Albany Medical Center

Patient Pavilion

Albany, NY

PROJECT PHASING

PHASE 1: EXISTING DESIGN

- 348,000 SQUARE FEET
- 6 STORIES ABOVE GRADE PLUS SUBBASEMENT

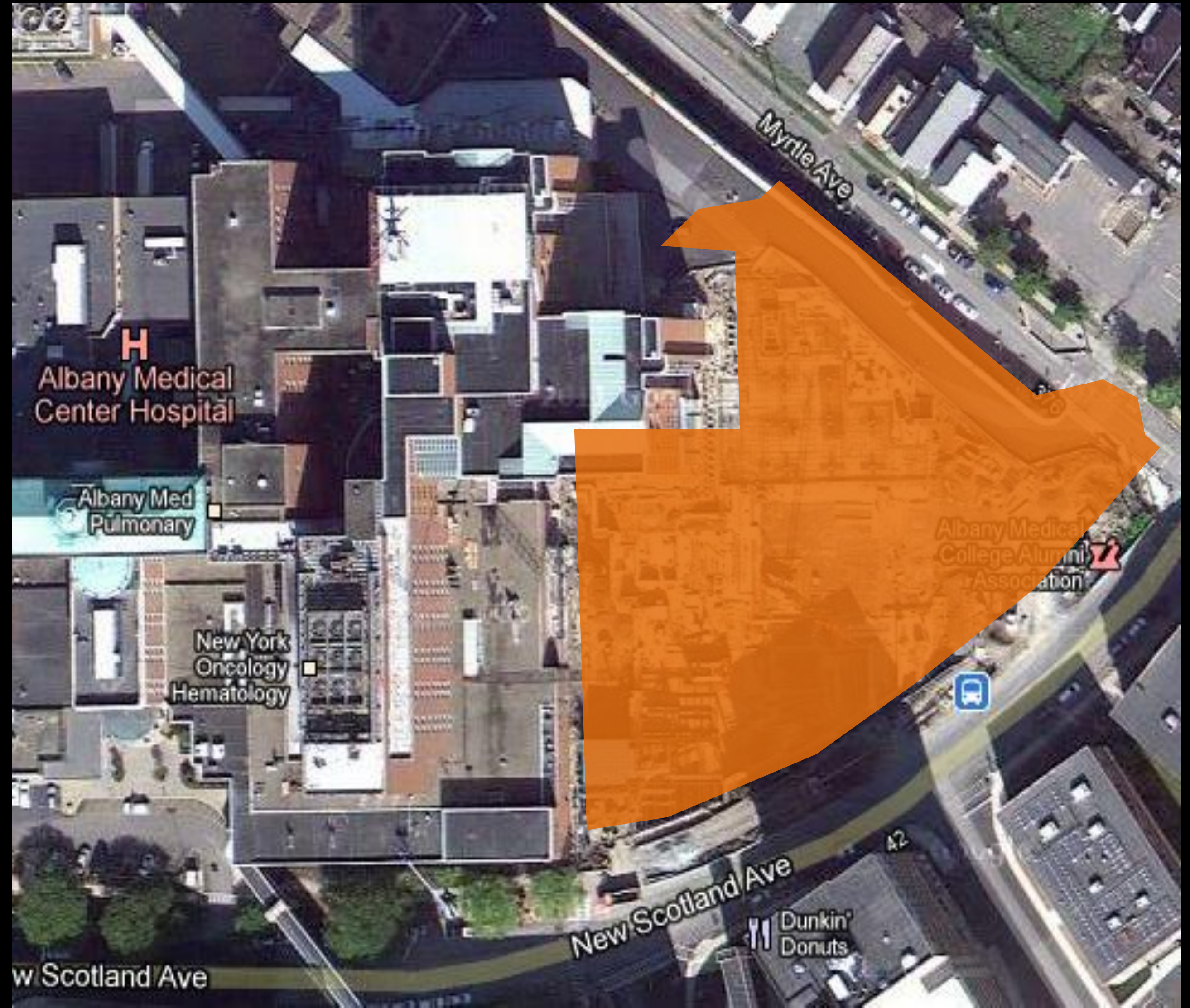
PHASE 2: VERTICAL EXPANSION

- 227,000 SQUARE FOOT EXPANSION
- 4 ADDITIONAL STORIES
- MECHANICAL PENTHOUSE ADDED

Building Statistics

- Patient Care Facility
- Max Height: 145'
- Square feet: 575,000 square feet
- Construction Cost: $360 Million
- Phase 1: September 2010 to June 2013
- Phase 2: TBD

