SUNY

Upstate Cancer Center

Syracuse, New York

EwingCole

EwingCole

AE Senior Thesis
Michael Kostick | Structural Option
April 10th, 2012

Presentation Outline

EwingCole

- Introduction
- Existing Structure
- Thesis Proposal
- Structural Depth
- Risk Mitigation / Site Redesign Breadth
- Conclusions
- Questions & Comments

EwingCole

Introduction

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Building Information:

- 5 stories – 90,000 square feet
- Healthcare Facility
- Syracuse, New York
- $ 74 Million
- Construction: March 2011- September 2013

Project Team:

- Owner: SUNY Upstate Medical University
- Architect / Engineer: EwingCole
- Construction Manager: LeChase Construction, LLC

Google Maps

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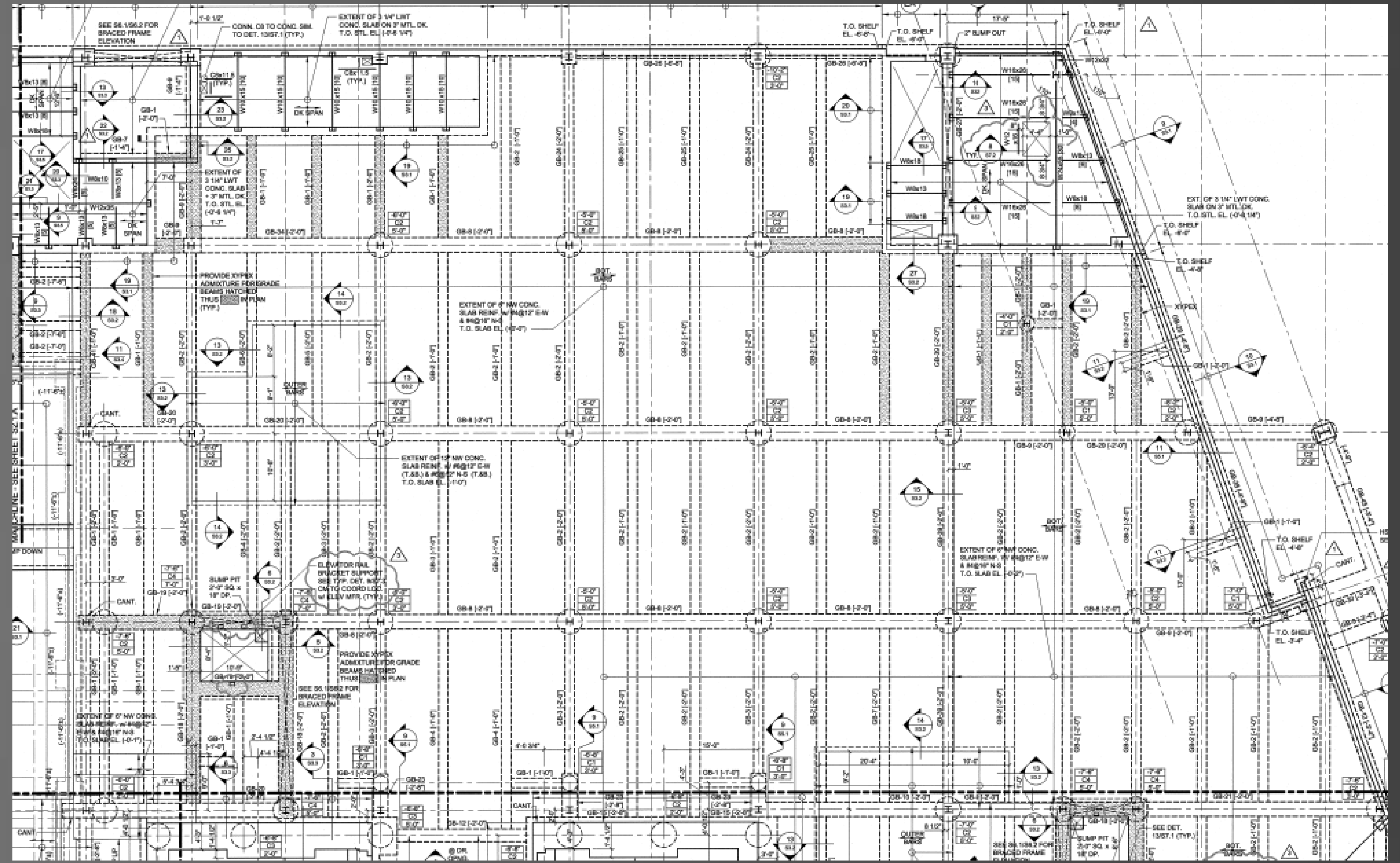
Existing Structural System

Foundation:

Drilled Caissons (5000 psi)
- •30" – 48" Diameter
- •Socketed 24" into dolostone bedrock

Grade Beams (4000 psi)

Slab-On-Grade (4000 psi)
- •6" – 8" deep



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Existing Structural System

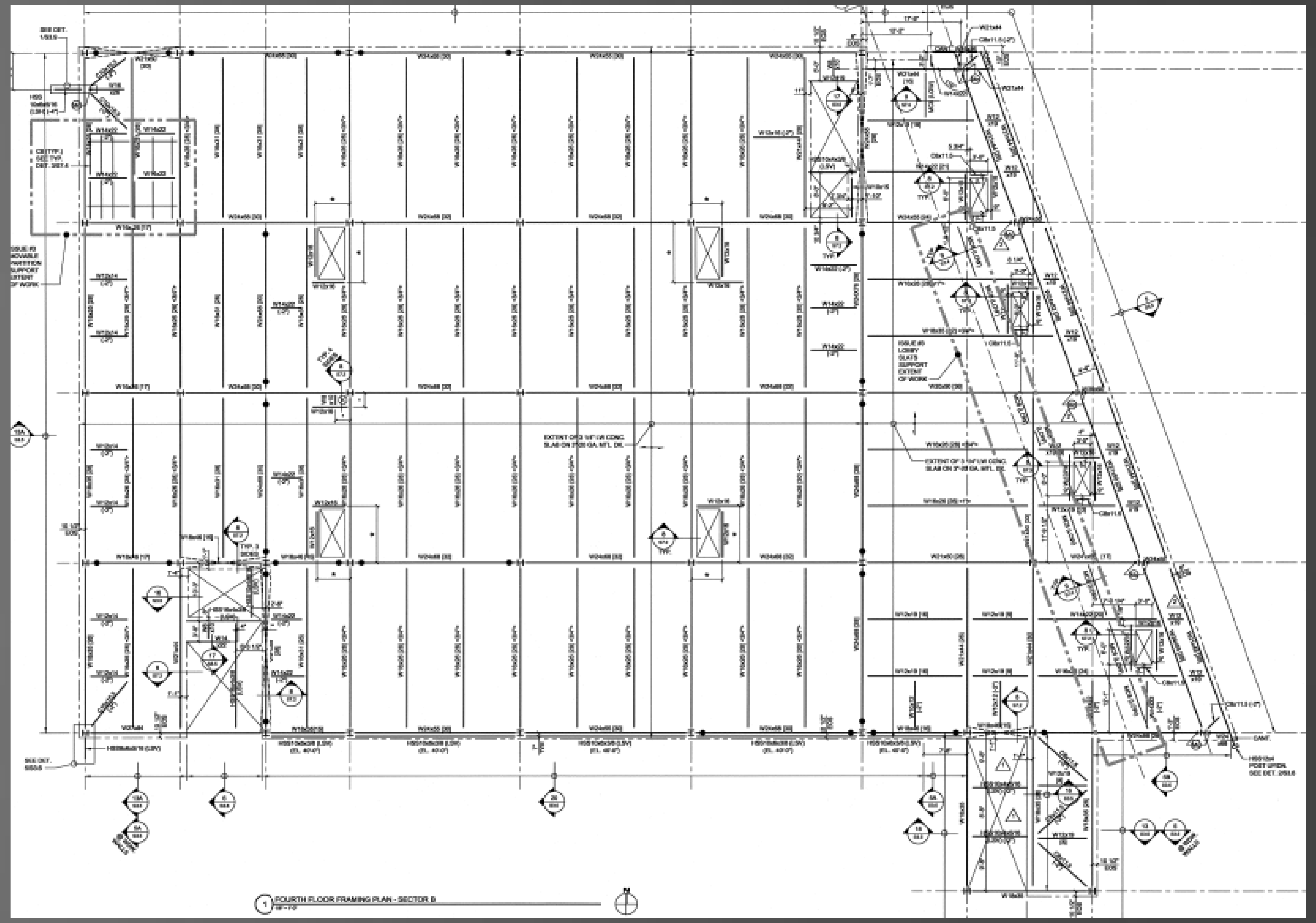
Gravity Force Resisting System:

Structural Grid:
- 30'-0" x 30'-0" (Typical)
- Infill beams at 10'-0" o.c.

Flooring System
- 3" 20 gauge composite metal deck with 3 ¼" lightweight topping (Typical)

Framing Members

Wide Flange Shapes
- Beams / Girders: Composite action
  W12's – W30's
- Columns: Spliced at 36'-0"
  W12's and W14's



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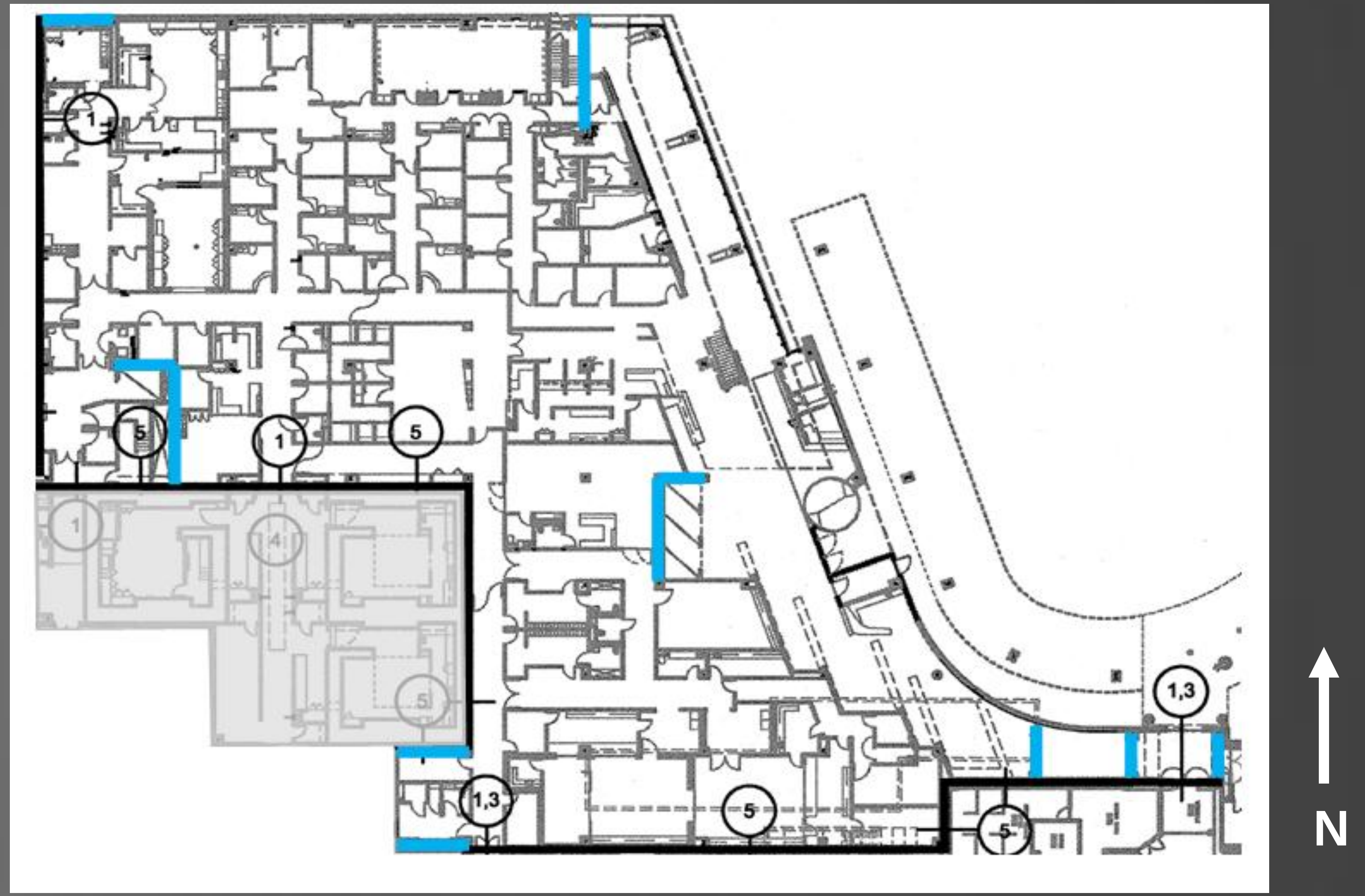
Existing Structural System

Lateral Force Resisting System:

Central Tower:

