# GATEWAY COMMONS


## GARY NEWMAN

STRUCTURES OPTION

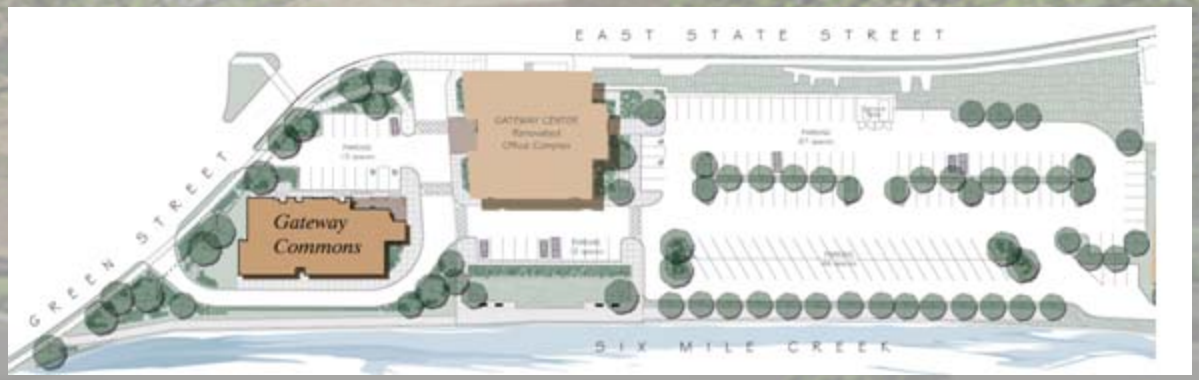
ADVISOR: DR. HANAGAN


SENIOR THESIS PRESENTATION SPRING 2008

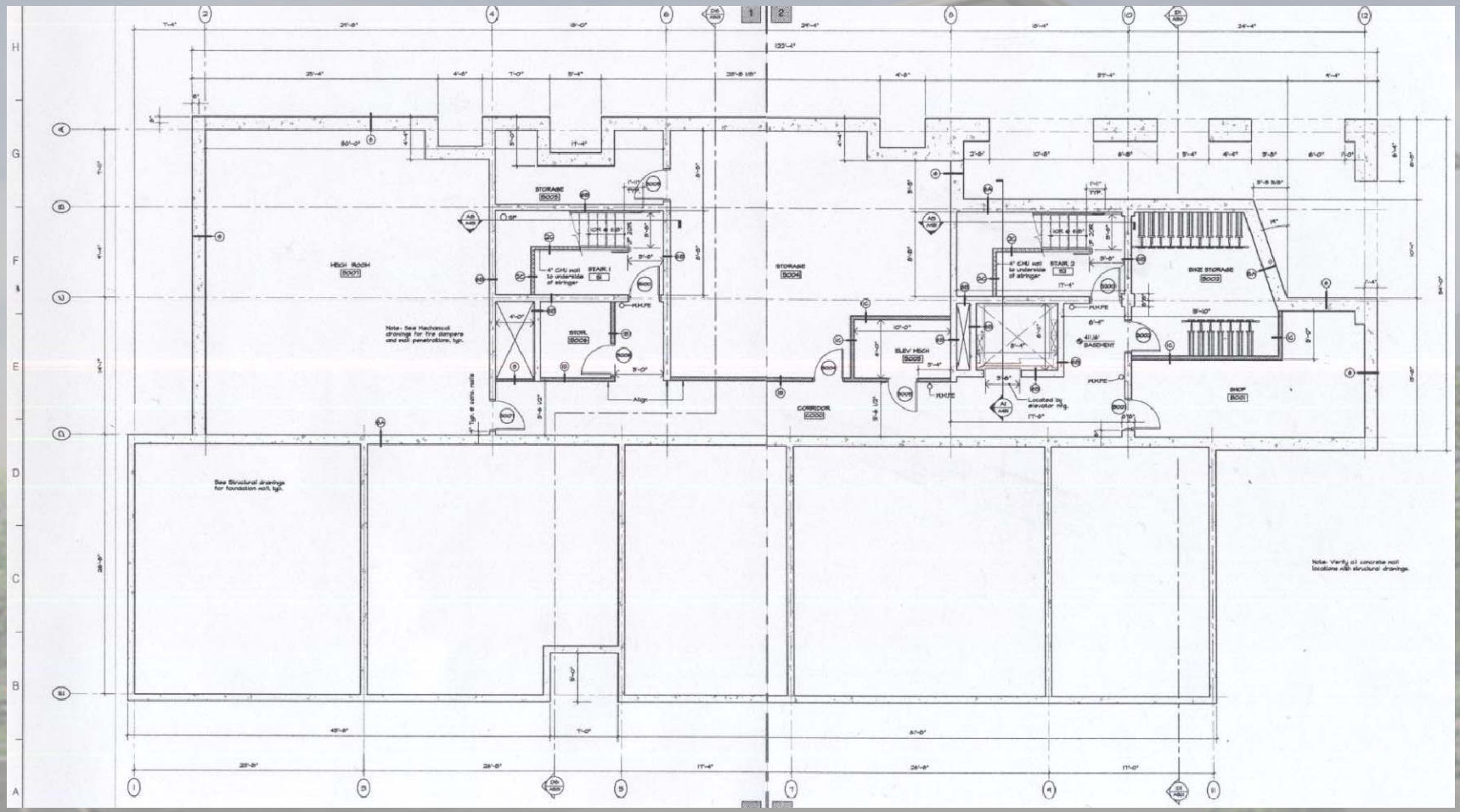
# INTRODUCTION


- Upscale, mixed use development
- 62’ - 6 stories
- 2 retail and 25 residential spaces.
- 43,000 square feet
- $7.4 million
- December 2005 – April 2007
- Façade of brick, EIFS, and metal panels

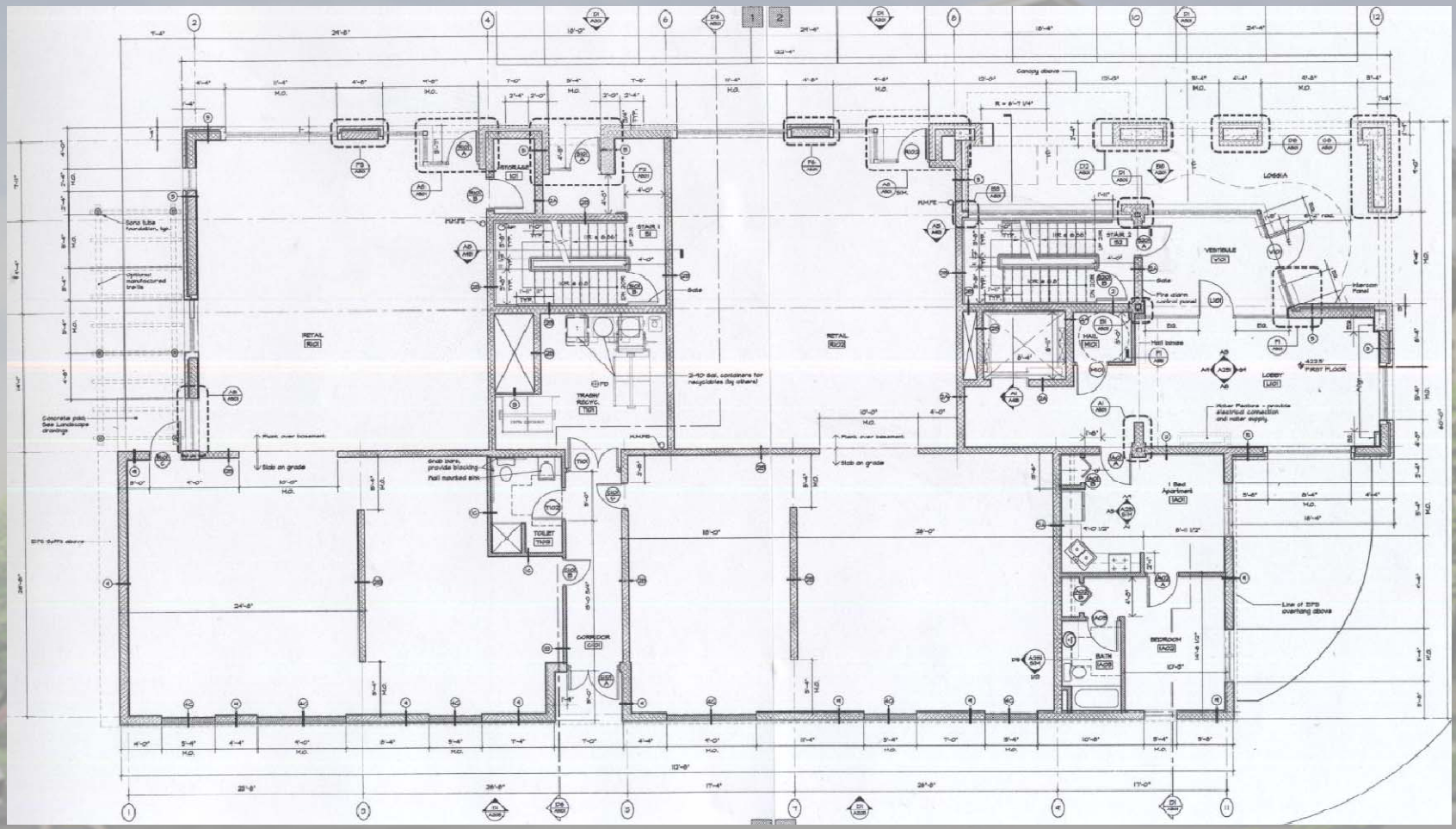
- 311 E. Green Street Ithaca, NY
- Located in between downtown area and nature area