Site Map



PROJECT OUTLINE

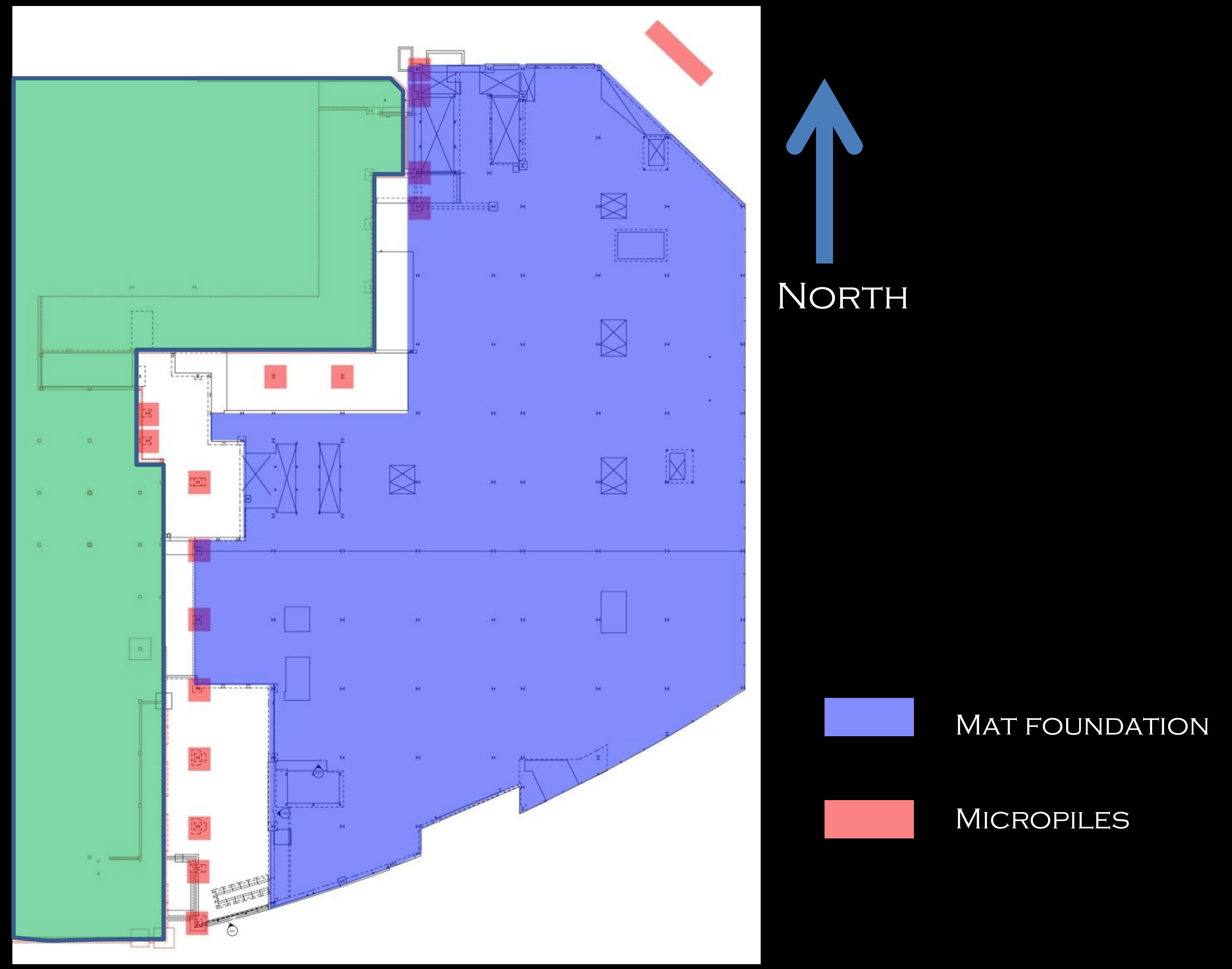
BUILDING STATISTICS

- Building Introduction
- Existing Structure
- Thesis Proposal
- Progressive Collapse
- MAE Incorporation
- Mechanical Breadth
- Conclusion

- Owner: Albany Medical Center
- Architect: TRO Jung|Brannen
- General Contractor: Gilbane Building Co.
- Structural Engineer: Ryan-Biggs Associates
- Mechanical Engineer: ICOR Associates
- Civil Engineers: Clark Patterson Lee

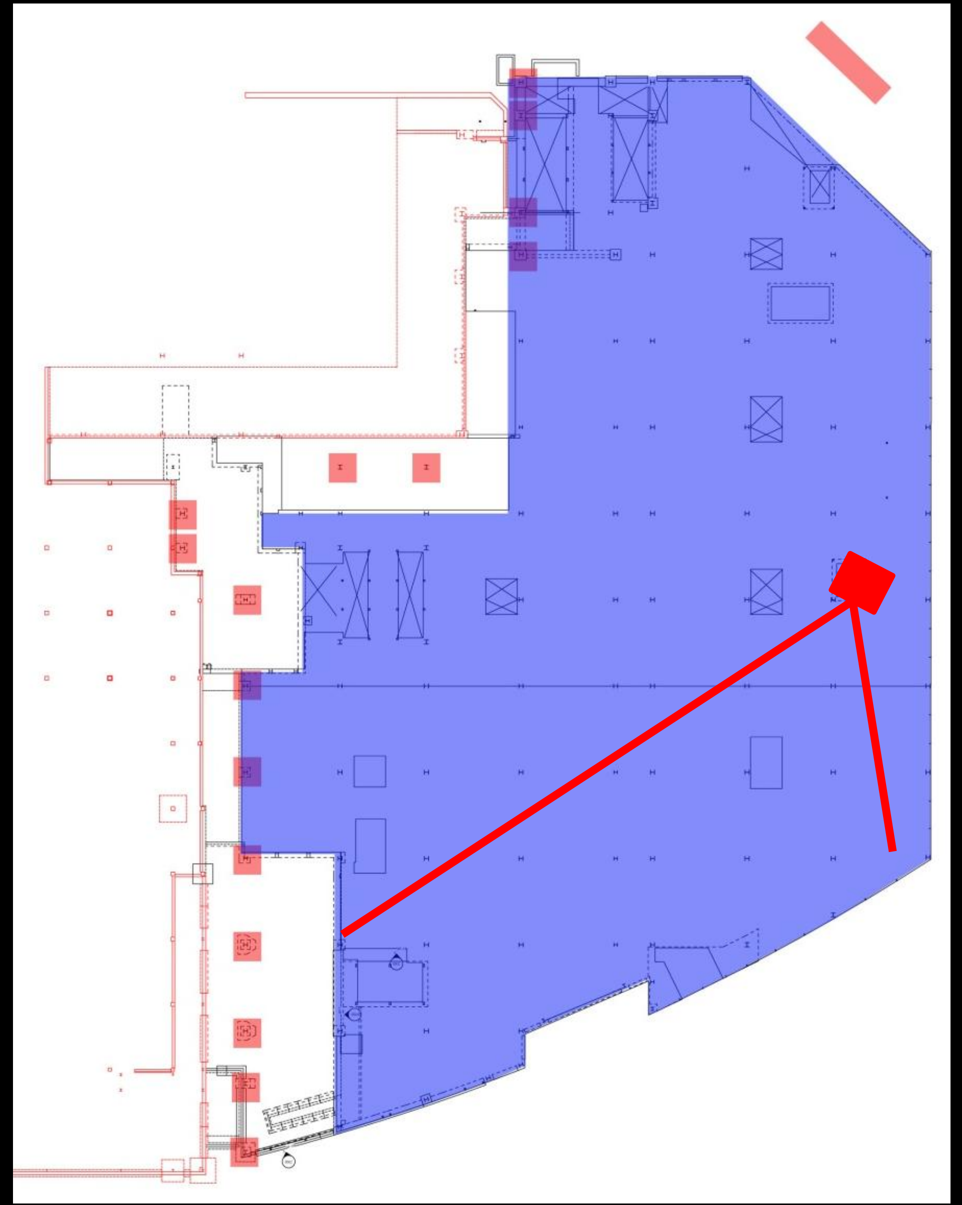
FOUNDATION

- ❑ 36" MAT FOUNDATION TYPICAL
  - EAST WEST DIRECTION
    - #9 AT 6" OC BOTTOM
    - #9 AT 12" OC TOP
  - NORTH SOUTH DIRECTION
    - #9 AT 6" OC TOP AND BOTTOM
- ❑ MICROPILES
  - 10" ROUND HSS
  - TWO TO FOUR PIPES PER PILE
  - NEAR EXISTING BUILDINGS



FOUNDATION

- ❑ BUILDING INTRODUCTION
- ❑ EXISTING STRUCTURE
  - FOUNDATION
  - GRAVITY & LATERAL
- ❑ THESIS PROPOSAL
- ❑ PROGRESSIVE COLLAPSE
- ❑ MAE INCORPORATION
- ❑ MECHANICAL BREADTH
- ❑ CONCLUSION



