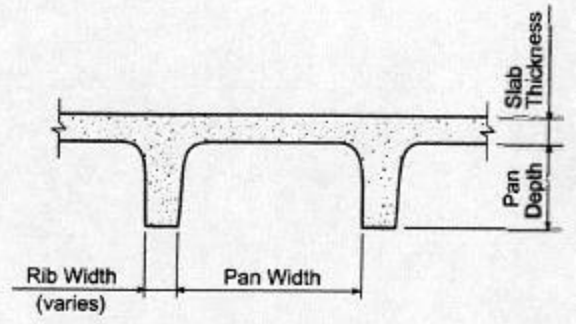
- **Additional slides**

Concrete Floor Systems
Guide to Estimating and Economizing

David A. Fanella

One-Way Joist System

A standard one-way joist floor system consists of regularly spaced concrete joists (ribs) spanning in one direction, a reinforced concrete slab cast integrally with the joists, and beams that span between the columns, perpendicular to the joists (Fig. 8). The joists are formed by using pan forms that are 30 in. wide and range in depth from 8 in. to 24 in. (Fig. 9). The varying depths provide flexibility to satisfy a wide range of span and loading conditions. The main advantages of this system are: 1) they are economical for long spans with heavy loads, 2) the pan voids reduce the dead load, and 3) electrical and mechanical equipment can be placed between joists, which means the overall floor depth need not be increased to accommodate this equipment. The longer spans and inherent vibration resistance make this an attractive floor system for office buildings, hospitals, and schools.



Pan Width (in.)	Pan Depth (in.)
30	8, 10, 12, 14, 16, 20, 24
53	16, 20, 24
66	14, 16, 20, 24

Figure 9. Standard Form Dimensions for One-Way Joist Construction

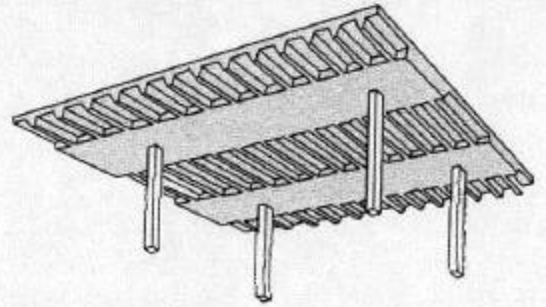


Figure 8. One-Way Joist

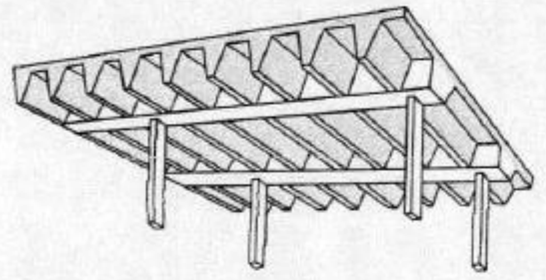


Figure 10. Wide-Module Joist

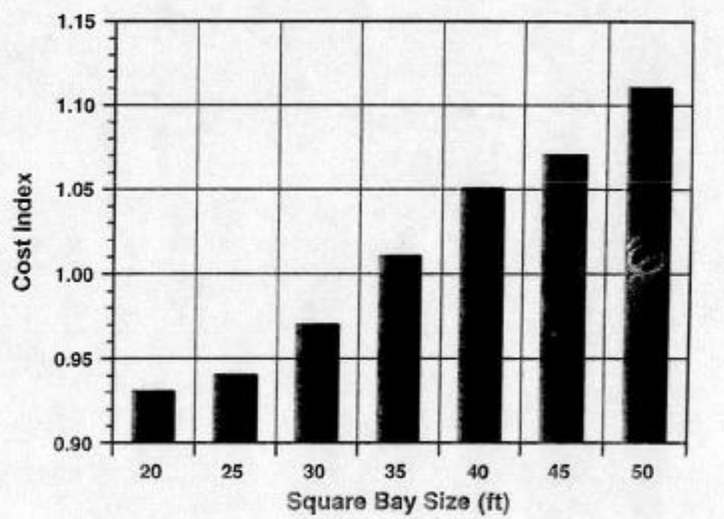
Wide-module joists, or "skip" joists, are similar to standard one-way joists, except the pans are 53 in. or 66 in. wide (Fig. 10). For the 53-in. pans, the pan depth varies from 16 in. to 24 in., and for the 66-in. pans, the range is 14 in. to 24 in. (Fig. 9). The advantages of a wide-module system are the same as those listed above. However, wide-module joists are more economical for very long span lengths, and provide large, column-free spaces for maximum flexibility in space planning—all without concerns for vibration.