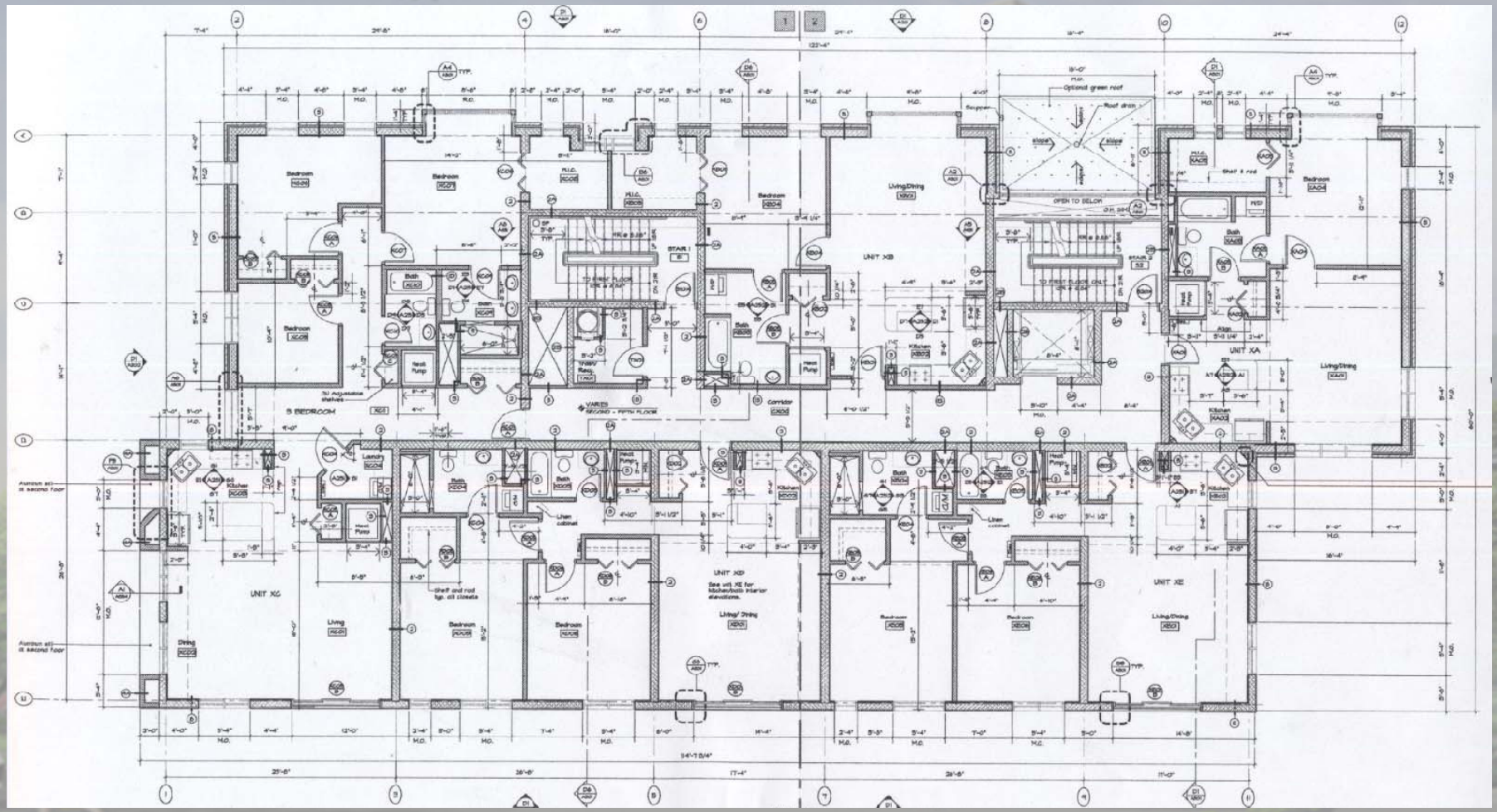
# INTRODUCTION - BASEMENT



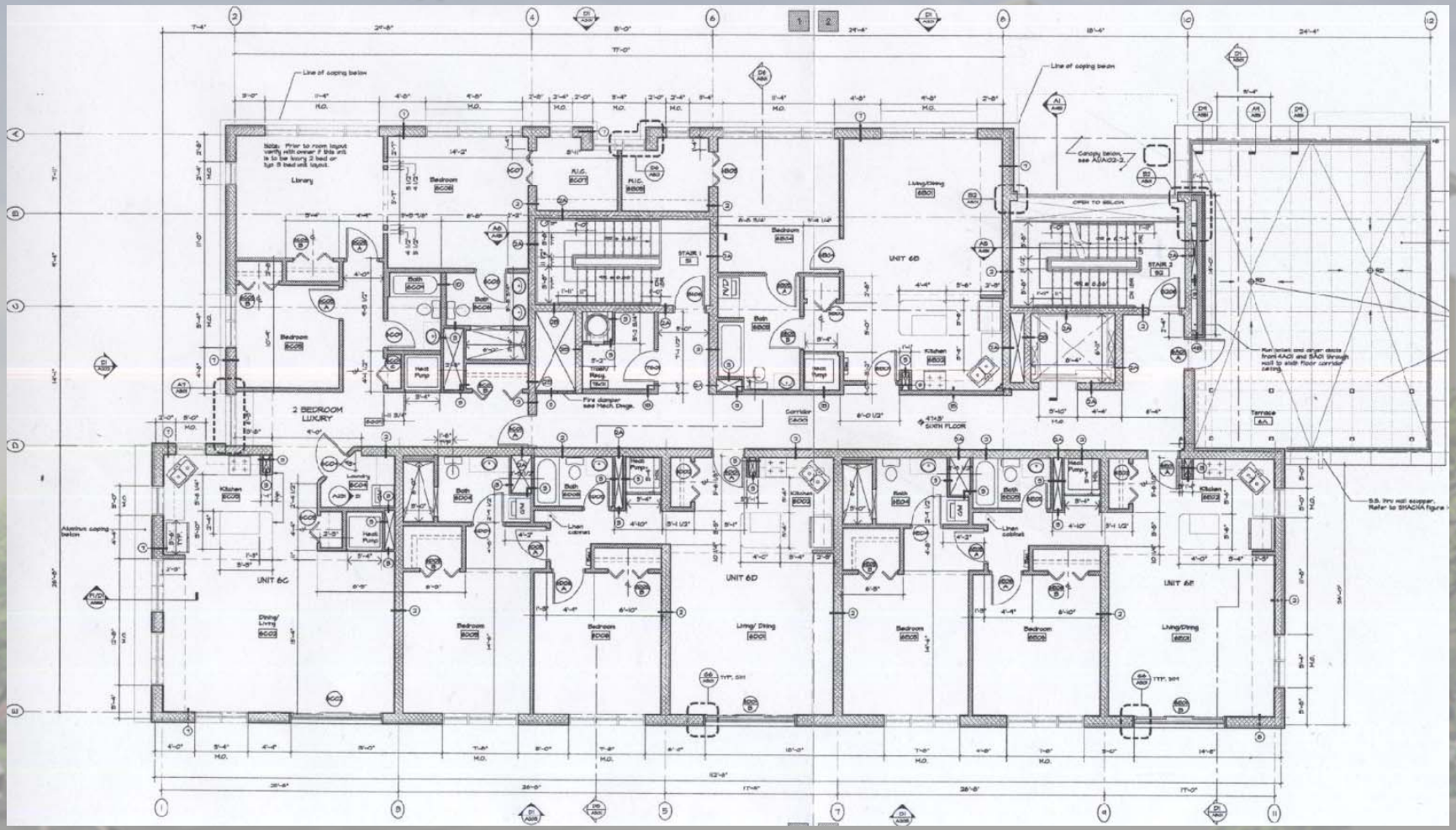
# INTRODUCTION – FIRST FLOOR



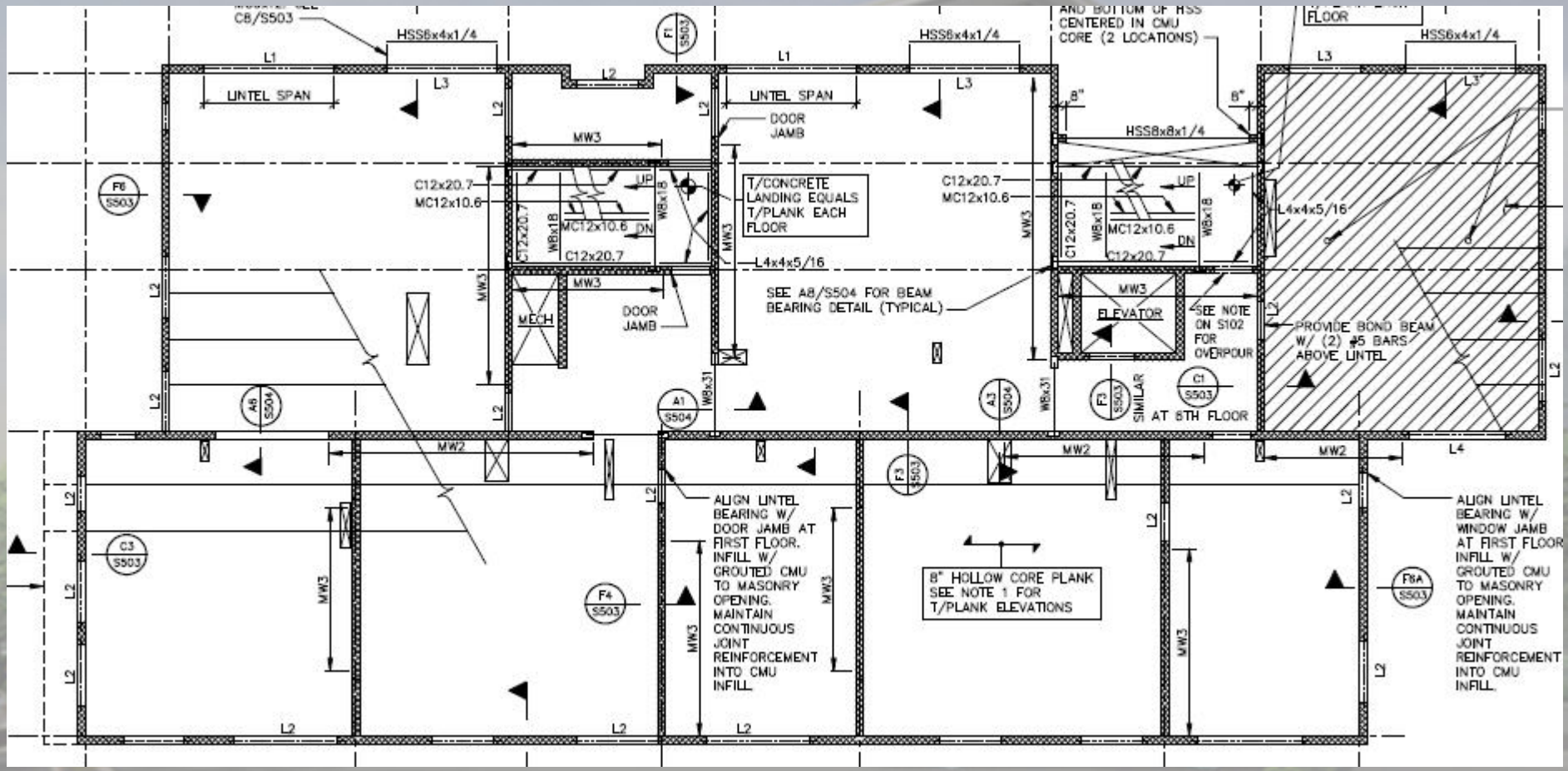
# INTRODUCTION – 2ND THROUGH 5TH FLOOR



# INTRODUCTION – 6TH FLOOR



# EXISTING STRUCTURE



# EXISTING STRUCTURE - WALLS

- 8" CMU walls
- Reinforced with #5 bars at 4' o.c. with standard joint reinforcing
- Fully grouted 1st - 2nd floors
- All wall types are gravity load bearing only MW2 and MW3 are part of lateral system

WALL ~~LINTEL~~ SCHEDULE

| MARK | VERTICAL REINFORCING | HORIZONTAL REINFORCING | REMARKS |
|---|---|---|---|
| MW1 | #5 AT 4'-0"OC | STANDARD JOINT REINFORCING AT 16"OC | GROUT WALL SOLID 1ST-2ND FLOORS<br>GROUT WALL AT 2'-0"OC 2ND-3RD FLOORS |
| MW2 | #5 AT 4'-0"OC (TYPICAL)<br>(6)#5 EACH END (1ST-2ND)<br>(4)#5 EACH END (2ND-4TH)<br>(2)#5 EACH END (4TH-ROOF) | STANDARD JOINT REINFORCING 1ST-2ND AND 6TH-ROOF,<br>HEAVY DUTY JOINT REINFORCING AT 8"OC 2ND-6TH | GROUT WALL SOLID 1ST-2ND FLOORS |
| MW3 | #5 AT 4'-0"OC (TYPICAL)<br>(2)#5 EACH END | STANDARD JOINT REINFORCING 1ST-2ND AND 6TH-ROOF,<br>HEAVY DUTY JOINT REINFORCING AT 8"OC 2ND-6TH | GROUT WALL SOLID 1ST-2ND FLOOR |

NOTES:
1. UNLESS NOTED OTHERWISE ON PLAN, ALL WALLS ARE TYPE MW1.
2. MINIMUM REINFORCING REQUIREMENTS SHOWN ON A3/S506 APPLY TO ALL WALLS.
3. SEE F6/S506 FOR PLACEMENT OF VERTICAL BARS AT ENDS OF WALLS.

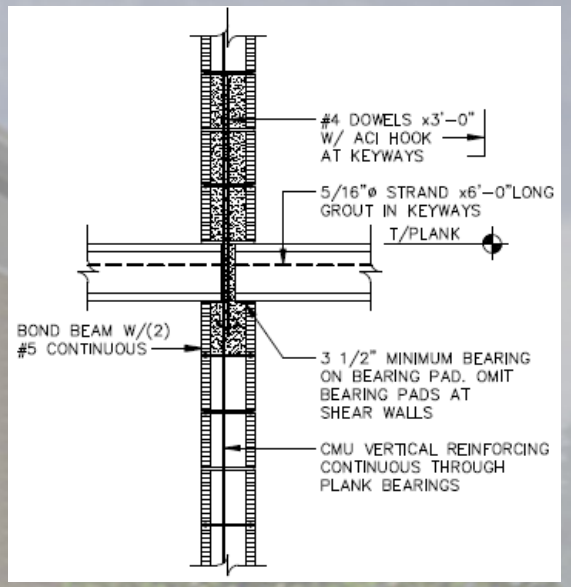
# EXISTING STRUCTURE - FLOORS

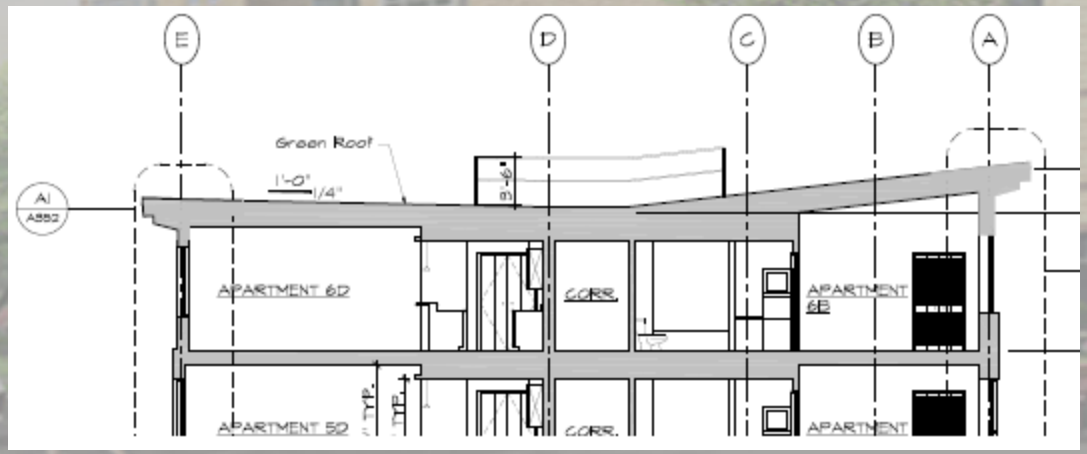
**Precast concrete hollow core plank**

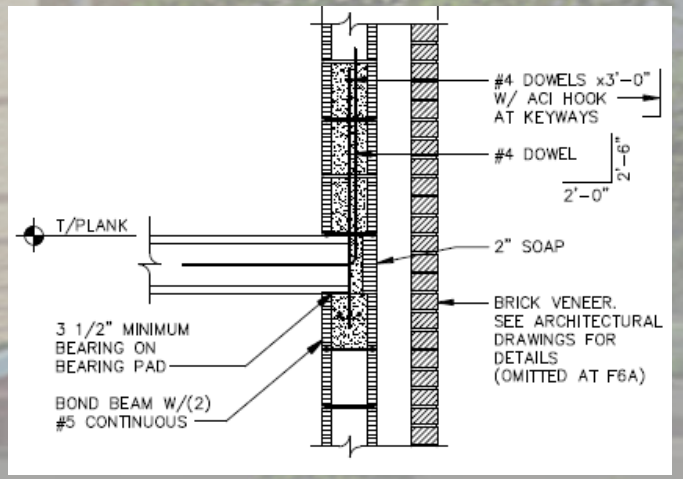
- First floor 10″ thick, 2″ topped planks
- 2nd – 6th floor 8″ thick, un-topped planks