- Ordinary steel braced frames, N-S; E-W (Blue)
  Wide flange shapes



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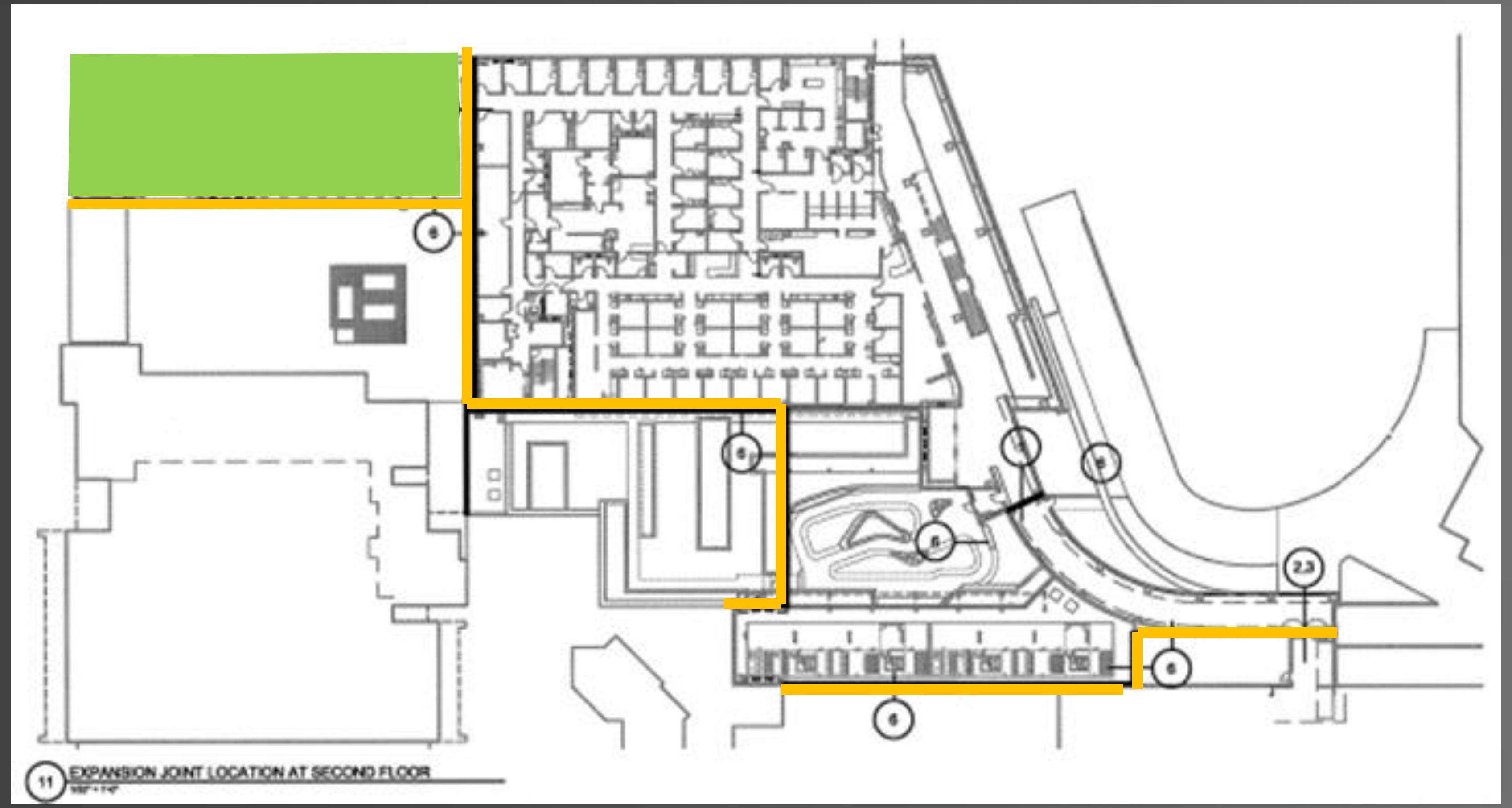
Existing Structural System



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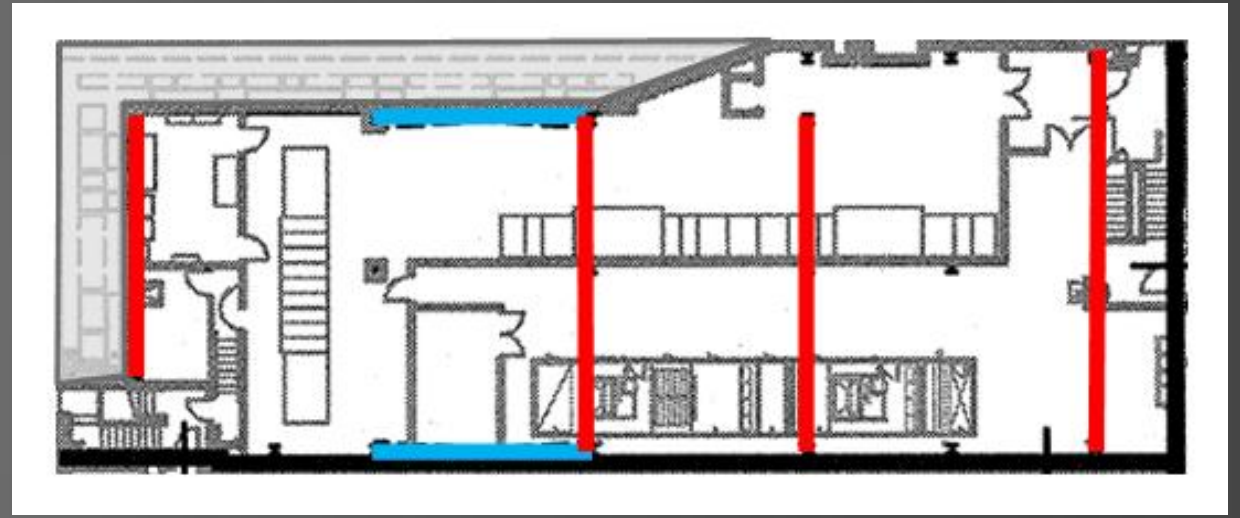
Lateral Force Resisting System:

Central Tower:

- Ordinary steel braced frames, N-S; E-W (Blue)
  - Wide flange shapes

Central Plant:

- Ordinary steel braced frames, E-W (Blue)
  - Wide flange shapes
- Moment frames, N-S (Red)
  - Bolted connections



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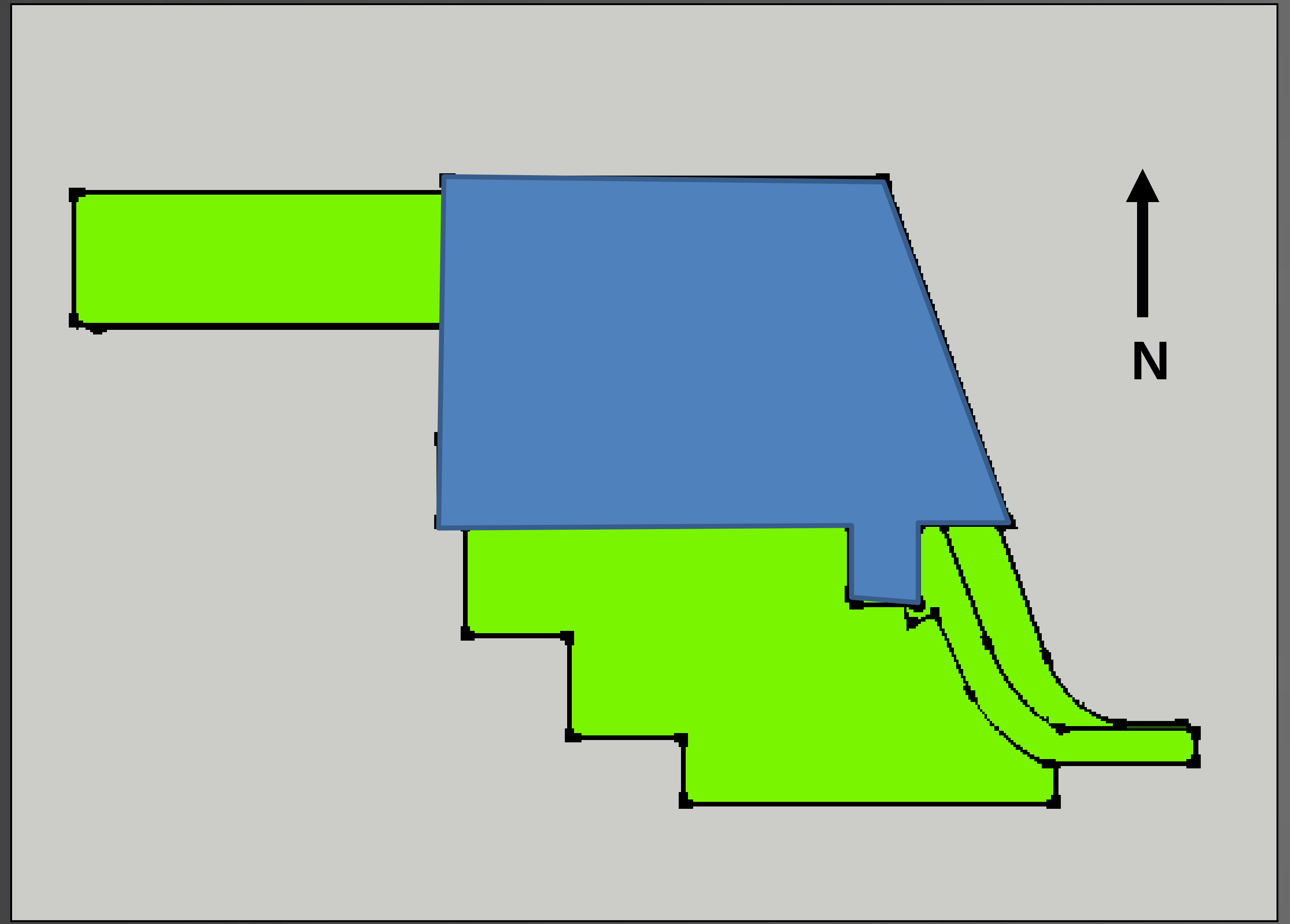
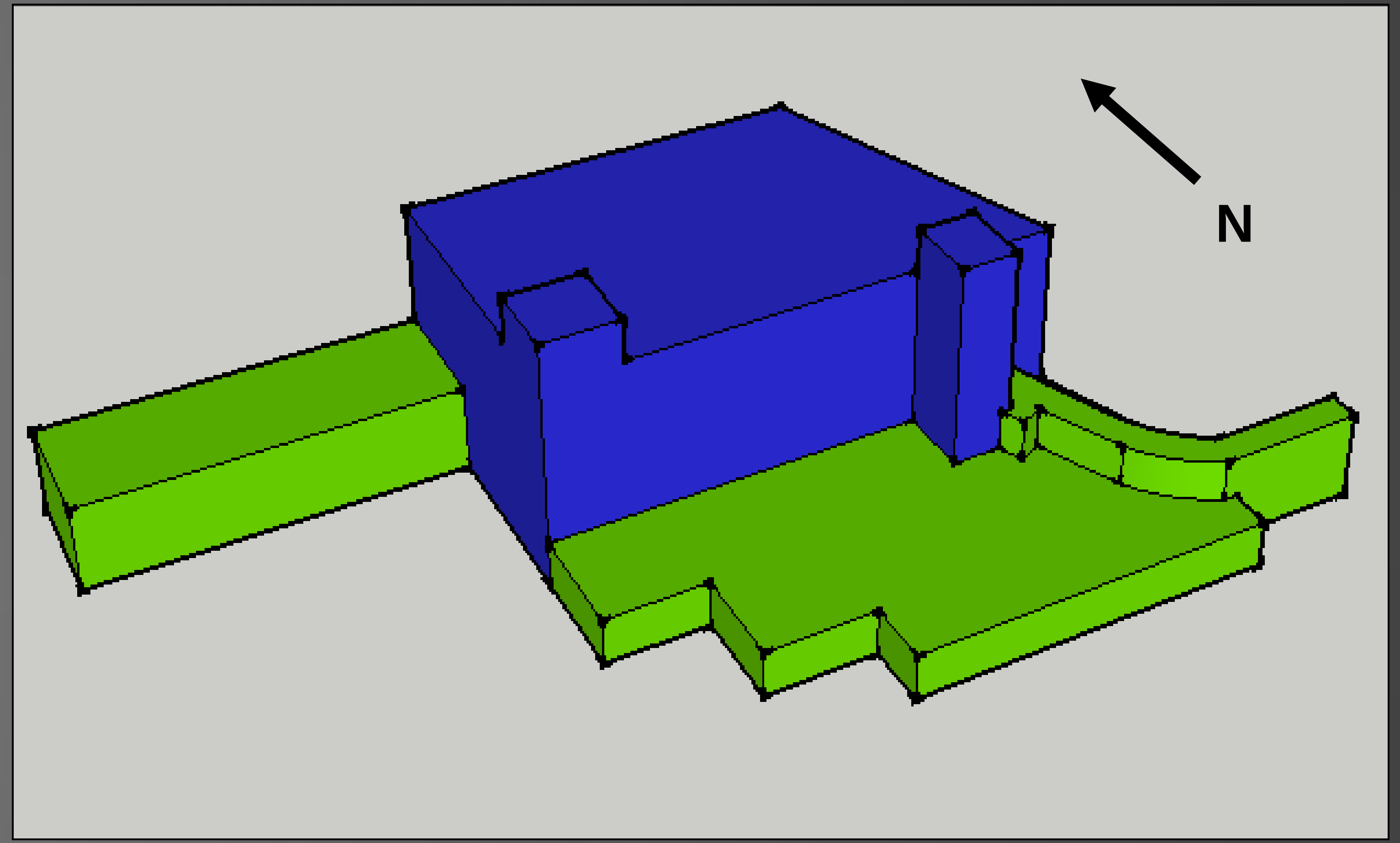
Thesis Proposal