The requirements for standard joist construction are contained in Sect. 8.11 of ACI 318-99 (Ref. 1). For ribs that satisfy the cross-section limitations of Sect. 8.11.2 and a clear spacing of no more than 30 in. between ribs, a 10% increase in the nominal shear strength provided by the concrete is permitted (Sect. 8.11.8). For joist construction that does not satisfy one or more of the limitations of Sects. 8.11.1 through 8.11.3 (i.e., systems formed by the 53-in. and 66-in. pans), the members of the floor system shall be designed as slabs and beams (Sect. 8.11.4).

One-Way Joist – 66″ pan

f'_c = 4,000 psi SIDL = 20 psf
Slab h = 4½″ LL = 100 psf

Bay Size (ft)	Pan Depth (in.)	Rib Width (in.)	Beam Width (in.)	Square Column Size (in.)	Concrete (ft^3/ft^2)	Reinforcement (psf)	Pan Area (%)
20 × 20	14	6	22	22	0.61	2.13	89
20 × 25	14	6	24	24	0.60	2.02	91
20 × 30	16	6	26	26	0.62	2.17	91
20 × 35	16	6	32	32	0.62	2.47	91
20 × 40	16	6	34	34	0.61	2.82	92
25 × 25	14	6	28	28	0.60	2.30	89
25 × 30	16	6	32	32	0.63	2.50	90
25 × 35	16	6	34	34	0.62	2.65	90
25 × 40	16	6	36	36	0.61	3.23	91
30 × 30	16	6	34	34	0.63	2.76	89
30 × 35	16	6	38	38	0.62	2.99	89
30 × 40	16	6	40	40	0.62	3.24	90
35 × 35	20	6	40	40	0.72	3.20	89
35 × 40	20	6	42	42	0.70	3.45	90
40 × 40	20	6	44	44	0.71	3.94	89
45 × 45	24	6	44	44	0.76	4.09	90
50 × 50	24	6	48	48	0.75	4.80	91



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Design Moments for Lateral System Beams

Beam #	M_D^+ (k-ft)	M_D^- (k-ft)	M_L^+ (k-ft)	M_L^- (k-ft)	M_E^- (k-ft)	M_U^+ (1.2D+1.6L+0.5Lr) (k-ft)	M_U^- (1.2D+1.6L+0.5Lr) (k-ft)	M_U^- (1.2D+E+L+0.2S) (k-ft)
1	73.8	147.6	30.4	60.8	65.8	137.2	274.3	303.7
2	79.4	158.8	32.7	65.3	58.9	147.5	295.0	314.7
3	32.8	65.6	13.5	27.0	79.9	61.0	121.9	185.6
4	58.3	116.6	24.0	48.0	63.9	108.4	216.8	251.9
5	12.3	24.5	5.0	10.1	109.1	22.8	45.5	148.6
6	31.1	62.1	9.2	18.4	140.7	52.0	104.0	233.7
7	16.8	33.7	5.0	10.0	127.9	28.2	56.4	178.3
8	48.4	96.7	30.7	61.5	88.7	107.2	214.4	266.3
9	66.6	133.3	42.4	84.7	72.4	147.8	295.5	317.1
10	39.0	78.1	24.8	49.7	86.8	86.6	173.1	230.1
11	7.0	14.0	5.1	10.3	107.2	16.6	33.3	134.3
12	47.0	93.9	29.9	59.7	83.1	104.1	208.3	255.5
13	118.5	236.9	75.3	150.7	71.2	262.7	525.4	506.2
14	67.0	133.9	19.8	39.7	97.1	112.1	224.2	297.4
15	45.6	91.3	31.7	63.5	104.0	105.5	211.1	277.0
16	45.6	91.3	31.7	63.5	99.6	105.5	211.1	272.6
17	3.1	6.2	2.2	4.3	191.2	7.2	14.4	202.9
18	3.1	6.2	2.2	4.3	185.7	7.2	14.4	197.5
19	45.6	91.3	31.7	63.5	89.3	105.5	211.1	262.3
20	67.0	133.9	19.8	39.7	76.3	112.1	224.2	276.7
21	18.4	36.8	9.2	18.4	122.8	36.8	73.6	185.3
22	18.4	36.8	9.2	18.4	119.7	36.8	73.6	182.3
23	49.6	99.2	31.7	63.5	89.7	110.3	220.6	272.2
24	68.3	136.7	43.7	87.5	73.2	152.0	304.0	324.7
25	40.0	80.1	25.6	51.3	87.5	89.1	178.1	234.8
26	6.9	13.8	3.8	7.6	105.8	14.3	28.6	129.8
27	48.2	96.3	30.8	61.7	84.1	107.1	214.2	261.3
28	121.5	243.0	77.8	155.5	67.3	270.2	540.4	514.4
29	37.3	74.6	7.7	15.5	132.1	57.1	114.3	237.1
30	37.3	74.6	7.7	15.5	102.4	57.1	114.3	207.4
31	79.0	158.0	34.0	68.0	68.3	149.2	298.4	325.9
32	84.9	169.9	36.6	73.2	61.4	160.5	320.9	338.4
33	84.9	169.9	36.6	73.2	61.4	160.5	320.9	338.4
34	79.0	158.0	34.0	68.0	68.0	149.2	298.4	325.6