**Slab on Grade**

- 5″ thick SOG, f′c = 3,500 psi
- #4 @ 16″ o.c. both ways

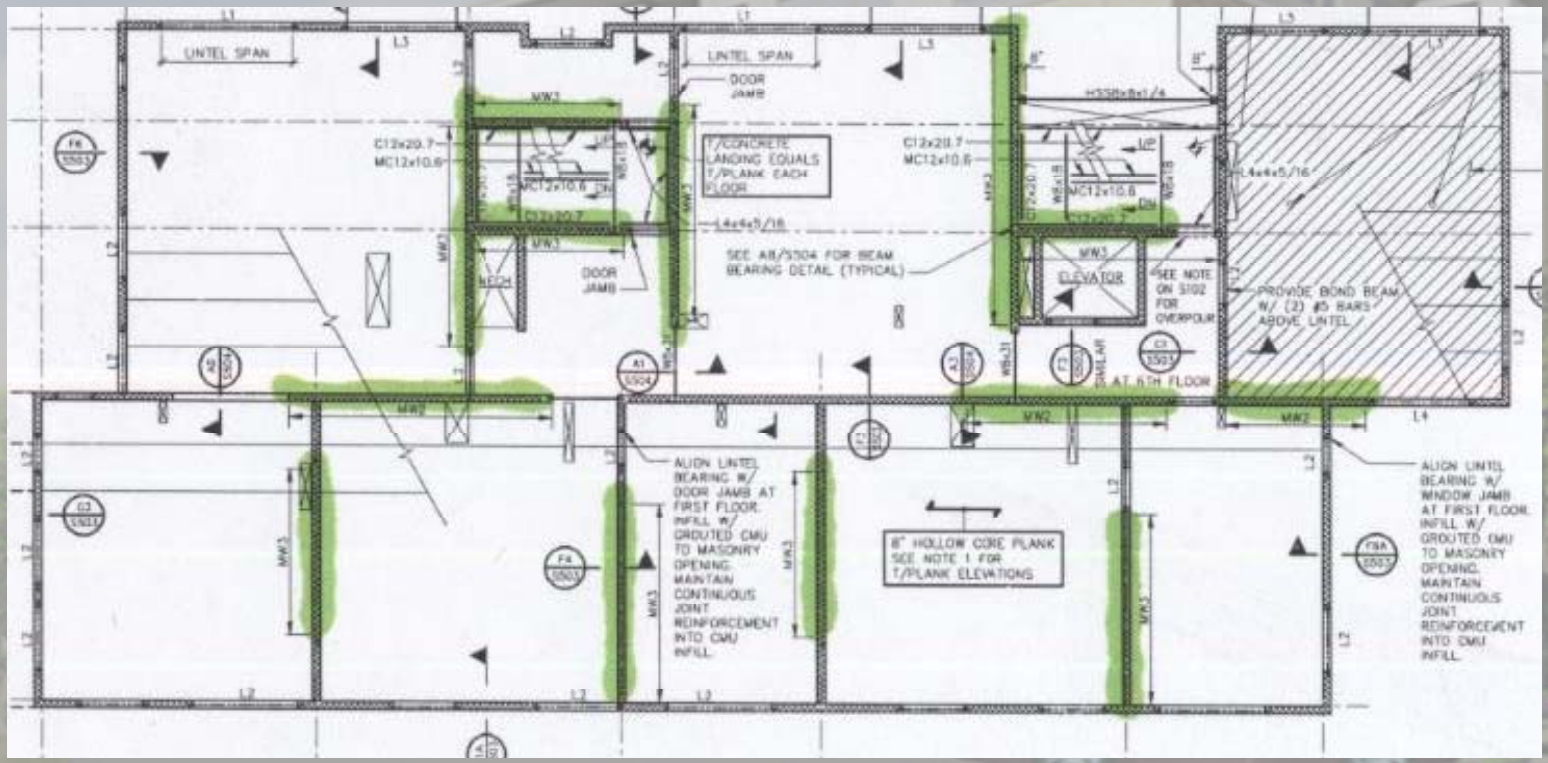


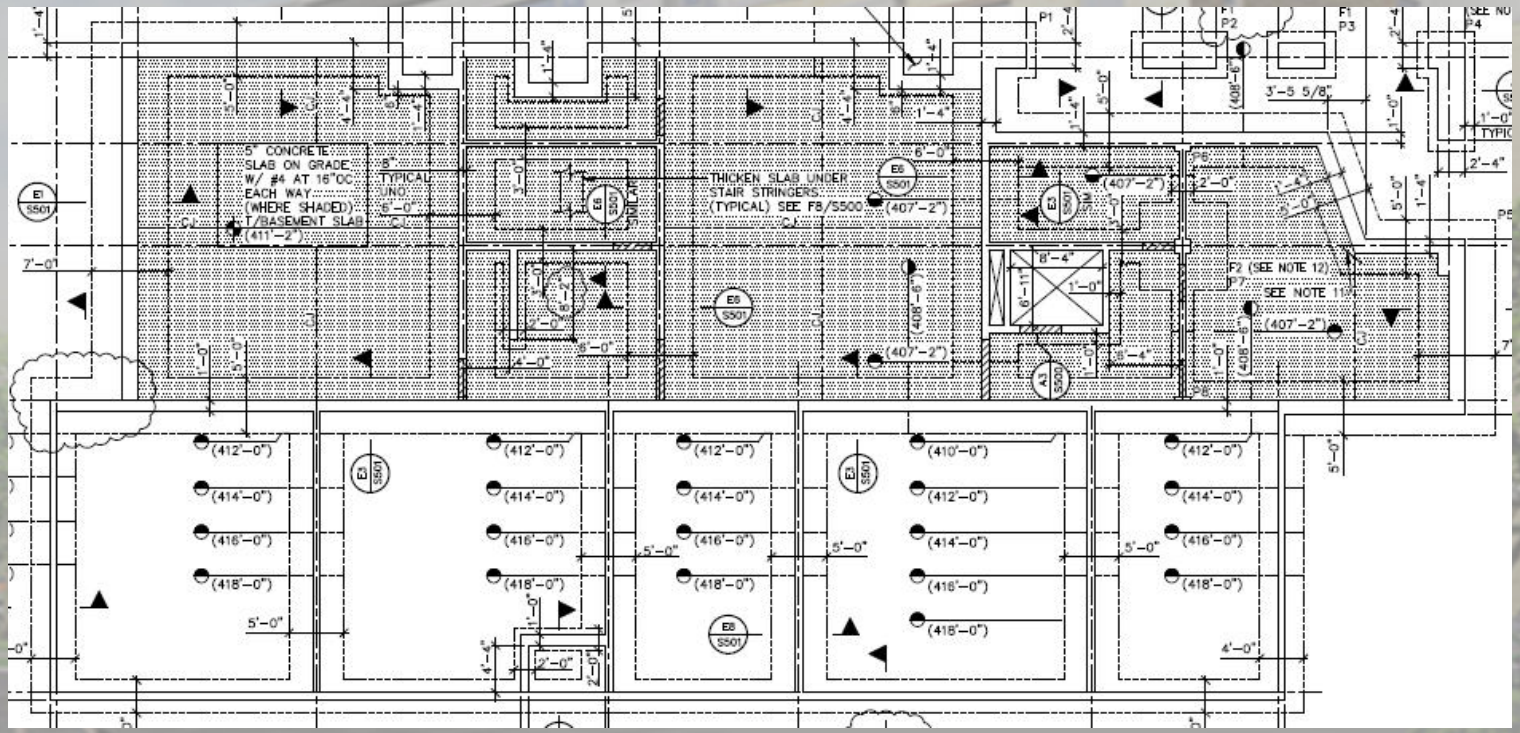
# EXISTING STRUCTURE – LATERAL SYSTEM

- 13 intermediate reinforced masonry shear walls
- 8″ CMU reinforced like MW1 except includes boundary elements



# EXISTING STRUCTURE - FOUNDATIONS

- Walls supported by strip footing, f'c = 3000 psi
- 1'-4" thick concrete retaining walls, f'c = 4000 psi
- Soil with allowable bearing capacity of 5,000 psf



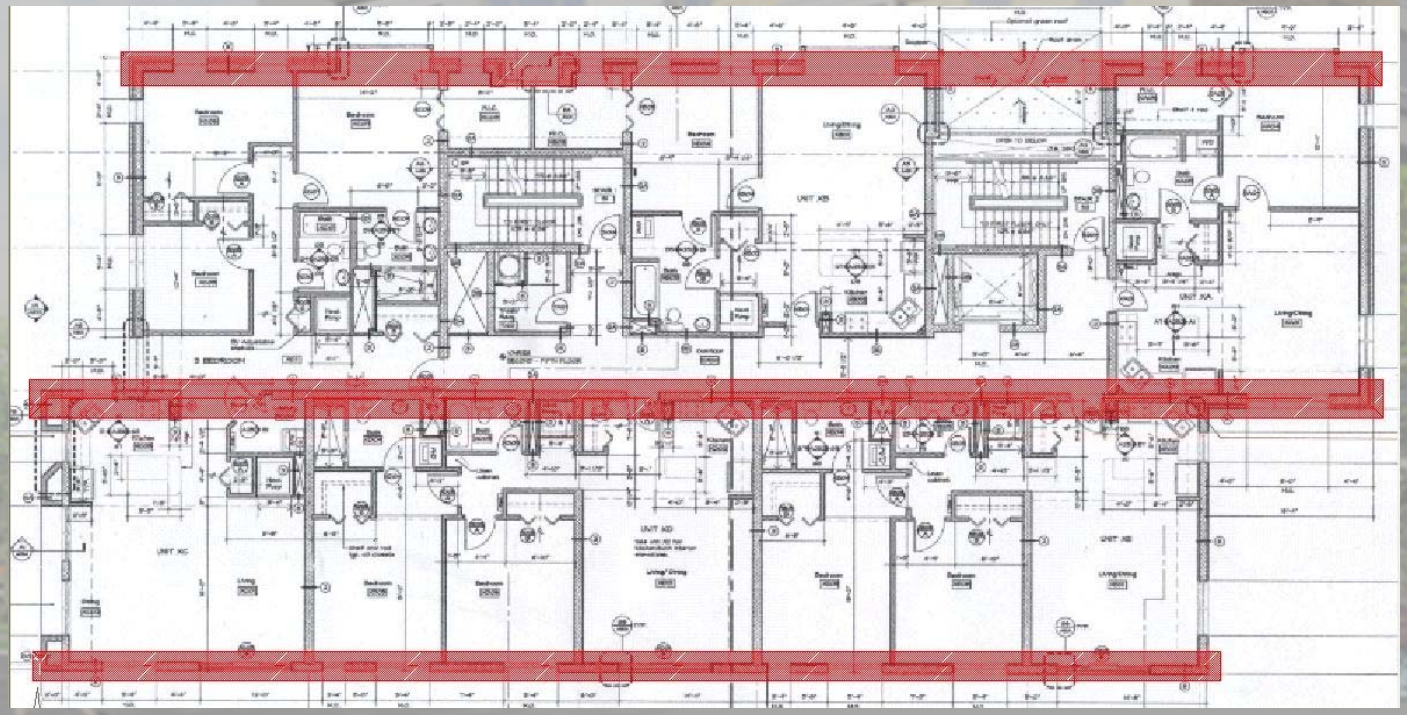
# PROBLEM STATEMENT

- The existing structure is the best choice for the building's use
- Tech 2 showed existing system to be cheapest compared to steel and concrete structures
- Custom structure

- If a change in the architecture of the building was to be considered the large amount of load bearing walls would make an effective redesign of the architecture almost impossible.

