

# HOTEL | **NORTHEAST U.S.**

JORDAN RUTHERFORD | **STRUCTURAL OPTION**

FACULTY ADVISOR | **DR. THOMAS BOOTHBY**

AE SENIOR THESIS | **APRIL 8, 2013**



# HOTEL N.E.U.S.

# BUILDING INFORMATION

# SITE

## Building Overview

Existing Building

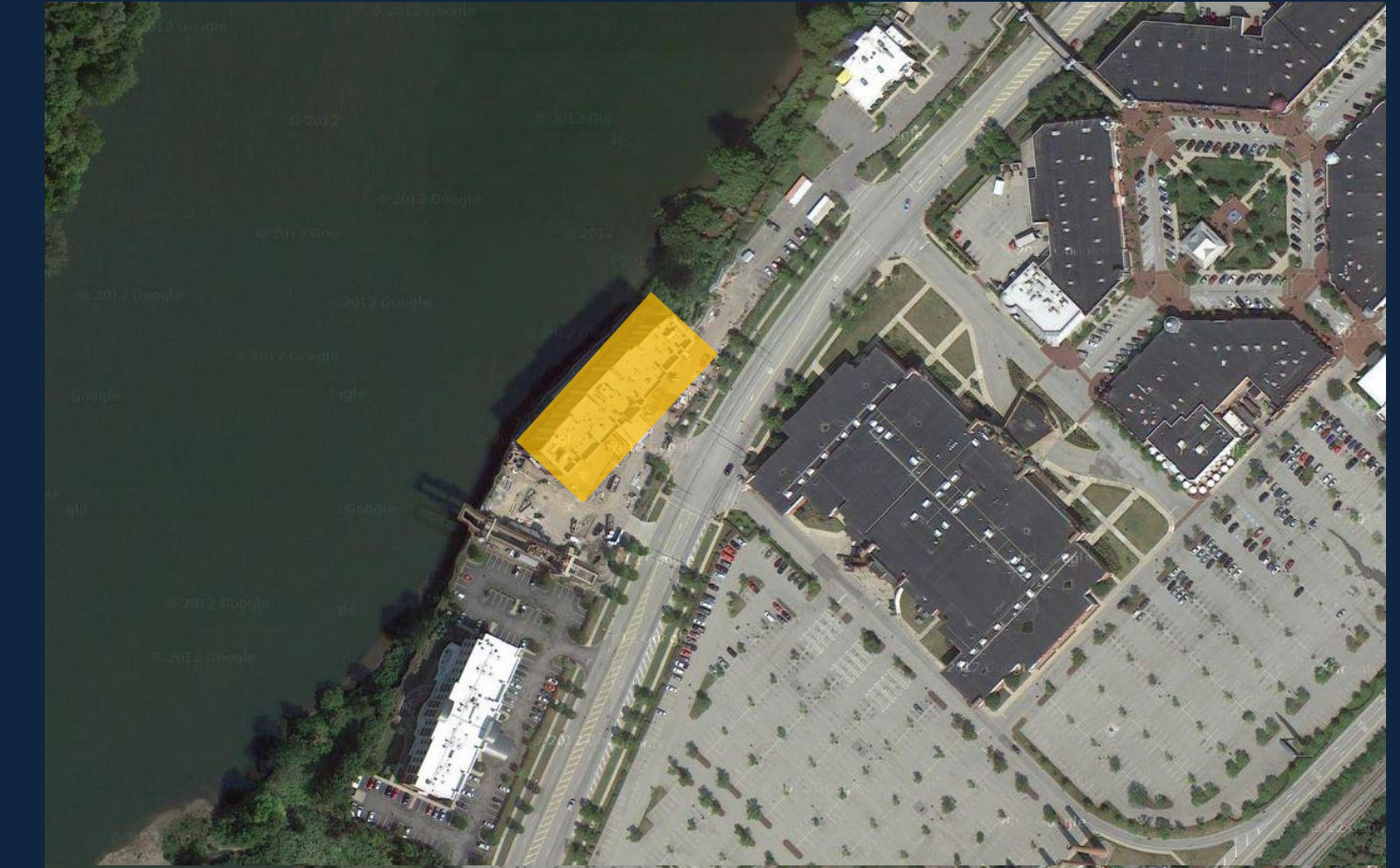
Problem Statement

Proposed Solution

Redesign

Conclusion

- Located in the Northeast United States
- 5 stories above grade
- 113 rooms
- 75,209 ft<sup>2</sup>
  - 63' x 257'
- Maximum Height: 60'-8"
- Construction Cost: \$9.2 million
- October 2011 – November 2012