Controlling design moment

Reinforcing for Lateral System Beams

Beam #	As,req$^+$ (in^2)	Bars	As,provided$^+$ (in^2)	øMn$^+$ (k-ft)	As,req$^-$ (in^2)	Bars	As, provided$^-$ (in^2)	øMn$^-$ (k-ft)
1	1.46	*	*	*	3.58	6#7s	3.60	347.3
2	1.58	*	*	*	3.72	5#8s	3.95	380.4
3	0.64	*	*	*	2.15	5#6s	2.20	216.3
4	1.15	*	*	*	2.95	5#7s	3.00	291.8
5	0.24	*	*	*	1.71	*	*	*
6	0.55	*	*	*	2.72	9#5s	2.79	272.2
7	0.30	*	*	*	2.06	5#6s	2.20	216.6
8	1.14	*	*	*	3.12	4#8s	3.16	306.7
9	1.58	*	*	*	3.75	5#8s	3.95	380.2
10	0.92	*	*	*	2.68	9#5s	2.79	272.4
11	0.17	*	*	*	1.54	*	*	*
12	1.11	*	*	*	2.99	5#7s	3.00	291.7
13	2.86	5#7s	3.00	292.2	6.45	6#8s & 2#9s	6.74	626.6
14	1.19	*	*	*	3.51	8#6s	3.52	339.9
15	1.12	*	*	*	3.25	8#6s	3.52	341.0
16	1.12	*	*	*	3.20	8#6s	3.52	341.3
17	0.08	*	*	*	2.35	8#5s	2.48	243.2
18	0.08	*	*	*	2.29	8#5s	2.48	243.4
19	1.12	*	*	*	3.07	7#6s	3.08	299.1
20	1.19	*	*	*	3.25	8#6s	3.52	341.1
21	0.39	*	*	*	2.14	5#6s	2.20	216.3
22	0.39	*	*	*	2.11	5#6s	2.20	216.4
23	1.17	*	*	*	3.20	8#6s	3.52	341.3
24	1.63	*	*	*	3.85	5#8s	3.95	379.7
25	0.94	*	*	*	2.74	9#5s	2.79	272.2
26	0.15	*	*	*	1.49	*	*	*
27	1.14	*	*	*	3.06	7#6s	3.08	299.2
28	2.94	5#7s	3.00	291.8	6.65	6#8s & 2#9s	6.74	625.0
29	0.60	*	*	*	2.77	9#5s	2.79	272.1
30	0.60	*	*	*	2.41	8#5s	2.48	243.0
31	1.59	*	*	*	3.86	5#8s	3.95	379.7
32	1.72	*	*	*	4.02	7#7s	4.20	402.9
33	1.72	*	*	*	4.02	7#7s	4.20	402.9
34	1.59	*	*	*	3.86	5#8s	3.95	379.7

	As,min (in^2)	Bars	As, provided (in^2)	øMn (k-ft)
*	1.91	5#6s	2.2	211.02

University Academic Center

- **Additional slides**

Spread Footing Design Summary

RAM Foundation v14.05.01.00
DataBase: office wing
Building Code: IBC
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Date: 04/02/13 11:05:19
Design Code: ACI318-08