# PROPOSED SOLUTION

- A structural system that used columns would allow for a more open structure
- A two way concrete system was first proposed but it was too difficult to determine a feasible column layout
- A one way concrete structure was determined to be the best structure



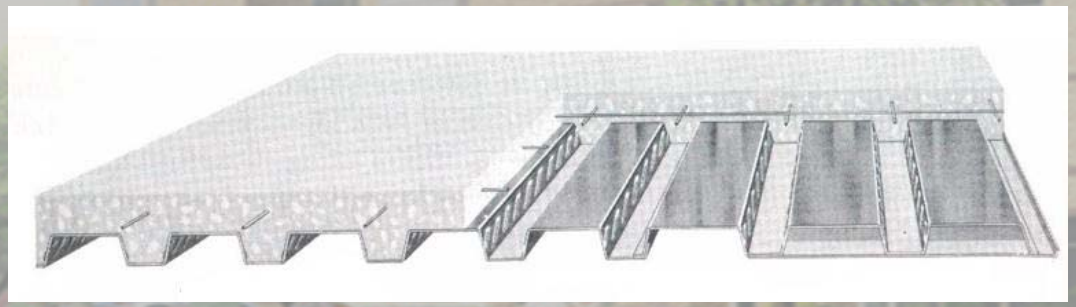
# PROPOSED SOLUTION

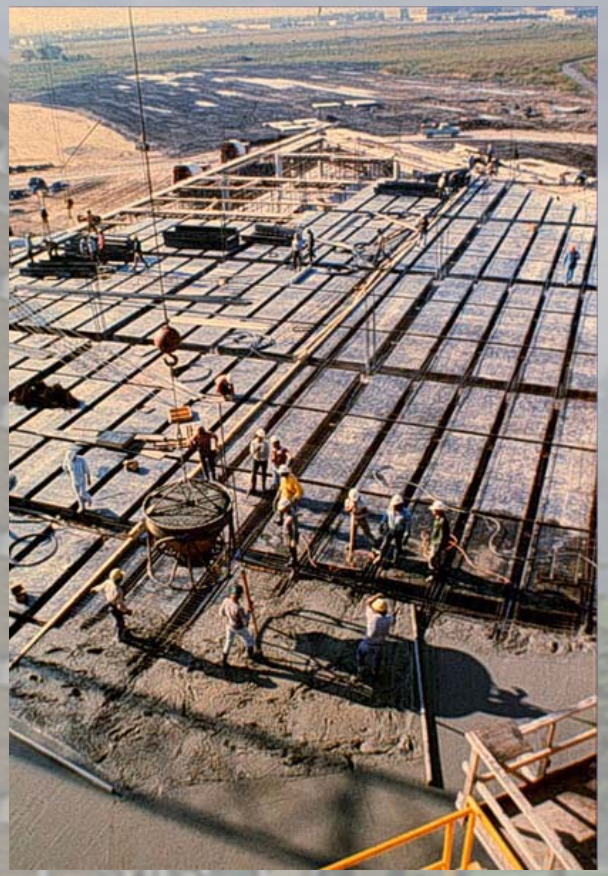
**Goals**

- To gain a better understanding of concrete structures and the engineering design process
- To create a complete and economical structural redesign of Gateway Commons
- To compare the new structure to the old one
- To architecturally design the new structure for an office building to show that the new structure allows for versatility in architectural redesign
- To determine the cost and schedule of the new structure and determine if the redesign is economically feasible

# STRUCTURAL REDESIGN - SLAB

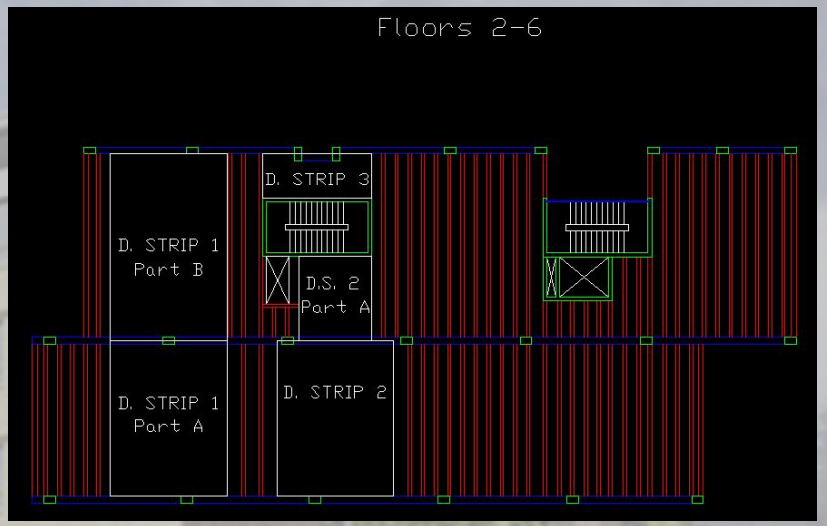
- SOG on first floor and basement are the same as in original design
- Pan joist slab is good for long spans with relatively light loads
- Live load increases from 40 psf to 80 psf to allow for office redesign
- f′c = 5000 psi
- 4.5″ top slab to provide 2 hour fire rating

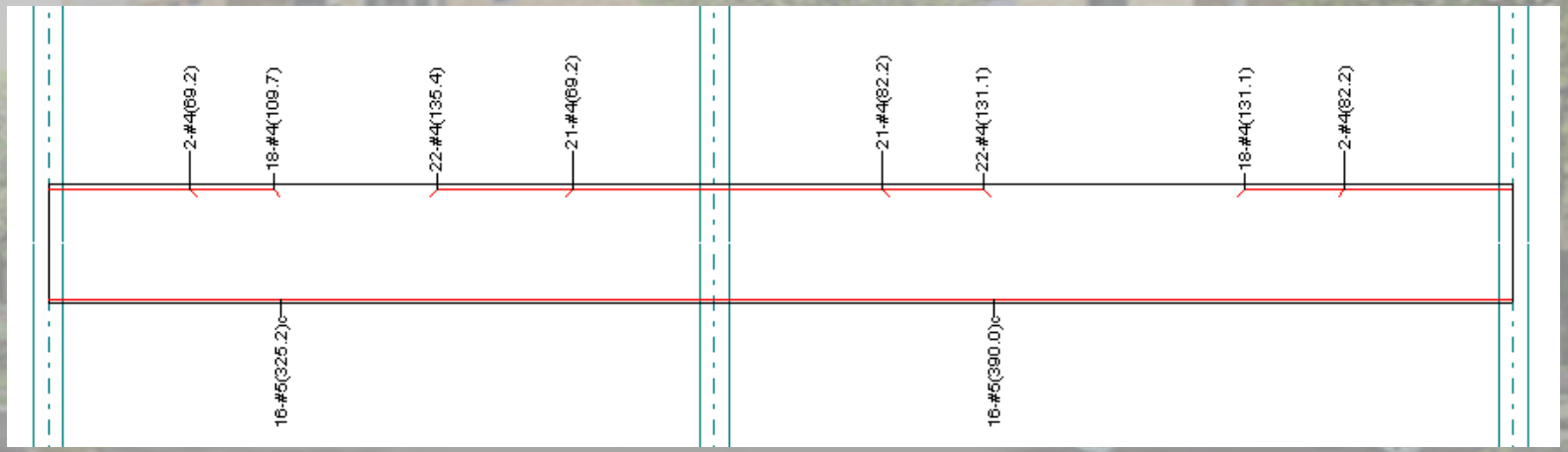




# STRUCTURAL REDESIGN - SLAB

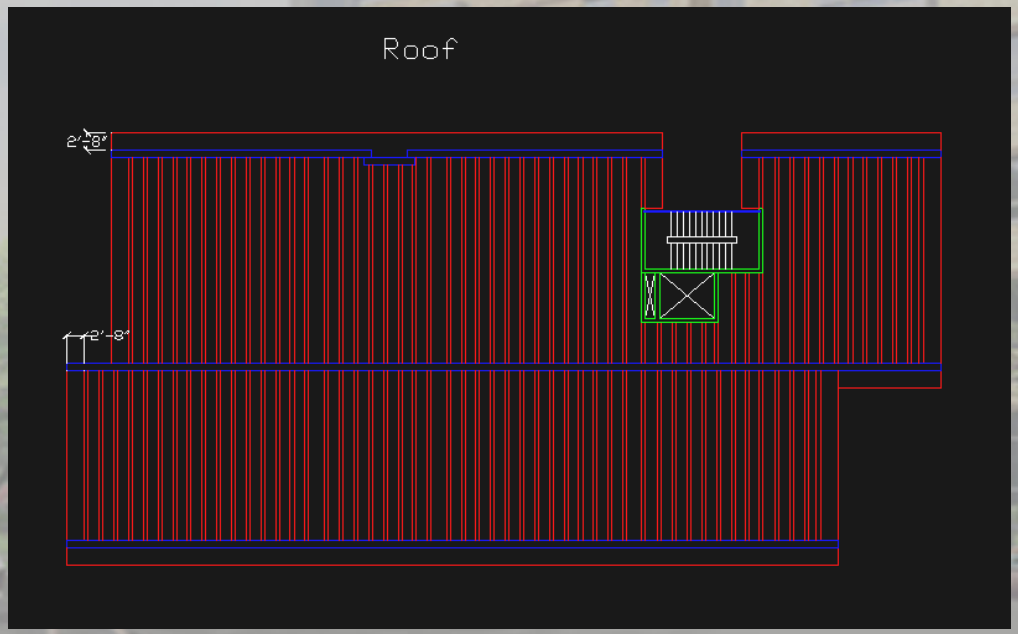
- Representative design strips of the slab were designed for in PCA slab
- Bar size, spacing and cut off point used in slab design
- 7″x 10″ ribs spaced at 20″ were determined to withstand the slab shear capacity and deflections
- #4 for top slab and between #4 - #6 for ribs



# STRUCTURAL REDESIGN - SLAB

- The roof will use the same slab dimensions as the floors and the roof will continue over 6th floor terrace
- 4″ thick roof overhangs either cantilevered from beam or was designed as a slab between cantilevered beams



# STRUCTURAL REDESIGN - GIRDERS

- Girders designed as continuous beams
- Width of girders restricted by mechanical openings and hallways
- Depth controlled by deflection:

  Top & Bottom = 14″x 16″  Middle = 14″x 18″
- f′c = 5000 psi

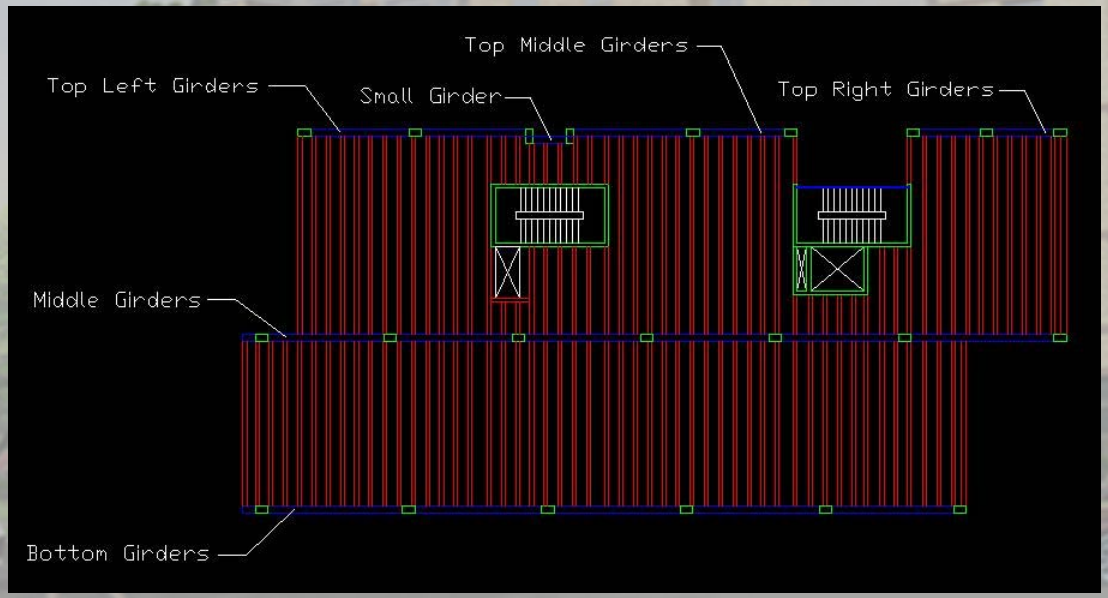
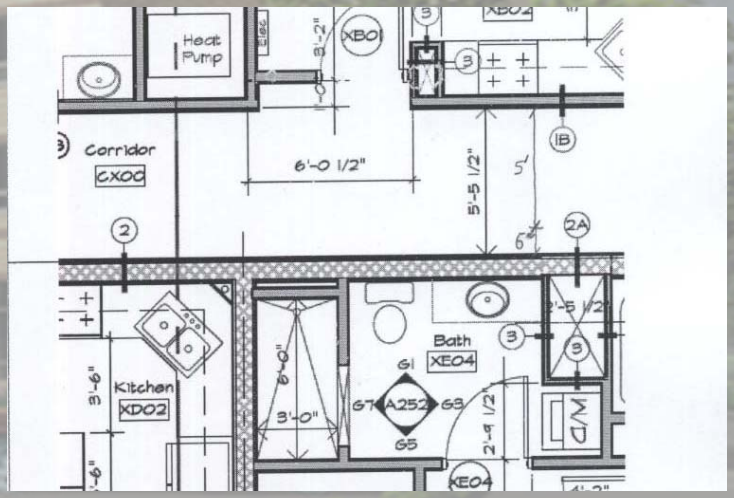



**TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED**

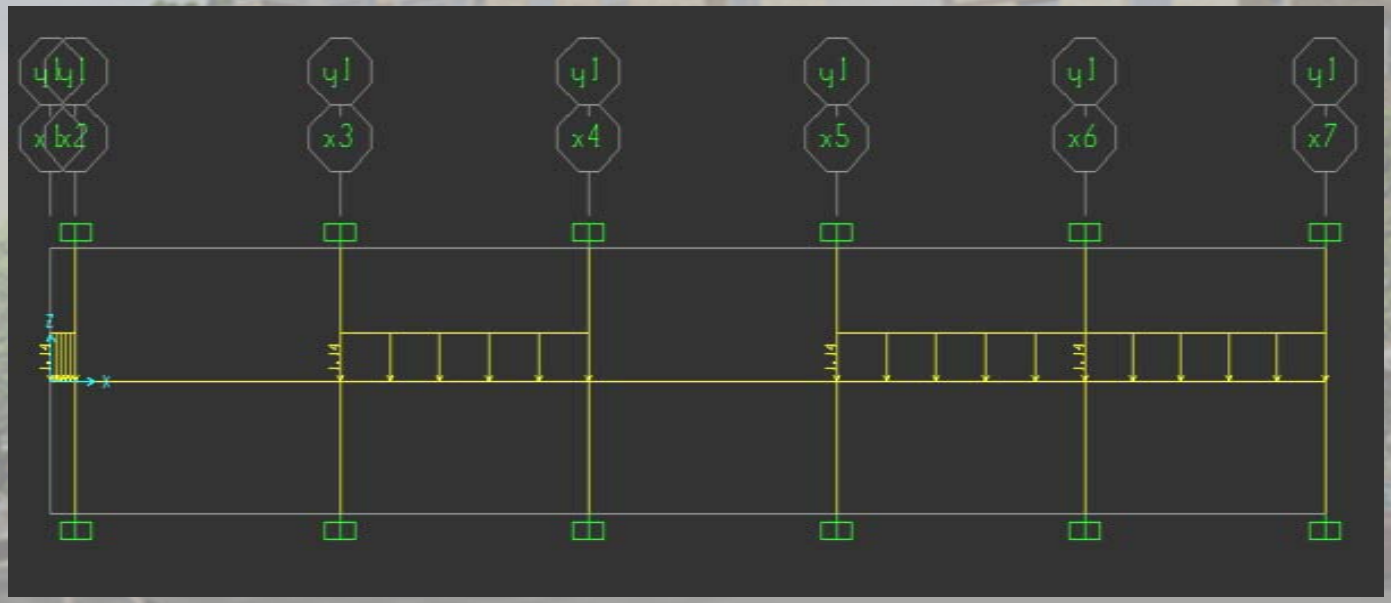
| | Minimum thickness, $h$ | | | |
|---|---|---|---|---|
| | Simply supported | One end continuous | Both ends continuous | Cantilever |
| Member | Members not supporting or attached to partitions or other construction likely to be damaged by large deflections. | | | |
| Solid one-way slabs | $\ell/20$ | $\ell/24$ | $\ell/28$ | $\ell/10$ |
| Beams or ribbed one-way slabs | $\ell/16$ | $\ell/18.5$ | $\ell/21$ | $\ell/8$ |

Notes:
Values given shall be used directly for members with normalweight concrete ($w_c$ = 145 lb/ft$^3$) and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
a) For structural lightweight concrete having unit weight, $w_c$, in the range 90-120 lb/ft$^3$, the values shall be multiplied by $(1.65 - 0.005w_c)$ but not less than 1.09.
b) For $f_y$ other than 60,000 psi, the values shall be multiplied by $(0.4 + f_y/100{,}000)$.



