Jackson Crossing

Alexandria, Virginia

Michael Bologna

Structural Option

Advisor: Dr. Linda M. Hanagan

The Pennsylvania State University

Spring 2016

Introduction

- General Building Information
- Existing Gravity System
- Existing Lateral System

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- ❖ General Building Information
- ❖ Existing Gravity System
- ❖ Existing Lateral System

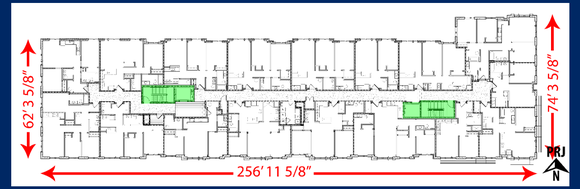
Project Site | Highway(Jefferson Davis Hwy) | Residential | Commerical

Design Team

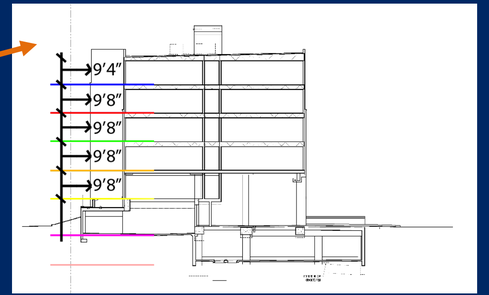
- Owner: AHC, Inc.
- CM: Harkins Builders, Inc.
- Architect: Bonstra | Haresign Architects, LLP
- Structural: Rathgeber and Goss Associates
- Civil: VIKA, Virginia, LLC
- MEP: Metropolitan Engineering, Inc.

Introduction

- ❖ General Building Information
- ❖ Existing Gravity System
- ❖ Existing Lateral System

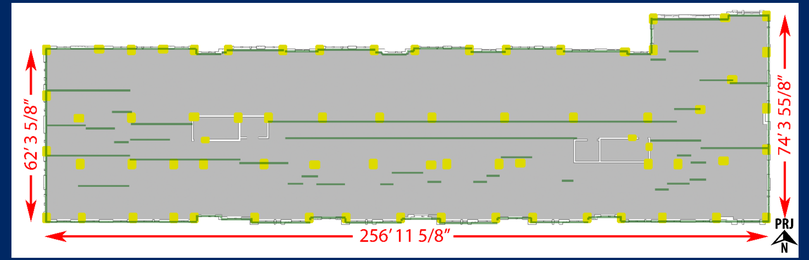


▪ North Elevation

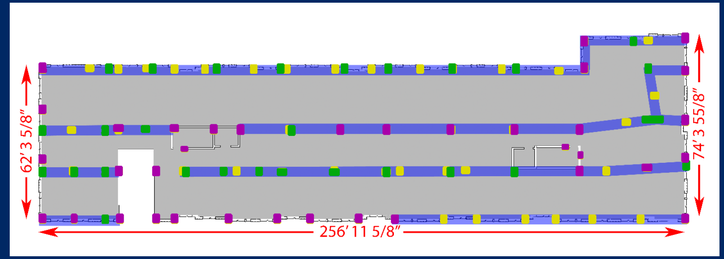


Existing Gravity System

- 4 Floors of wood framing
  - Rests on second floor podium slab



▪ Second Floor Plan



▪ First Floor Plan

Yellow – Supporting First Floor
Green – Supporting Second Floor
Purple – Supporting Both Floors
Blue – Concrete Beams

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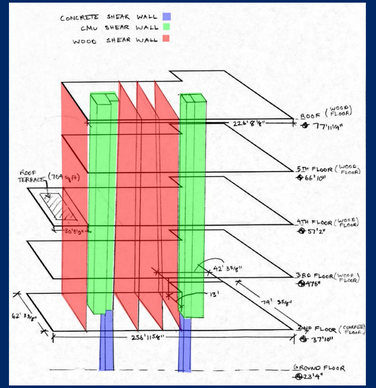
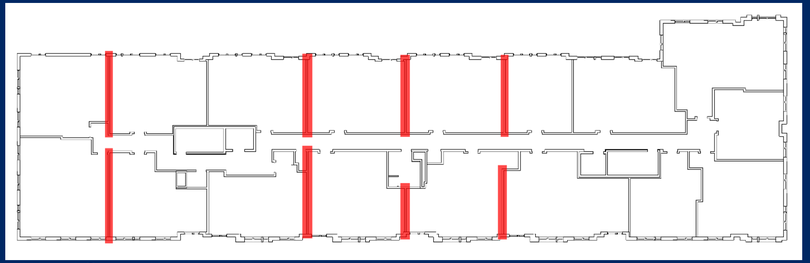
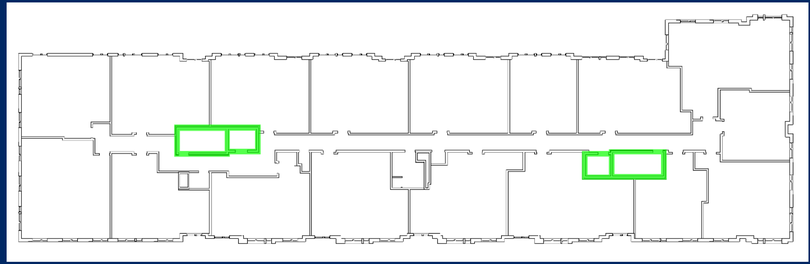
▪ Concrete Shear Walls at First Floor





▪ Wood Shear Walls on Typical Floor Plan



▪ CMU Shear Walls on Typical Floor Plan

Problem Statement/Goal

- Reduce amount of transfer members and the structural floor depth

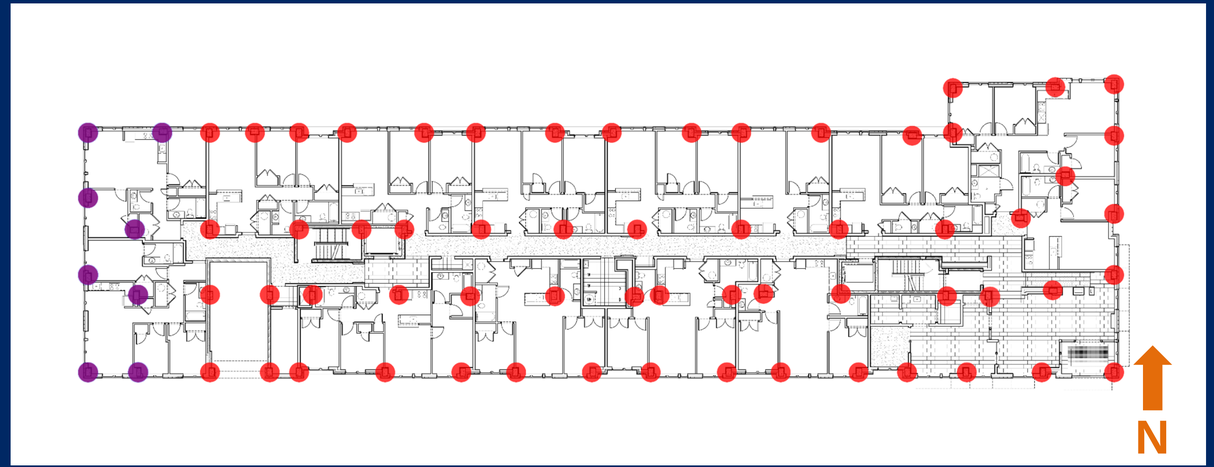
Gravity System Redesign

- Gravity Columns
- Two-Way Flat Plate Slab
- Transfer Beams

Gravity System Redesign

- ❖ Gravity Columns
- ❖ Two-Way Flat Plate Slab
- ❖ Transfer Beams

- Location of Columns on Typical Plan
- Columns not continuous to Roof in purple



Gravity System Redesign

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- ❖ Two-Way Flat Plate Slab
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- Location of Columns on Typical Plan
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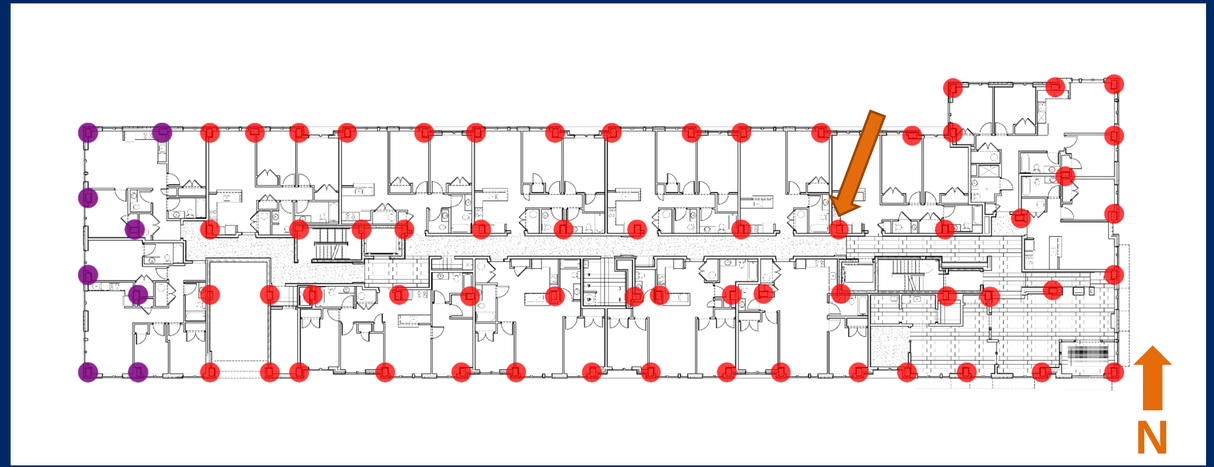