MAT FOUNDATION

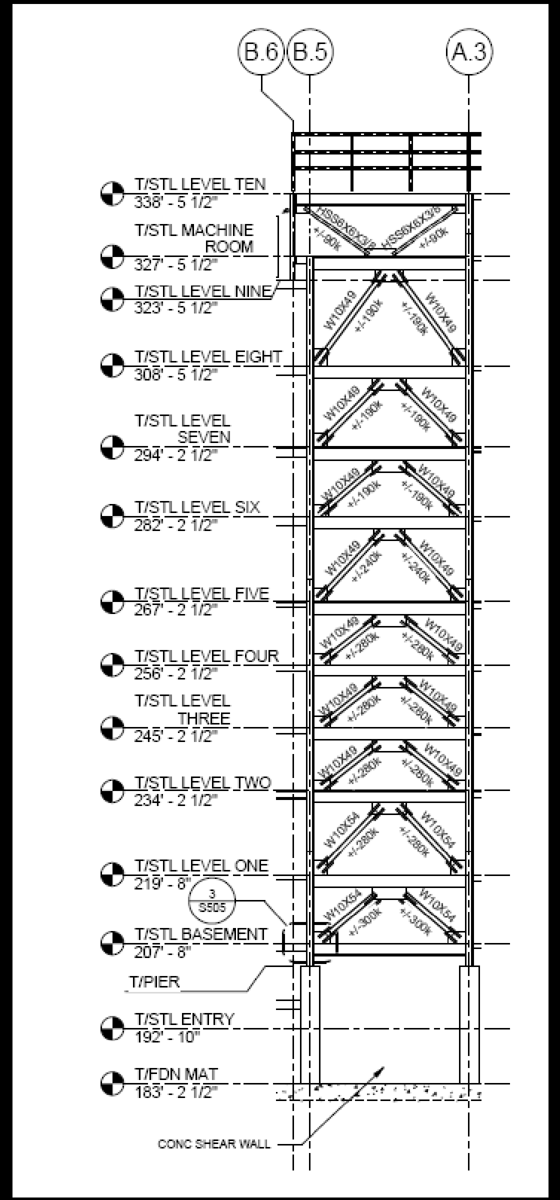
MICROPILES

Framing System

- ❑ Building Introduction
- ❑ Existing Structure
  - Foundation
  - Framing
- ❑ Thesis Proposal
- ❑ Progressive Collapse
- ❑ MAE Incorporation
- ❑ Mechanical Breadth
- ❑ Conclusion

❑ Gravity system
- Composite steel framing
  - 27 to 30 foot spans
- 3" VLI Decking w/ 3½" topping
  -10 foot max spans

❑ Lateral System
- Eccentric braced frames
- Moment frames



Lateral Frame Layout

Problem Statement

- ❑ Structural Depth (per UFC 04-023-03):
  - Progressive Collapse Analysis:
    - Alternate Path Method (direct method)
    - Tie-Force Method (indirect method)
- ❑ Mechanical Breadth:
  - Façade Redesign:
    - Analyze Thermal Performance
    - Cost comparison
- ❑ Construction Management Breadth:
  - Site Logistics:
    - Develop site logistics for precast facade
    - Develop site logistics for existing building
- ❑ MAE Course Related Study:
  - AE 534: Design of Steel Connection
    - Extended Shear Tab Connection
    - Welded Unreinforced Flange Moment Connection

Progressive Collapse

Per occupancy category IV:

- ❑ Tie-Force Method
  - Must redesign ties if required tie strength is not met
- ❑ Alternate Path Method
  - Must be performed at all corner columns and mid span of all sides
  - Enhanced local resistance check must be performed

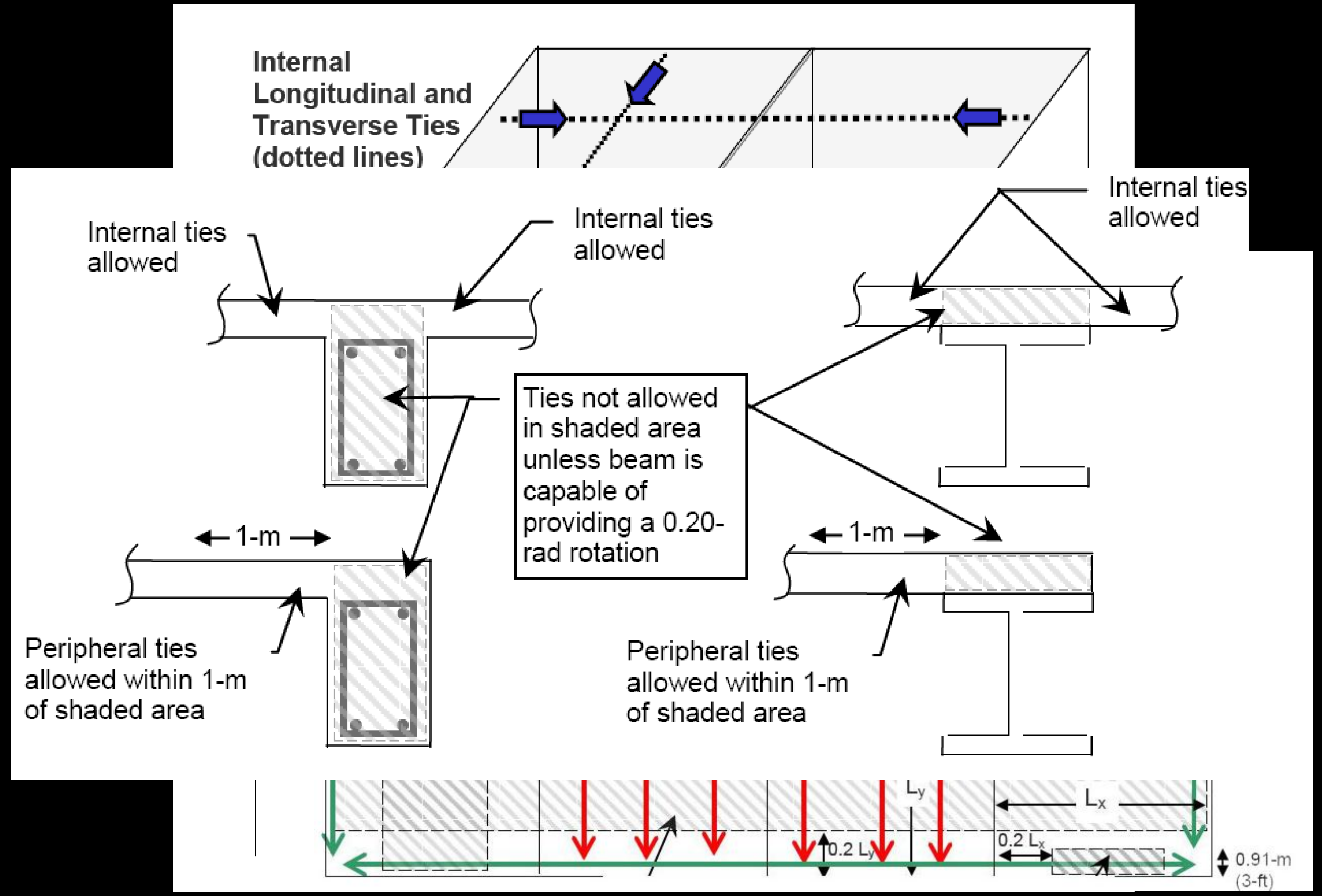
Occupancy Category	Design Requirement
I	No specific requirements
II	Option 1: Tie Forces for the entire structure and Enhanced Local Resistance for the corner and penultimate columns or walls at the first story. **OR** Option 2: Alternate Path for specified column and wall removal locations.
III	Alternate Path for specified column and wall removal locations; Enhanced Local Resistance for all perimeter first story columns or walls.
IV	Tie Forces; Alternate Path for specified column and wall removal locations; Enhanced Local Resistance for all perimeter first and second story columns or walls.