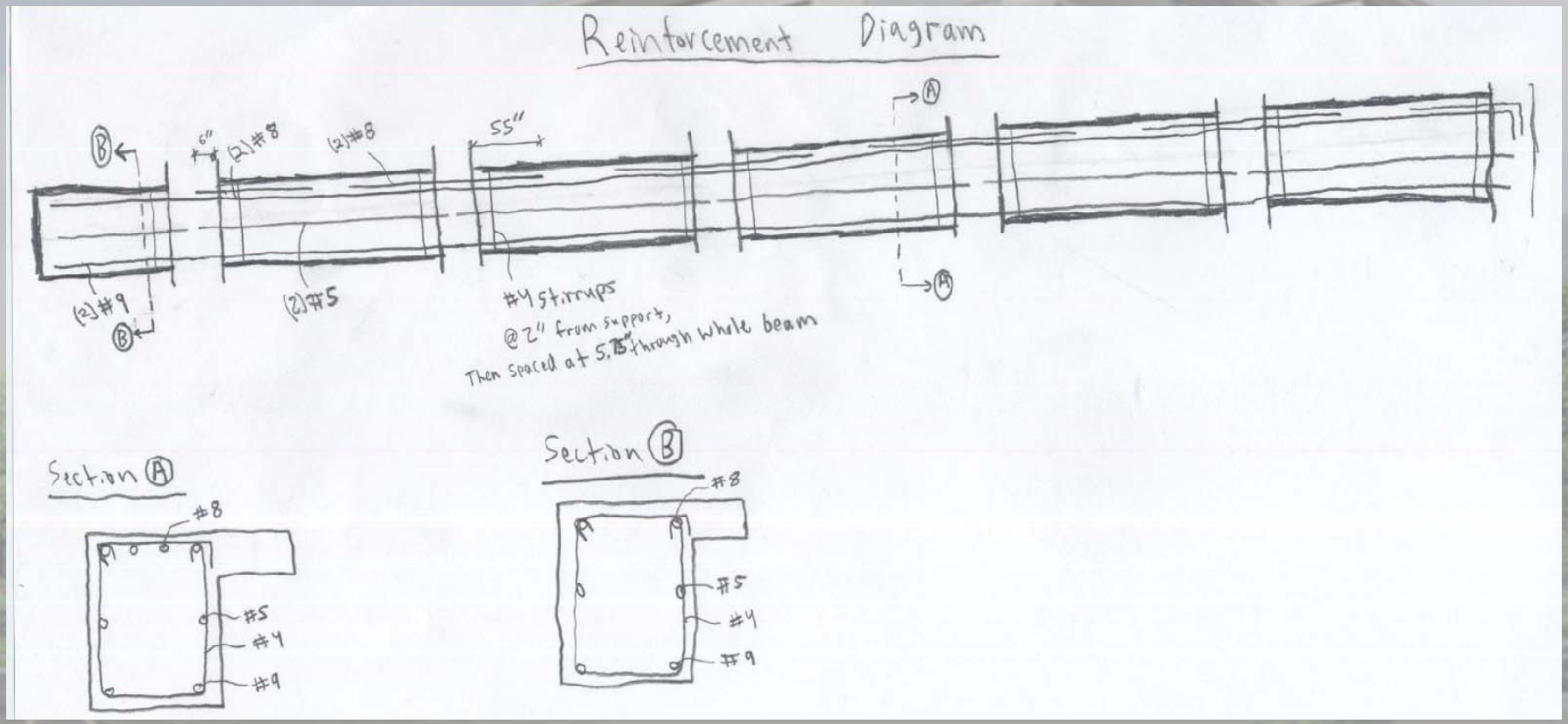
# STRUCTURAL REDESIGN - GIRDERS

- Continuous beams were modeled in SAP
- Design moments for flexure determined by use of pattern loading
- Continuity of slab puts compatibility torsion on the beams
- Moment coefficients were used to determine the net moment the slab puts on the girders



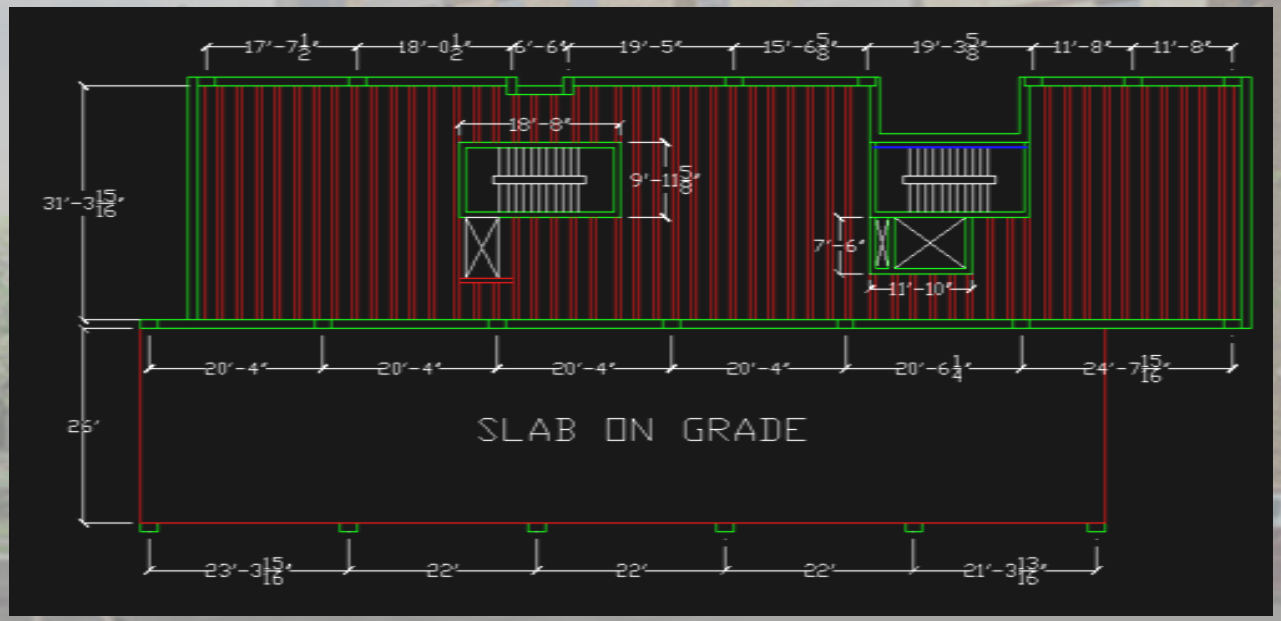
# STRUCTURAL REDESIGN - GIRDERS

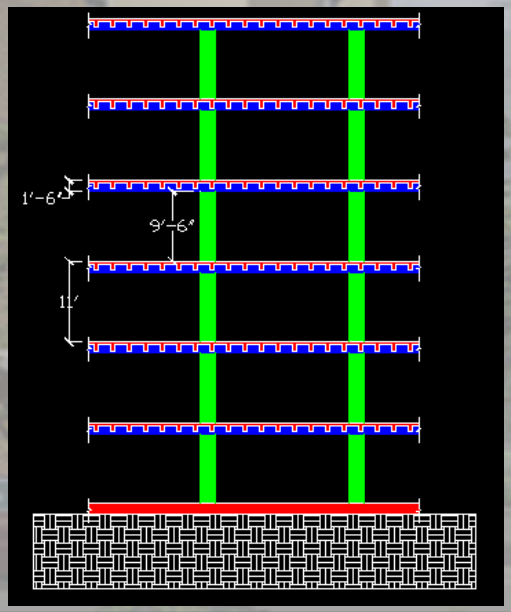
- Flexure and shear/torsion reinforcement was calculated by hand



# STRUCTURAL REDESIGN - COLUMNS

- Floor to floor height is 11′
- Column height will be 9′-6″ for 16″ deep girders and 9′-8″ for 18″ deep girders
- Column dimensions are 14″x 24″,  f′c = 5000 psi
- SAP model used to determine axial and moment on each column
- Applied to PCA column as factored loads
- Majority of columns use (4) #9.  Largest amount of reinforcement is (6) #10



# STRUCTURAL REDESIGN – LATERAL SYSTEM

**WIND**

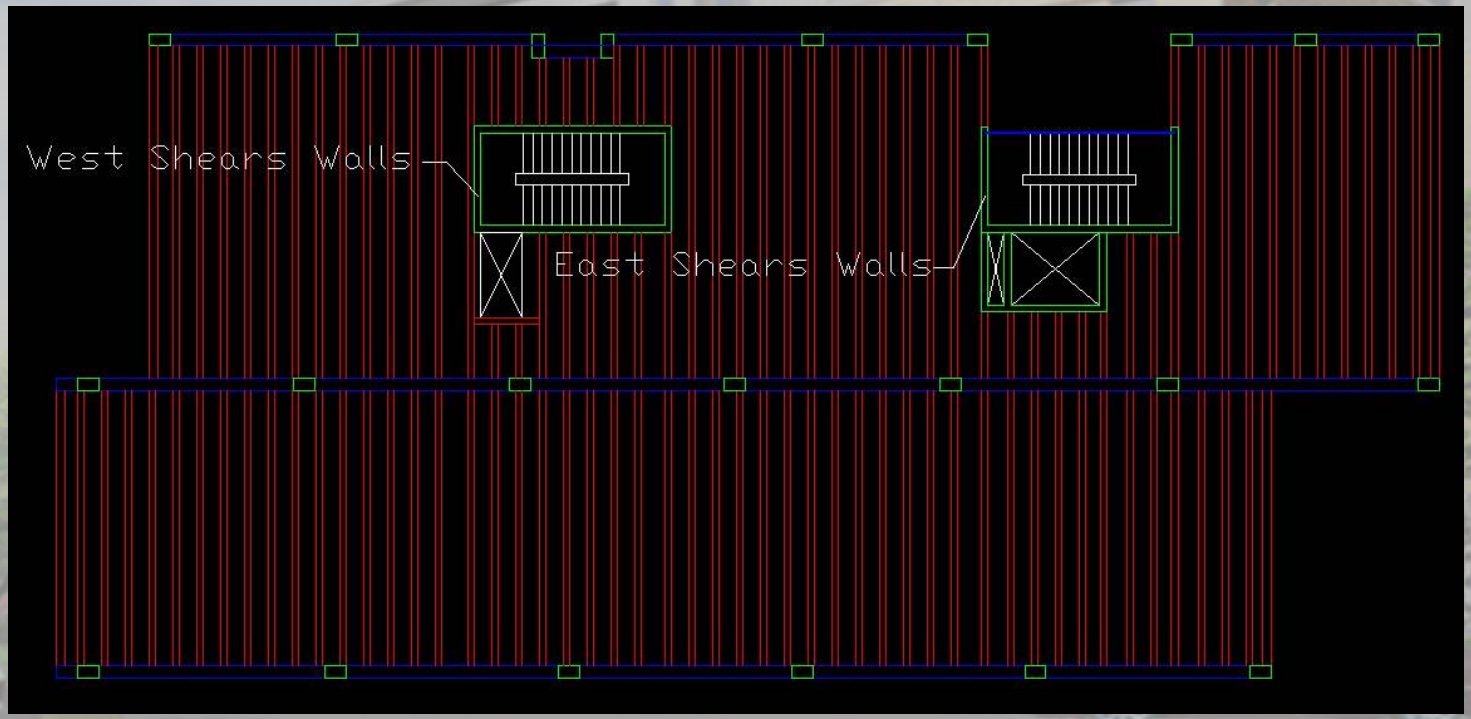
- Basic Wind Speed 90 mph
- Exposure category B
- Base shear N-S = 165.2 kips  Base shear E-W = 86.7 kips