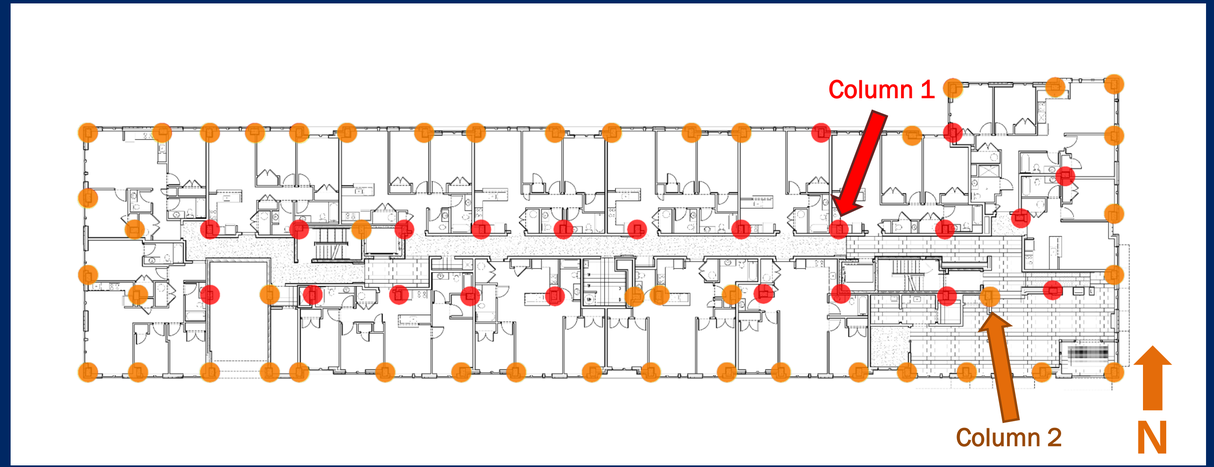
Initial Column Dimension

- Chose to base off of compressive strength, φPn
  $\varphi P_{n,max} = 0.80\varphi[0.85f'_c(A_g - A_{st}) + f_y A_{st}]$
- Pu for worst column equal to 525.1k
  Need Ag=198.5in^2
- Initial Column Size:

  14” by 14”

- Gravity Columns
- Two-Way Flat Plate Slab
- Transfer Beams

▪ Location of Columns on Typical Plan



Designed Columns

- Column 1
  - Pu=525k
  - Mu1=30 k-ft
  - Mu2=10 k-ft
- Column 2
  - Pu=260k
  - Mu1=2 k-ft
  - Mu2=11 k-ft

Gravity System Redesign

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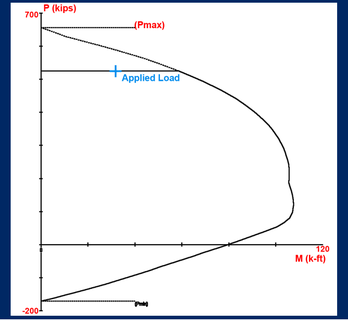
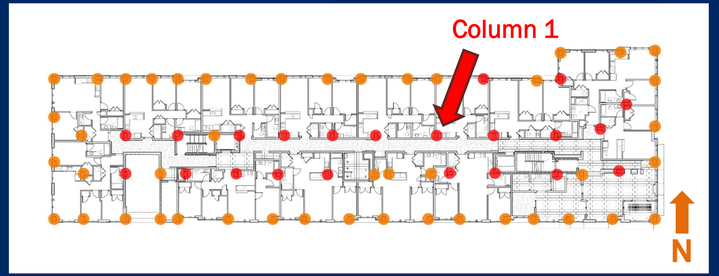
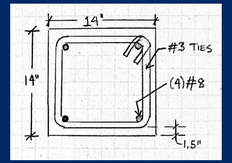
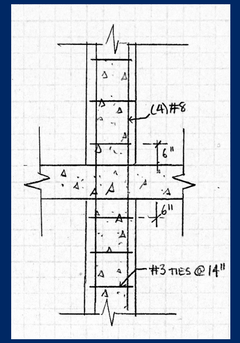






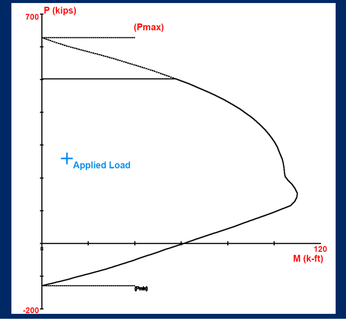


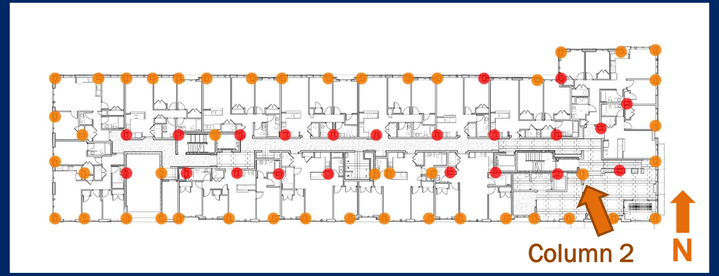
Column 1

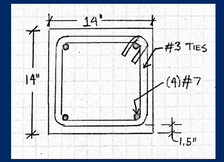
- 14” by 14”
- 5,000 psi
- Longitudinal Bars
  - (4) #8
  - 1.61% Reinforcement
- Stirrups
  - #3 Ties
  - 14” o.c. (Maximum stirrup spacing)

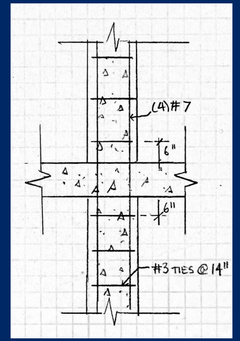
Gravity System Redesign

- ❖ Gravity Columns
- ❖ Two-Way Flat Plate Slab
- ❖ Transfer Beams







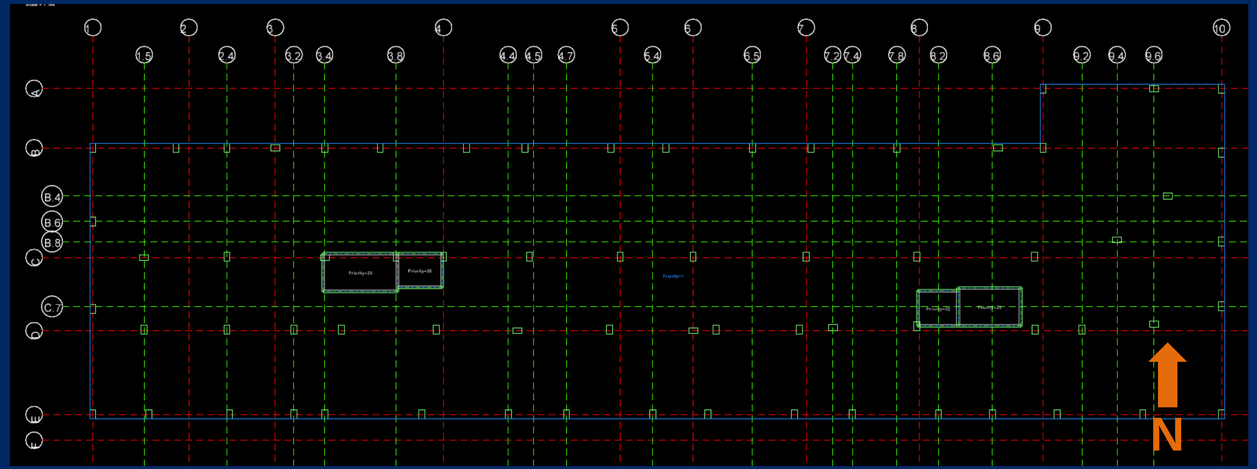


Column 2

- 14” by 14”
- 5,000 psi
- Longitudinal Bars
  - (4) #7
  - 1.22% Reinforcement
- Stirrups
  - #3 Ties
  - 14” o.c. (Maximum stirrup spacing)

Gravity System Redesign

- Gravity Columns
- Two-Way Flat Plate Slab
- Transfer Beams

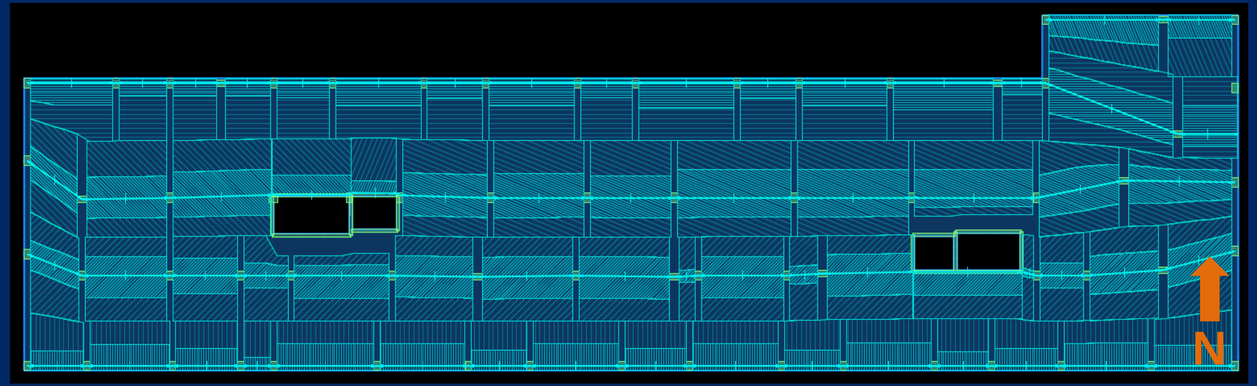


Initial Assumptions

- 9” Slab Thickness
  - Based on 23’7” interior span
  - Minimum thickness of ln/33
- 5,000 psi
- No edge beams or drop panels

- Gravity Columns
- Two-Way Flat Plate Slab
- Transfer Beams

▪ Latitude Design Strips for Floors 2 and 3



Slab Reinforcement

- Top Cover: 1.5”
- Bottom Cover: 1.5”
- Design System: Two-Way Slab

Gravity System Redesign

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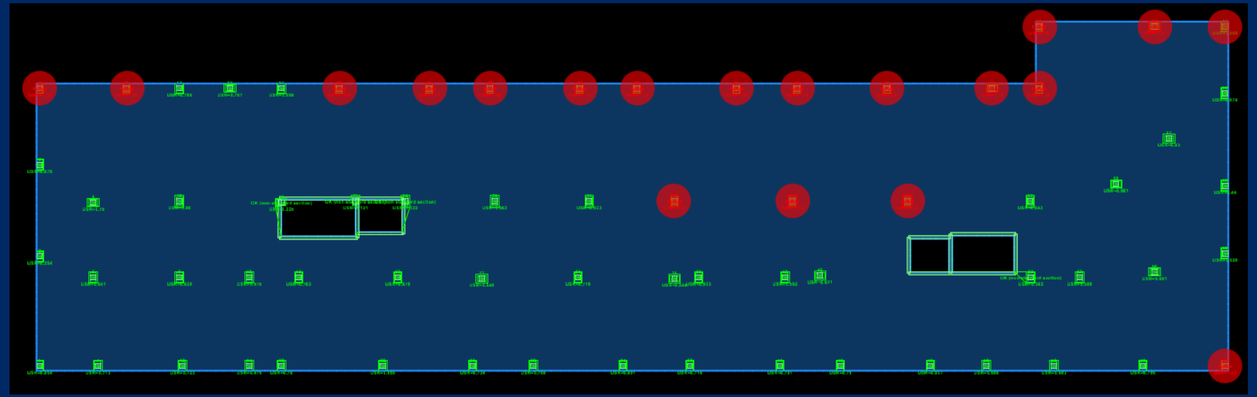
▪ Locations of Punching Shear Failure