PROJECT OUTLINE

Tie-Forces Method

- Building Introduction
- Existing Structure
- Thesis Proposal
- Progressive Collapse
  - Tie-Force Method
  - Preliminary Member Sizes
  - Alternate Path Method
- MAE Incorporation
- Mechanical Breadth
- Conclusion

- Indirect Method
- Requires ductility, continuity, and redundancy
- Mechanically "ties" the building together
- Tie placement
  - Restrictions



Longitudinal and Transverse Ties

- ❑ Building Introduction
- ❑ Existing Structure
- ❑ Thesis Proposal
- ❑ Progressive Collapse
  - Tie-Force Method
  - Preliminary Member Sizes
  - Alternate Path Method
- ❑ MAE Incorporation
- ❑ Mechanical Breadth
- ❑ Conclusion

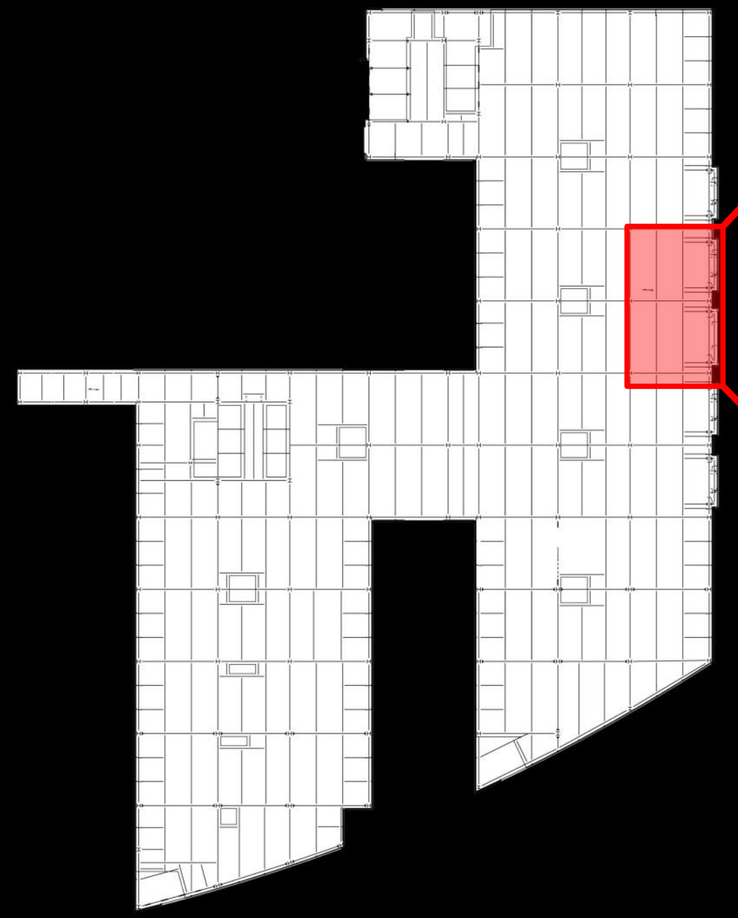
❑ Longitudinal and Transverse Reinforcement:

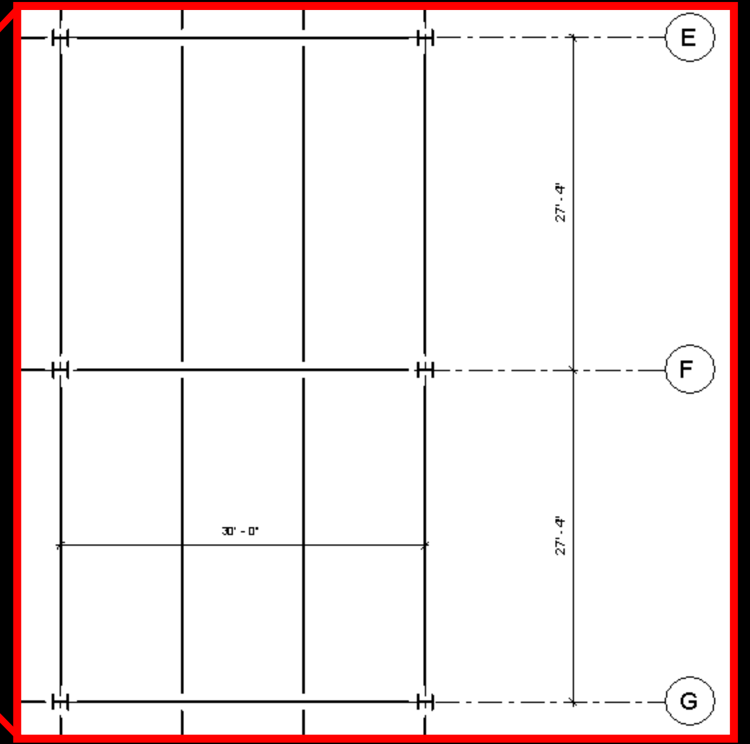
- Required Tie Strength (lb/ft):

$$F_i = 3w_F L_1$$
$$w_f = 1.2D + 0.5L$$
$$L_1 = \text{greatest bay length}$$

- Reinforcement Design:

$$A_{min} = \frac{F_i}{\emptyset \cdot \Omega \cdot F_y}$$





LONGITUDINAL AND TRANSVERSE TIES

❑ TYPICAL SPA

PENTHOUSE LEVEL - WF = 213 PSF		
	LONGITUDINAL	TRANSVERSE
LENGTH (FT.)	30	27.33
F_i/F_P (KIP/FT)/(KIP)	19.2	17.5
$A_{S\ MIN}$ (IN.^{2})	0.284	0.259
BAR USED	NO. 4	NO. 4
SPACING (IN.)	8	9
MAX SPACING (IN.)	65	72

BASEMENT TO 2ND LEVEL - WF = 164 PSF		
	LONGITUDINAL	TRANSVERSE
LENGTH (FT.)	30	27.33
F_i/F_P (KIP/FT)/(KIP)	14.8	13.5
$A_{S\ MIN}$ (IN.^{2})	0.219	0.2
BAR USED	NO. 4	NO. 4
SPACING (IN.)	10	12
MAX SPACING (IN.)	65	72

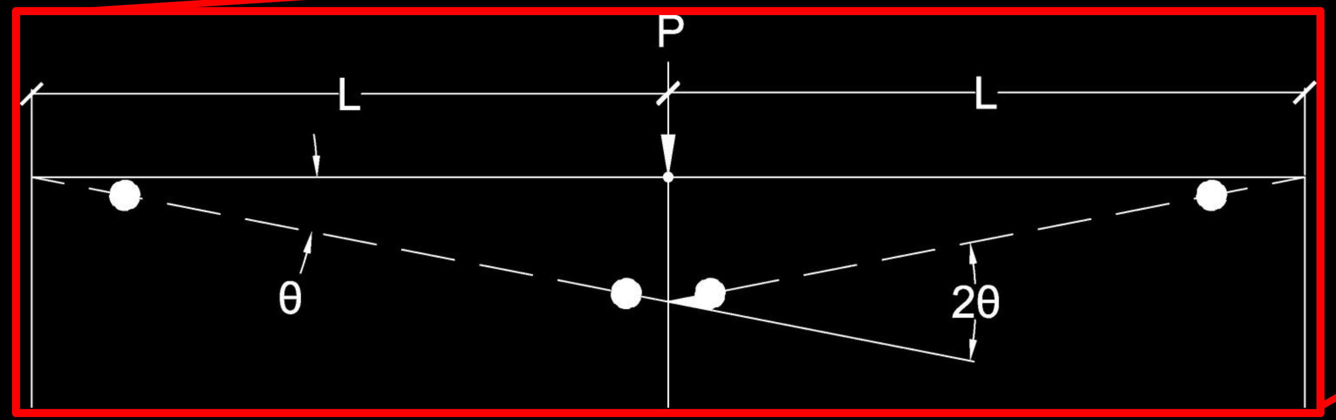
ROOF LEVEL - WF = 124 PSF		
	LONGITUDINAL	TRANSVERSE
LENGTH (FT.)	30	27.33
F_i/F_P (KIP/FT)/(KIP)	11.2	10.2
$A_{S\ MIN}$ (IN.^{2})	0.166	0.151
BAR USED	NO. 4	NO. 4
SPACING (IN.)	14	15
MAX SPACING (IN.)	65	72