**SEISMIC**

- Site class D
- Seismic Design Category B
- R = 5
- Base Shear = 120 kips

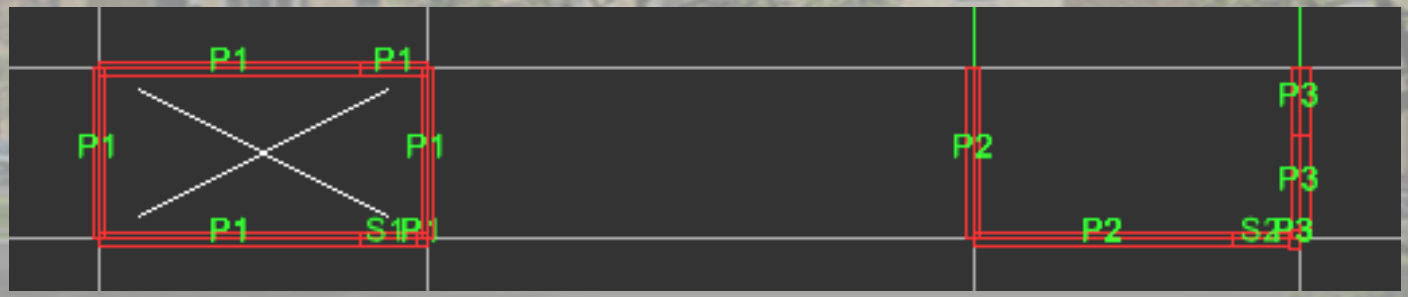
# STRUCTURAL REDESIGN – LATERAL SYSTEM

- Shear walls are located around the stair towers
- 8″ thick ordinary reinforced concrete shear walls
- f′c = 5000 psi



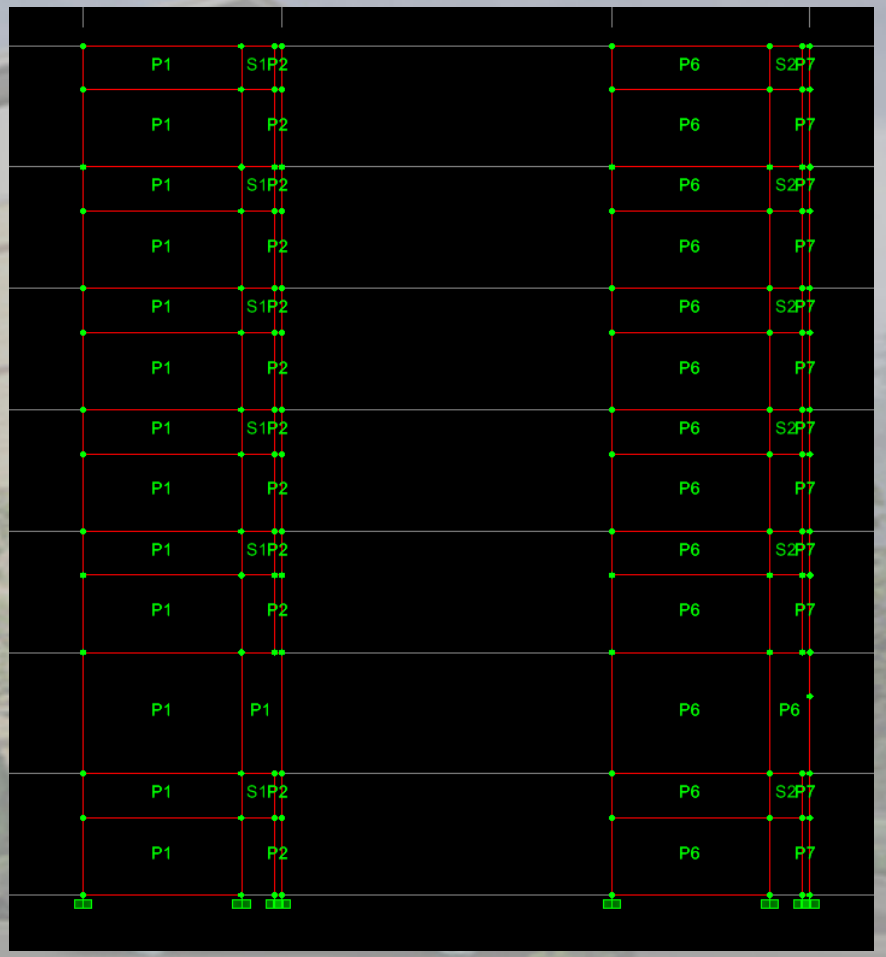
# STRUCTURAL REDESIGN – LATERAL SYSTEM

- Shear and flexure ETABS models were created
- In the shear model, each wall is assigned its own pier label
- In the flexure model, walls that connect are assigned the same pier label

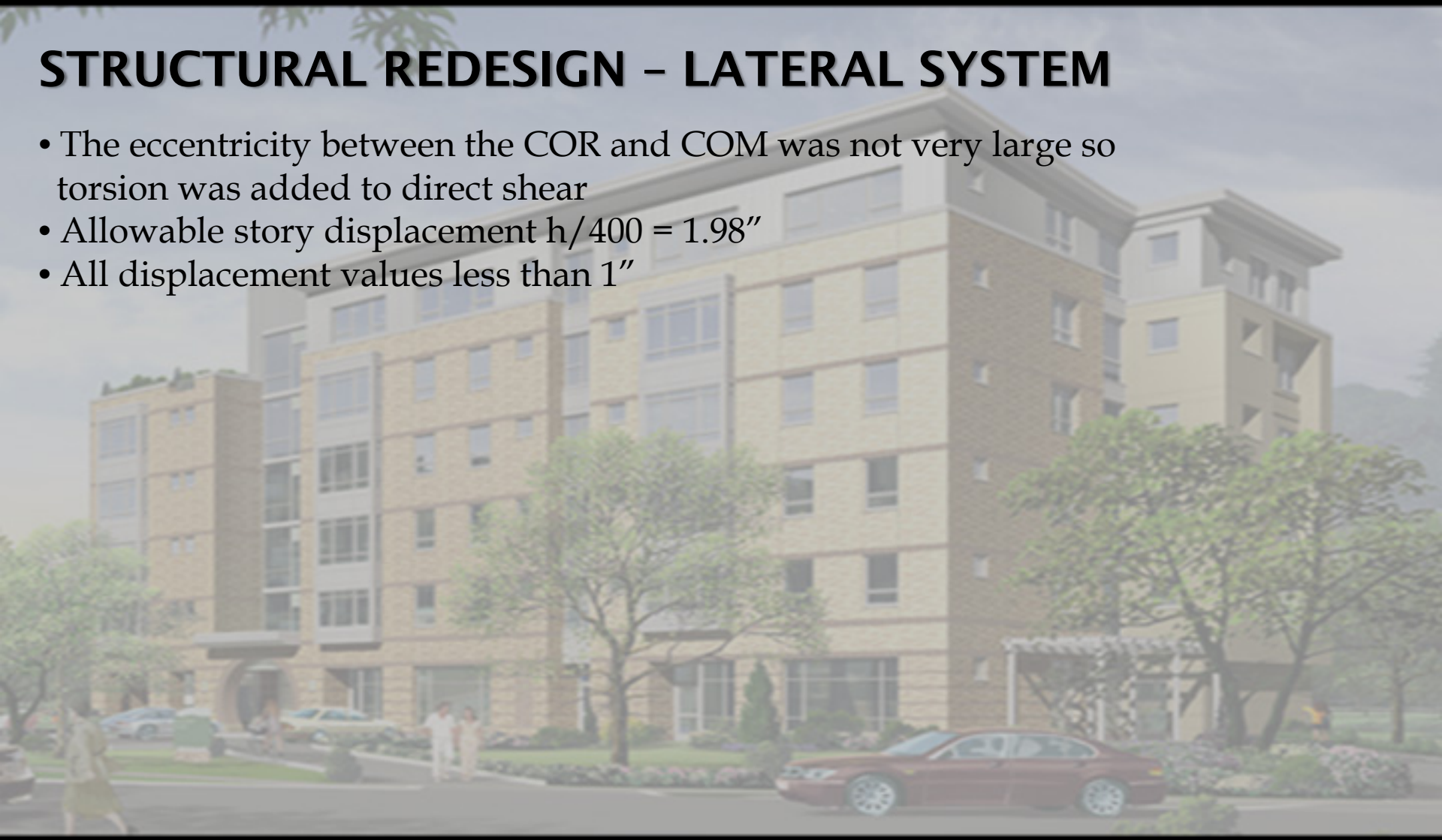
# STRUCTURAL REDESIGN – LATERAL SYSTEM

- Shear forces on each wall were factored and used to design for shear reinforcing
- Moment and axial loads were used to design for flexure reinforcement.
- In PCA column flexure forces were input as service loads and load combinations were created
- Large part of wall design carried into small section over door opening and (2) #5 around opening per ACI 22.6.6.5
- Horizontal shear reinforcing is #4 @ 18”
- Vertical reinforcing controlled by flexure and is mostly #4 @ 18”
- Pier 3 in flexure model designed as an isolated wall and required an increase in reinforcement



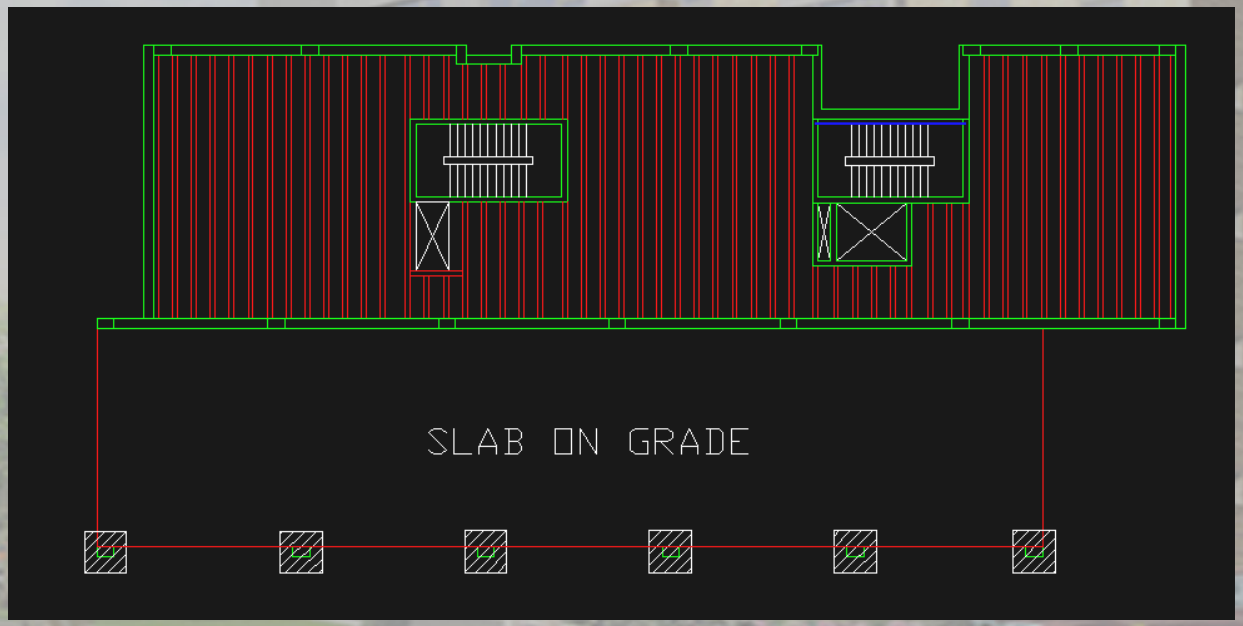
# STRUCTURAL REDESIGN – LATERAL SYSTEM

- The eccentricity between the COR and COM was not very large so torsion was added to direct shear
- Allowable story displacement h/400 = 1.98”
- All displacement values less than 1”



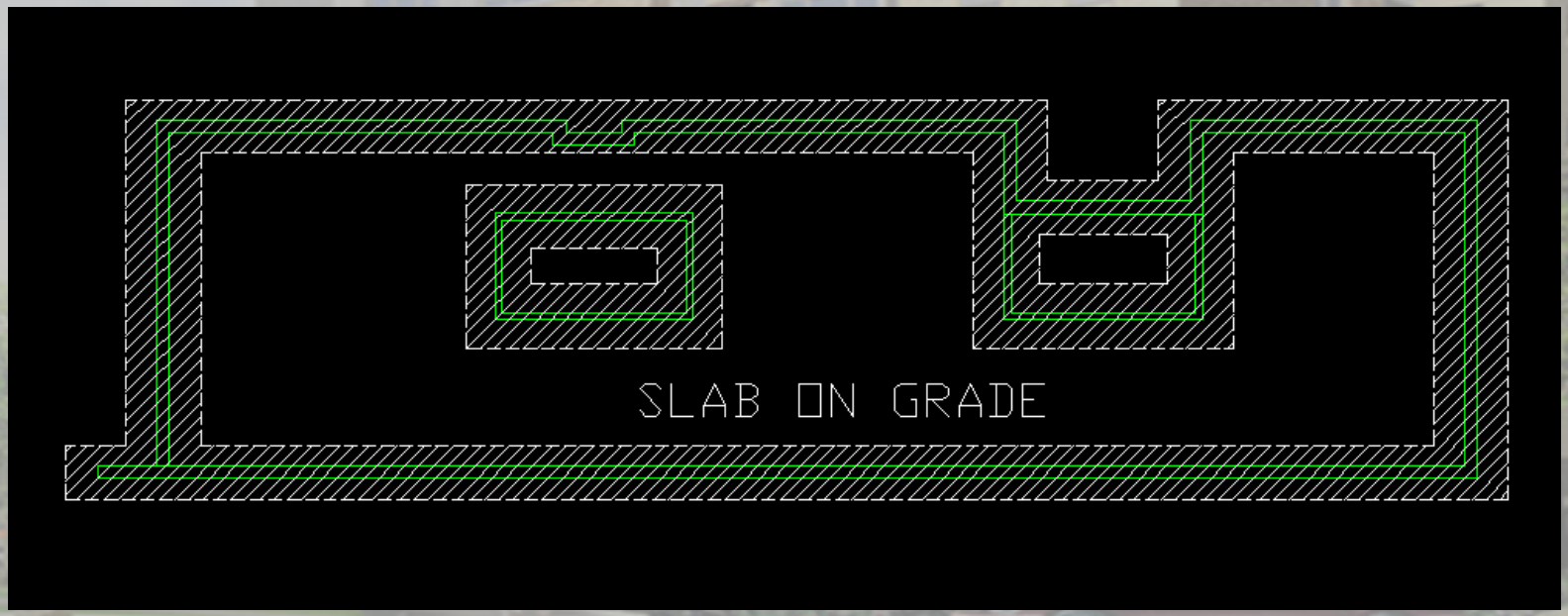
# STRUCTURAL REDESIGN - FOUNDATIONS

- 9'x 9'x 3' spread footings for the columns
- Retaining walls will use the same dimensions and reinforcing
- Columns are integrated with retaining walls
- Slab on first floor is supported by retaining walls