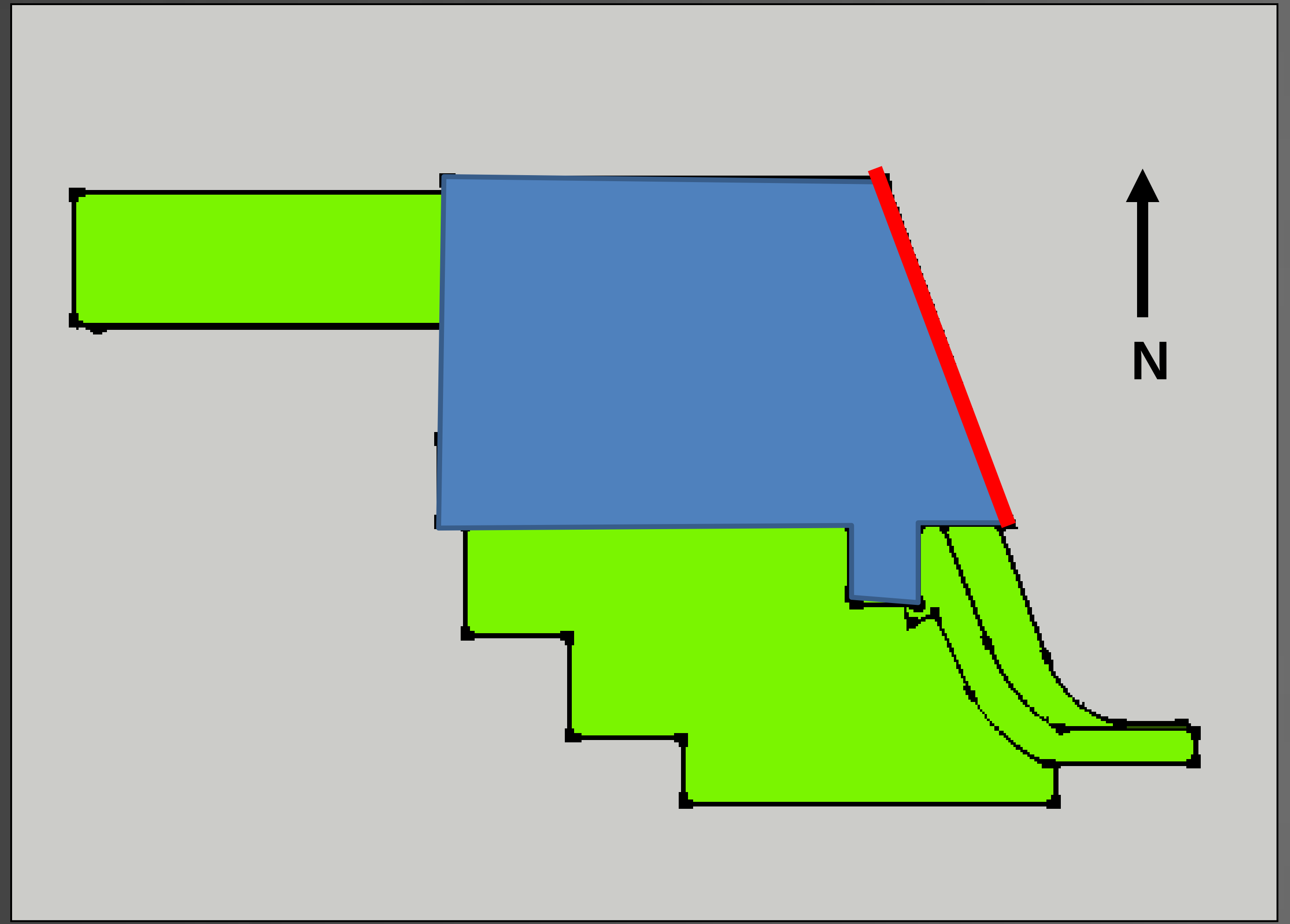


Structural Depth

- Redesign using reinforced concrete
- Select floor system from Technical Report 2 alternatives:
  - Precast hollow core plank
  - Two-way flat slab
  - One-way pan joists
- Redesign gravity force resisting system
- Redesign lateral force resisting system
- Design to resist progressive collapse
  - U.S. D.o.D. requirements
- Intent is to reduce structural system cost



Thesis Proposal

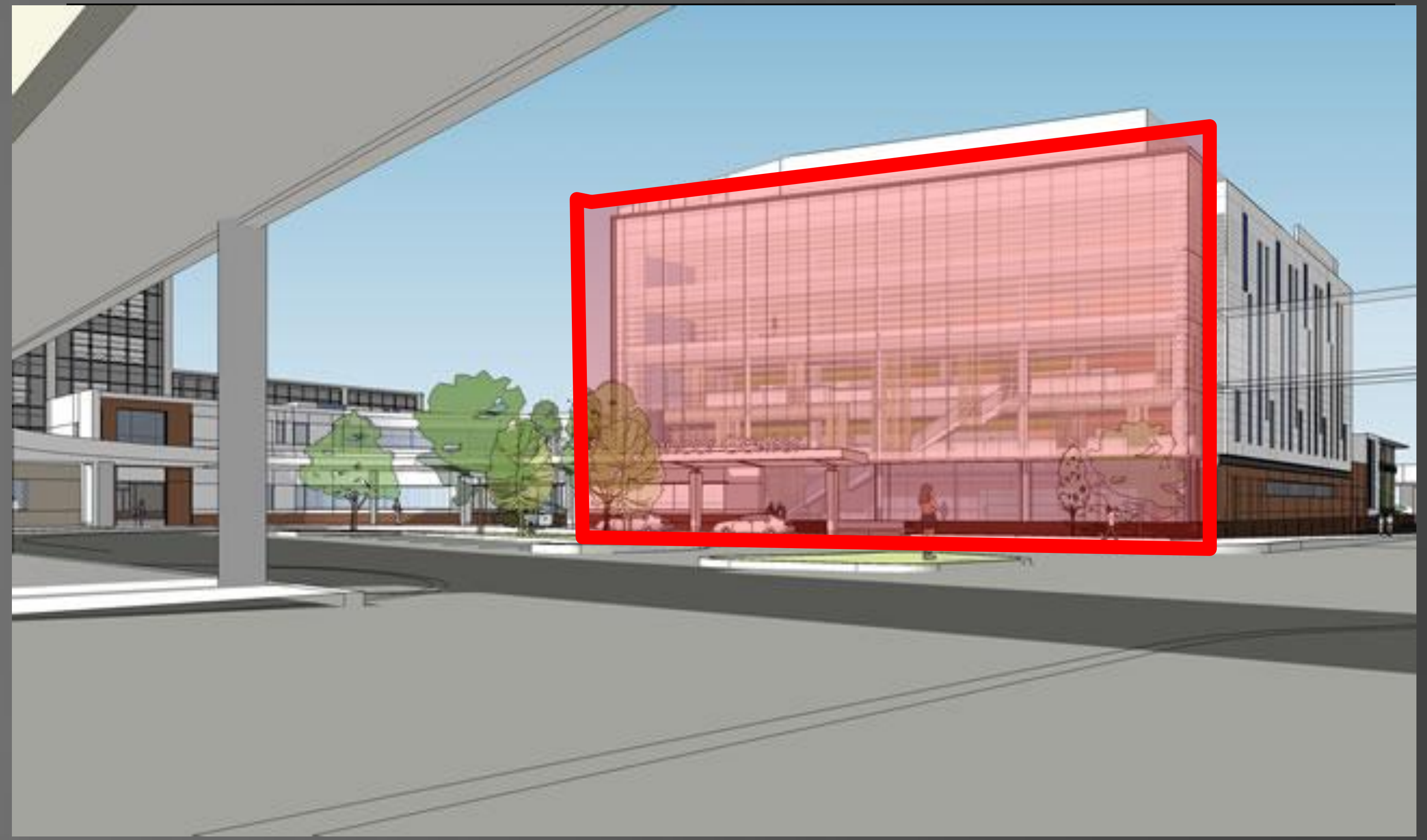


Breadth 1 – Risk Mitigation & Site Redesign

- Review current site for potential security issues
- Implement site improvements to increase protection

Breadth 2 – Building Envelope Redesign

- Design NE façade for building loads
- Compare heat flow through original and redesigned façade.



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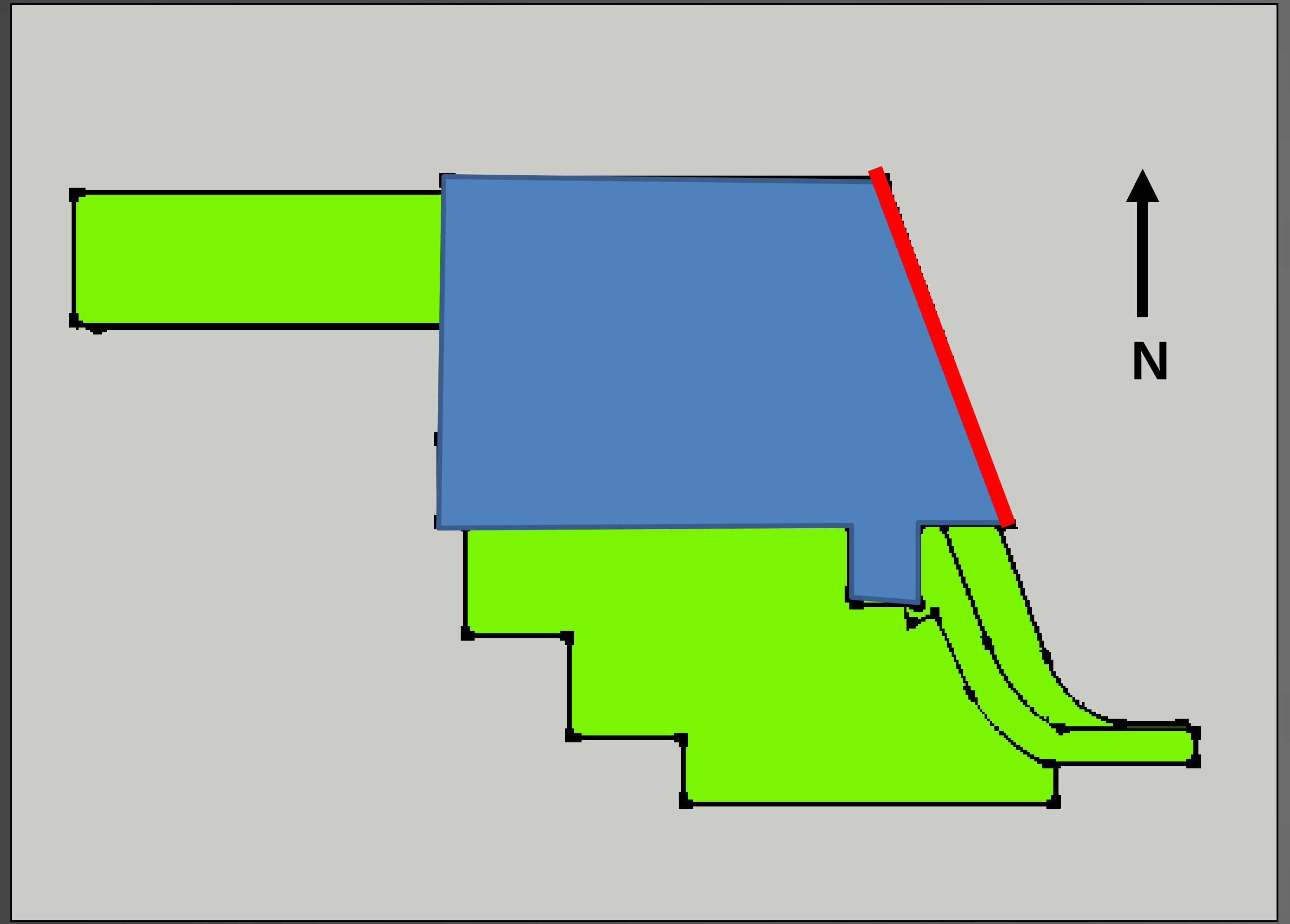

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Breadth 2 – Building Envelope Redesign

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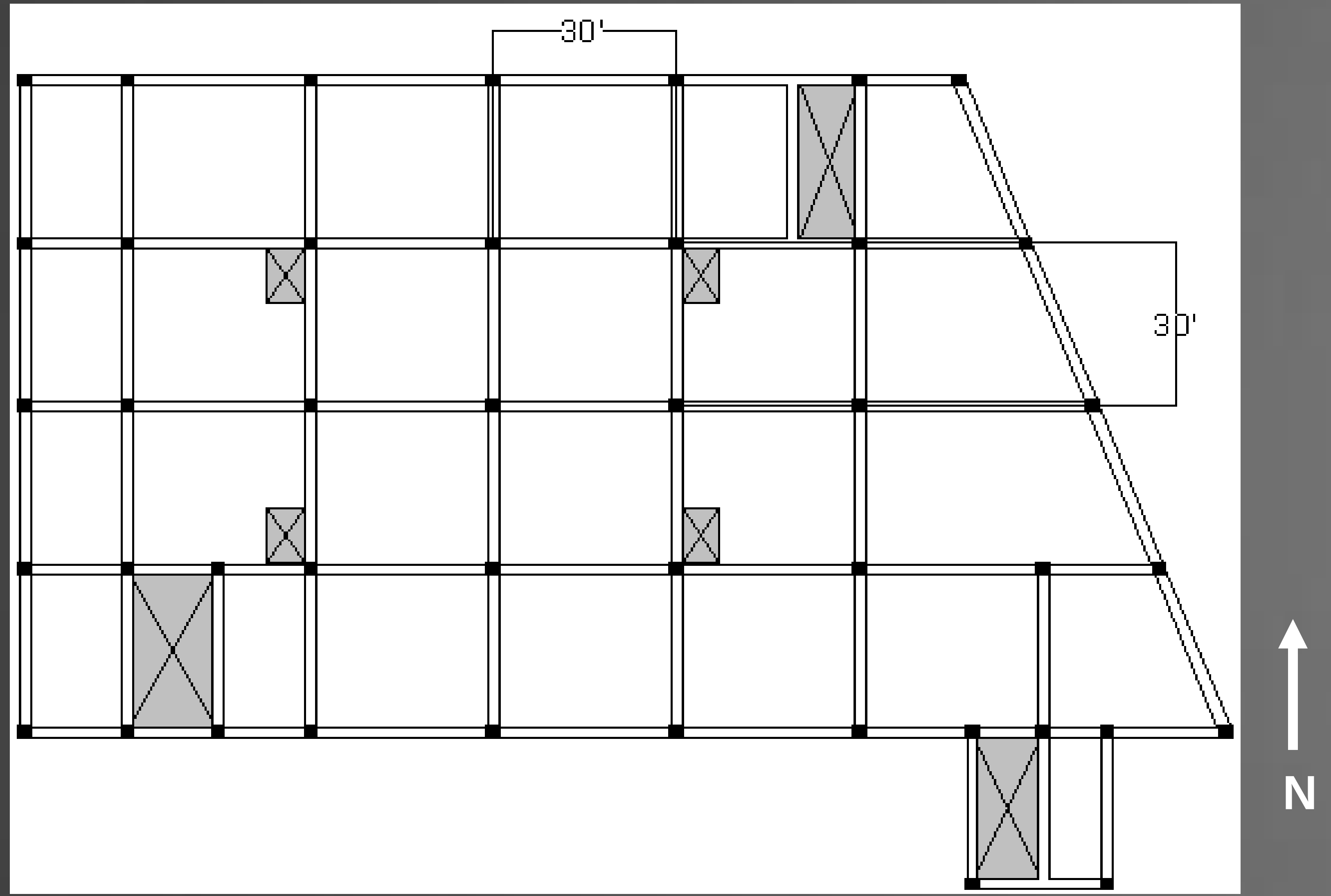
MAE Requirements