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- Transfer Beams

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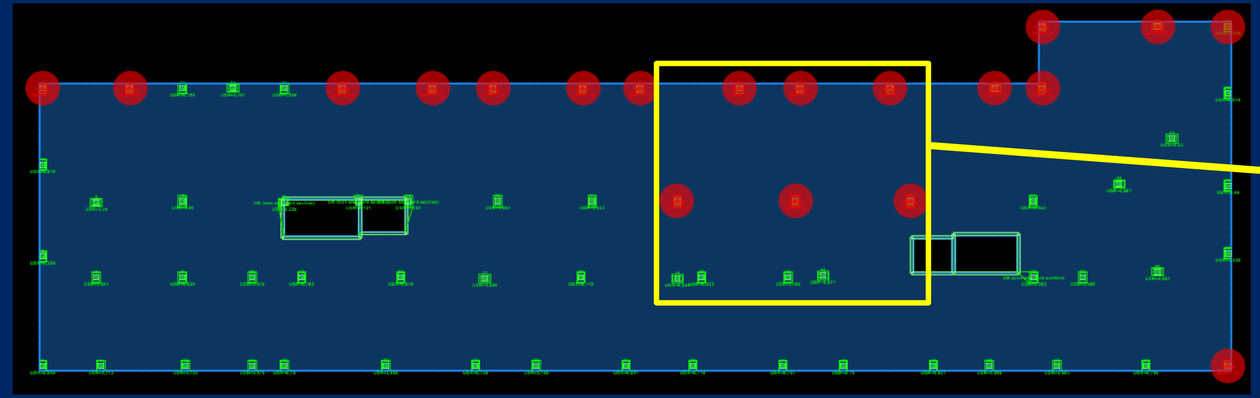
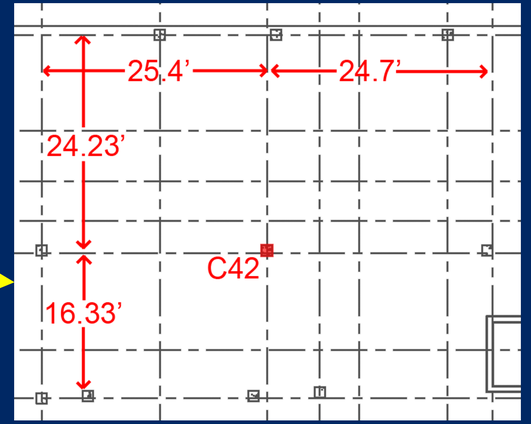
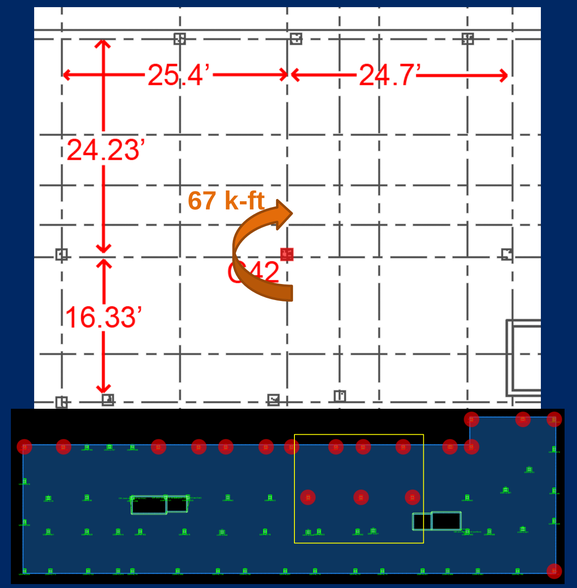




Punching Shear

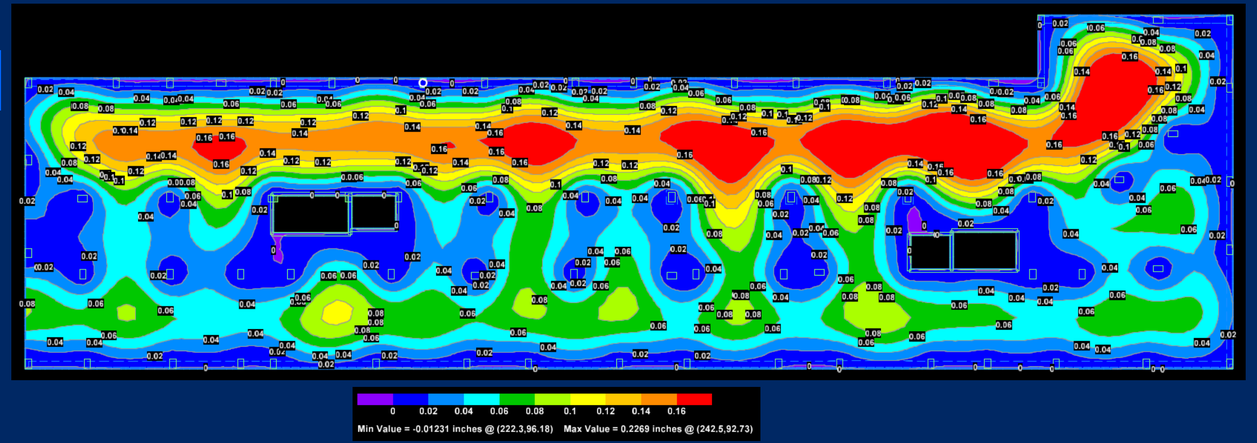
- Shear stress with unbalanced moment
  - 358.82psi
- b_o required due to this stress:
  - b_o=135”
- Solution:
  - 28” by 28” by 12” deep shear caps
  - Edge beams



Gravity System Redesign

- Gravity Columns
- Two-Way Flat Plate Slab
- Transfer Beams

▪ Long Term Deflection on Second Floor



Final Slab

- 8” Thickness
  - Meets deflection requirements

Sustained Load Deflection		
Level	Sustained Load Δ (in)	Code Allowable Δ (in)
Floor 2	0.307	0.590
Floor 3	0.307	0.590
Floor 4	0.232	0.590
Floor 5	0.225	0.590
Roof	0.214	0.590

- Bottom mat of #5 at 12” o.c. each way
- Edge beams and shear caps where necessary

Gravity System Redesign

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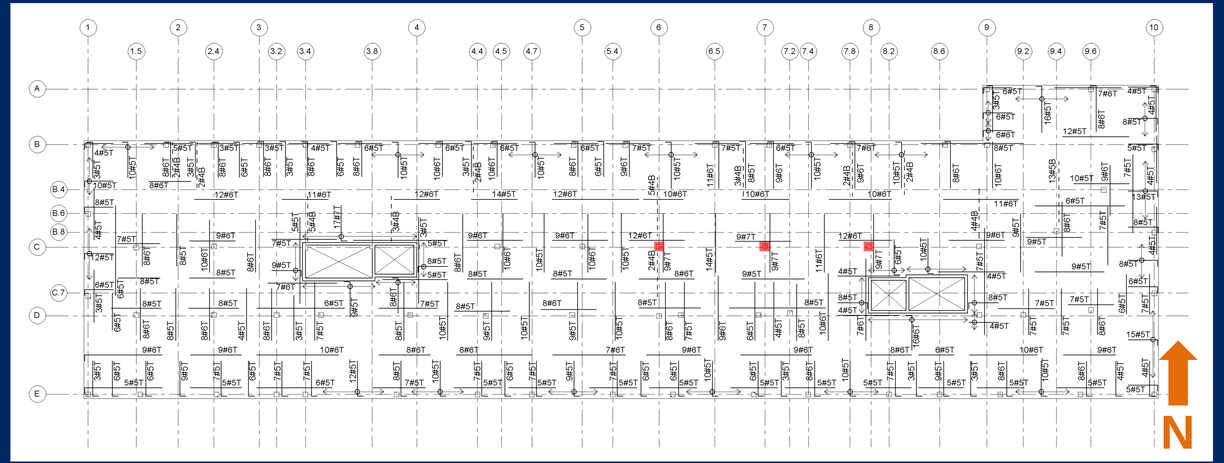
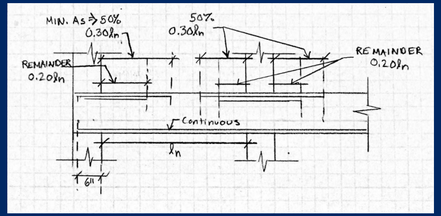
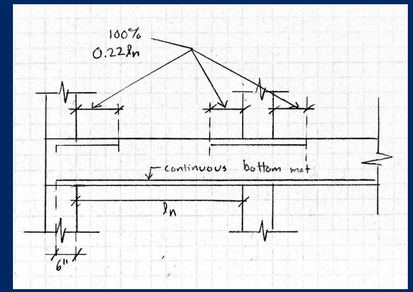
▪ Reinforcement Plan of Second Floor



- Column Strip



- Middle Strip



Gravity System Redesign

- Gravity Columns
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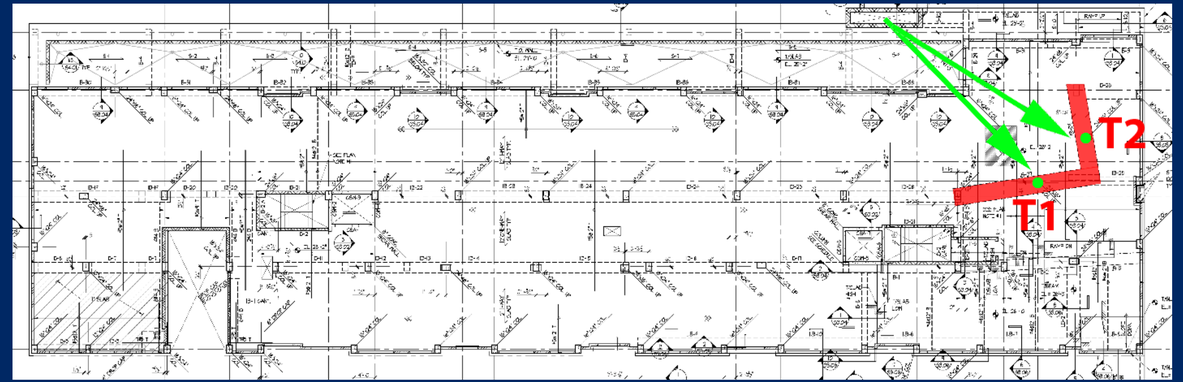