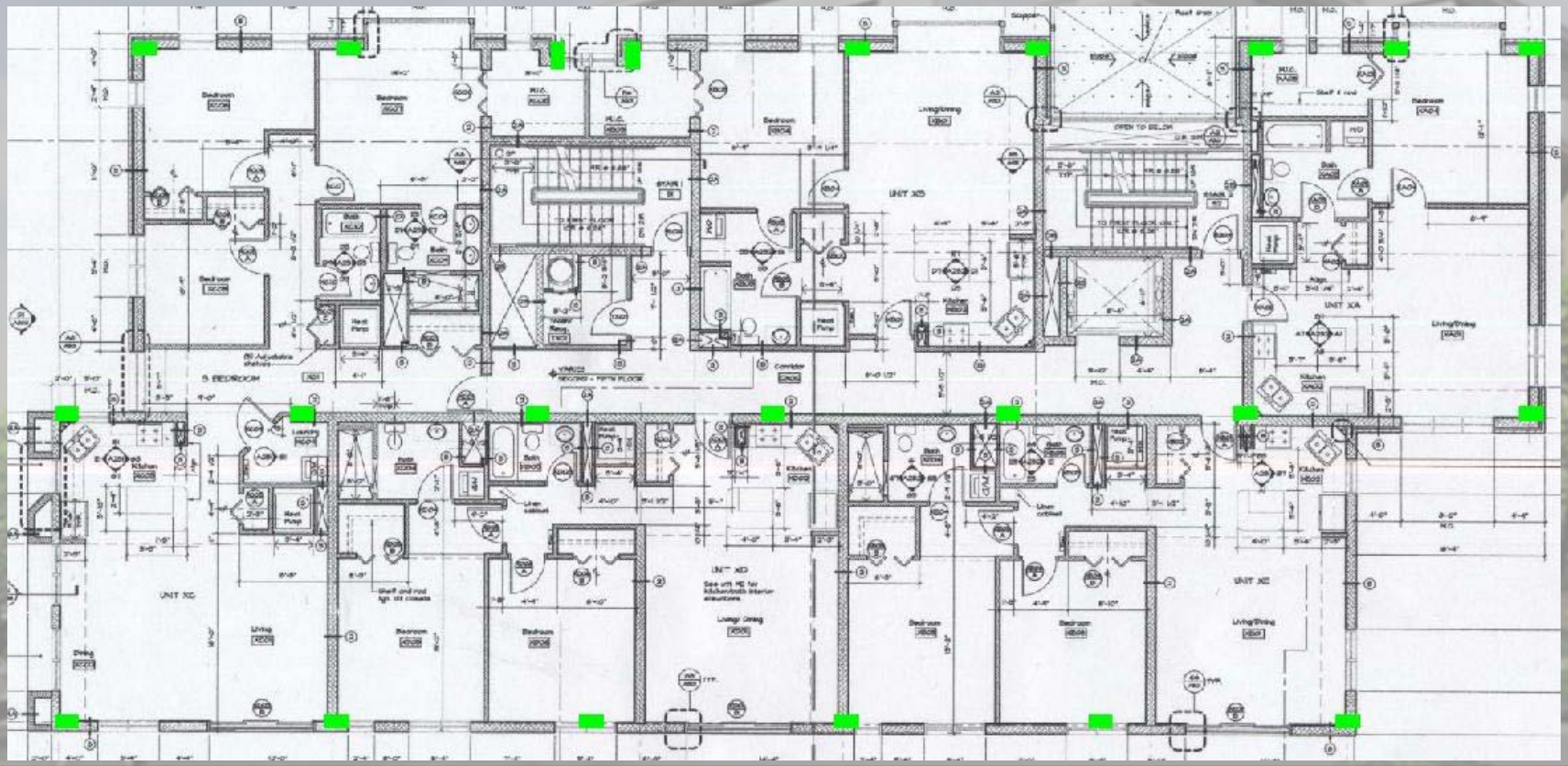
# STRUCTURAL REDESIGN - FOUNDATIONS

- Strip footings will be used for the shear walls and the retaining walls
- Footings will have an f'c = 3000 psi
- Retaining walls will have an f'c = 4000 psi



# ARCHITECTURE BREADTH

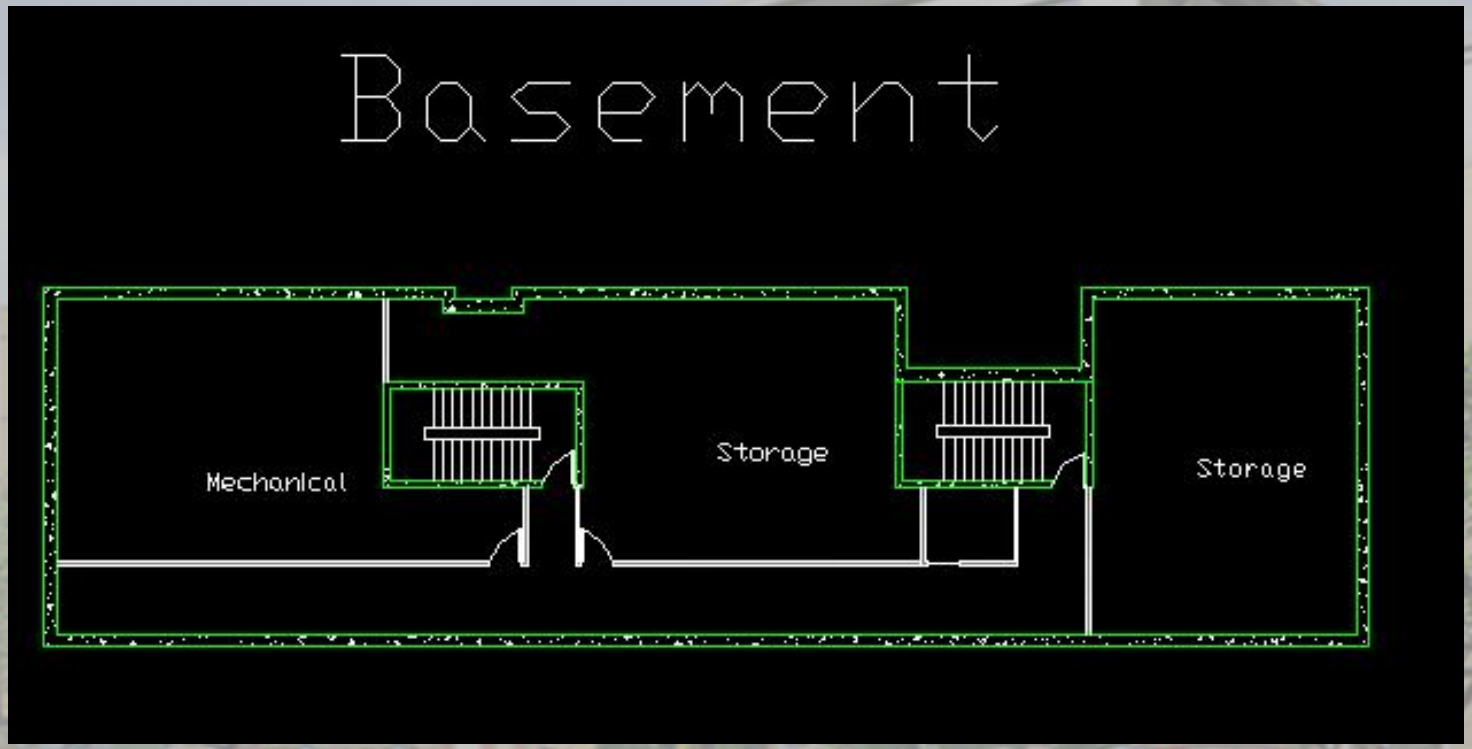
- Where columns are placed on windows the windows can be moved and the architecture will still work.



# ARCHITECTURE BREADTH

- A roof will be placed over the 6th floor roof terrace in the redesign of the structure
- This will be done to allow for this area to have more versatility in a redesign of the architecture
- The area that was the 6th floor terrace will be able to be redesigned as a community gathering place that is open to the outdoors.

# ARCHITECTURE BREADTH



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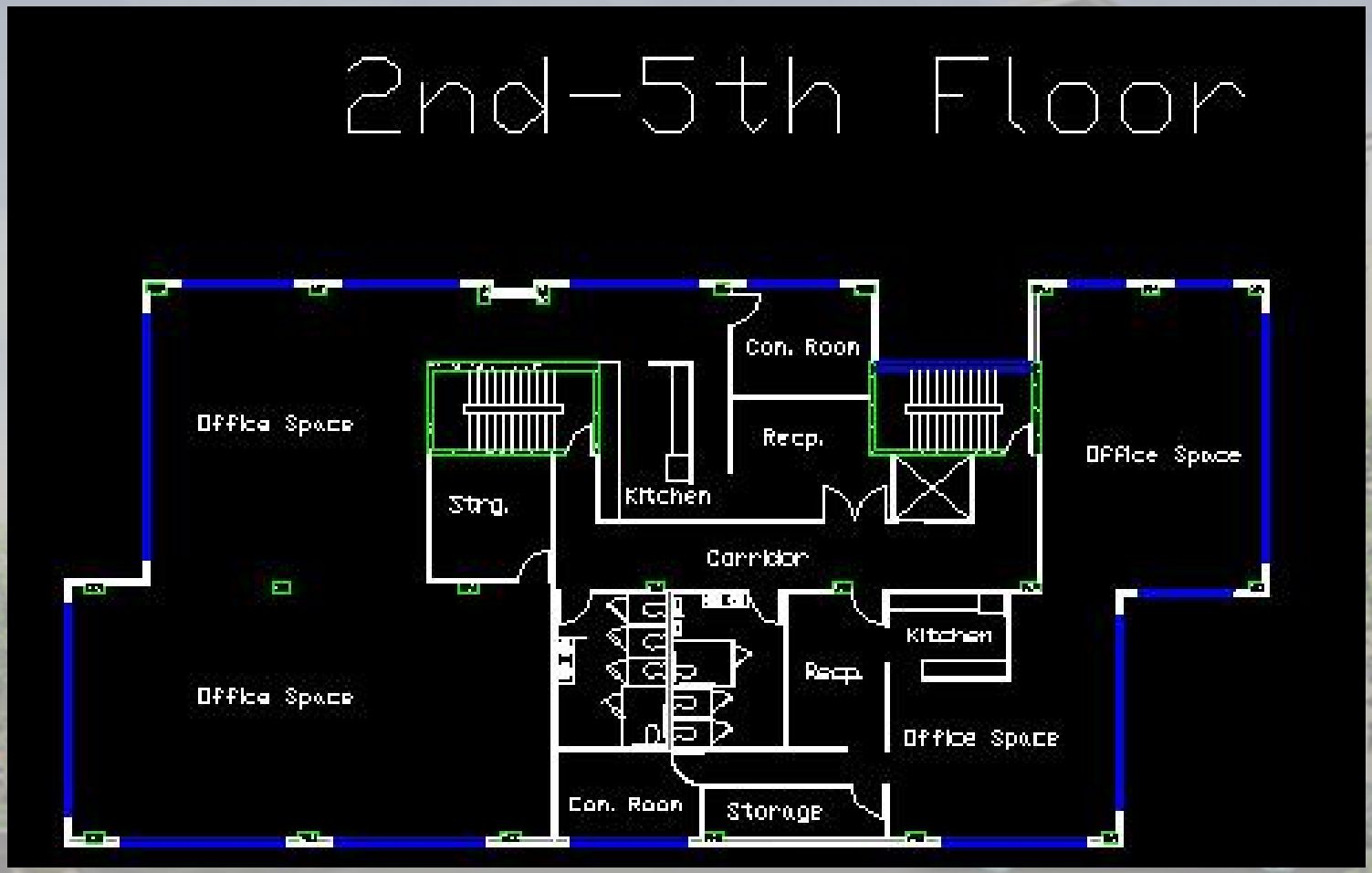