Grid	Orientation Col/Foot	Dimensions (ft) Length	Width	Thick	f'c/fy ksi	Bottom Reinforcement Parallel to Length	Parallel to Width	Top Reinforcement Parallel to Length	Parallel to Width
(A - 5)	0.00/ 0.00	12.00	12.00	1.50	4.50/60.00	12-#7	13-#7	None	None
(A - 4)	0.00/ 0.00	15.00	15.00	2.00	4.50/60.00	17-#7	17-#7	None	None
(A - 2)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	15-#7	15-#7	None	None
(0.00 - 0.00)	177.00/177.00	12.00	12.00	1.50	4.50/60.00	11-#7	12-#7	None	None
(B - 4)	0.00/ 0.00	17.00	17.00	2.50	4.50/60.00	21-#7	22-#7	None	None
(B - 2)	0.00/ 0.00	17.00	17.00	2.50	4.50/60.00	15-#8	16-#8	None	None
(C - 5)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	12-#8	13-#8	None	None
(29.00 - -1.52)	177.00/177.00	14.00	14.00	2.00	4.50/60.00	14-#7	15-#7	None	None
(D - 4)	0.00/ 0.00	17.00	17.00	2.50	4.50/60.00	15-#8	16-#8	None	None
(D - 2)	0.00/ 0.00	16.00	16.00	2.50	4.50/60.00	18-#7	18-#7	None	None
(E - 5)	0.00/ 0.00	15.00	16.00	2.00	4.50/60.00	19-#7(17)	19-#7	None	None
(E - 4)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	10-#8	11-#8	None	None
(E - 3)	0.00/ 0.00	12.00	12.00	1.50	4.50/60.00	10-#7	13-#7	9-#3	9-#3
(E - 2)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	13-#7	14-#7	None	None
(59.00 - -3.09)	177.00/177.00	13.00	13.00	2.00	4.50/60.00	9-#8	9-#8	None	None
(F - 4)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	14-#7	15-#7	None	None
(F - 3)	0.00/ 0.00	12.00	12.00	1.50	4.50/60.00	10-#7	13-#7	9-#3	9-#3
(F - 2)	0.00/ 0.00	14.00	14.00	2.00	4.50/60.00	10-#8	11-#8	None	None
(78.89 - -4.13)	177.00/177.00	12.00	12.00	1.50	4.50/60.00	12-#7	13-#7	None	None
(H - 5)	0.00/ 0.00	16.00	17.00	2.50	4.50/60.00	14-#8(12)	14-#8	None	None
(H - 4)	0.00/ 0.00	19.00	19.00	3.00	4.50/60.00	26-#7	26-#7	None	None
(H - 2)	0.00/ 0.00	19.00	18.00	2.50	4.50/60.00	21-#8	21-#8(19)	None	None
(J - 6)	0.00/ 0.00	9.00	9.00	1.50	4.50/60.00	9-#5	9-#5	7-#3	7-#3
(105.00 - -5.50)	177.00/177.00	11.00	11.00	1.50	4.50/60.00	10-#7	10-#7	None	None
(K - 2)	0.00/ 0.00	13.00	13.00	2.00	4.50/60.00	9-#8	9-#8	None	None
(L - 5)	0.00/ 0.00	13.00	13.00	1.50	4.50/60.00	14-#7	14-#7	None	None
(L - 4)	0.00/ 0.00	16.00	16.00	2.50	4.50/60.00	18-#7	18-#7	None	None
(118.00 - -6.18)	177.00/177.00	10.00	10.00	1.50	4.50/60.00	9-#6	10-#6	8-#3	8-#3
(M - 2)	0.00/ 0.00	12.00	12.00	1.50	4.50/60.00	10-#7	9-#7	None	None

* - Number between () in reinforcement is quantity of bars in center strip of rectangular footing

Spread Footing Design

RAM Foundation v14.05.01.00
DataBase: office wing
Building Code: IBC
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Date: 03/29/13 15:27:22
Design Code: ACI318-08

FOOTING DESIGN

Footing # 84 Footing Column Location: ----- (H - 4)
Footing Orientation (deg): ------ 0.00 Column Orientation (deg): ----- 0.00
Length (ft): ------------------ 19.00
Width (ft): ------------------- 19.00
Thickness (ft): --------------- 3.00
Bottom Reinf. Parallel to Length: 20 - #8 Width: 20 - #8
Concrete fc (ksi): 4.50 fct (ksi): CODE Density (pcf): 150.00 Ec (ksi): 4066.84
Reinf. fy (ksi): 60.00
Safety Factor Overturning: Major.... 28.7 (84) Minor.... 26.2 (65)