- ETABS and SAP2000 computer models: AE 597 – Computer Modeling of Building Structures
- Façade redesign: AE 542 – Building Enclosure Science and Design
- Progressive collapse: Independent research



Gravity Redesign

Gravity System Redesign

Floor System Chosen: Two-way slab
- •Lowest cost
- •No changes to architecture
- •Reduced floor assembly thickness

Two-way slab designed with beams
- •Integration with lateral system
- •Integration with progressive collapse design

Modified column / beam layout

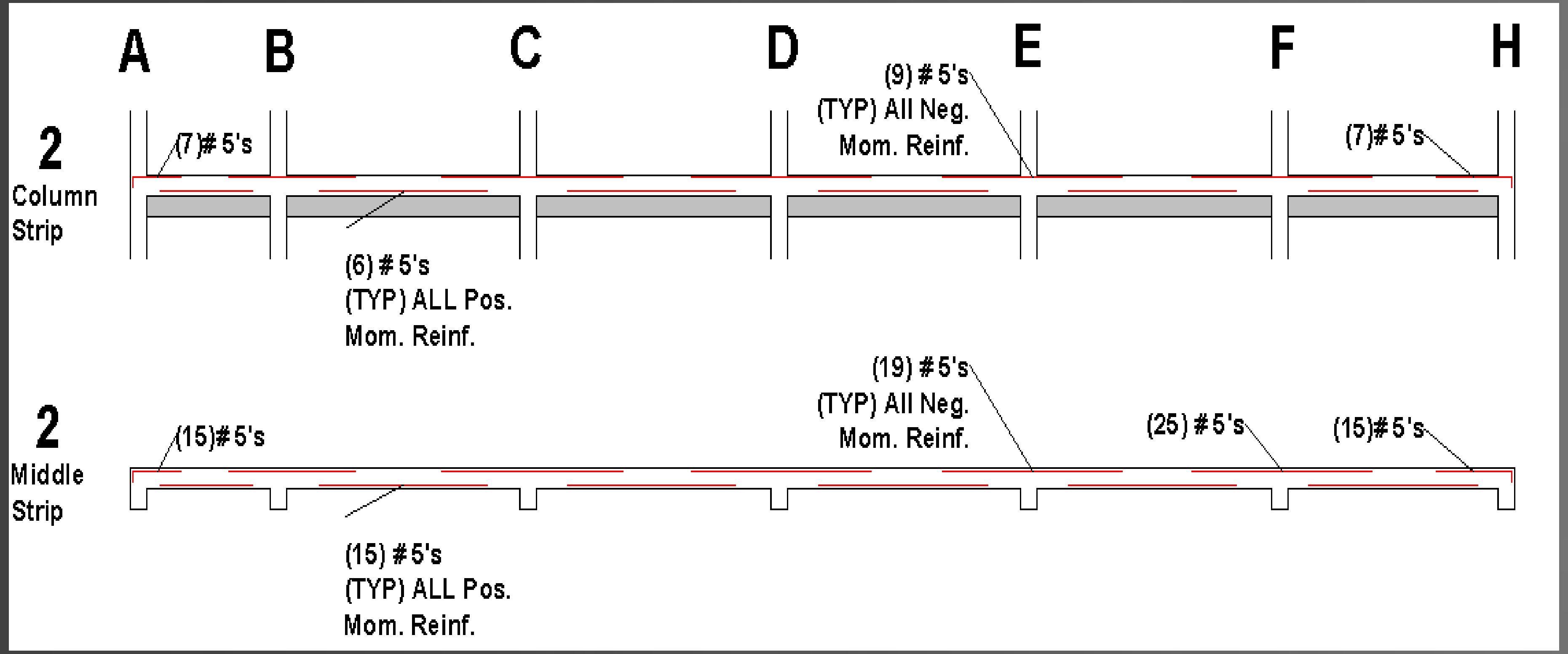
Gravity Loads

Dead Loads
- •Member self weight
- •Super imposed: 25 psf (Floors)
- •Façade weight

Live Loads
- •100 psf (Floors)

Snow Loads
- •Flat roof snow load: 42 psf

Gravity Redesign

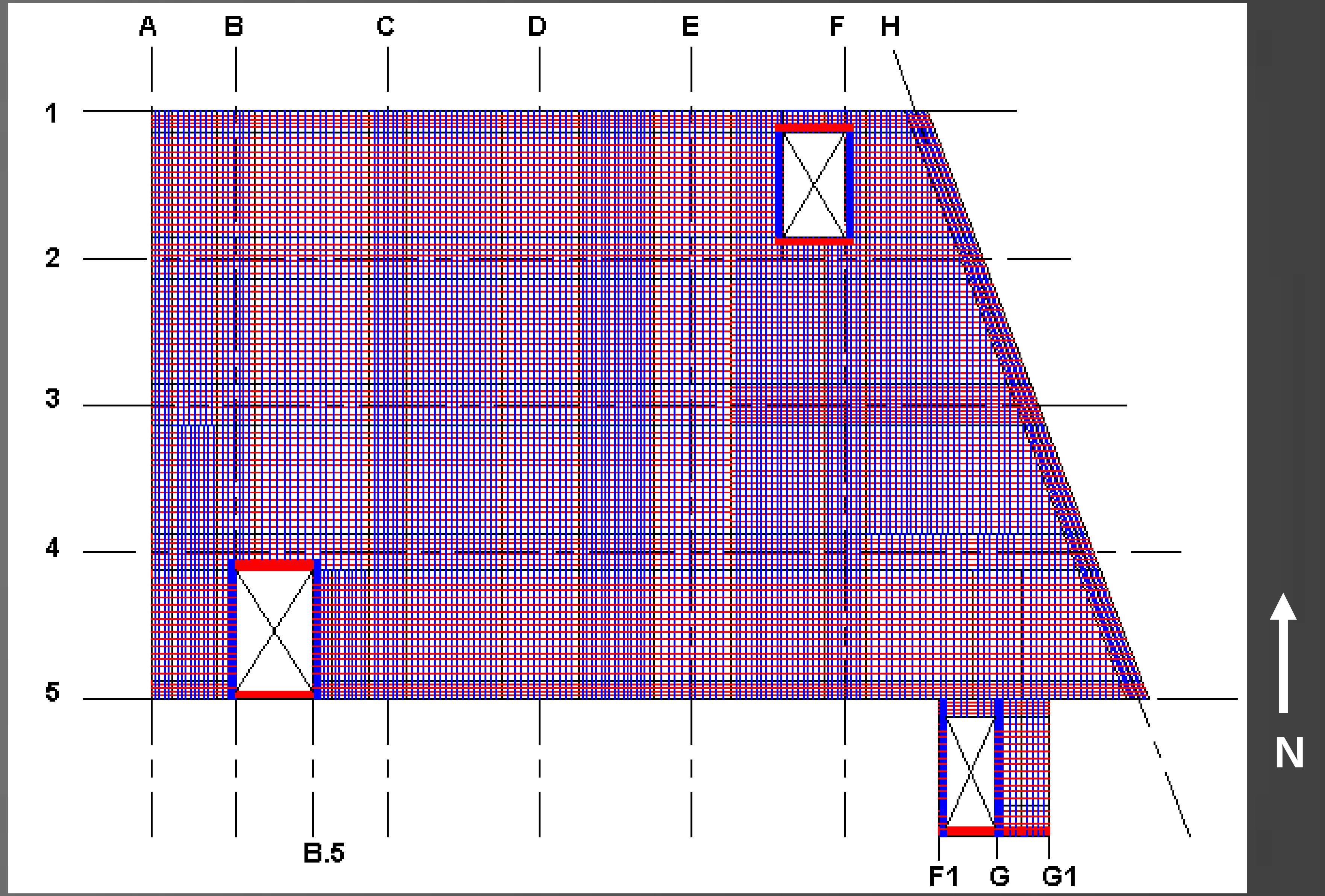


Slab Design

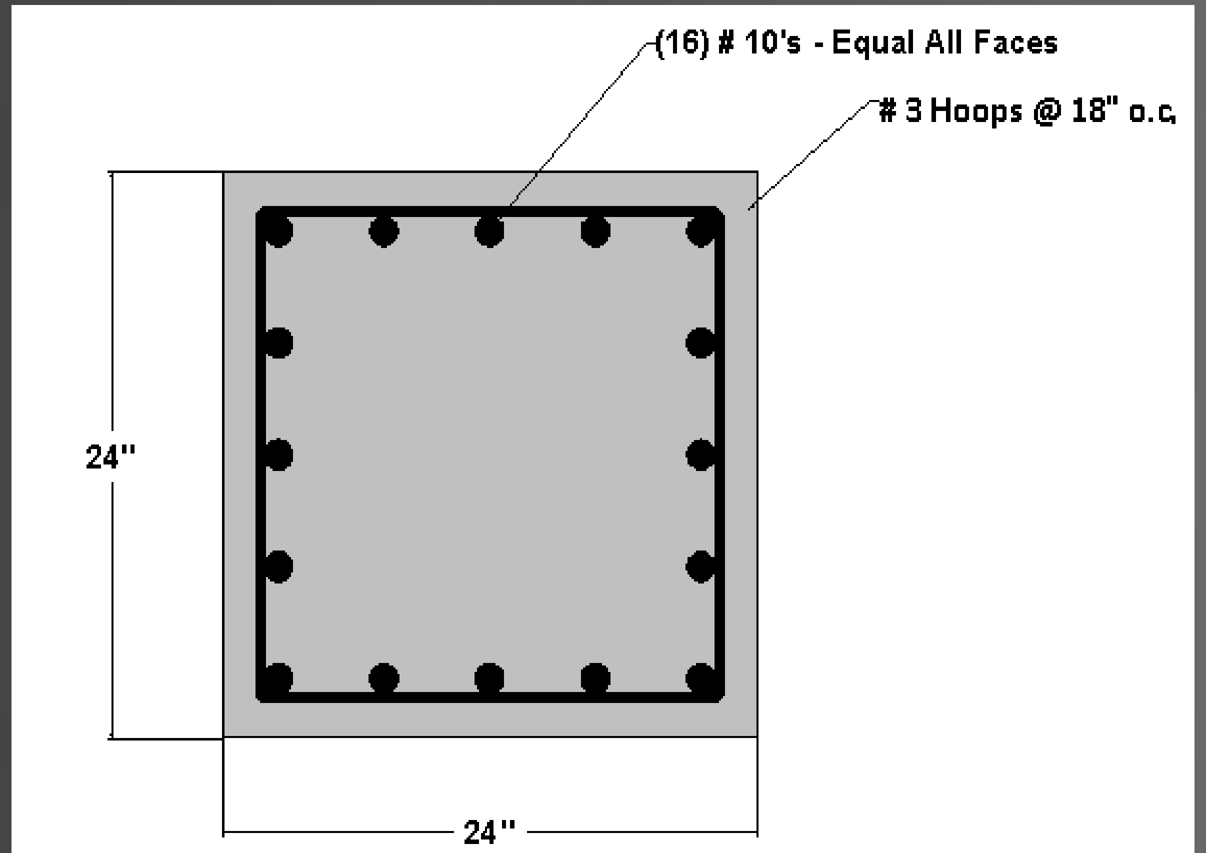
All slabs – 4000psi compressive strength

Slab designed using Equivalent Frame Method
- Slab thickness: 9”
- Reinforcement: #5’s ASTM A615 top & bottom
  Middle & Column strips