Transfer Beams

- Existing Transfer Beam T1
  - Width x Depth: 48” x 36”
  - Bottom Bars: 14#10
  - Top Bars: 8#9 at Full Length
  - Stirrups: 4 Leg #4, 1 at 2” and rest at 8” on center
- Existing Transfer Beam T2
  - Width x Depth: 48” x 36”
  - Bottom Bars: 12#9
  - Top Bars: 6#9 at Full Length
  - Stirrups: 4 Leg #4, 1 at 2” and rest at 12” on center
- New Transfer Beam T1
  - Width x Depth: 48” x 36”
  - Bottom Bars: 14#10
  - Top Bars: **12#10** at Full Length
  - Stirrups: 4 Leg #4, 1 at 2” and rest at **6**” on center
- New Transfer Beam T2
  - Width x Depth: 48” x 36”
  - Bottom Bars: 12#9
  - Top Bars: **8#9** at Full Length
  - Stirrups: 4 Leg #4, 1 at 2” and rest at 12” on center

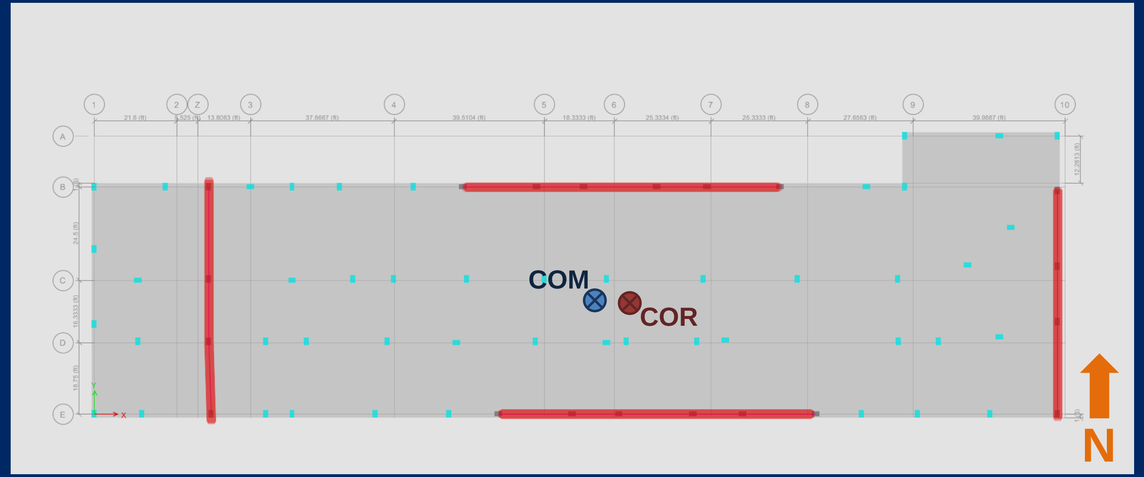
Lateral System Redesign

- Lateral Loads
- Moment Frame Columns
- Moment Frame Beams

Lateral System Redesign

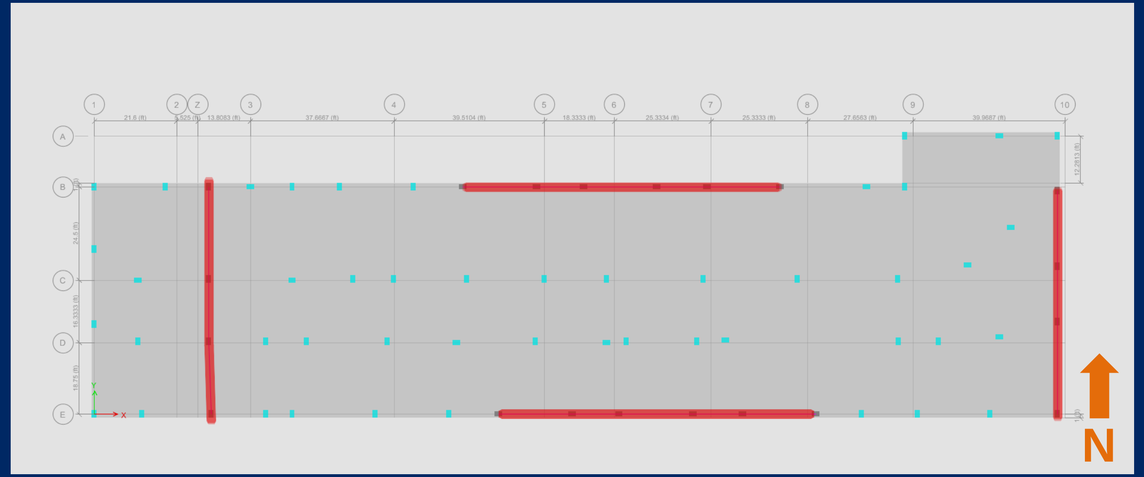
- ❖ Lateral Loads
- ❖ Moment Frame Columns
- ❖ Moment Frame Beams

▪ Location of Moment Frames on Typical Plan



- Moment Frames are located on exterior of structure to reduce twist
- Difference between C.O.R. and C.O.M.
  - For first 3 stories
    - ~3 ft in X direction
    - ~1 ft in Y direction
  - For Fifth and Roof
    - ~3 ft in X direction
    - ~1.5 ft in Y direction

▪ Location of Moment Frames on Typical Plan



Lateral Loads

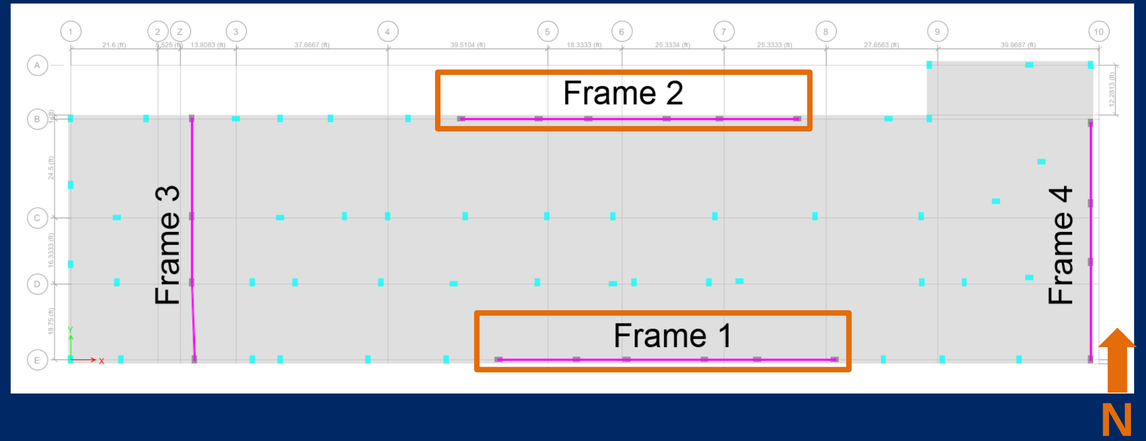
- Seismic was controlling case in both directions

Base Shear (k)		
Direction of Loading	Wind	Seismic
NS	272.46	401.66
EW	65.78	401.66

Lateral System Redesign

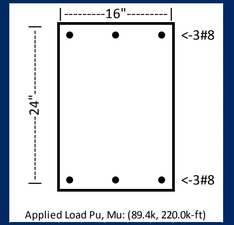
- ❖ Lateral Loads
- ❖ Moment Frame Columns
- ❖ Moment Frame Beams

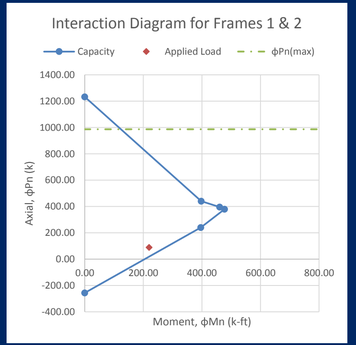
▪ Location of Moment Frames on Typical Plan



Frames 1 and 2

- Final Reinforcing
  - 2 Layers of 3#8
  - #4 Stirrups spaced at 16” on center

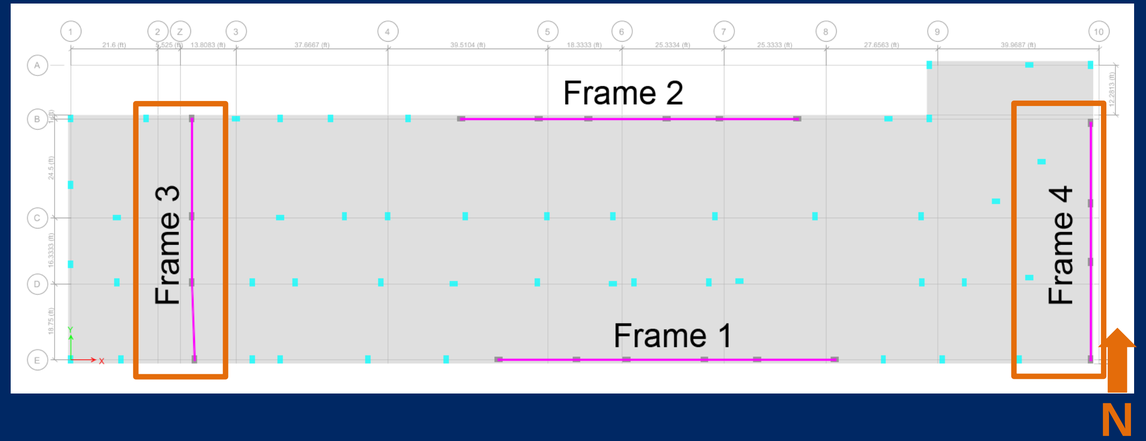




Lateral System Redesign

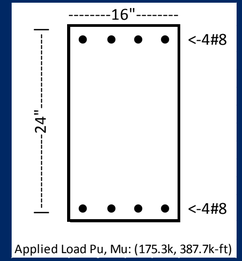
- Lateral Loads
- Moment Frame Columns
- Moment Frame Beams