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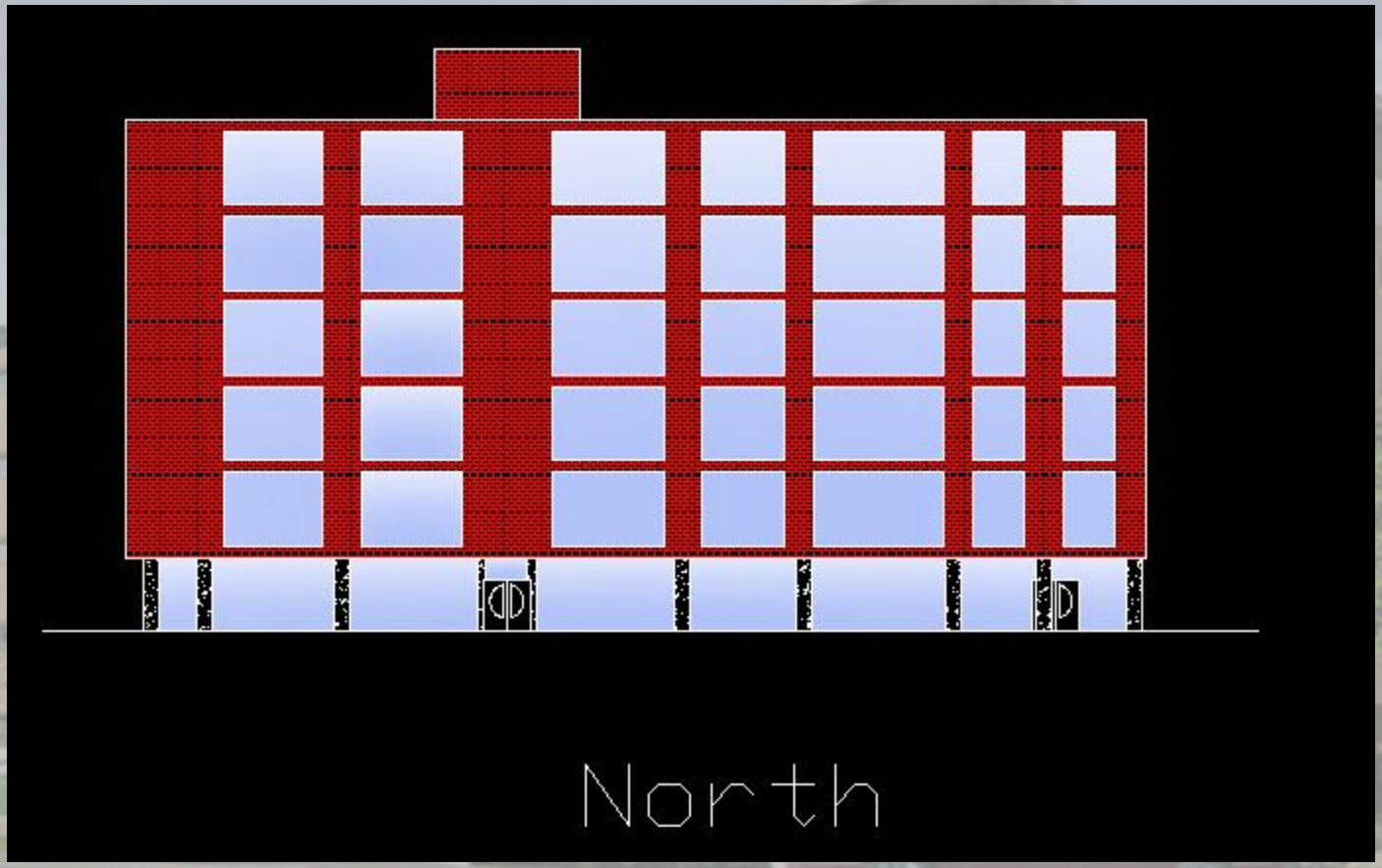

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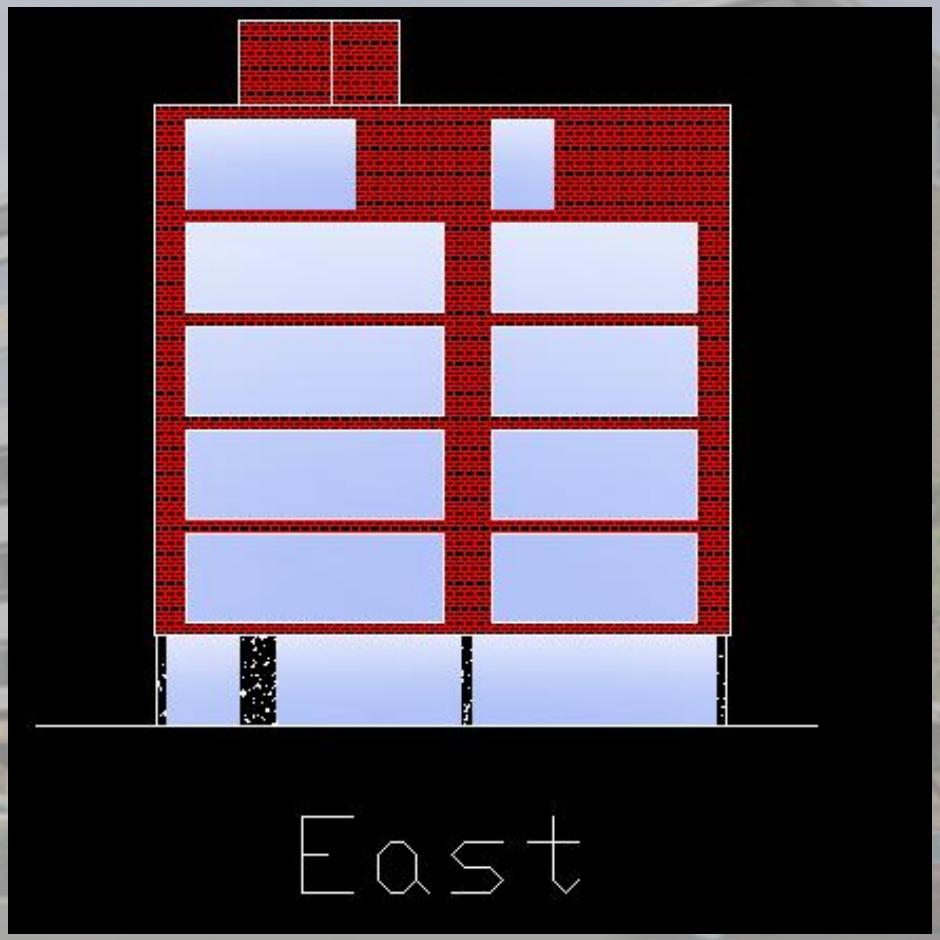

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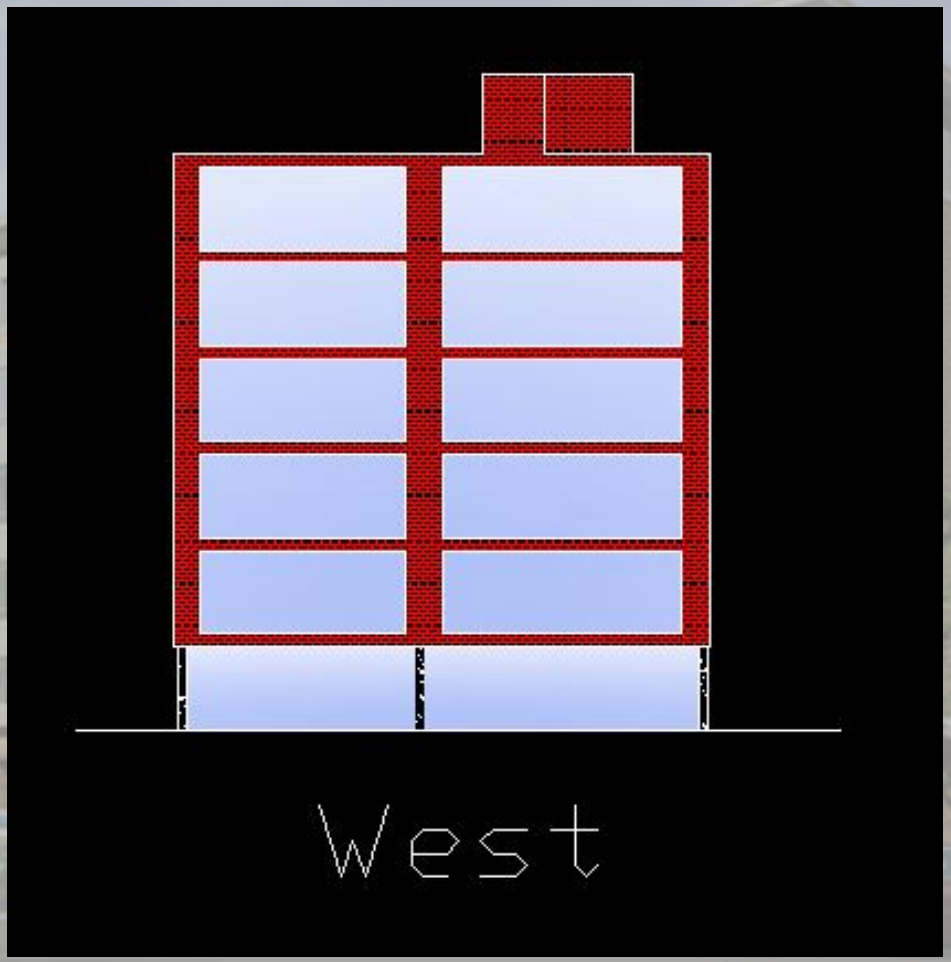

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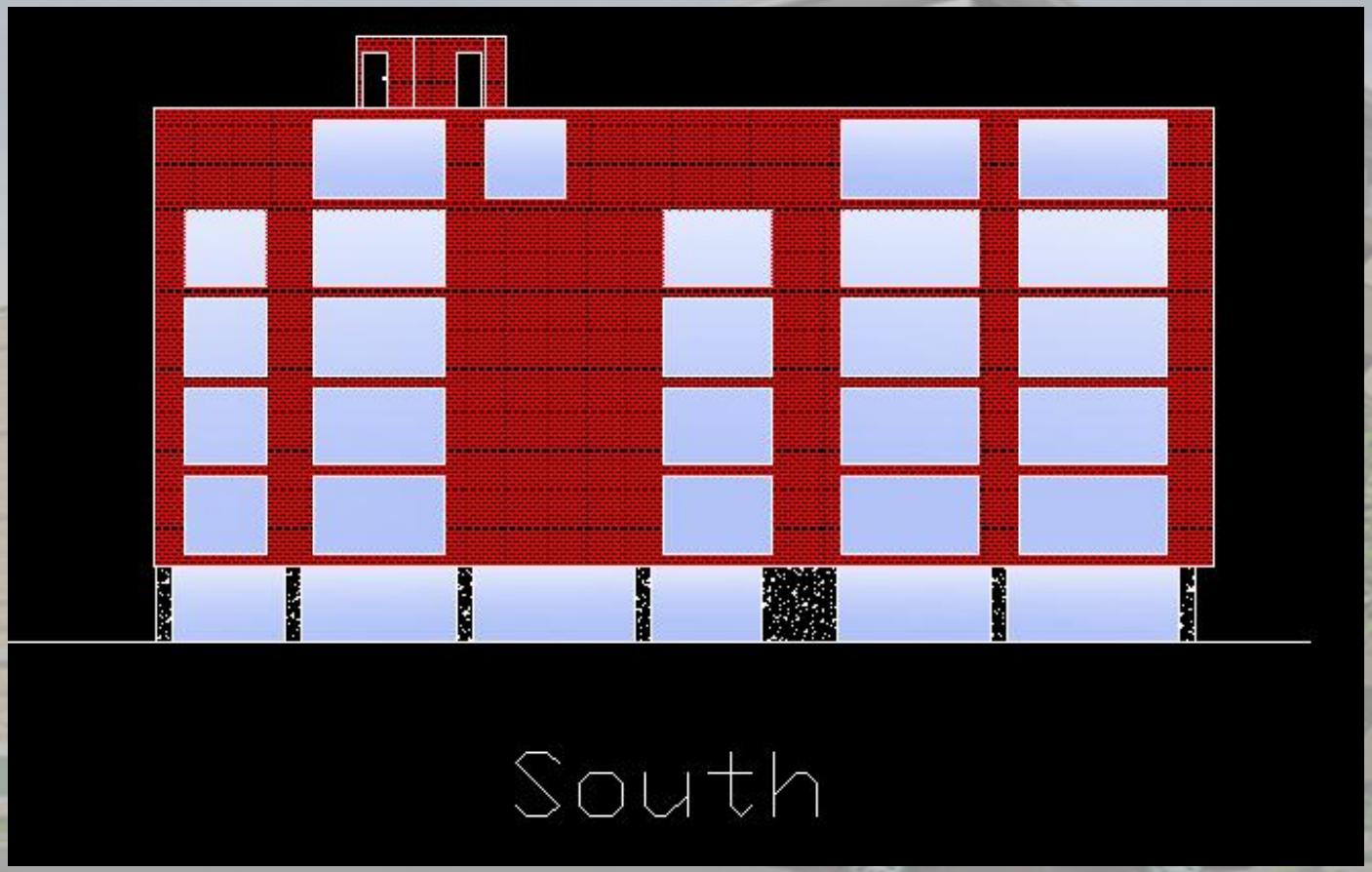

# CONSTRUCTION MANAGEMENT BREADTH

**COST**

- Cost of existing structure = $2,078,841
- Cost of new structure = $1,293,136
- Total savings of $785,705
- RS Means Facilities Construction Cost Data 2006

# CONCLUSION

- Pan joist system proved to be compatible with the existing architecture
- The structure allows for versatility in architectural redesign
- The cost of the structure decreases and the schedule increases according to my results

- I would recommend that Gateway Commons be constructed with the new pan joist structural system instead of the precast concrete hollow core plank on CMU walls

## ACKNOWLEDGMENTS

The AE faculty

Friends and Family

Ryan Biggs Associates

Northeast Construction


QUESTIONS ?