# HOTEL N.E.U.S.

# PROJECT TEAM

# SITE

## Building Overview

Existing Building

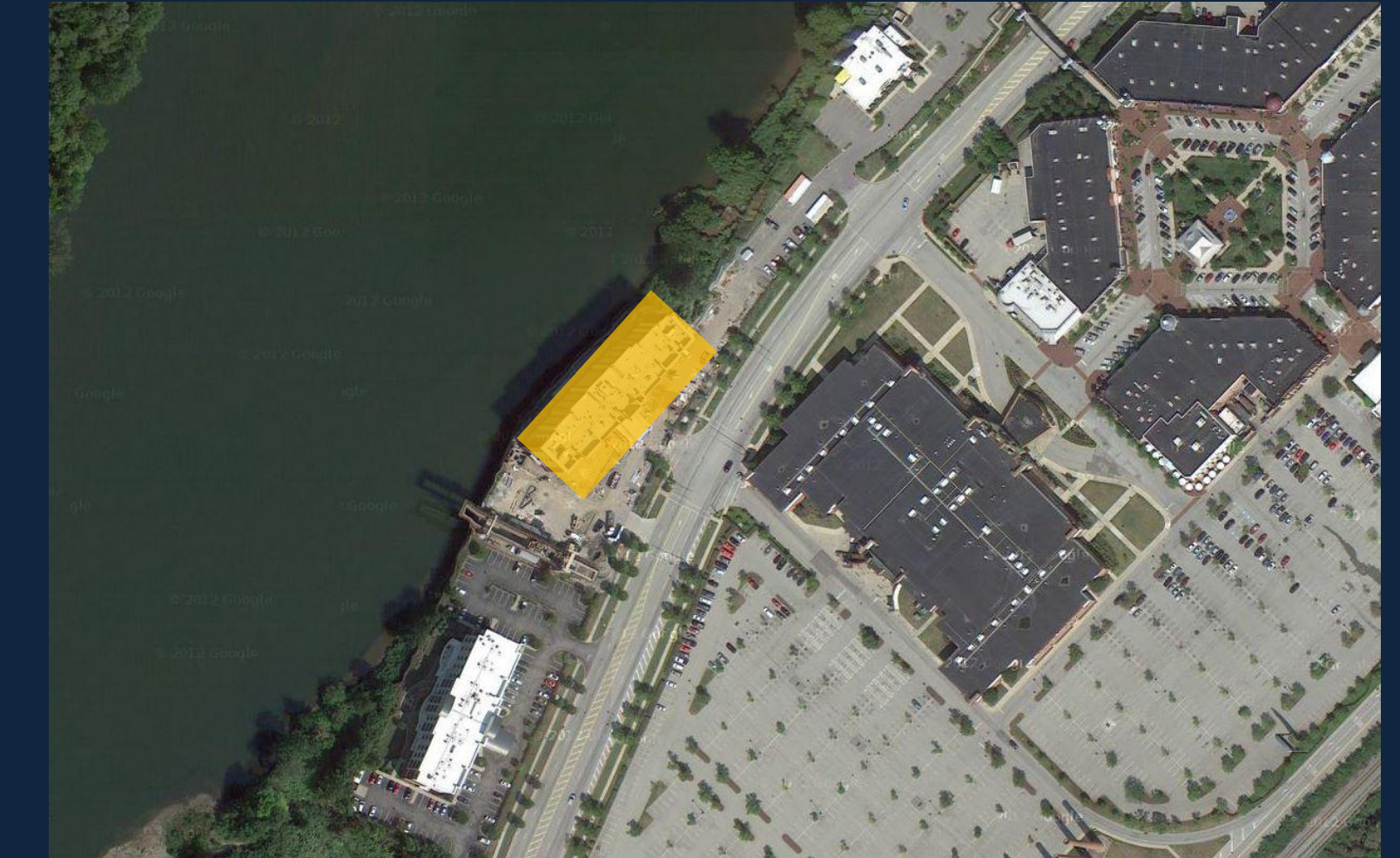
Problem Statement

Proposed Solution

Redesign

Conclusion

- Construction Manager | [Continental Real Estate](#)
- Architect | [Meyer and Associates](#)
- MEP | [Prater Engineering Associates](#)
- Fire Protection | [Prater Engineering Associates](#)
- Civil Engineer | [Civil and Environmental Consultants, Inc.](#)
- Landscape Arch. | [Civil and Environmental Consultants, Inc.](#)
- Structural Engineer | [Atlantic Engineering Services](#)