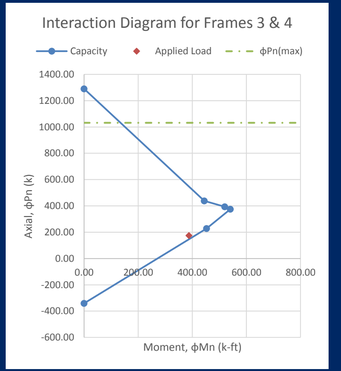
▪ Location of Moment Frames on Typical Plan



Frames 3 and 4

- Final Reinforcing
  - 2 Layers of 4#8
  - #4 Stirrups spaced at 16” on center

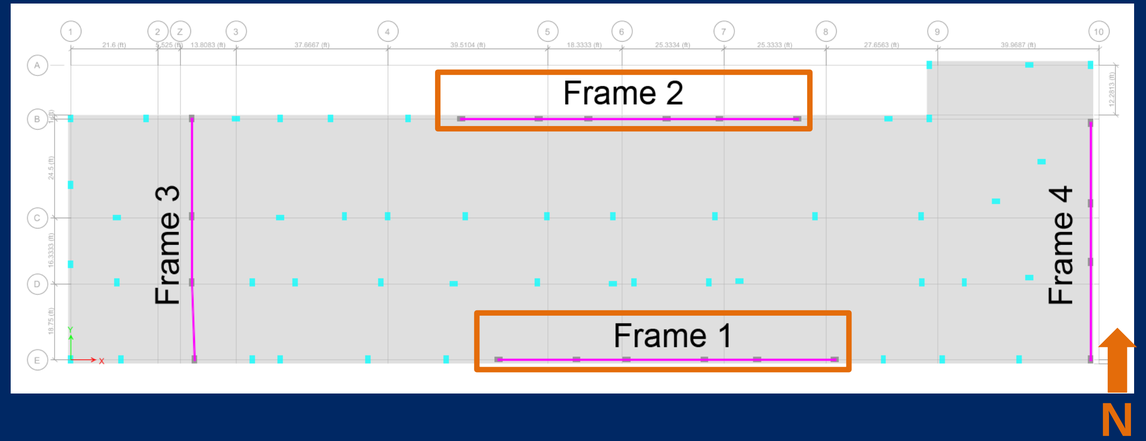




Lateral System Redesign

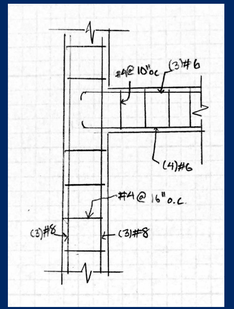
- Lateral Loads
- Moment Frame Columns
- Moment Frame Beams

▪ Location of Moment Frames on Typical Plan



Frames 1 and 2

- Final Reinforcing
  - Bottom Bars: (4) #6 Full Length
  - Top Bars: (3) #6 Full Length
  - Stirrups: 2 leg #4 at 10” o.c.



Lateral System Redesign

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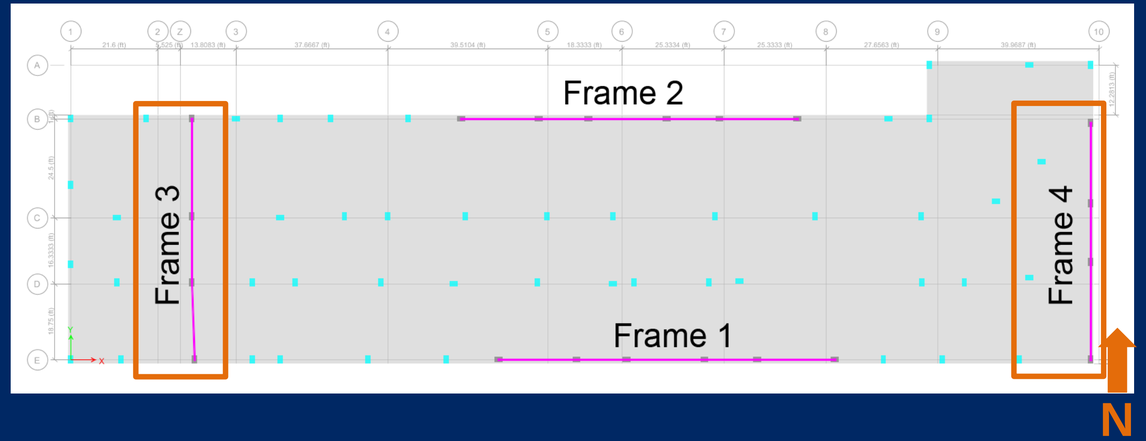
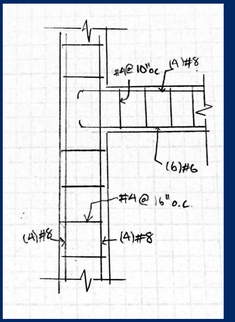
▪ Location of Moment Frames on Typical Plan



Frames 3 and 4

- Final Reinforcing
  - Bottom Bars: (6) #6 Full Length
  - Top Bars: (4) #8 Full Length
  - Stirrups: 2 leg #4 at 10” o.c.



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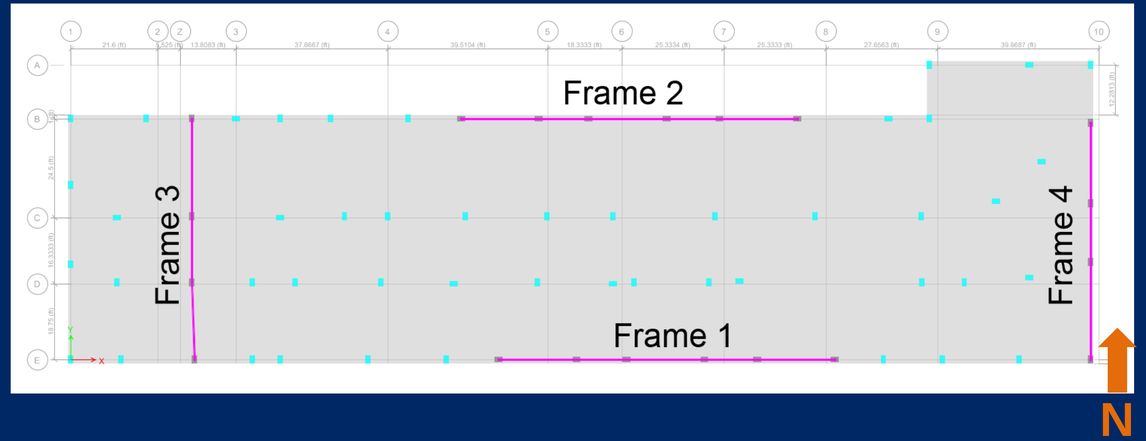
▪ Location of Moment Frames on Typical Plan



Deflections					
Story	Story Height (ft)	Δx (in)	Δy (in)	$0.020h_{sx}$ (in)	l/400 (in)
Roof	10.60	0.095	0.183	2.545	0.318
5th	9.67	0.115	0.199	2.320	0.290
4th	9.67	0.141	0.226	2.320	0.290
3rd	9.67	0.147	0.224	2.320	0.290
2nd	9.67	0.115	0.166	2.320	0.290

Construction Management Breadth

- Cost Analysis
- Schedule Analysis

Breadth Topics:

- Impact on:
  - Structural cost
  - Critical Path

Other Breadth Topics:

- Acoustical Consideration
  - Impact on:
    - STC Rating
    - IIC Rating

Construction Management Breadth

- Cost Analysis
- Schedule Analysis

Cost Analysis

The cost estimate for the redesign structure will take into account the following:

- Material costs of concrete mix for the slab, beams, columns, and shear caps
- Labor and equipment costs for placing the concrete mix with pumping
- Material and labor costs for formwork
- Material and labor costs for reinforcement of slabs and columns.

Individual Costs:

- Concrete Mix: $272,200
- Placing Concrete: $60,600
- Formwork: $648,200
- Rebar: $36,900

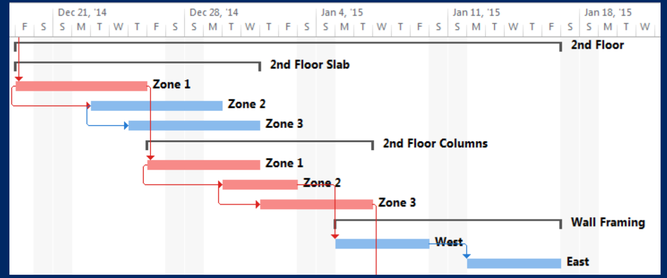
Total Cost: $1,063,500 or **$212,700 per floor**

Existing Structure Cost: **$175,000 per floor**

22% Increase in Cost

Construction Management Breadth

- Cost Analysis
- Schedule Analysis



- Placing of concrete and columns split into 3 zones
- The duration for slabs and columns:
  - Formwork: 2 days
  - Reinforcement: 2 days
  - Pour: 1 days

Schedule Analysis

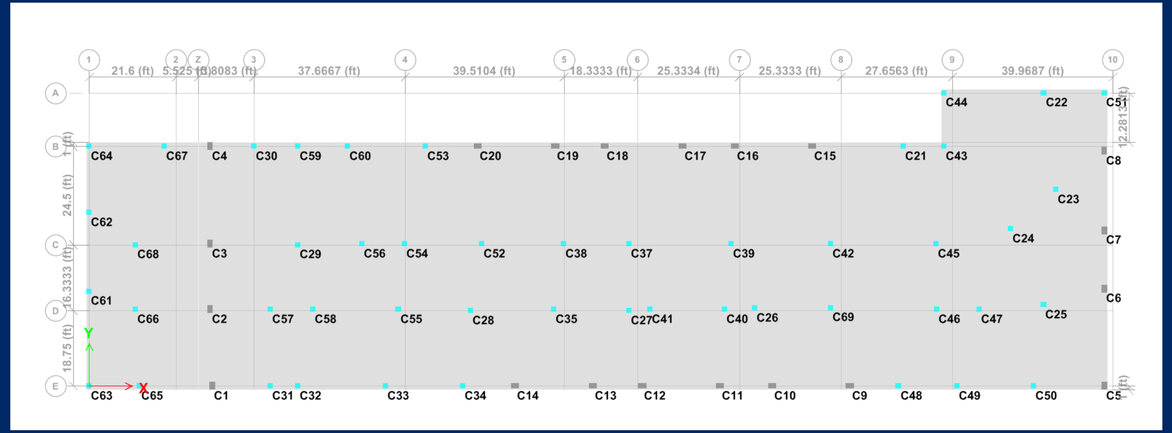
- Existing schedule had a duration of 45 days for wood framing
- Total duration of concrete structure was 69 days
  - Increase of 24 days along the critical path

Thank you to the following people:

- Rathgeber and Goss Associates, especially Justin Domire
- AHC, Inc.
- Harkins Builders, especially Russell Tipton
- My classmates at Penn State along with my friends and family at home.
- Professors in the AE Department, especially my advisor Dr. Linda Hanagan.