Punching shear resisted through gravity beams



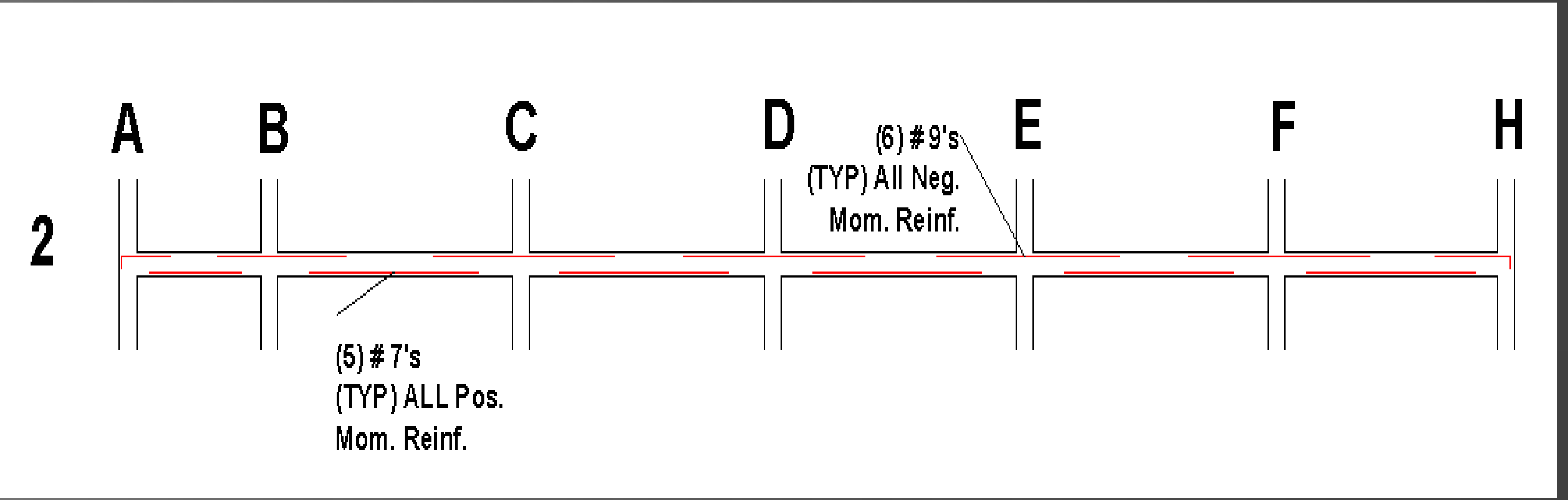
Gravity Redesign

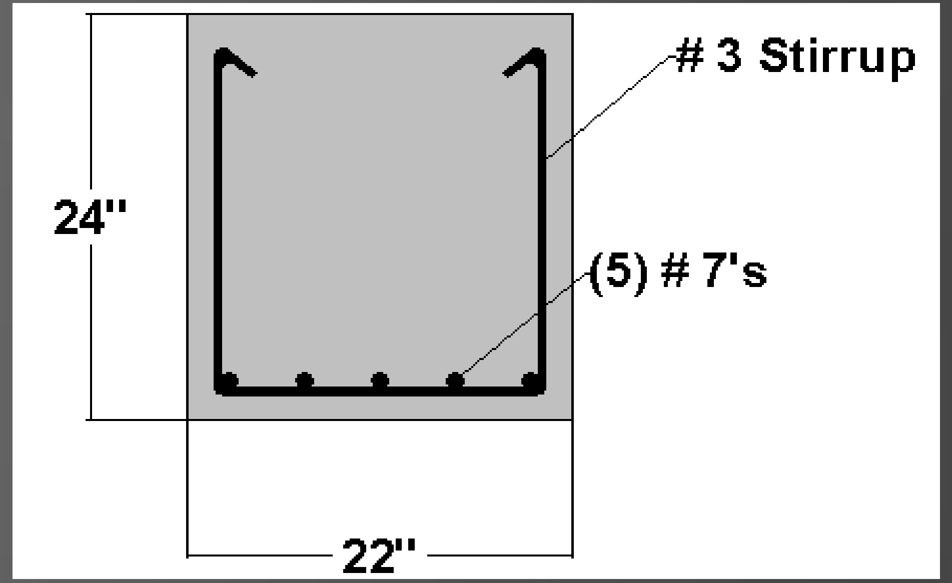


Beam / Column Design

- All beams / columns – 4000 psi
- Initial beam sizes:
  - Depth: 2.5 x slab depth = 24”
  - Width: Trial column width = 22”
- Flexural reinforcement limited to #9 ASTM A615
- Shear stirrups: #3 @ 3” o.c.

- Columns sized for pure axial loads
  - Square: 24” x 24”
  - (16) # 10 ASTM A615 – Equal all faces
  - Confinement reinforcement: #3 Hoops @ 18” vertically





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Lateral Redesign

Lateral System Redesign

•Gravity system is base design for lateral system
•Lateral forces resisted through reinforced concrete moment frames, N-S; E-W
 Creates open floor plan
 Aid in progressive collapse design

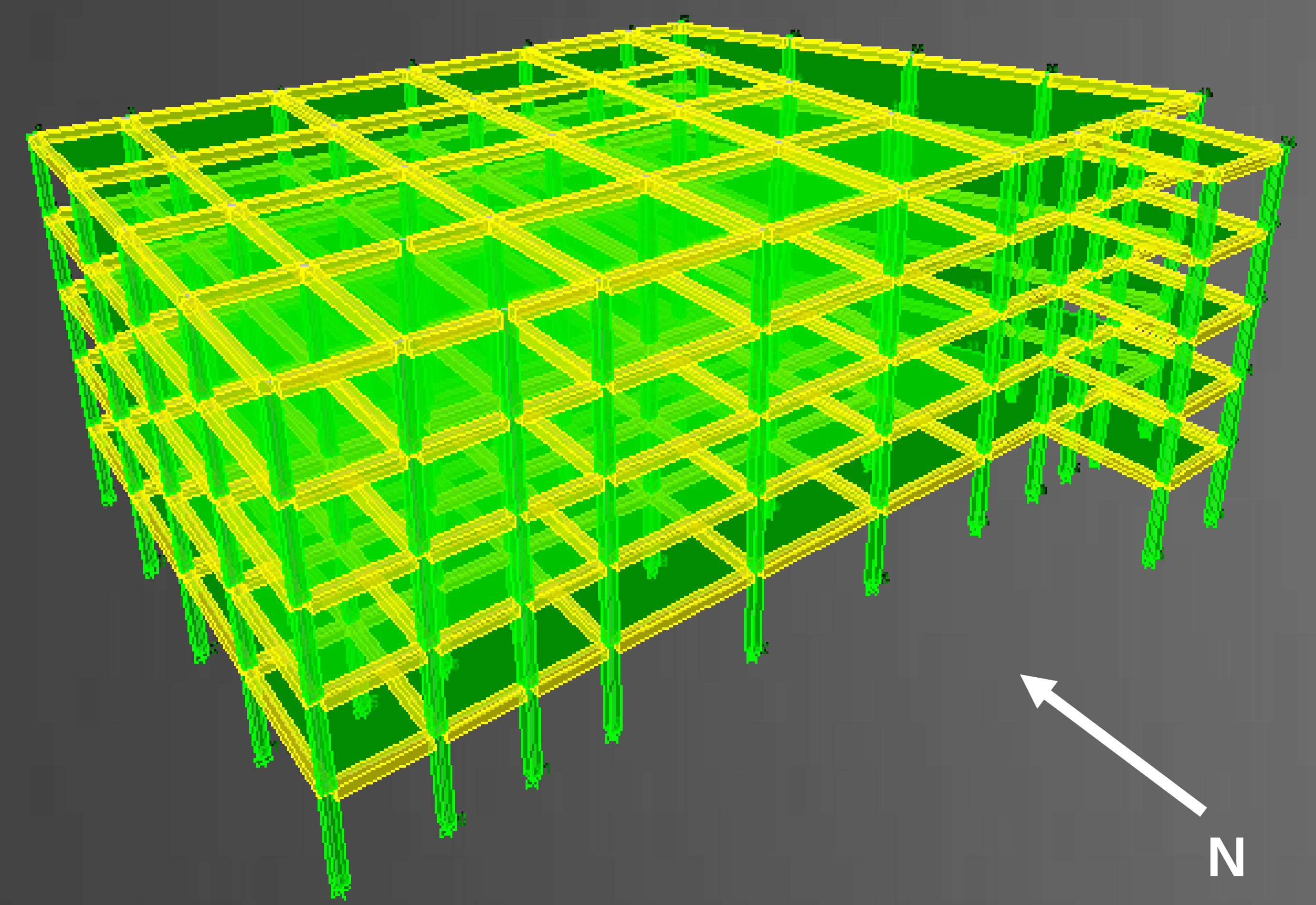
•Computer modeling assumptions:
 Only full height frames modeled
 Cracked member sections
 Rigid end offset – rigid zone factor = 0.5

Lateral Loads – ASCE 7-10

• Wind Load: Exposure B
 •Roof height = 72'
 •Max pressure = 41 psf
 •Controlling base shear = 529 kips
 •Drift limited to: H/400

•Seismic Load: SDC - C
 •Building weight = 19,760 kips
 •Base shear = 765 kips
 •Drift limited to: $0.01{*}h_{sx}$

Lateral Redesign



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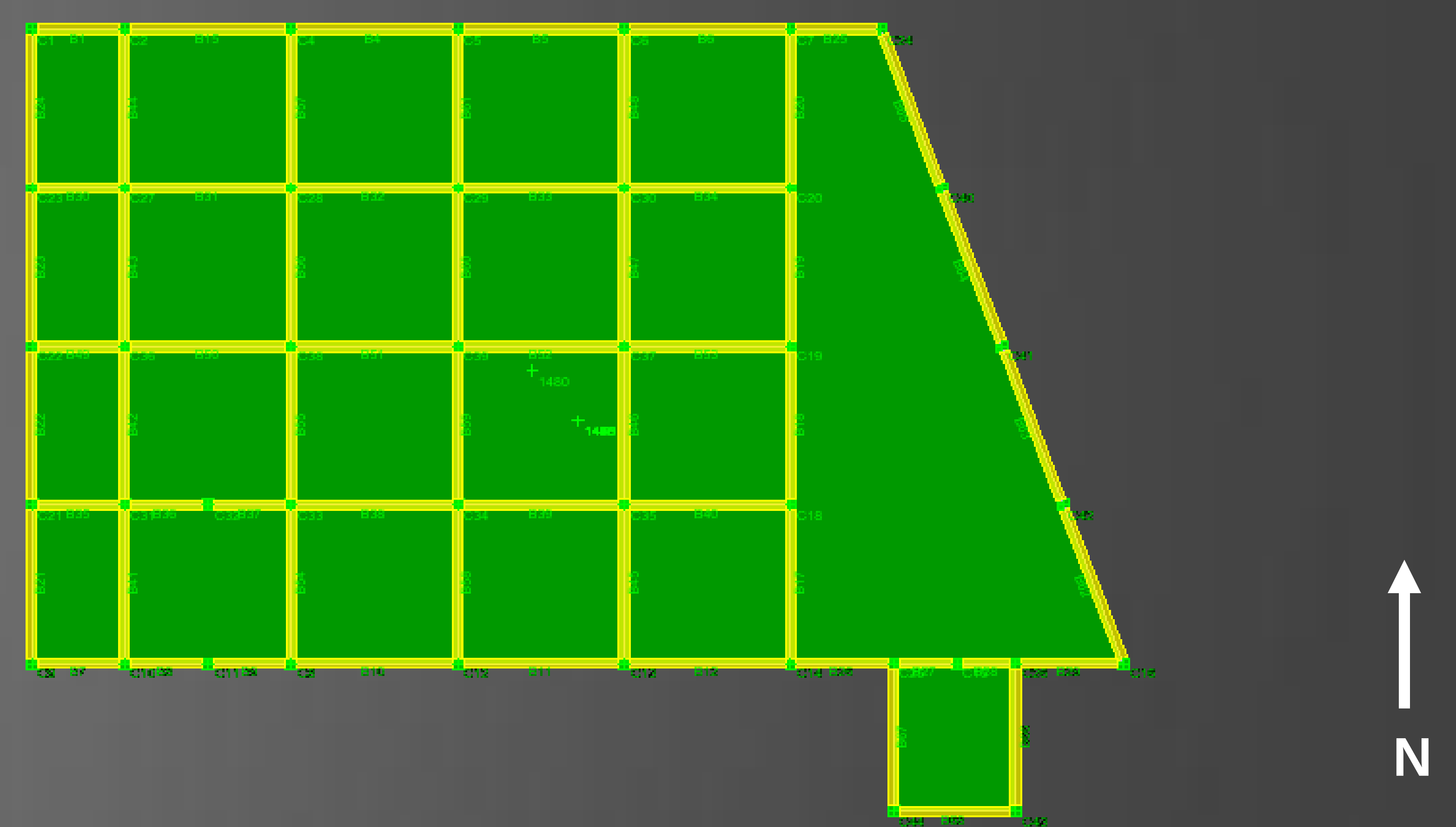

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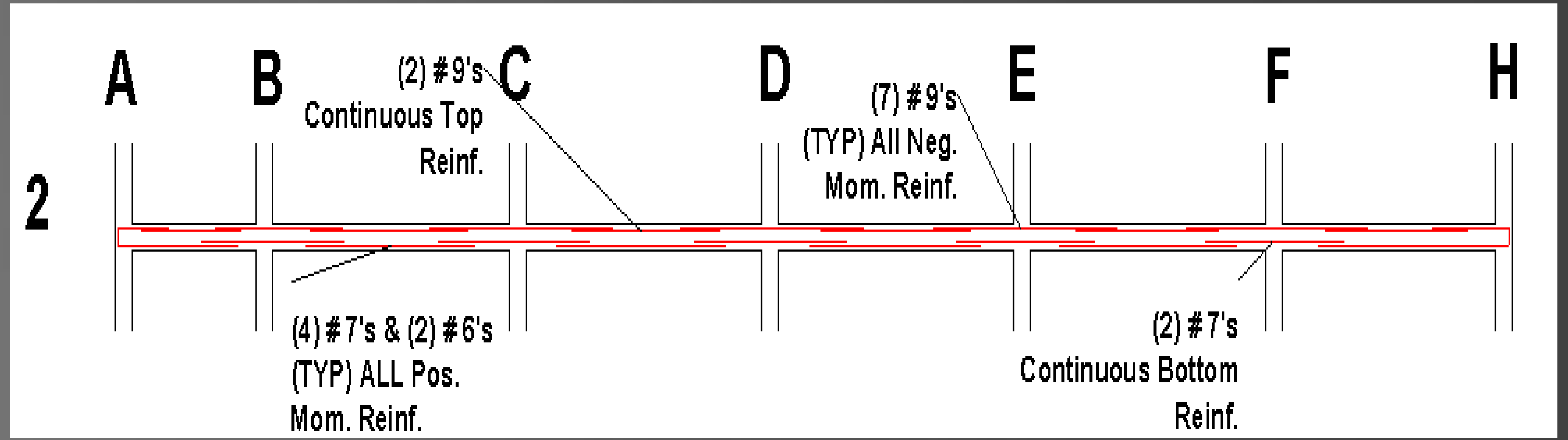
Lateral Redesign