# HOTEL N.E.U.S.

## ARCHITECTURE

## ELEVATIONS

Building Overview

**Existing Building**

Problem Statement

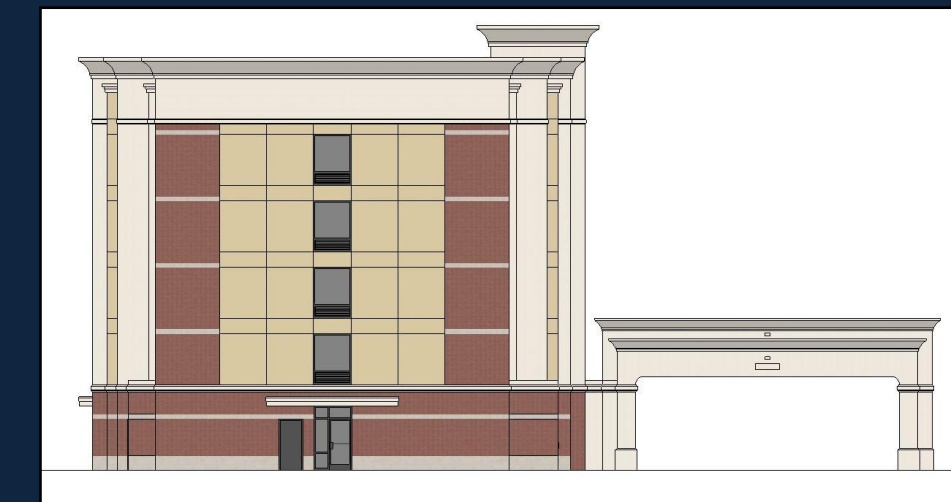
Proposed Solution

Redesign

Conclusion



- Synthetic Stucco (EIFS)
- Brick
- Cornices
- Arches



# HOTEL N.E.U.S.

# EXISTING STRUCTURE

# FLOOR PLANS

Building Overview