INPUT DATA

Column Size: *24 x 24
Base Plate Dimensions (in) 0.00 x 0.00 Percent of overhang to assume Rigid: 0.00

LOADS

Surcharge (ksf)	Dead Load:	0.000	Live Load:	0.000
Axial (kip)	Dead Load:	595.00		
	Pos. Live:	249.65	Neg. Live:	N/A
	Pos. Roof:	14.31	Neg. Roof:	N/A

CONCRETE CAPACITY

	Major	Ld Co/Code Ref.	Minor	Ld Co/Code Ref.
Required Shear (kip)	347.96	2	350.54	2
Provided Shear: (kip)	745.62	Sec. 11.5.6.1 a) b) c)	722.67	Sec. 11.5.6.1 a) b) c)
Required Moment: (kip-ft)	2170.76	2	2155.81	2
Provided Moment: (kip-ft)	2272.11		2201.01	
Required Punching Shear: (kip)	1076.51	2		
Provided Punching Shear: (kip)	1442.53			

REINFORCEMENT

	Bottom Bars Parallel to Length	Width	Top Bars Parallel to Length	Width
Bar Quantity/Bar Size:	20-#8	20-#8	None	None
Required Steel/Provided Steel (in^2)	15.08/15.80	15.47/15.80	None	None
Required Steel Code Ref.	Sec. 7.12	Sec. 7.12	None	None
Bar Spacing (in)	11.63	11.63	None	None
Bar Depth (in)	32.50	31.50	None	None