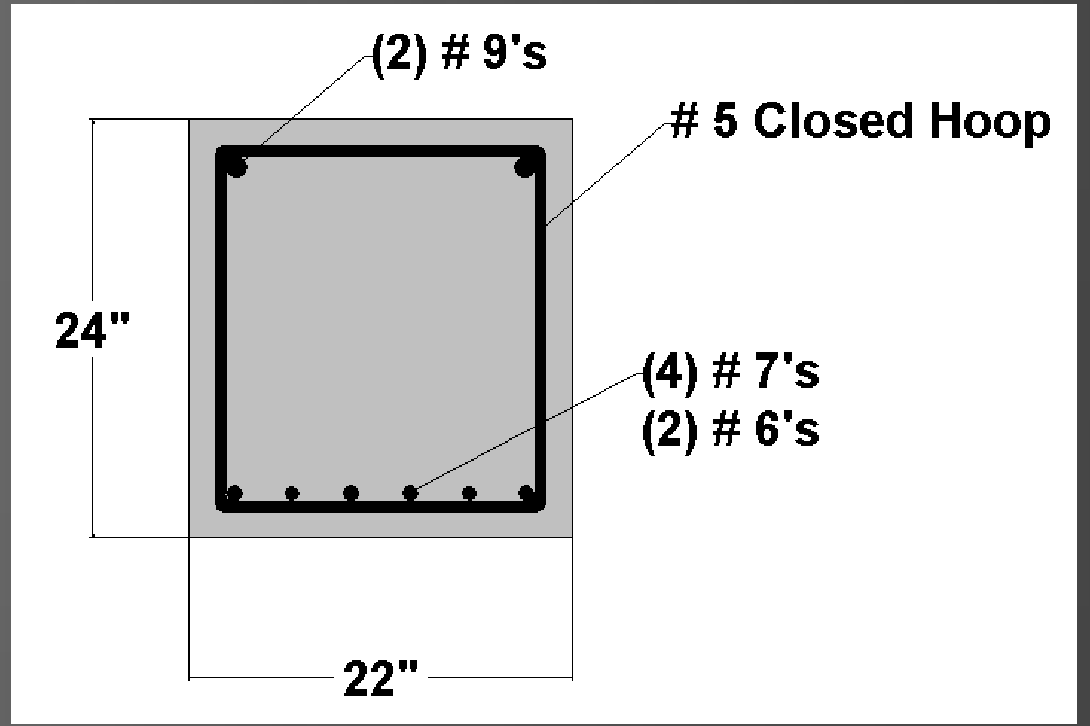
Beam Design

Controlling load combination:
- 1.2D + 1.0E + L + 0.2S (ASCE 7-10)

ACI 318-08: Intermediate moment frames (SDC-C)
- Two continuous bars along beam
- Hoops for shear

22” x 24”:
- Continuous bars – Top: (2) #9 ASTM A615
  Bottom: (2) #7’s
- Shear: #5 closed hoops @ 3” o.c. (worst case)
- ρ limited to 2.5%





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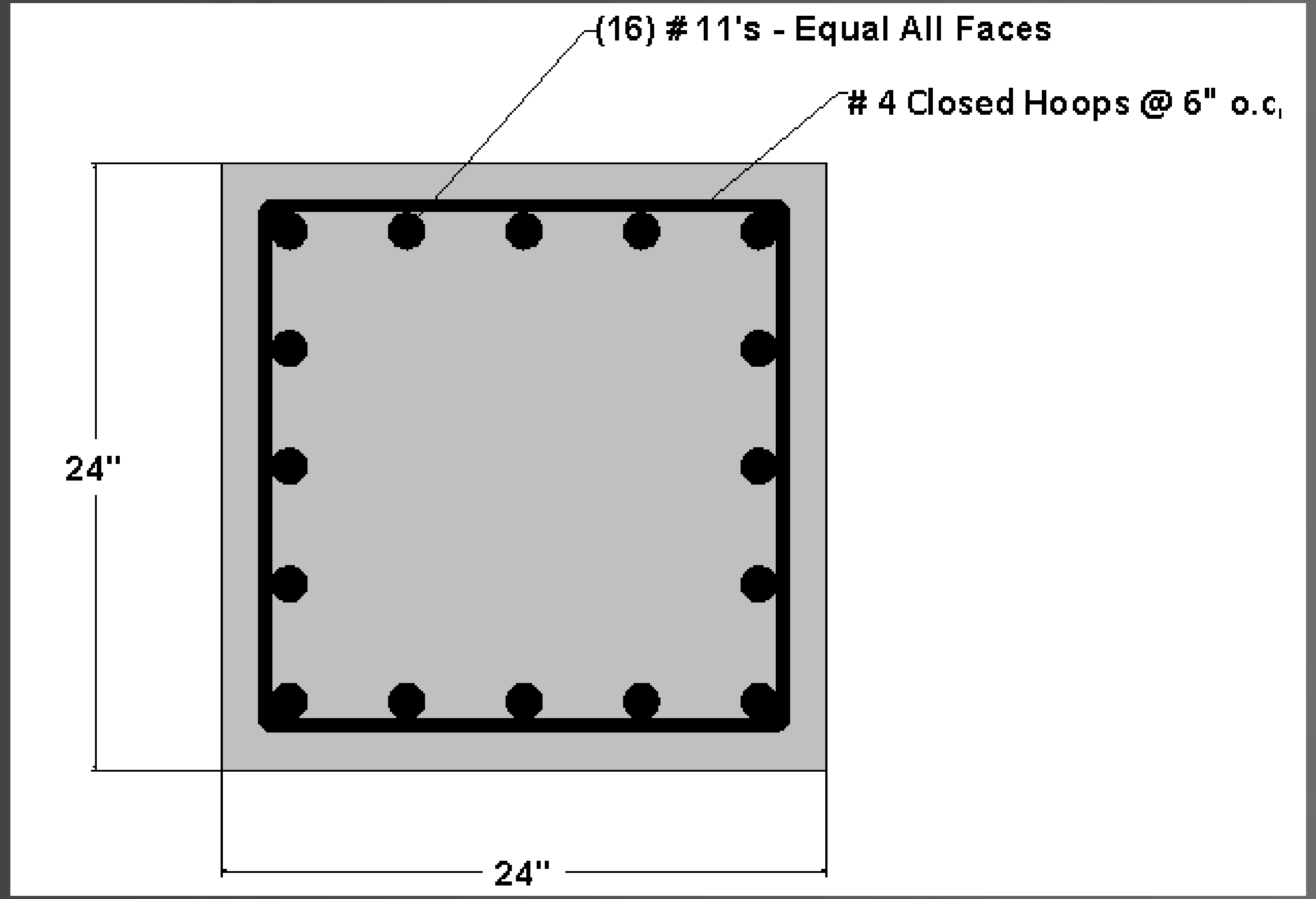


Column Design – Axial & Bending

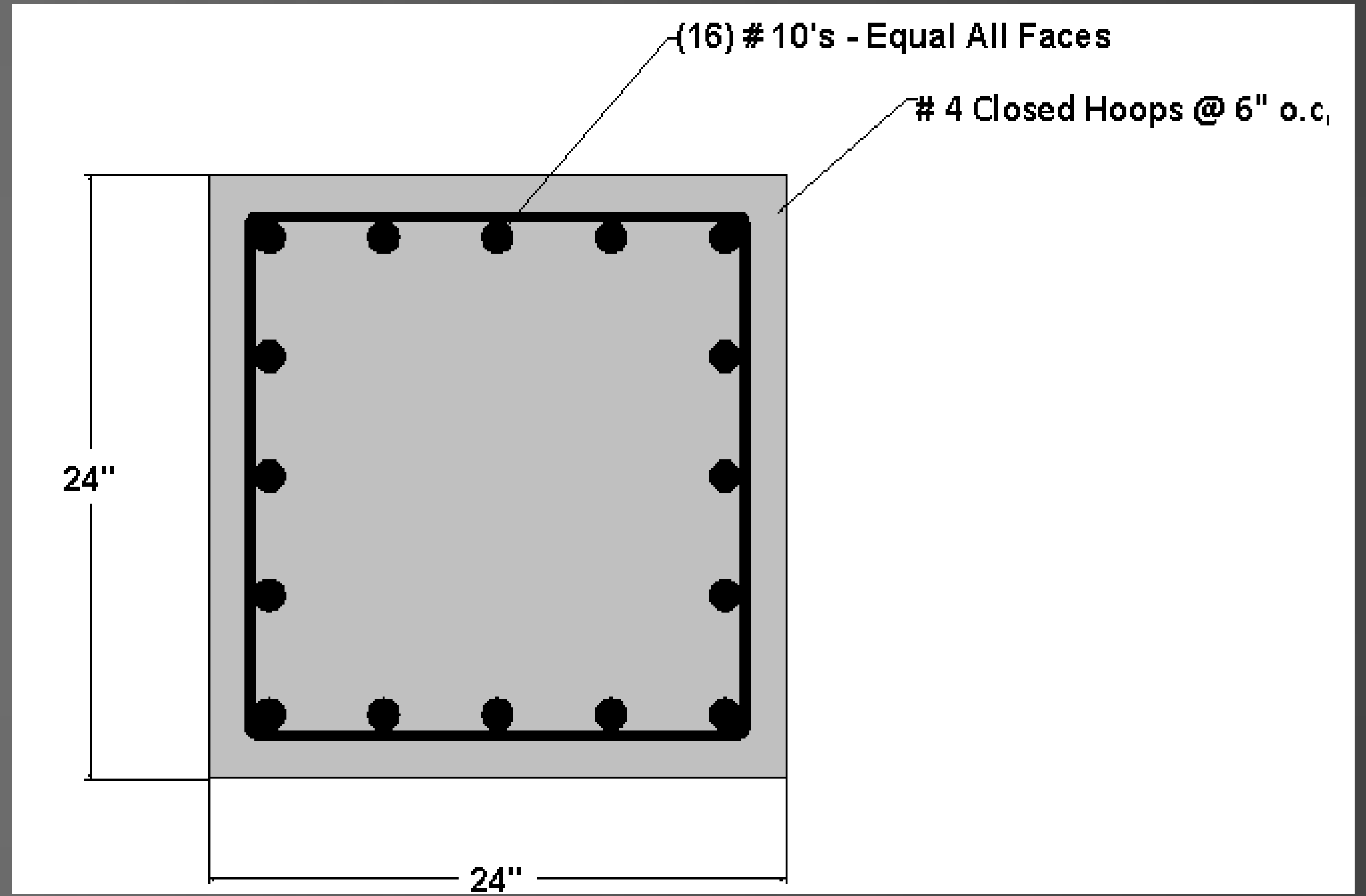
- Considered second order & slenderness
- Two column designations: Top, Bottom
- ρ targeted between 1% - 8%
- SpColumn

Bottom Columns: Ground – 3rd

- 24” x 24”
- (16) #11 ASTM A615 – equal all faces
- #4 Hoops @ 6” o.c. – Transverse

Top Columns: 4th - Roof

- 24” x 24”
- (16) #10 ASTM A615 – equal all faces
- #4 Hoops @ 6” o.c. – Transverse