**Existing Building**

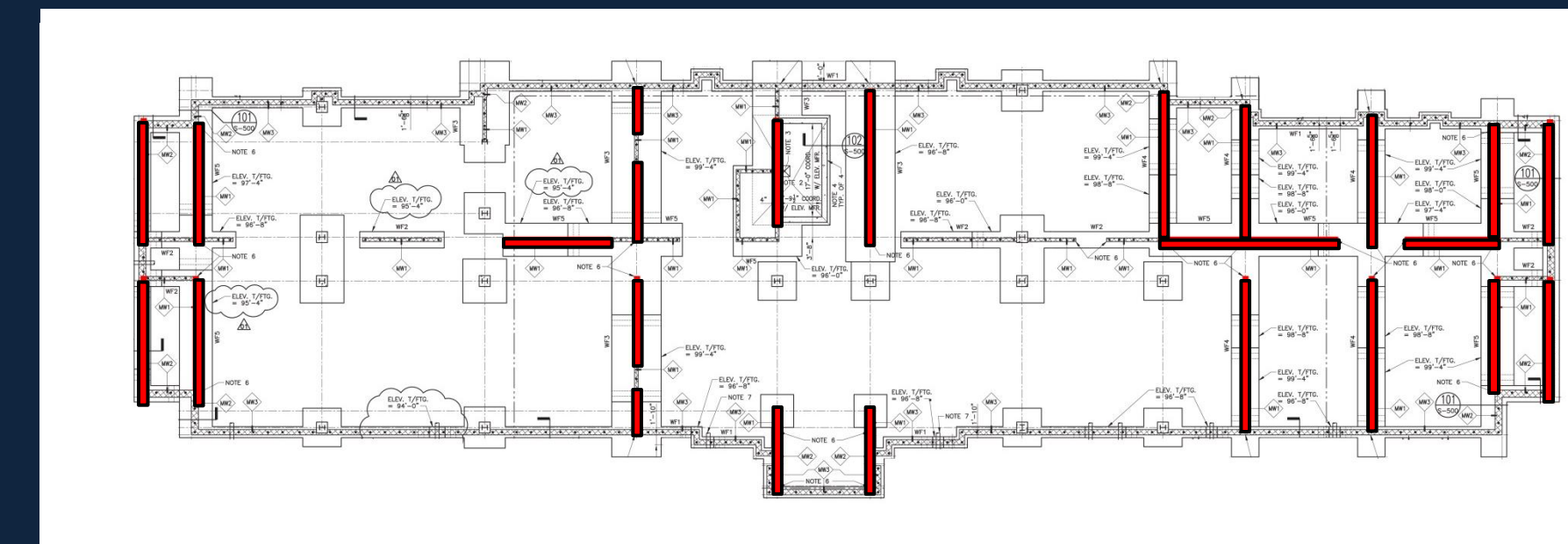
Problem Statement

Proposed Solution

Redesign

Conclusion

- Foundation | **Spread and Strip Footings**
- Floor | **Slab on grade**  
| **8" Hollowcore precast Plank**
- Framing | **Steel Beams and Columns**  
| **Masonry Bearing Walls**
- Lateral System | **Masonry Shear Walls**