Questions?

Gravity Column Loads

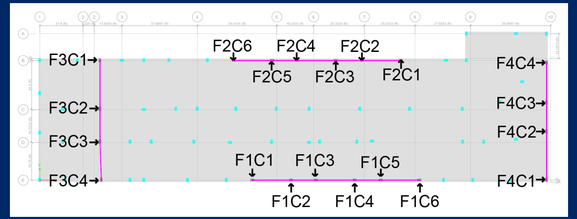


Gravity Column Loads

Column	Load Combination	Axial	Shear		Moment	
		P(k)	V2 (k)	V3 (k)	M2 (k-ft)	M3 (k-ft)
C42	**1.2D+1.6L+0.5S**	**524.70**	**-0.35**	**-4.24**	**30.14**	**10.04**
C39	1.2D+1.6L+0.5S	516.78	-0.75	-0.30	6.11	10.85
C45	1.2D+1.6L+0.5S	465.11	-0.81	-0.73	8.70	14.53
C37	1.2D+1.6L+0.5S	430.29	-0.44	0.41	1.77	7.34
C52	1.2D+1.6L+0.5S	397.67	-0.53	-0.01	4.32	5.51
C23	1.2D+1.6L+0.5S	386.28	0.91	-0.91	17.13	-10.67
C35	1.2D+1.6L+0.5S	384.66	0.51	-0.08	3.68	0.33
C38	1.2D+1.6L+0.5S	377.27	-0.50	-0.39	6.62	6.63
C55	1.2D+1.6L+0.5S	373.61	-0.02	-0.36	5.39	1.02
C3	1.2D+1.6L+0.5S	368.86	-0.82	0.00	10.92	-7.16
C29	1.2D+1.6L+0.5S	356.19	0.51	-0.70	3.54	-7.35
C69	1.2D+1.6L+0.5S	355.20	0.16	4.85	-26.34	6.90
C24	1.2D+1.6L+0.5S	351.40	-0.88	3.69	-11.77	0.87
C28	1.2D+1.6L+0.5S	344.68	-0.09	0.14	1.25	-2.65
C46	1.2D+1.6L+0.5S	343.25	0.26	-1.01	9.38	8.02
C54	1.2D+1.6L+0.5S	340.82	-0.65	0.53	1.05	4.96
C2	1.2D+1.6L+0.5S	326.15	0.30	-0.78	12.98	-14.13
C25	1.2D+1.6L+0.5S	323.13	2.31	-3.91	35.22	-17.36
C43	1.2D+1.6L+0.5S	322.74	0.90	1.04	-0.48	4.28
C15	1.2D+1.6L+0.5S	315.22	-0.43	1.43	10.72	-30.98
C26	1.2D+1.6L+0.5S	305.15	-1.04	0.18	5.59	3.10
C58	1.2D+1.6L+0.5S	297.81	0.12	0.44	0.54	-1.20
C47	**1.2D+1.6L+0.5S**	**259.96**	**-0.05**	**0.31**	**1.33**	**10.60**
C56	1.2D+1.6L+0.5S	253.38	-0.53	-0.33	6.26	3.54
C22	1.2D+1.6L+0.5S	251.20	0.30	0.96	5.49	-8.54
C40	1.2D+1.6L+0.5S	248.19	0.28	-0.57	6.68	4.47
C68	1.2D+1.6L+0.5S	244.98	-0.77	-0.70	0.93	0.42
C20	1.2D+1.6L+0.5S	243.59	-0.44	1.29	-2.28	-30.93
C17	1.2D+1.6L+0.5S	242.05	-0.11	1.15	7.09	-32.97
C19	1.2D+1.6L+0.5S	241.85	0.30	1.27	1.08	-35.50
C57	1.2D+1.6L+0.5S	241.59	0.10	-0.13	3.99	-1.79
C18	1.2D+1.6L+0.5S	240.42	-0.70	1.28	3.06	-29.31
C9	1.2D+1.6L+0.5S	236.85	0.78	-1.17	28.18	-16.23
C33	1.2D+1.6L+0.5S	231.40	-0.75	-0.02	2.12	5.28
C53	1.2D+1.6L+0.5S	231.39	1.07	-0.40	8.31	-5.19

Column	Load Combination	Axial	Shear		Moment	
		P(k)	V2 (k)	V3 (k)	M2 (k-ft)	M3 (k-ft)
C21	1.2D+1.6L+0.5S	228.41	0.19	0.86	3.87	-7.00
C41	1.2D+1.6L+0.5S	226.46	0.11	0.50	0.16	4.30
C60	1.2D+1.6L+0.5S	223.15	1.06	0.28	4.14	-6.38
C16	1.2D+1.6L+0.5S	221.22	-0.35	1.00	10.16	-31.49
C50	1.2D+1.6L+0.5S	212.21	-0.78	0.03	1.82	15.92
C27	1.2D+1.6L+0.5S	207.19	0.45	0.09	4.11	-5.91
C12	1.2D+1.6L+0.5S	204.22	-0.39	-0.88	17.84	-8.92
C66	1.2D+1.6L+0.5S	203.78	0.16	0.74	-1.30	-4.33
C6	1.2D+1.6L+0.5S	197.50	0.71	-0.29	10.87	66.62
C7	1.2D+1.6L+0.5S	194.09	-0.06	-0.30	13.32	71.38
C49	1.2D+1.6L+0.5S	192.31	-0.75	0.19	0.85	14.51
C4	1.2D+1.6L+0.5S	192.20	1.70	-0.20	16.16	-22.88
C14	1.2D+1.6L+0.5S	190.41	-0.51	-0.79	12.03	-8.22
C11	1.2D+1.6L+0.5S	190.36	0.37	-0.72	20.04	-13.69
C34	1.2D+1.6L+0.5S	186.87	-0.73	-0.16	2.92	6.39
C13	1.2D+1.6L+0.5S	182.15	0.53	-0.75	14.96	-14.66
C1	1.2D+1.6L+0.5S	175.08	-1.15	-0.51	8.18	-4.89
C10	1.2D+1.6L+0.5S	170.45	-0.18	-0.65	21.80	-10.26
C48	1.2D+1.6L+0.5S	164.60	-0.60	0.28	0.28	12.65
C32	1.2D+1.6L+0.5S	164.49	-0.60	0.57	-1.47	2.95
C30	1.2D+1.6L+0.5S	161.24	-0.39	0.79	-6.24	-3.48
C59	1.2D+1.6L+0.5S	158.37	0.76	-0.03	6.00	-5.33
C67	1.2D+1.6L+0.5S	155.27	1.13	-0.32	7.78	-9.76
C8	1.2D+1.6L+0.5S	145.65	0.31	-0.42	17.33	69.08
C5	1.2D+1.6L+0.5S	143.51	-0.82	-0.43	7.65	76.15
C31	1.2D+1.6L+0.5S	130.48	-0.60	-0.18	3.09	2.47
C65	1.2D+1.6L+0.5S	126.95	-0.82	0.37	-0.25	1.69
C44	1.2D+1.6L+0.5S	126.41	0.26	0.69	2.50	8.15
C61	1.2D+1.6L+0.5S	114.02	0.11	0.95	-2.30	-4.76
C62	1.2D+1.6L+0.5S	107.77	-0.04	0.43	2.18	-3.87
C51	1.2D+1.6L+0.5S	81.12	0.29	-0.28	8.39	10.55
C64	1.2D+1.6L+0.5S	76.87	0.39	0.53	2.65	-6.45
C63	1.2D+1.6L+0.5S	70.11	-0.52	-0.31	3.84	-0.90

Lateral Column Loads



Column	Combo	Axial (K)	M1 (k-ft)	M2 (k-ft)	Vu (k)
F1C1	**0.9D+E**	**89.428**	**220.0426**	**2.2502**	**37.801**
F1C2	0.9D+E	183.104	212.3095	2.5668	35.244
F1C3	0.9D+E	94.885	218.4238	2.3529	37.266
F1C4	0.9D+E	163.094	213.8092	2.3566	35.74
F1C5	0.9D+E	69.139	184.7505	2.2748	26.129
F1C6	0.9D+E	206.98	194.1208	3.0609	29.228
F2C1	0.9D+E	187.156	214.867	1.9381	35.838
F2C2	0.9D+E	122.426	219.7743	2.2003	37.461
F2C3	0.9D+E	204.248	213.9049	2.4737	35.52
F2C4	0.9D+E	118.728	222.4997	2.514	38.363
F2C5	0.9D+E	245.231	195.2924	2.7696	29.364
F2C6	0.9D+E	96.391	185.6097	2.6498	26.162
F3C1	0.9D+E	197.157	350.5509	5.5244	53.479
F3C2	0.9D+E	292.737	371.1651	0.7407	60.297
F3C3	**0.9D+E**	**175.2994**	**387.6746**	**3.3348**	**65.757**
F3C4	0.9D+E	83.43399	334.8581	6.6203	48.336
F4C1	0.9D+E	42.24	291.1087	4.7919	38.883
F4C2	0.9D+E	80.817	350.4922	0.7431	58.523
F4C3	0.9D+E	182.28	347.89	2.1545	57.662
F4C4	0.9D+E	200.124	310.3013	6.044	45.231