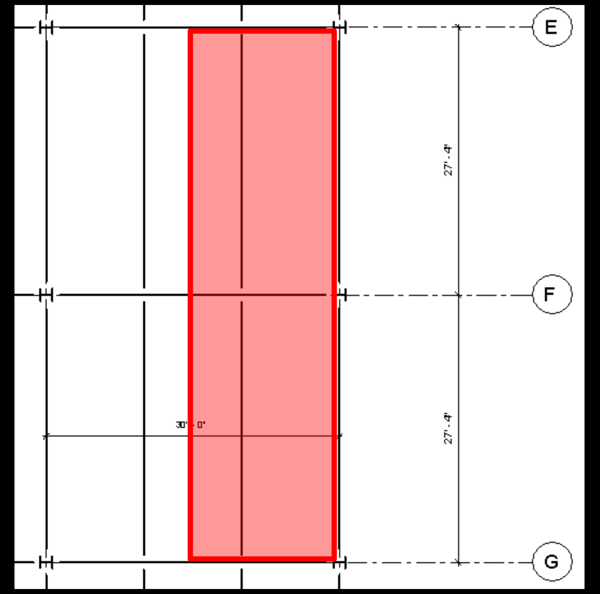
3RD TO 8TH LEVEL - WF = 154 PSF		
	LONGITUDINAL	TRANSVERSE
LENGTH (FT.)	30	27.33
F_i/F_P (KIP/FT)/(KIP)	13.9	12.6
$A_{S\ MIN}$ (IN.^{2})	0.205	0.187
BAR USED	NO. 4	NO. 4
SPACING (IN.)	11	12
MAX SPACING (IN.)	65	72

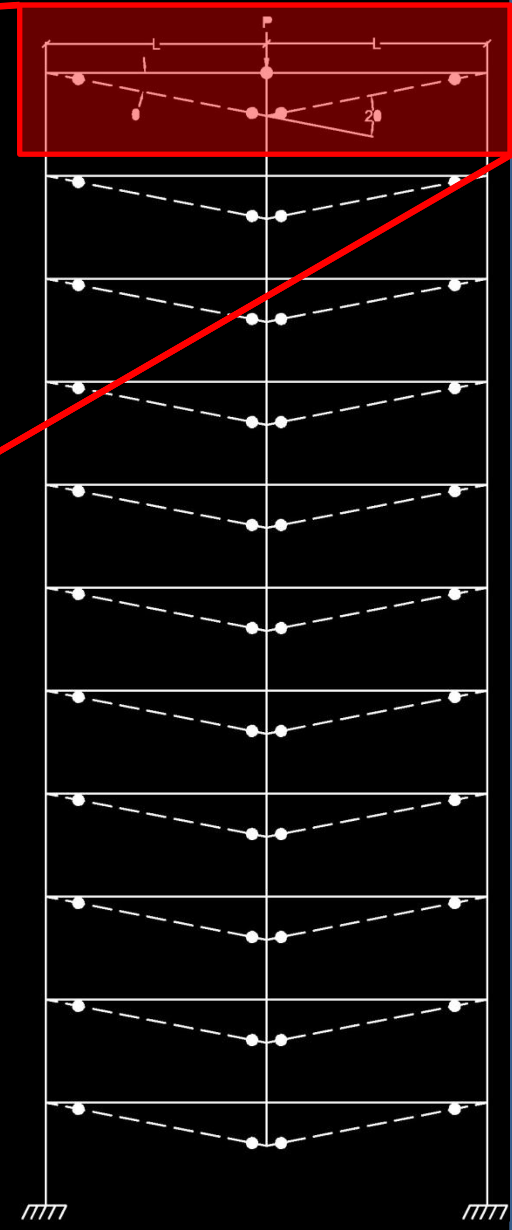
Preliminary Member Sizes

Virtual Work:

- ❑ External Work = Internal Work
- ❑ External Work
  - Resulting point load
- ❑ Internal Work
  - Work absorbed by the hinges
  - Product of the moment and the rotation
- ❑ Small angle theory
  - $\sin(\theta) = \tan(\theta) = \theta(radians)$