# HOTEL N.E.U.S.

# PROBLEM STATEMENT

Building Overview

Existing Building

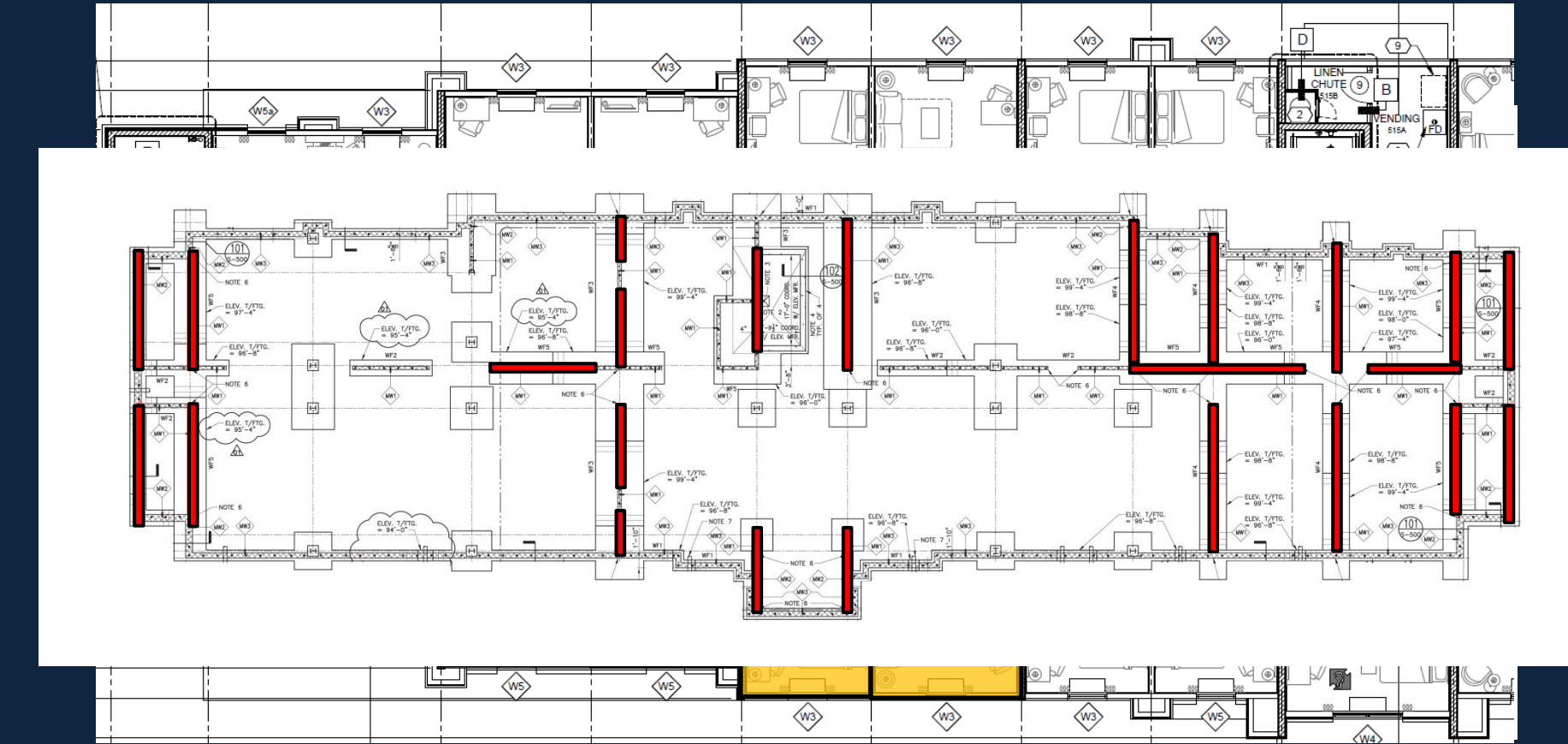
**Problem Statement**

Proposed Solution

Redesign

Conclusion

- Steel / Masonry System
- Open spaces on ground level
- Room sizes
- Lateral Elements layout



# HOTEL N.E.U.S.

# PROPOSED SOLUTION/GOALS

# MAE REQUIREMENTS

Building Overview

Existing Building

Problem Statement

**Proposed Solution**

Redesign

Conclusion

- Steel Gravity and Lateral System
- Maintain floor plan and room sizes
- Maintain window and door placement
- Lateral Layout

- AE 530- **Computer Modeling of Building Structures**
- AE 534- **Steel Connections**
- AE 537- **Building Performance Failures and Forensic Techniques**
- AE 542- **Building Enclosures Science Design**