Lateral Beam Loads

Forces in Frame 1 and Frame 2							
Beam	Mu (k-ft)-	Mu (k-ft)+	Vu (k-ft)	Beam	Mu (k-ft)	+	Vu (k-ft)
F1B1	-67.73	106.97	15.98	F2B1	-52.97	24.04	13.23
F1B2	-102.15	94.31	19.64	F2B2	-117.36	45.47	22.96
F1B3	-129.32	88.19	23.12	F2B3	-143.94	60.67	25.92
F1B4	-143.06	56.46	24.76	F2B4	-160.56	73.29	27.74
F1B5	-142.49	42.26	24.97	F2B5	**-165.03**	75.99	28.16
F1B6	-45.74	13.40	11.79	F2B6	-58.28	20.47	15.11
F1B7	-89.21	64.04	21.13	F2B7	-103.56	70.84	24.01
F1B8	-125.31	98.15	27.93	F2B8	-132.94	100.10	29.31
F1B9	-146.30	119.39	32.01	F2B9	-150.67	118.68	32.59
F1B10	-150.39	120.81	32.55	F2B10	-152.16	119.93	32.84
F1B11	-74.16	38.85	17.91	F2B11	-80.22	37.76	19.67
F1B12	-114.16	51.43	22.39	F2B12	-118.57	52.05	24.16
F1B13	-137.20	68.63	25.09	F2B13	-139.17	68.35	26.55
F1B14	-148.32	78.97	26.34	F2B14	-149.98	78.74	27.77
F1B15	-143.35	74.78	25.81	F2B15	-146.03	75.57	27.36
F1B16	-59.68	19.68	10.71	F2B16	-54.78	29.01	14.71
F1B17	-92.85	66.02	20.84	F2B17	-95.63	67.85	22.62
F1B18	-127.61	99.52	27.04	F2B18	-127.79	99.95	28.84
F1B19	-146.51	119.39	30.57	F2B19	-147.60	119.70	32.67
F1B20	-147.54	120.15	30.73	F2B20	-151.76	**121.06**	**33.20**
F1B21	-62.88	29.99	13.26	F2B21	-57.90	36.89	11.64
F1B22	-100.31	44.54	17.85	F2B22	-112.75	59.54	23.08
F1B23	-132.38	68.70	21.38	F2B23	-136.89	80.19	26.00
F1B24	-148.67	83.27	23.16	F2B24	-150.31	95.00	27.64
F1B25	-151.65	84.49	23.40	F2B25	-150.52	100.07	27.95

F1B1	F1B6	F1B11	F1B16	F1B21
F1B2	F1B7	F1B12	F1B17	F1B22
F1B3	F1B8	F1B13	F1B18	F1B23
F1B4	F1B9	F1B14	F1B19	F1B24
F1B5	F1B10	F1B15	F1B20	F1B25

F2B1	F2B6	F2B11	F2B16	F2B21
F2B2	F2B7	F2B12	F2B17	F2B22
F2B3	F2B8	F2B13	F2B18	F2B23
F2B4	F2B9	F2B14	F2B19	F2B24
F2B5	F2B10	F2B15	F2B20	F2B25

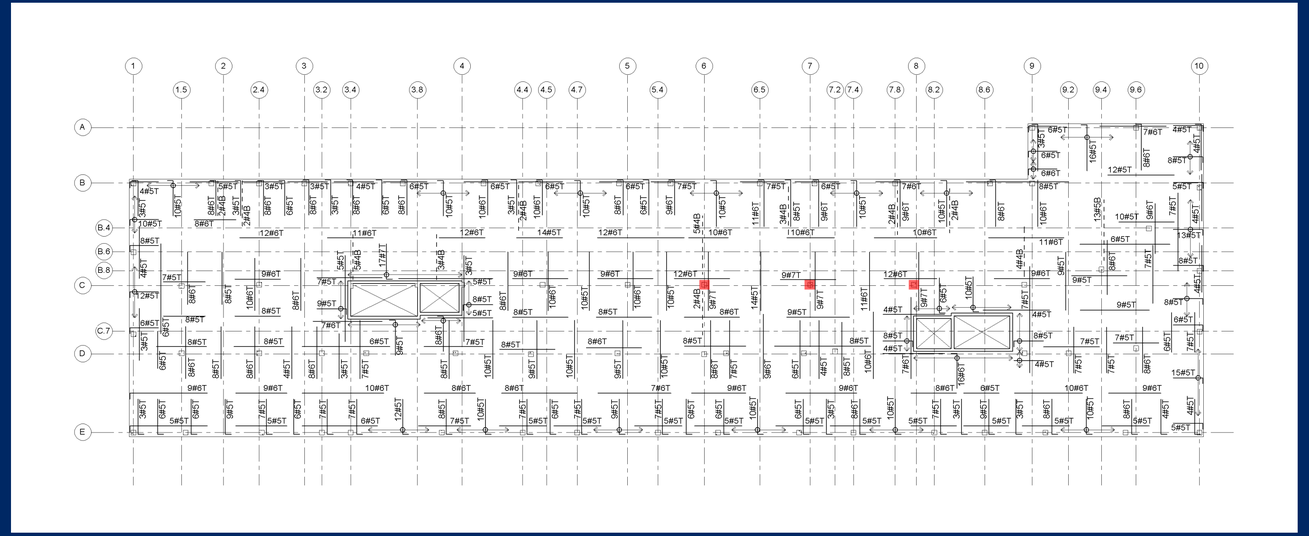
Lateral Beam Loads

Forces in Frame 3 and Frame 4							
Beam	Mu (k-ft)	+	Vu (k-ft)	Beam	Mu (k-ft)	+	Vu (k-ft)
F3B1	-193.76	111.61	32.41	F4B1	-147.85	85.92	25.05
F3B2	-254.99	100.96	36.62	F4B2	-206.40	109.77	30.04
F3B3	-280.53	114.55	41.91	F4B3	-228.05	132.72	32.21
F3B4	-286.69	115.62	42.35	F4B4	-237.93	142.53	33.09
F3B5	**-287.81**	115.32	42.40	F4B5	-229.80	139.45	32.59
F3B6	-202.66	89.97	40.69	F4B6	-111.76	70.78	22.30
F3B7	-208.98	151.48	37.46	F4B7	-198.76	166.10	37.11
F3B8	-240.24	161.53	42.14	F4B8	-228.44	194.55	41.76
F3B9	-251.36	174.05	43.79	F4B9	-244.82	**211.60**	44.43
F3B10	-258.30	176.56	**44.45**	F4B10	-233.08	198.25	42.43
F3B11	-141.58	90.83	-25.65	F4B11	-140.89	83.61	20.93
F3B12	-198.88	127.68	-32.19	F4B12	-212.37	149.01	28.79
F3B13	-235.01	121.82	-41.50	F4B13	-238.47	172.97	31.59
F3B14	-247.16	127.85	-42.83	F4B14	-250.14	183.30	32.82
F3B15	-254.19	139.50	-44.11	F4B15	-241.16	172.02	31.69