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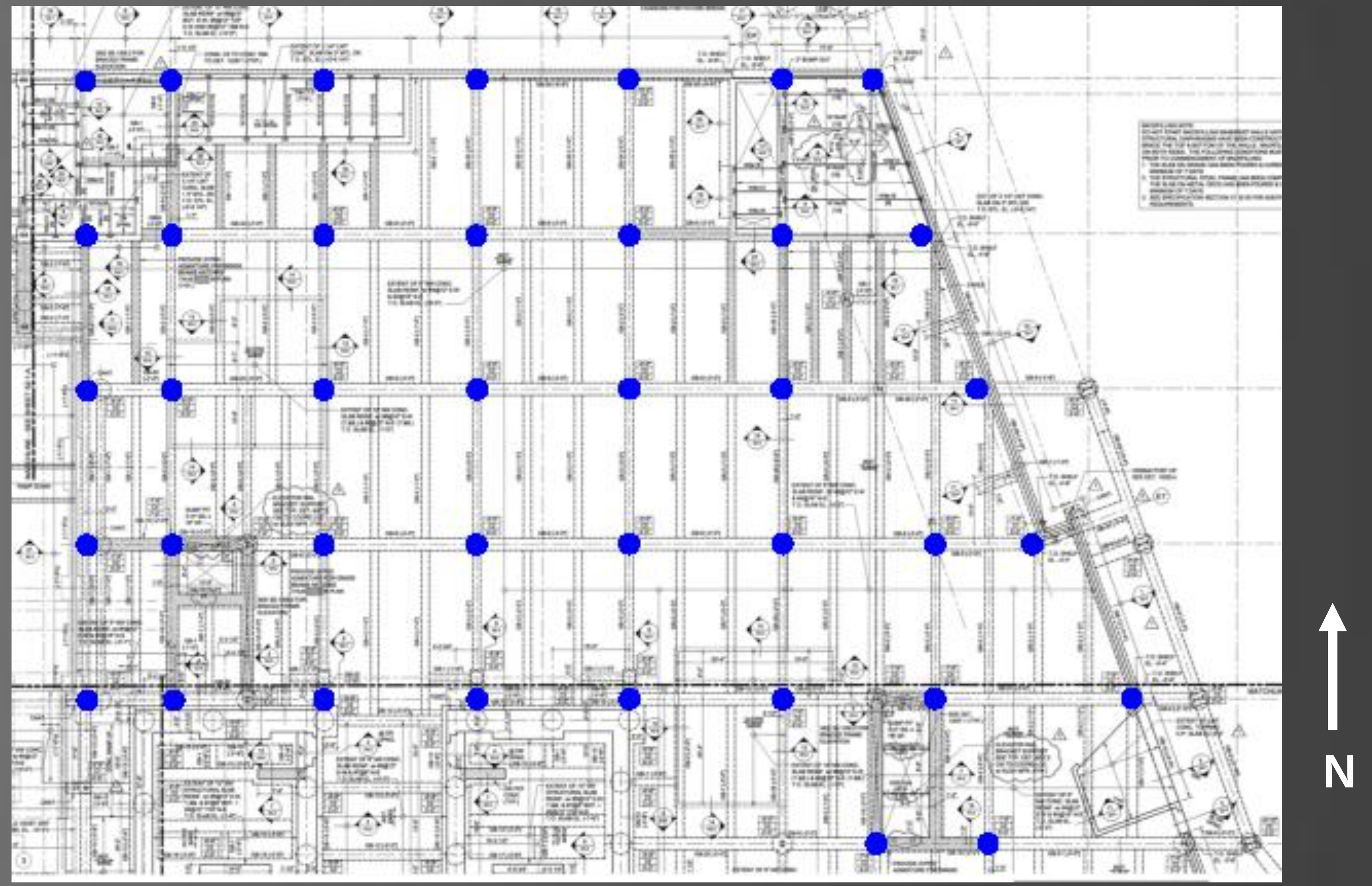
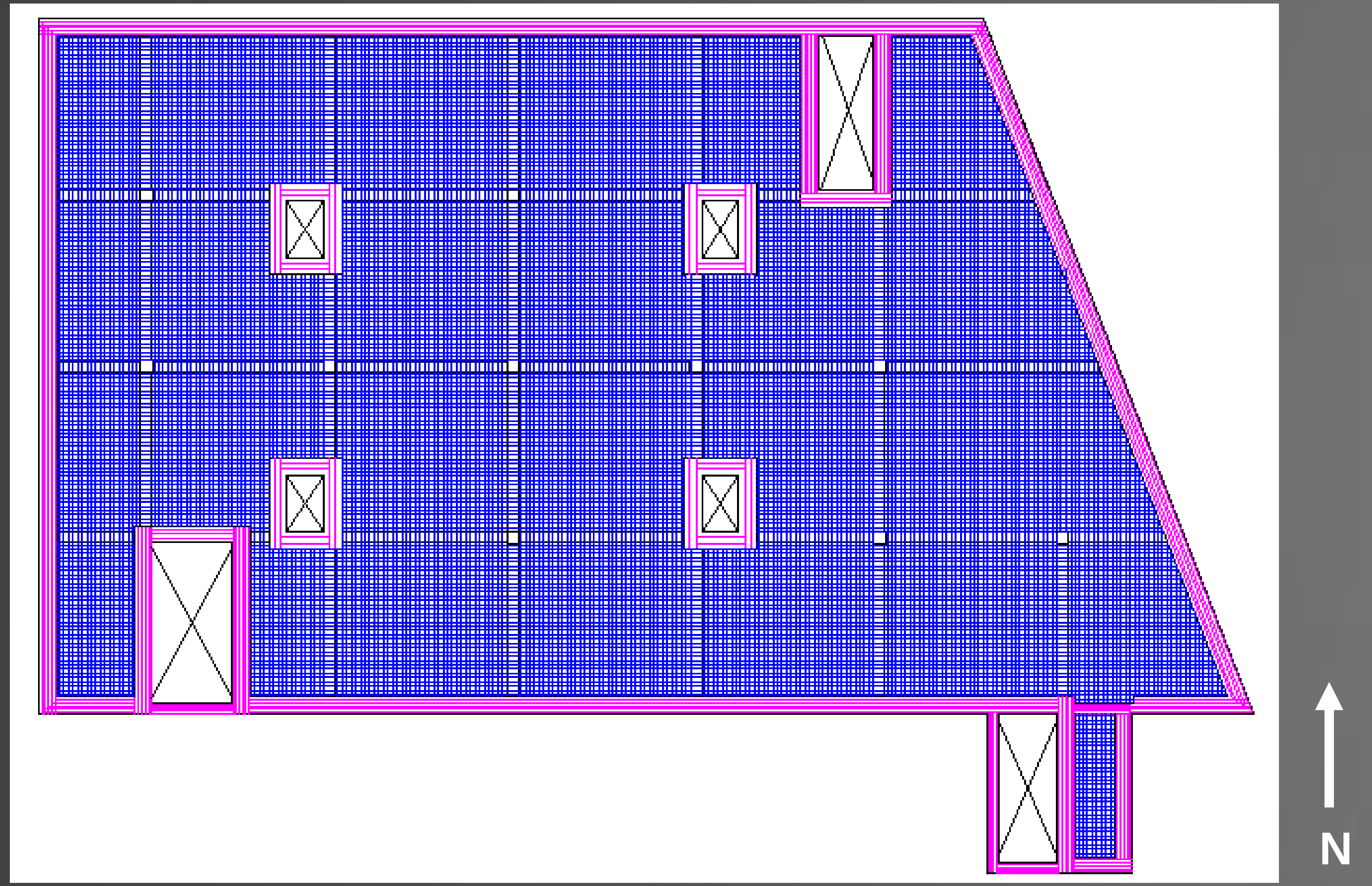
Foundation Redesign

Caissons:

- 48" diameter capacity = 628 kips
- Use (39) 48" diameter caissons along typical grid intersections





Progressive Collapse Design

Progressive Collapse Design Requirements:

(UFC 4-023-03)

Occupancy Category IV

- Tie Force Method
- Alternative Path Analysis
- Enhanced Local Resistance

Selected Ties:

- Internal = #6 ASTM A615 @ 9” o.c. (both directions)
- Peripheral = varies per opening
- Vertical = satisfied by existing

Tie Force Method

Load Combination: $W_F = 1.2D + .5L$

Perform analysis For:

- Internal Ties: $Fi = 3W_F L_i$
- Peripheral Ties: $F_i = 6W_F L_i L_p$
- Vertical Ties: $F_v = A_T W_F$

Provide ties such that $\phi R_n > F$

- $\phi R_n = \phi\ \Omega\ A_s\ F_y$
- Ω = 1.25 (Over strength Factor – ASCE 41 – 60 ksi steel)

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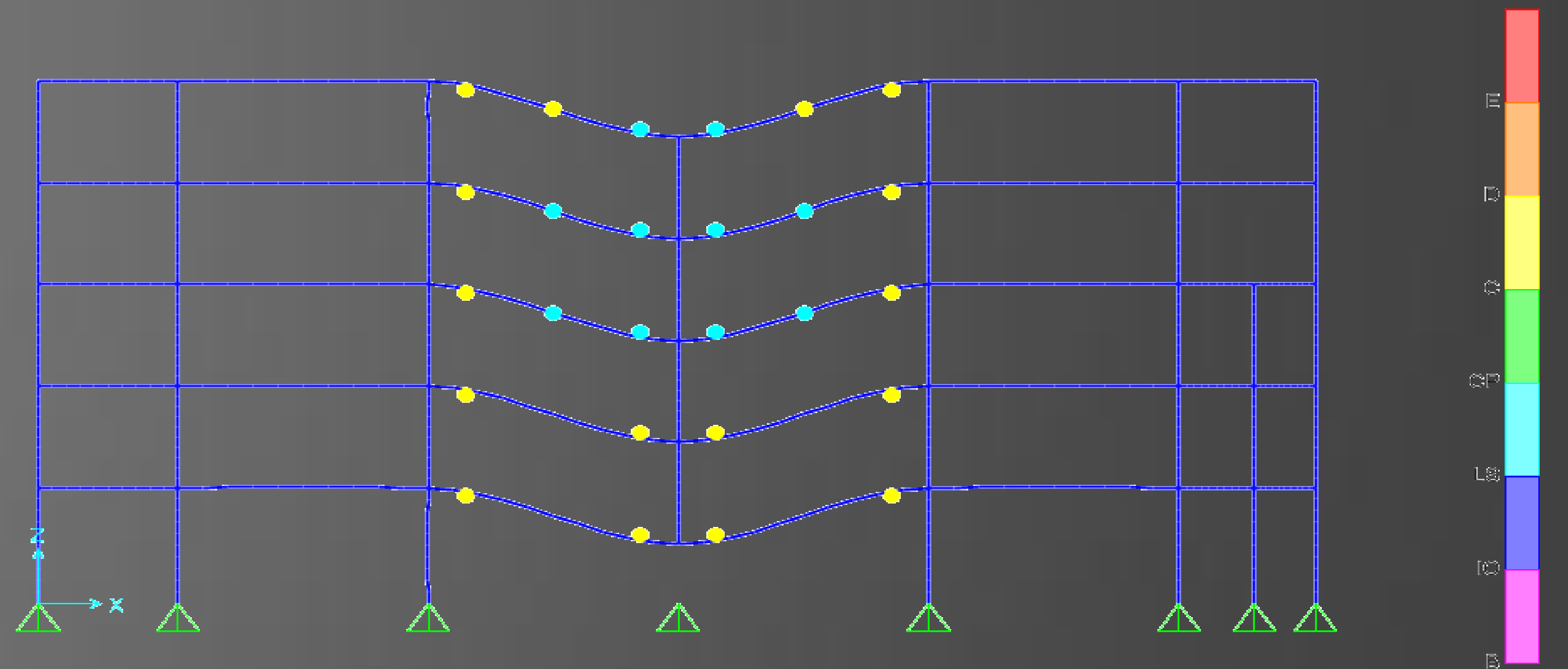
Alternative Path Analysis

- Load Combination:
  - $G_N = \Omega_N$ [(0.9 or 1.2)*D + (0.5*L or 0.2*S)]
    - Ω_N = Dynamic increase factor
  - G = (0.9 or 1.2)*D + (0.5*L or 0.2*S)
  - $L_{LAT} = 0.002*\Sigma P$

Alternative Path Method (Non Linear Static)

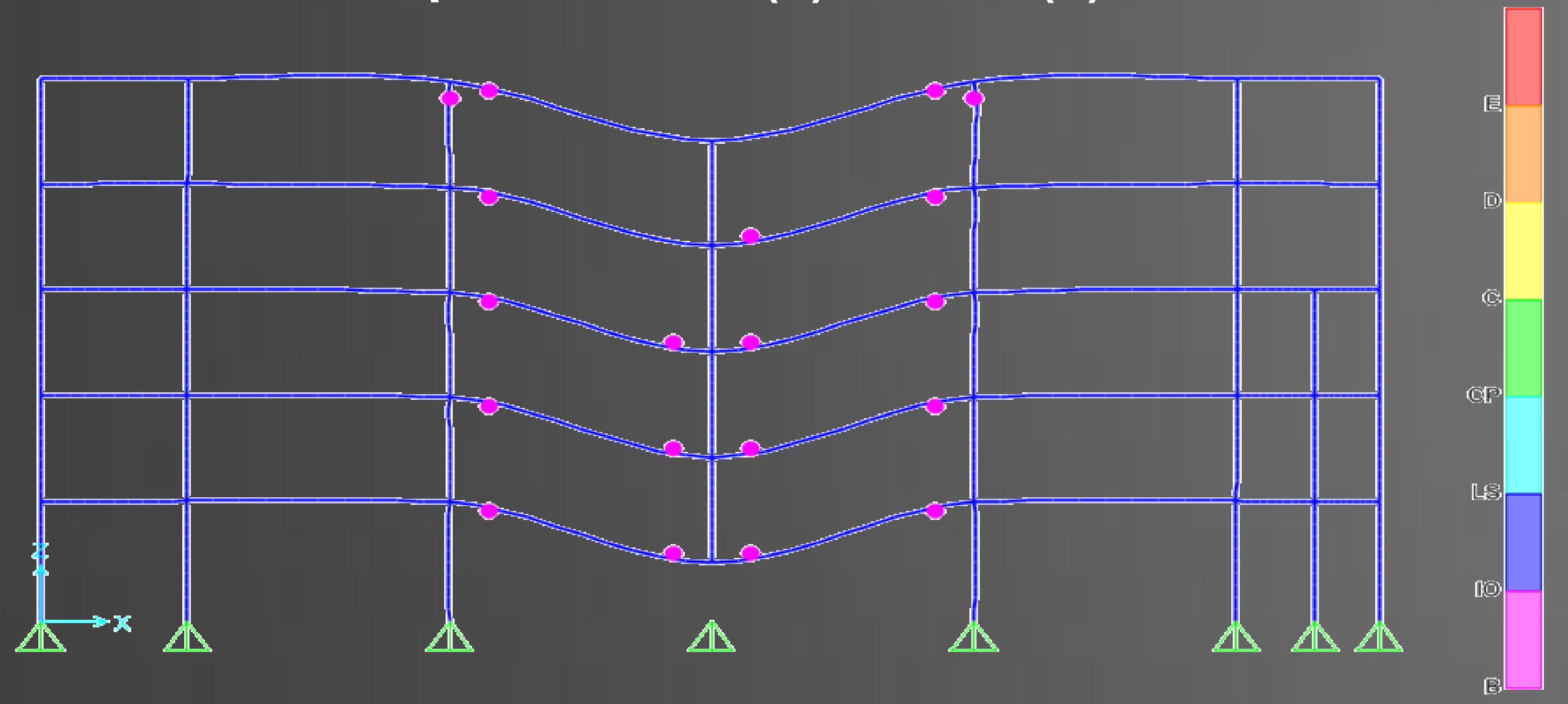
Alternative Path Analysis – Utilizing SAP 2000 Non Linear