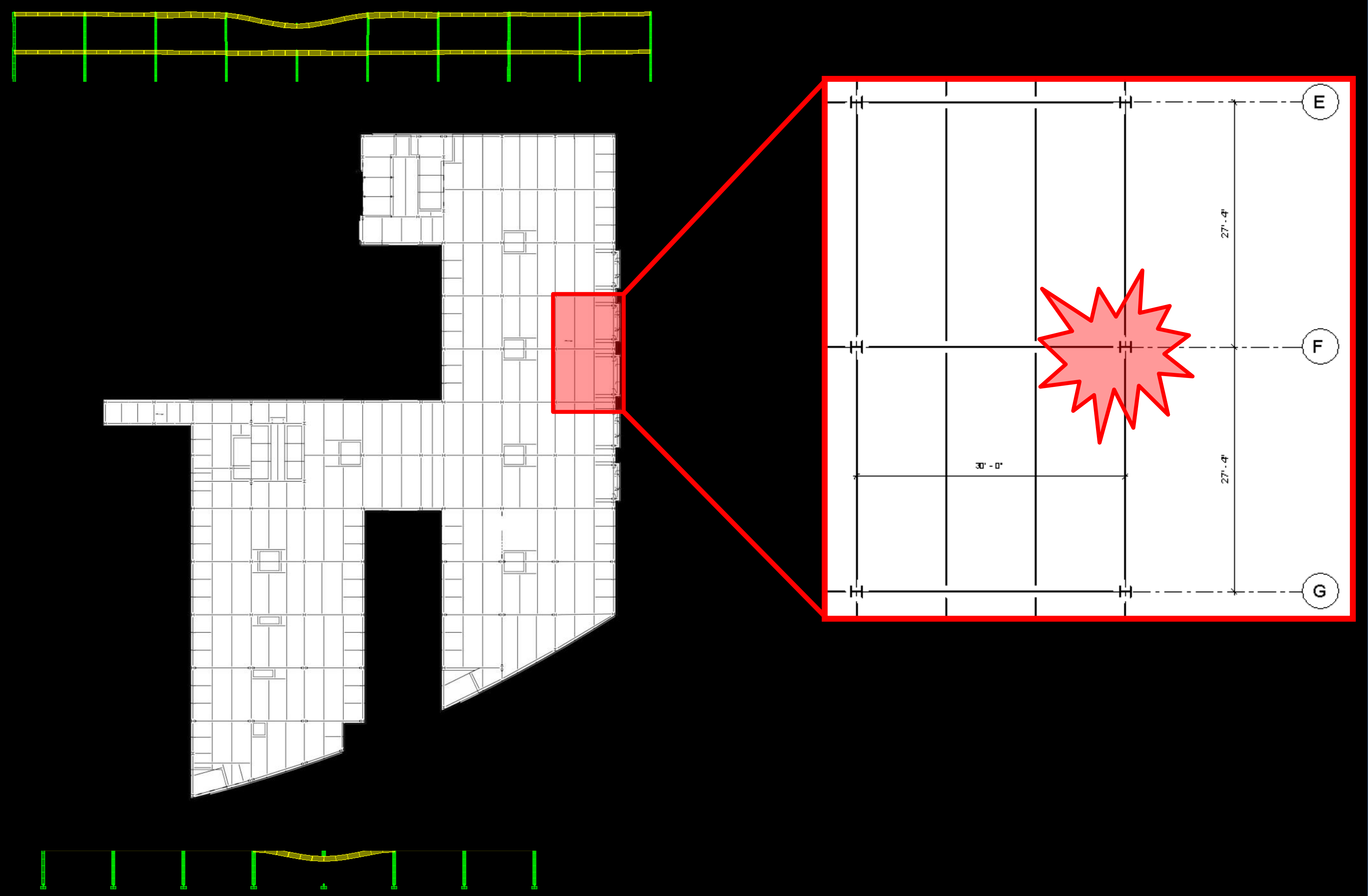


ALTERNATE PATH METHOD

- ❑ BUILDING INTRODUCTION
- ❑ EXISTING STRUCTURE
- ❑ THESIS PROPOSAL
- ❑ PROGRESSIVE COLLAPSE
  - ▪ TIE-FORCE METHOD
  - ▪ PRELIMINARY MEMBER SIZES
  - ▪ ALTERNATE PATH METHOD
- ❑ MAE INCORPORATION
- ❑ MECHANICAL BREADTH
- ❑ CONCLUSION

DESCRIPTION:

- ❑ DIRECT METHOD
- ❑ BRIDGE OVER REMOVED ELEMENTS
- ❑ COLUMN REMOVAL REQUIREMENTS
- ❑ EXTERIOR FRAMES MODELED AS MOMENT FRAMES



Alternate Path Method

- Load Combination and Assignments
  - $G = \Omega[1.2D + (0.5L \; or \; 0.2S)] + L_{LAT}$

$$\Omega_{LD} = 0.9m_{LIF} + 1.1$$
$$\Omega_{LF} = 2.0$$

- Define Members
  - Primary members
  - Secondary members
- Deformation- and Force-Controlled Actions
  - A model was created explicitly for each action
- m-Factors

m-Factors for Linear Procedures

Component/Action	IO	Primary LS	Primary CP	Secondary LS	Secondary CP

Component	Deformation-Controlled Action	Force- Controlled Action
Moment Frames • Beams • Columns • Joints	 Moment (M) M --	 Shear (V) Axial load (P), V V^1
Shear Walls	M, V	P
Braced Frames • Braces • Beams • Columns • Shear Link	 P -- -- V	 -- P P P, M
Connections	P, V, M^2	P, V, M

$^3m = 15(1 - 5/3\ P/P_{CL})$.
$^4m = 18(1 - 5/3\ P/P_{CL})$.

$+ L_{LAT}$

PROJECT OUTLINE

- ❑ BUILDING INTRODUCTION
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  - ▪ TIE-FORCE METHOD
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ALTERNATE PATH METHOD

BEAM ANALYSIS

- ❑ CALCULATE M-FACTORS
- ❑ INTERACTION EQUATION (AISC CHAPTER H)

$$\frac{P_r}{2P_c} + \left[\frac{\left[\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right]}{m\ factor}\right] \leq 1.0$$

- ❑ RESULTS

RESULTS

Member Location	Member	Mr	Pr	Mc	Pc	m-factor	nteraction	
Roof	W21X50	268.6	0	412.5	661.5	6	0.108525	PASS
Base								
Pent								

Member Properties	W21x50	W24x76	W24x62
bf/2tf	6.1	6.61	5.97
h/tw	49.4	49.00	50.10
52/√Fye	7.0117	7.0117	7.0117
418/√Fye	53.36	53.36	53.36
65/√Fye	8.76	8.76	8.76
640/√Fye	86.30	86.30	86.30
Beam m-factor	6.00	6.00	6.00

Men
Roof
Base
Pent

Member Location	Member	Mr	Pr	Mc	Pc	m-factor	Interaction	
Roof	W21X50	916.4	0	412.5	661.5	6	0.370262626	PASS
Basement to 8th	W24X62	85.4	0	573.75	819	6	0.024807553	PASS
Penthouse	W24X76	109.3	0	750	1008	6	0.024288889	PASS

ALTERNATE PATH METHOD

RESULTS

- BUILDING INTRODUCTION
- EXISTING STRUCTURE
- THESIS PROPOSAL
- PROGRESSIVE COLLAPSE
  - TIE-FORCE METHOD
  - PRELIMINARY MEMBER SIZES
  - ALTERNATE PATH METHOD
- MAE INCORPORATION
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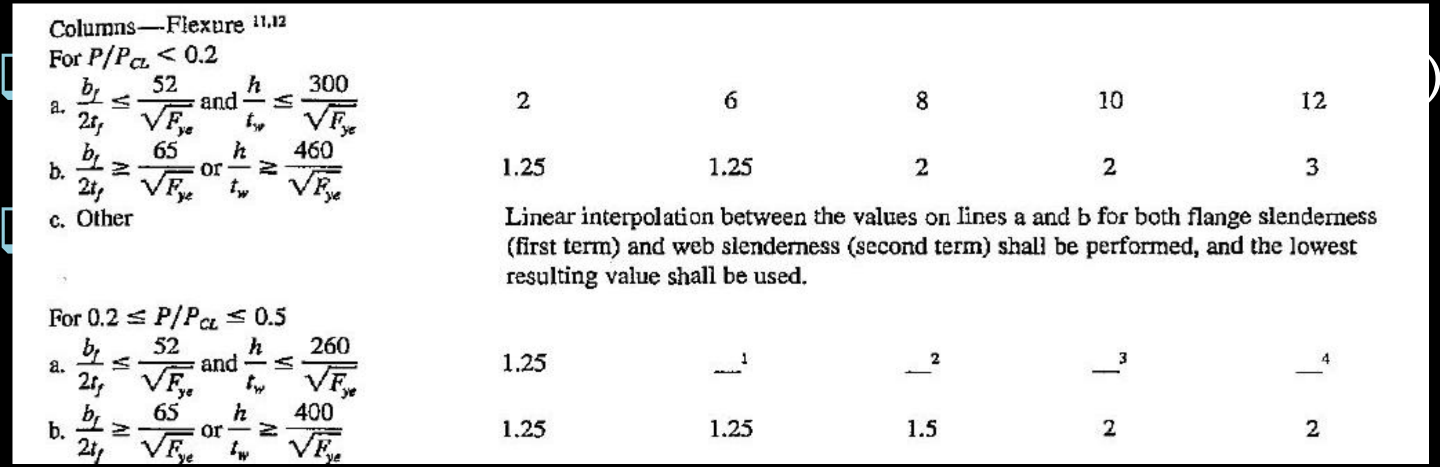
COLUMN ANALYSIS