F3B1	F3B6	F3B11
F3B2	F3B7	F3B12
F3B3	F3B8	F3B13
F3B4	F3B9	F3B14
F3B5	F3B10	F3B15

F4B1	F4B6	F4B11
F4B2	F4B7	F4B12
F4B3	F4B8	F4B13
F4B4	F4B9	F4B14
F4B5	F4B10	F4B15

2nd Floor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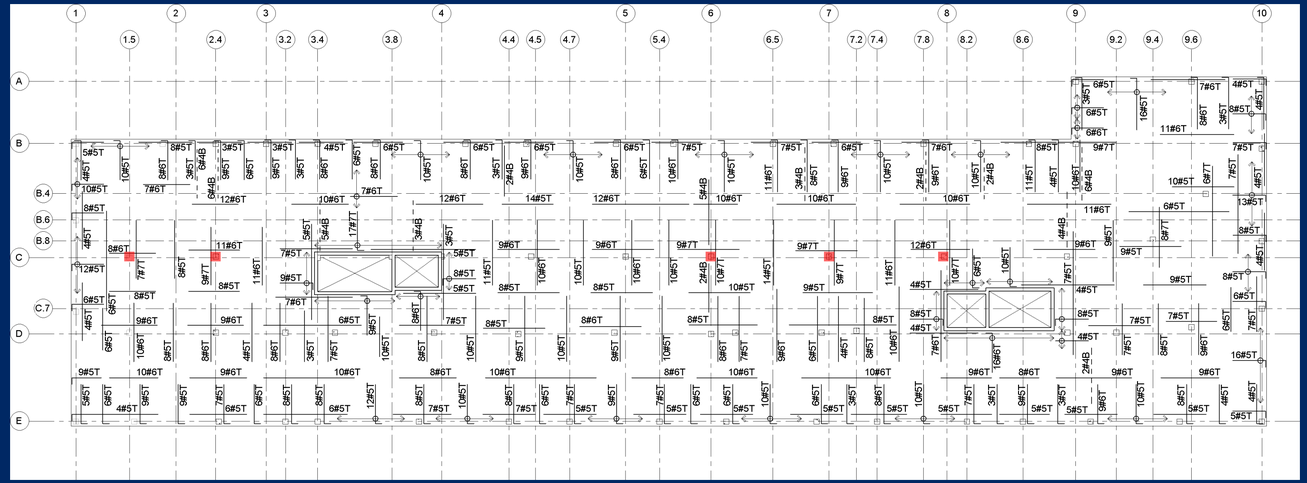
4th Floor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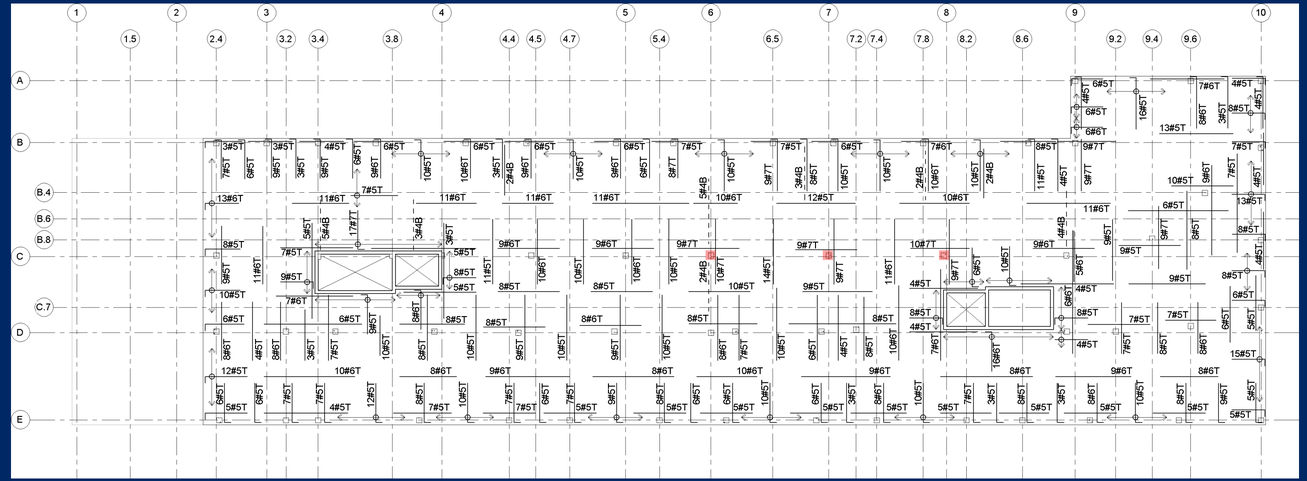
5th Floor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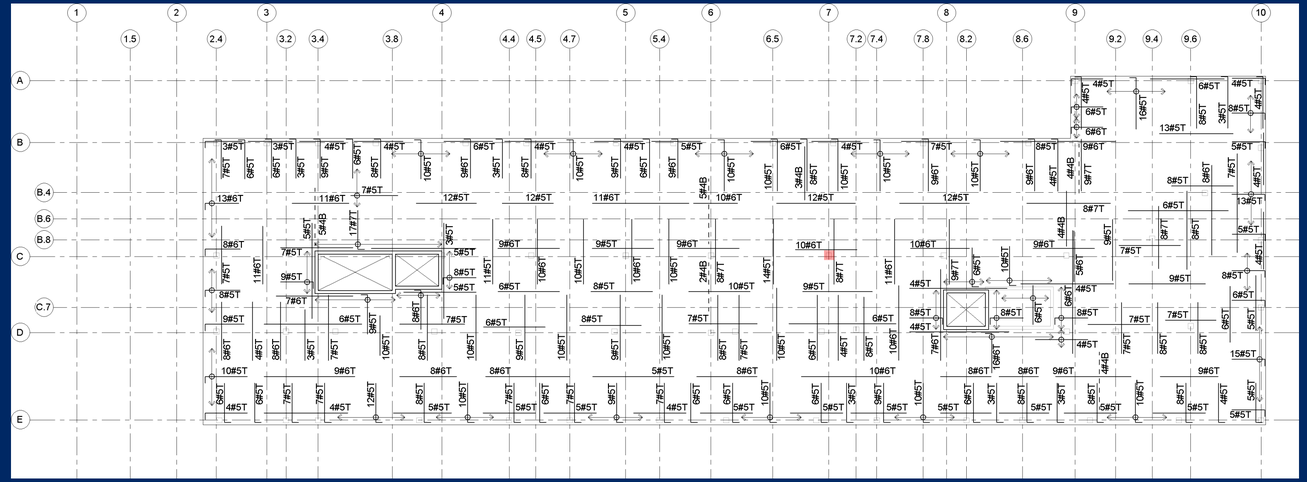
Roof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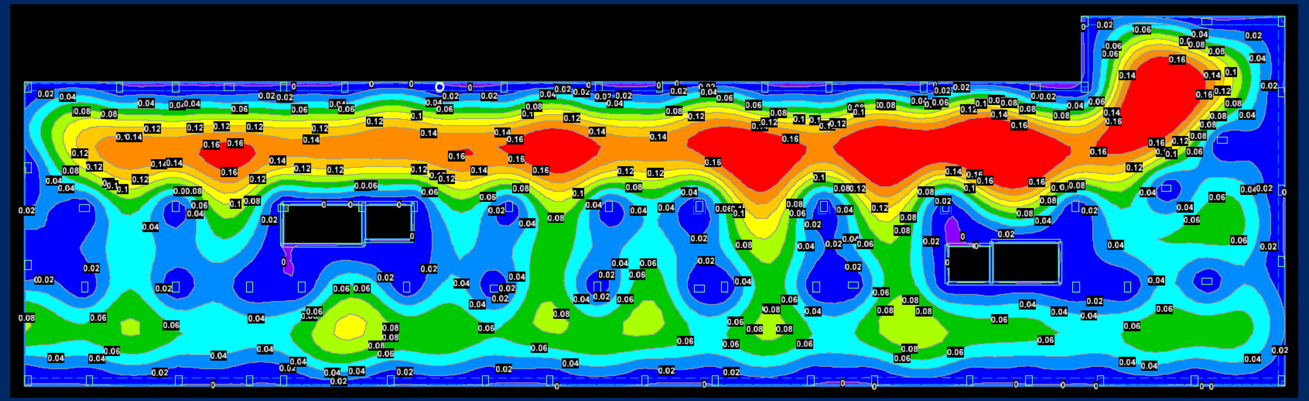
2nd Floor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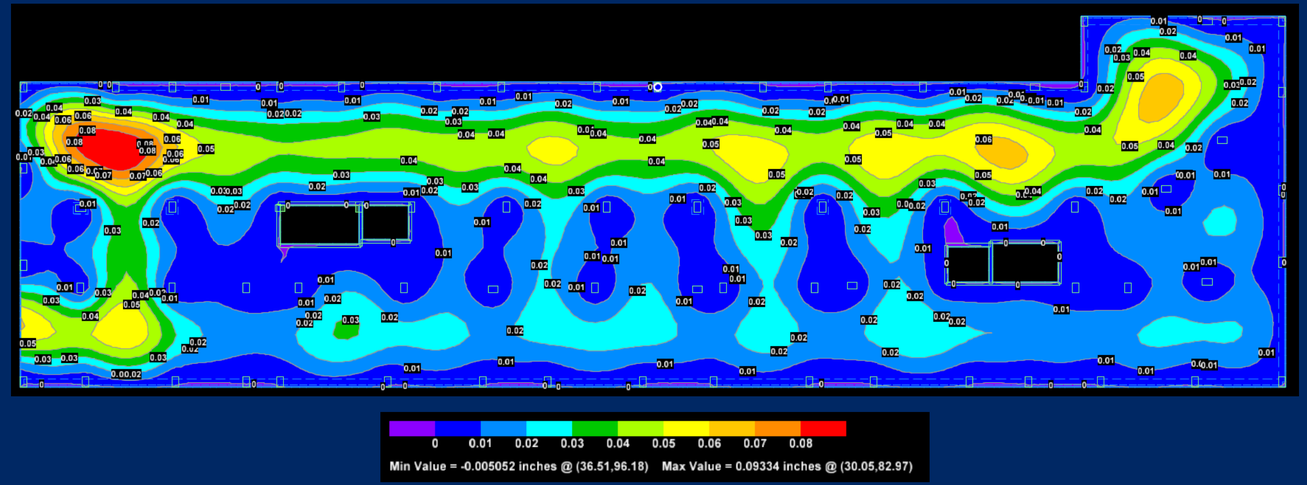
Min Value = -0.01231 inches @ (222.3,96.18)
Max Value = 0.2269 inches @ (242.5,92.73)

4th Floor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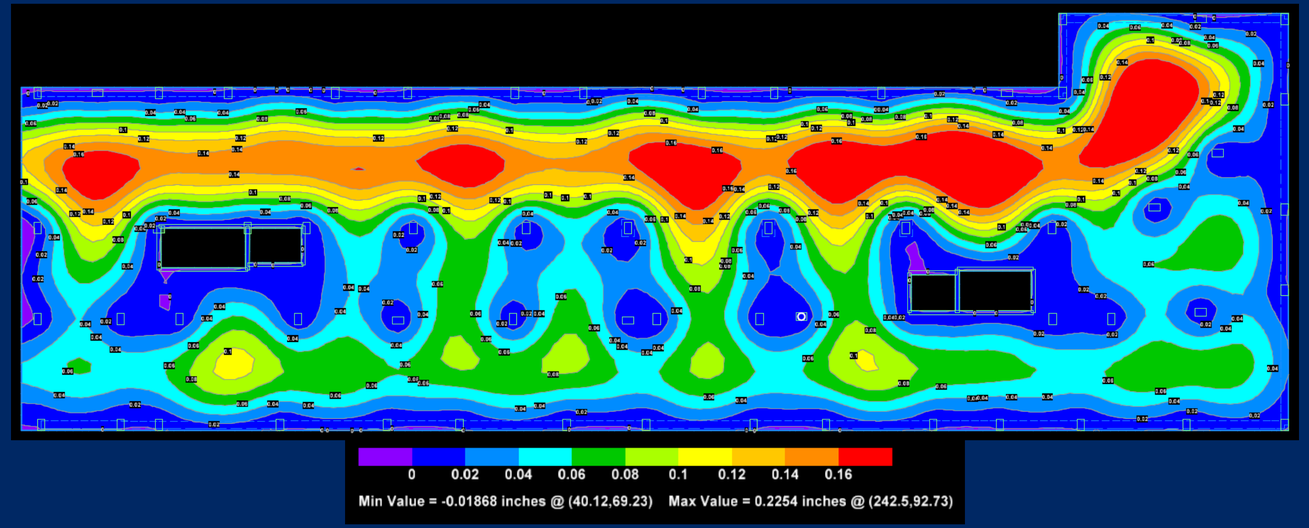
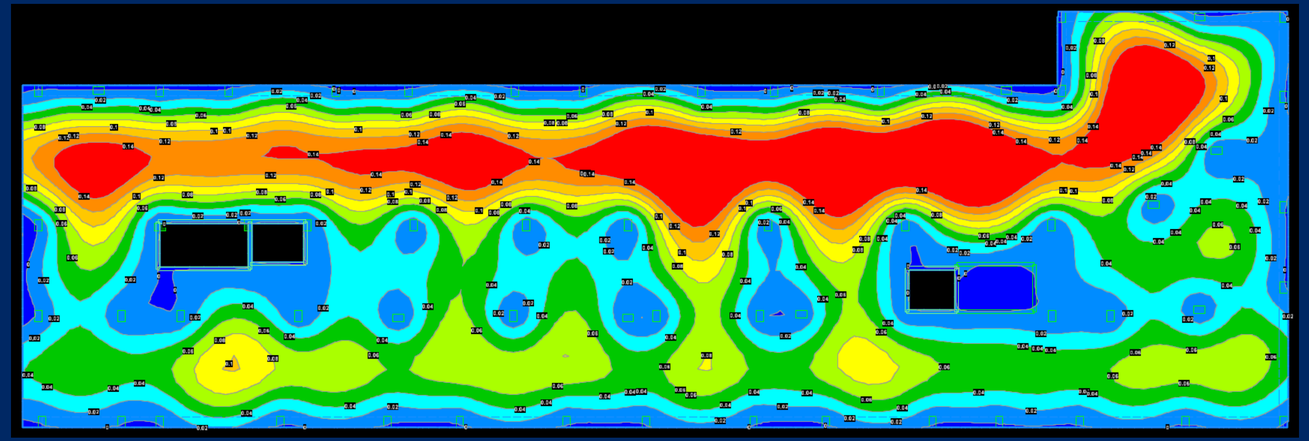
Min Value = -0.005052 inches @ (36.51,96.18) Max Value = 0.09334 inches @ (30.05,82.97)

5th Floor


0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16
Min Value = -0.01868 inches @ (40.12,69.23) Max Value = 0.2254 inches @ (242.5,92.73)

Roof


-0.02
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Min Value = -0.02045 inches @ (40.12,69.23)
Max Value = 0.214 inches @ (210.1,83.07)