- Model Primary and Secondary Members
- Assign hinges in accordance with ASCE 41
- Check member ability to span missing elements



Redesigned members:

- Spandrel Beams: 22" x 28"
  - Top & Bottom: (4) # 8's & (5) # 9's
- Framing into spandrel beams: 22" x 24"
  - Top & Bottom: (4) # 8's & (5) # 9's



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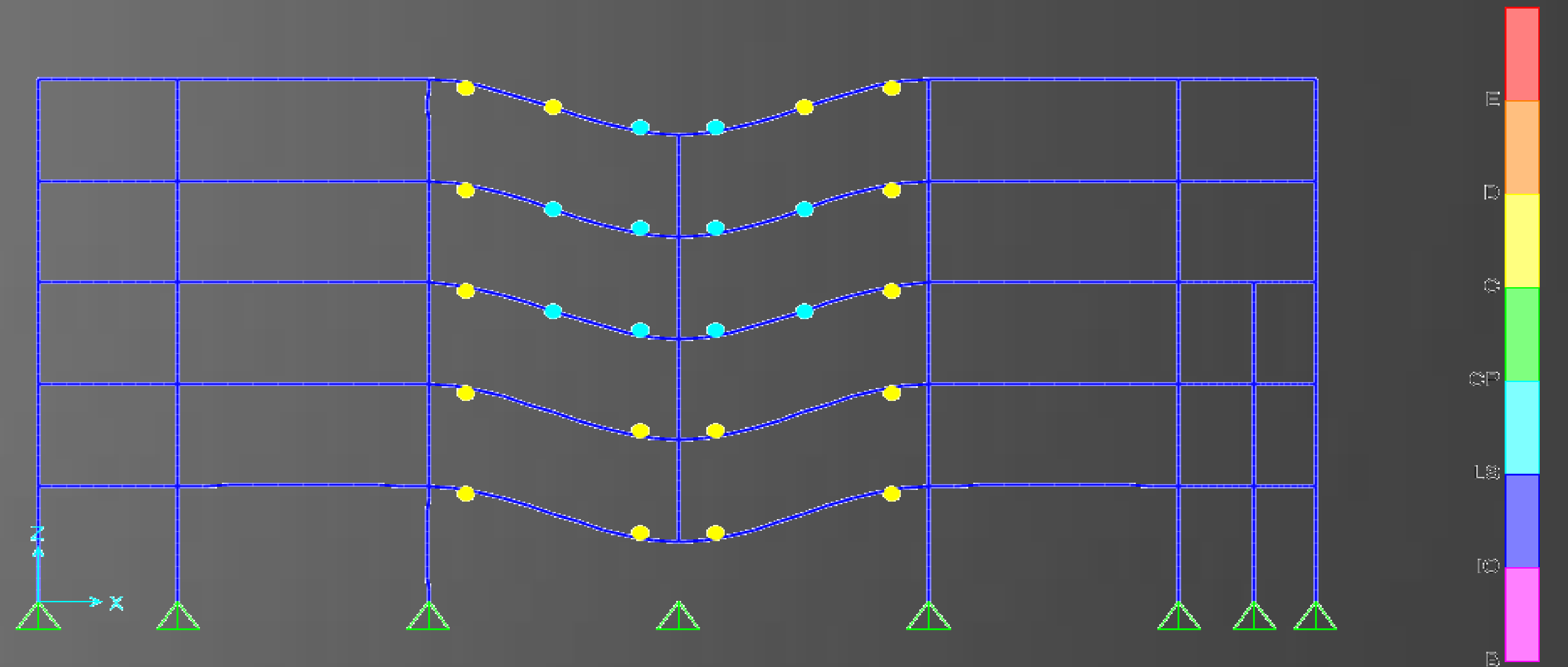

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Occupancy Category IV
- Tie Force Method
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- Enhanced Local Resistance

Enhanced Local Resistance

Occupancy Category IV:
- All perimeter columns, first two stories above grade

- Enhanced flexural resistance (EFR)
  - EFR = larger of:
    - 2.0*baseline flexural resistance
    - Alternative path flexural resistance

- New column size:
  - 30" x 30" – (20) #14 ASTM A 615 – equal all faces

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Structural Depth

Summary:

Slabs: 9” thick with #6’s @ 9” o.c. (Typical Floor)
(Tie Force Method)

Beams:
•Spandrel: 22” x 28”
(Alternative Path Analysis)
•Other: 22” x 24”

Columns:
•Top: 24” x 24” – (16) #10’s
•Bottom: 24” x 24” – (16) #11’s
•Perimeter (1^{st} & 2^{nd}): 30” x 30” – (20) # 14’s
(Enhanced Local Resistance)

Cost Analysis:

Analyzed typical bay and adjusted for entire building
RS Means Costworks

Steel estimate: $3,033,685

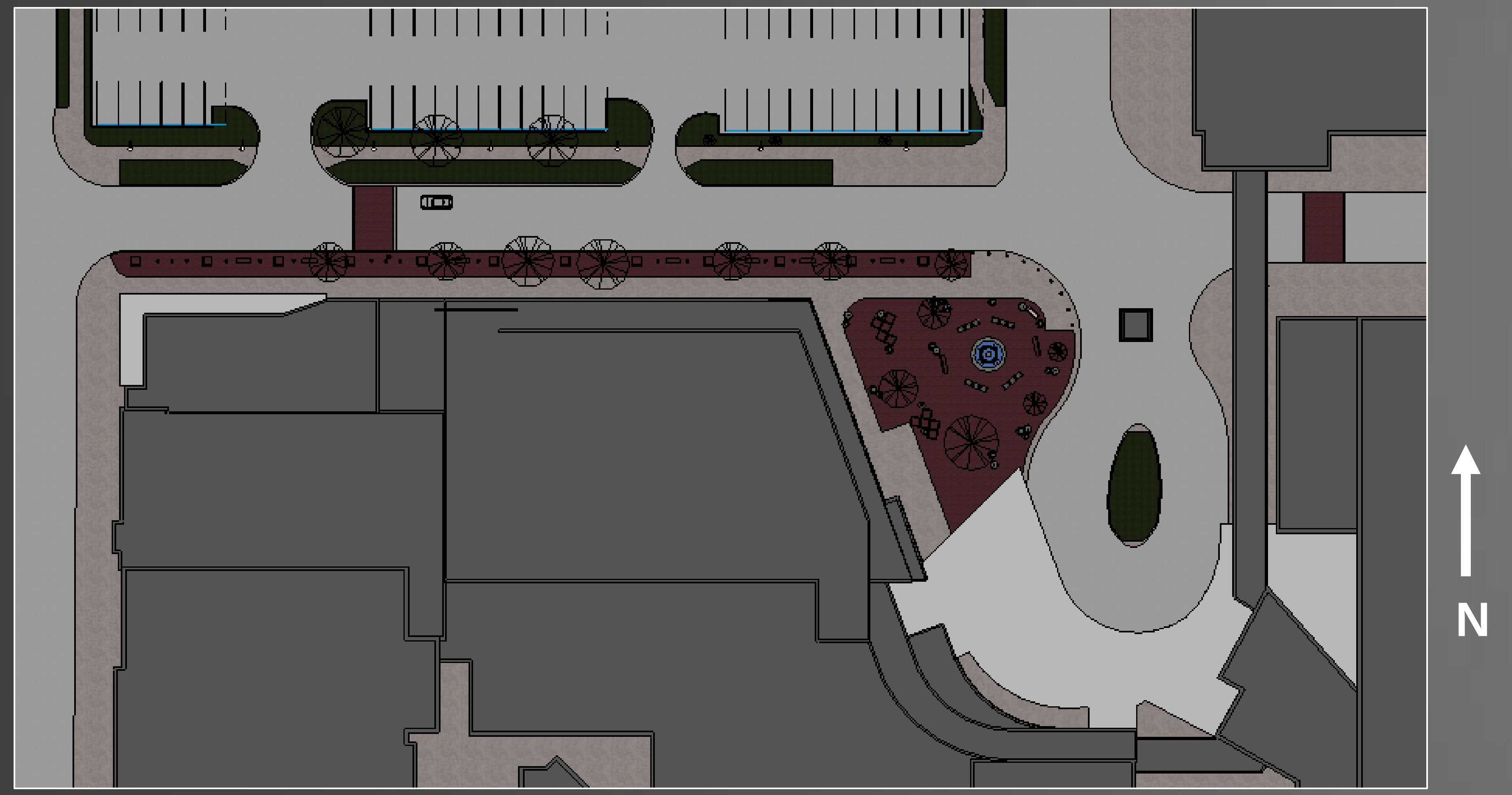
Concrete estimate: $3,449,330
•Includes 5 percent addition for progressive collapse requirements

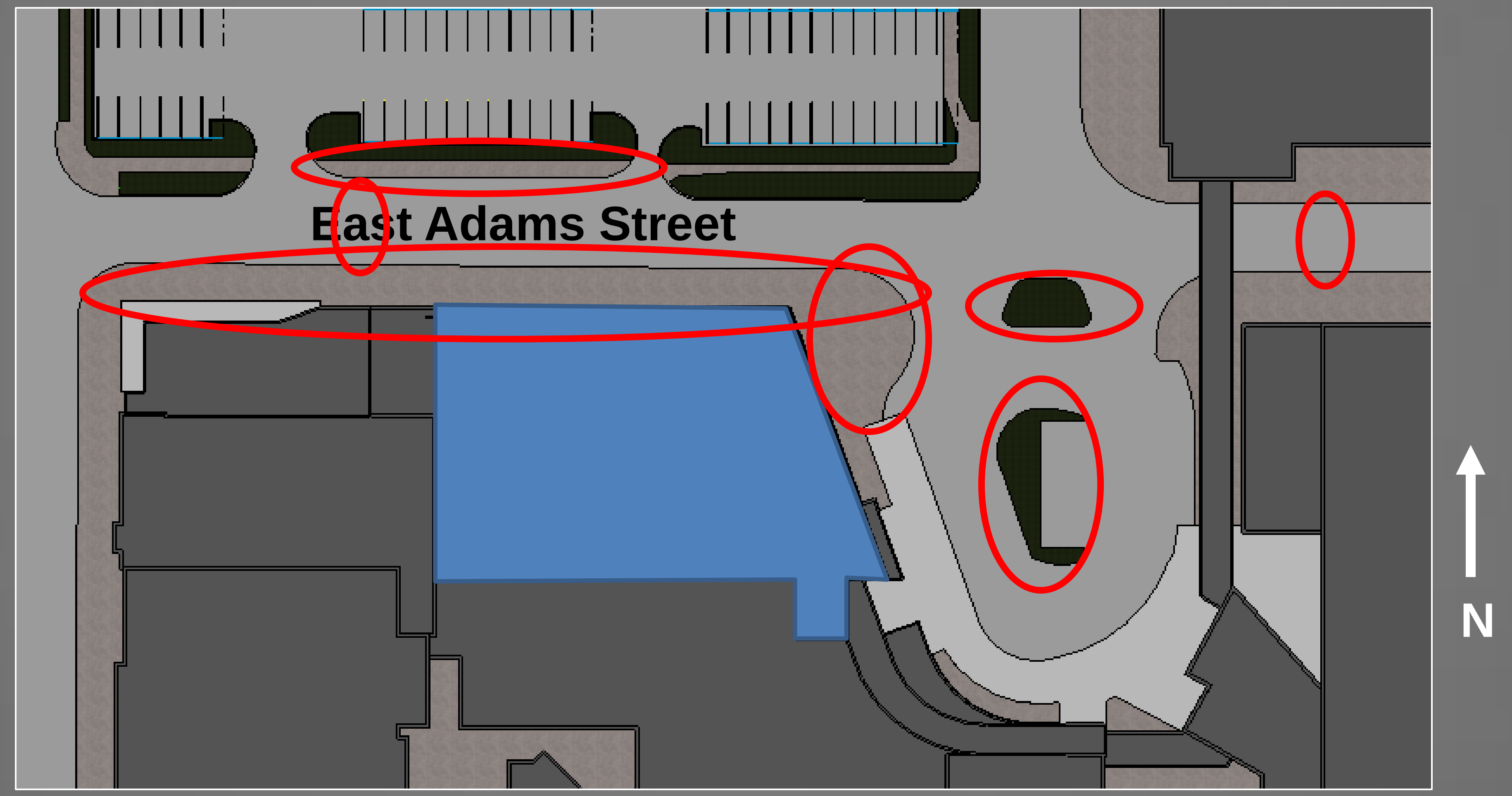
Difference: $415,644

Risk Mitigation Site Redesign (Breadth 1)

U.S. General Services Administration (GSA)

- Site Security Design Guide





Areas of Concern / Site Improvements:

- Narrow East Adams Street
- Reduce speed on East Adams Street
- Remove on-site parking
- Obstruct path along East Adams Street
  - Bollards, Planters, Trees, Benches
  - Collapsible fill under pavers
- Create plaza / increase standoff distance to NE façade
- Limit site access with security gate

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Conclusions

•Superstructure successfully redesigned using reinforced concrete

•Structure meets requirements of D.o.D. for progressive collapse

•Alternative concrete structure costs extra $415,644
Does not include foundation improvement cost

The original steel superstructure is more cost effective; however it was not designed to meet progressive collapse requirements.

Questions & Comments

Acknowledgements

- SUNY Upstate Medical University
  - Mr. Burton Thomas & Mr. Marius Dumitran
- EwingCole
  - Mr. Jason Wiley & Mr. Patrick Brunner
- Penn State Architectural Engineering Faculty
  - Dr. Richard Behr, Dr. Ali Memari, Dr. Linda Hanagan
  - Professor Kevin Parfitt, Professor Robert Holland
  - Ryan Solnosky
- My family and friends