- CALCULATE M-FACTORS
  - IF $\frac{P_r}{P_c} > 0.5$ THEN FORCE-CONTROLLED



Columns—Flexure [11,12]

For $P/P_{CL} < 0.2$					
a. $\frac{b_f}{2t_f} \le \frac{52}{\sqrt{F_{ye}}}$ and $\frac{h}{t_w} \le \frac{300}{\sqrt{F_{ye}}}$	2	6	8	10	12
b. $\frac{b_f}{2t_f} \ge \frac{65}{\sqrt{F_{ye}}}$ or $\frac{h}{t_w} \ge \frac{460}{\sqrt{F_{ye}}}$	1.25	1.25	2	2	3
c. Other	Linear interpolation between the values on lines a and b for both flange slenderness (first term) and web slenderness (second term) shall be performed, and the lowest resulting value shall be used.				
For $0.2 \le P/P_{CL} \le 0.5$					
a. $\frac{b_f}{2t_f} \le \frac{52}{\sqrt{F_{ye}}}$ and $\frac{h}{t_w} \le \frac{260}{\sqrt{F_{ye}}}$	1.25	—[1]	—[2]	—[3]	—[4]
b. $\frac{b_f}{2t_f} \ge \frac{65}{\sqrt{F_{ye}}}$ or $\frac{h}{t_w} \ge \frac{400}{\sqrt{F_{ye}}}$	1.25	1.25	1.5	2	2

Member Size	m-factor	Controlling Eq.	Interpolated	Force Controlled
W14X176	8.00	Equation (a)	No	No

Original Design	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Final Interaction
W14x74	W14x109	W14x145	W14x176	W14x193	0.07670476 0.145225037 0.329480016 0.42507717 0.625020449
W14x109	W14x145	W14x311	W14x342	W14x342	0.314130789 0.371236467 0.430889848 0.757731361
W14x176	W14x193	W14x370	W14x370	W14x370	0.572003466 0.652593825

EQUATION (A) IF: $\frac{P_r}{P_c} < 0.2$

EQUATION (B) IF: $0.2 < \frac{P_r}{P_c} < 0.5$

MAE Incorporation

Results

Design Limit States:

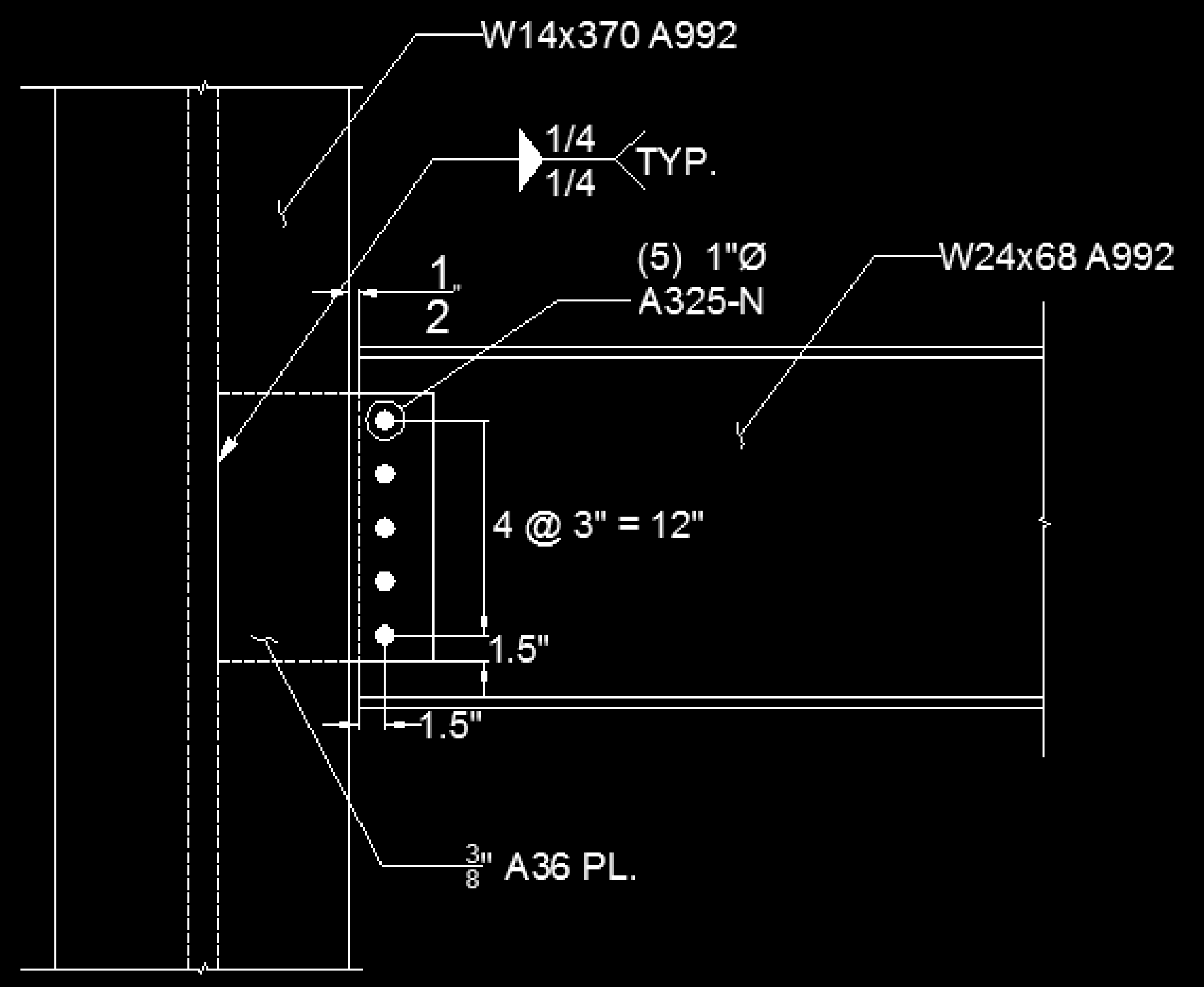
- Bolt Shear
- Plate and Web Bearing
- Max plate thickness
- Plate shear yield/rupture
- Plate block shear
- Plate flexure and shear interaction
- Plate buckling
- Weld strength

Load:

V_{ACTUAL}= 206kips

m-factor=6.79

V_{DESIGN}=206/6.79
=30.3kips



Mechanical Breadth

Introduction:

- Analyzing a typical patient room
- Calculate thermal performance of existing façade
- Propose a new precast façade

Process:

- Determine number of patient rooms on exterior of building in each direction
- Obtain pricing from precast and glass manufacturer
- Material cost analysis
- Run a trace model
- Energy cost analysis

MECHANICAL BREADTH

- Existing Wall Construction:

Glazing Cost Comparison			
	Existing	Proposed	Difference
Sq ft	58.67	58.67	
# Rooms	242	242	
Cost/sq ft	$ 11.00	$ 12.80	
Total Cost	$156,179.54	$181,736.19	$25,556.65