Cover (in) Top N/A Bottom: 3.00 Side: 3.00

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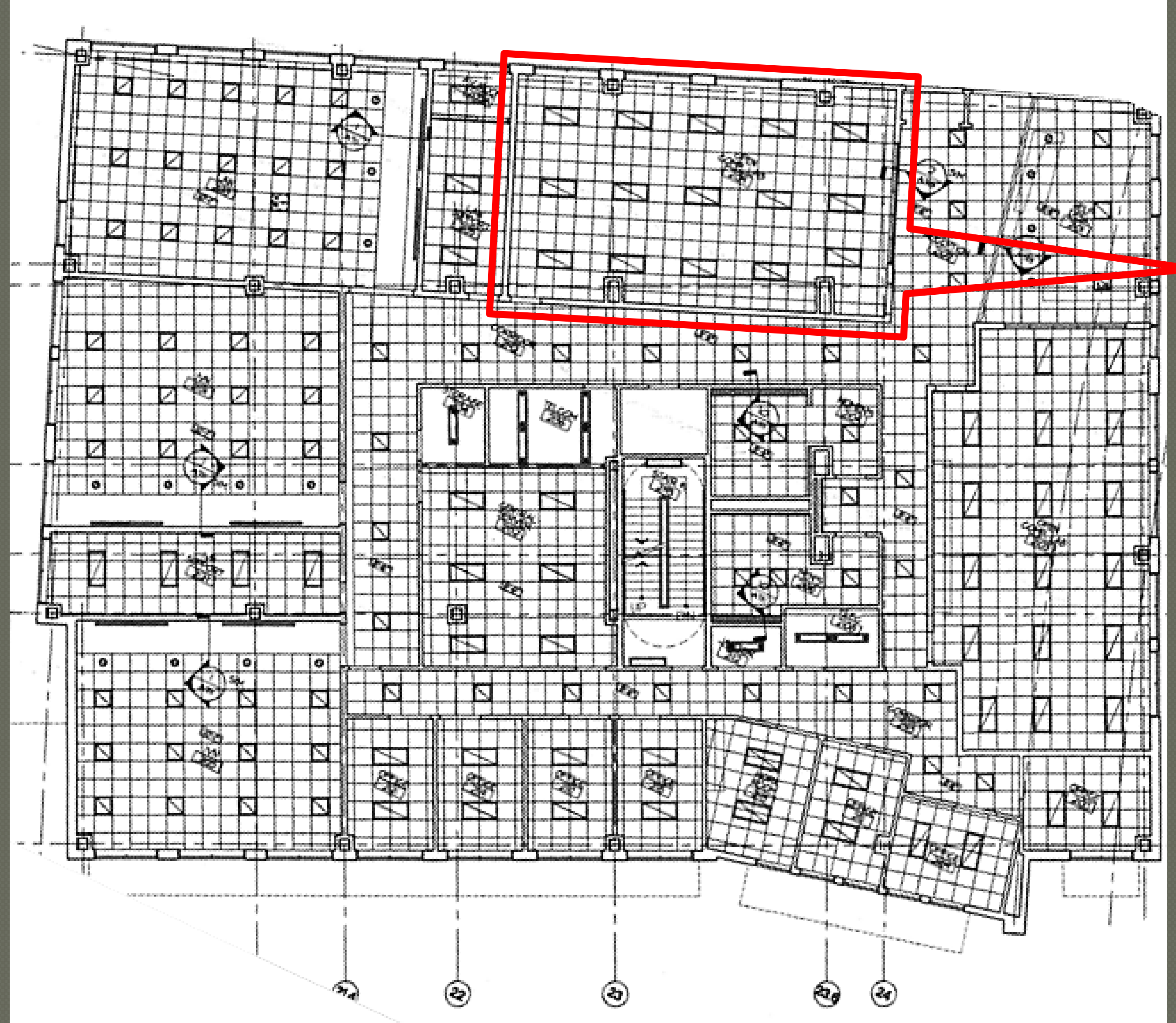
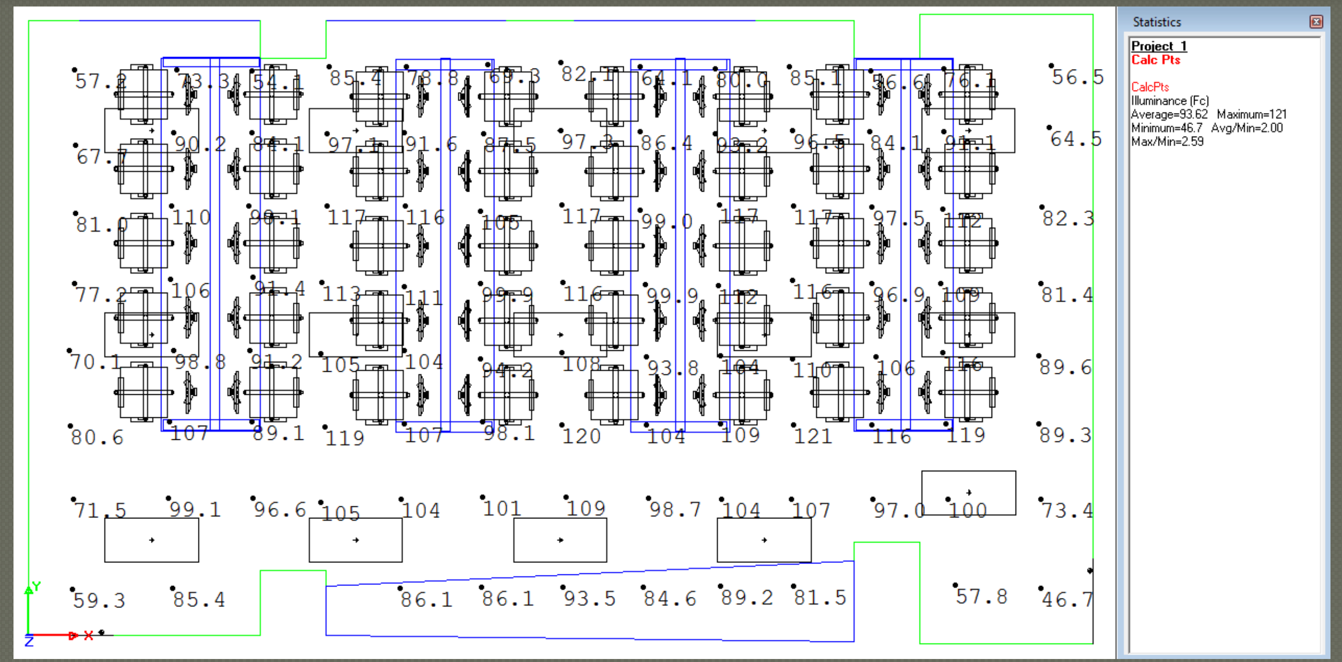
- **Additional slides**



Reflected Ceiling Plan

Computer Lab Room 2139

Original recessed lighting



New pendant lighting