- Existing Glazing:
  - Viracon VE19-2M
    - U-value=0.25
    - S.C.=0.30

- Proposed Precast Wall Construction:

Façade Cost Comparison			
	Existing	Proposed	Difference
Sq ft	105.33	105.33	
# Rooms	242	242	
Cost/sq ft	$ 26.14	$ 29.00	
Total Cost	$666,304.94	$739,205.94	$72,901.00

- Proposed Glazing:
  - Oldcastle BuildingEnvelope Low-E #2
    - U-value=0.24
    - S.C.=0.28

MECHANICAL BREADTH

TRACE MODEL:

- ❑ PATIENT ROOM MODEL
  - ROOM DESIGN LOADS PER DESIGN VALUES IN MEEB BOOK
  - FOUR ROOMS WERE MODELED
- ❑ TRACE RESULTS
  - COOLING LOADS
  - HEATING LOADS
- ❑ ANNUAL SAVINGS

Type
Load (Btu/h)

Existing Façade			
Wall	Envelope	Internal Loads	Total
South	-2359	0	-2359
East	-2359	0	-2359
North	-2359	0	-2359
West	-2359	0	-2359

Proposed Façade			
Wall	Envelope	Internal Loads	Total
South	-2284	0	-2284
East	-2284	0	-2284
North	-2284	0	-2284
West	-2284	0	-2284

	Existing	Proposed
Total Btu/h	9436	9136
Energy Saved		300

Conclusion

- ❑ Family

  Thank you for all your support and motivation you have given me in the past couple months.

- ❑ AE Faculty
  - Dr. Hanagan
  - Professor Parfitt
  - Dr. Geschwinder
- ❑ Friends ands co-workers
- ❑ Gilbane Building Co.
  - Emilio Genzano
- ❑ Ryan-Biggs Associates
  - Chris Lescher
  - Neil Weisel

Questions?

APPENDIX I

X-DIRECTION			
			AXX
Basement	0.1	0.12	0.57
Level 1	0.212	0.15	0.95
Level 2	0.55	0.383	0.97
Level 3	0.83	0.65	0.87
Level 4	1.14	0.95	0.83
Level 5	1.45	1.26	0.80
Level 6	1.93	1.7	0.79
Level 7	2.28	2.06	0.77
Level 8	2.67	2.48	0.75
Level 9	3.03	2.88	0.73
Level 10	3.29	3.22	0.71

Y-DIRECTION			
			AYY
Basement	0.1	0.06	1.085
Level 1	0.2	0.1	1.235
Level 2	0.53	0.26	1.250
Level 3	0.79	0.42	1.184
Level 4	1.07	0.6	1.140
Level 5	1.35	0.8	1.095
Level 6	1.79	1.08	1.081
Level 7	2.1	1.3	1.060
Level 8	2.47	1.57	1.0
Level 9	2.81	1.83	1.0
Level 10	3.07	2.05	1.00

Appendix I

- Building Introduction
- Existing Structure
- Problem Statement
- Proposed Solution
- Gravity System
- Progressive Collapse
- MAE Incorporation
- Mechanical Breadth
- Conclusion
  - Appendix

X-Direction

	P(kips)	Moment(k-ft)	δ_{xe}	δ_{ye}	$\delta_{xe}C_d/I$	$\delta_{ye}C_d/I$	Δ_{xe}	Δ_{ye}	Δ_{max}=0.010h_{sx}	
Basement	21	359	0.1	0	0.166666667	0	0	0	1.8	Pass
Level 1	52	1125	0.212	0.02	0.35	0.03	0.187	0.033	1.44	Pass
Level 2	100	1954	0.55	0.05	0.92	0.08	0.563	0.050	1.44	Pass
Level 3	121	2158	0.83	0.09	1.38	0.15	0.467	0.067	1.32	Pass
Level 4	159	2702	1.14	0.14	1.90	0.23	0.517	0.083	1.32	Pass
Level 5	213	3618	1.45	0.19	2.42	0.32	0.517	0.083	1.32	Pass
Level 6	290	4917	1.93	0.25	3.22	0.42	0.800	0.100	1.8	Pass
Level 7	355	6016	2.28	0.31	3.80	0.52	0.583	0.100	1.44	Pass
Level 8	454	7699	2.67	0.37	4.45	0.62	0.650	0.100	1.71	Pass
Level 9	586	9941	3.03	0.45	5.05	0.75	0.600	0.133	1.8	Pass
Level 10	43	737	3.29	0.51	5.48	0.85	0.433	0.100	1.8	Pass
V_{base} =	2394									

No Torsional Irregularity

APPENDIX I

Y-Direction

	P(kips)	Moment(k-ft)	δ_{xe}	δ_{ye}	$\delta_{xe}C_d/I$	$\delta_{ye}C_d/I$	Δ_{xe}	Δ_{ye}	$\Delta_{max}=0.010h_{sx}$	
Basement	21	248.5	0	0	0	0	0	0	1.8	Pass
Level 1	52	766.9	0.1	0.2	0.17	0.33	0.167	0.333	1.44	Pass
Level 2	100	1484.7	0.25	0.53	0.42	0.88	0.250	0.550	1.44	Pass
Level 3	121	1622.6	0.36	0.79	0.60	1.32	0.183	0.433	1.32	Pass
Level 4	159	1943	0.47	1.07	0.78	1.78	0.183	0.467	1.32	Pass
Level 5	213	2462.3	0.58	1.35	0.97	2.25	0.183	0.467	1.32	Pass
Level 6	290	3372.6	0.74	1.79	1.23	2.98	0.267	0.733	1.8	Pass
Level 7	355	4054.3	0.86	2.1	1.43	3.50	0.200	0.517	1.44	Pass
Level 8	454	4904	0.99	2.47	1.65	4.12	0.217	0.617	1.71	Pass
Level 9	586	6332	1.09	2.8	1.82	4.67	0.167	0.550	1.8	Pass
Level 10	43	470	1.16	3.07	1.93	5.12	0.117	0.450	1.8	Pass
V_{base} =	2394									

No Torsional Irregularity

Peripheral Ties

- Peripheral Tie Reinforcement:
  - Required tie strength (lb/ft):

$$F_o = 6w_F L_1 L_p$$
$$w_f = 1.2D + 0.5L$$
$$L_1 = \text{greatest bay length}$$

  - Reinforcement Design:

$$A_{min} = \frac{F_i}{\emptyset \cdot \Omega \cdot F_y}$$

Peripheral Ties

Basement to 2nd Level				
	F_p	$A_{s\ min}$	Bars	Spacing
East-West	88.7	1.314	(4) No.6	9
North-South	80.7	1.2	(3) No.6	12

Penthouse Level				
	F_p	$A_{s\ min}$	Bars	Spacing
East-West	115	1.7	(4) No.6	9
North-South	104.8	1.55	(4) No.6	9

3rd to 8th Level				
	F_p	$A_{s\ min}$	Bars	Spacing
East-West	83.2	1.23	(3) No.6	12
North-South	75.8	1.12	(3) No.6	12

Roof Level				
	F_p	$A_{s\ min}$	Bars	Spacing
East-West	67	0.99	(3) No.6	12
North-South	61	0.9	(3) No.6	12