# HOTEL N.E.U.S.

# GRAVITY

Building Overview

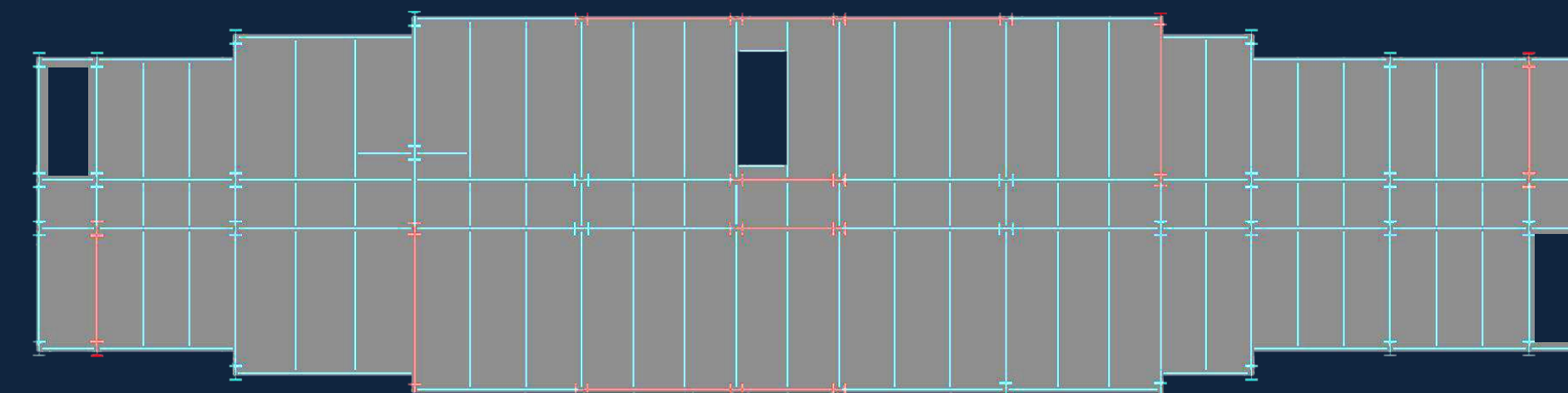
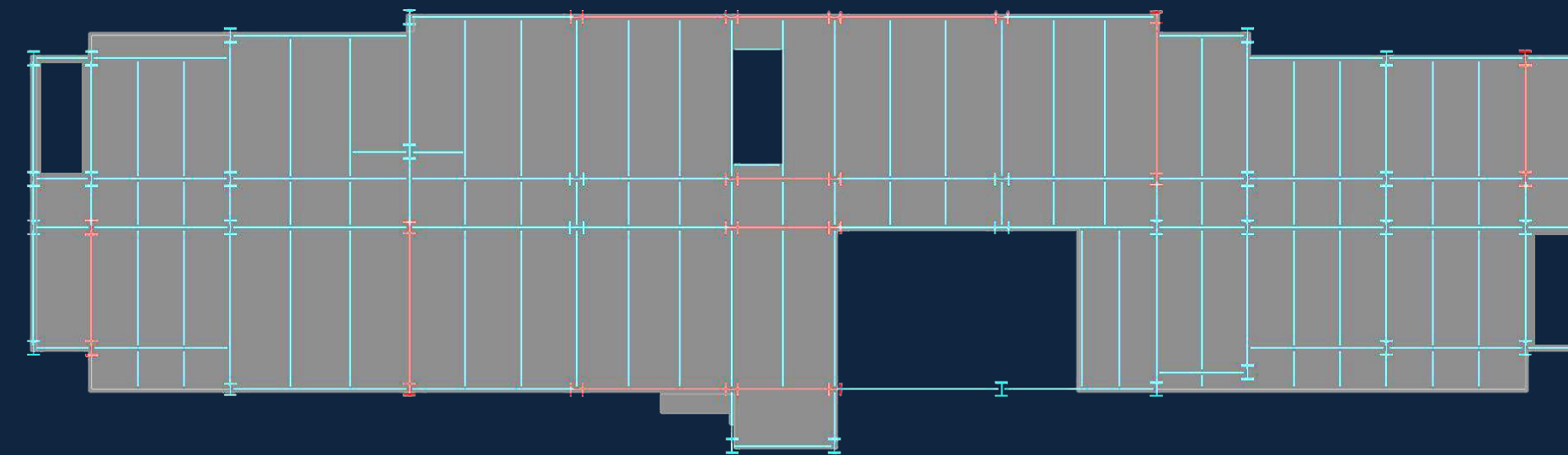
Existing Building

Problem Statement

Proposed Solution

**Redesign | Gravity**

Conclusion



- Concrete on Composite Metal Deck
  - 5.5" total thickness
  - 3" flutes

- Typical Beam: W14x22 (14) and W16x26 (16)
- Typical Girder: W18x40 (16)
- Typical Column: W10x33



# HOTEL N.E.U.S.

# GRAVITY

# CONNECTION

Building Overview

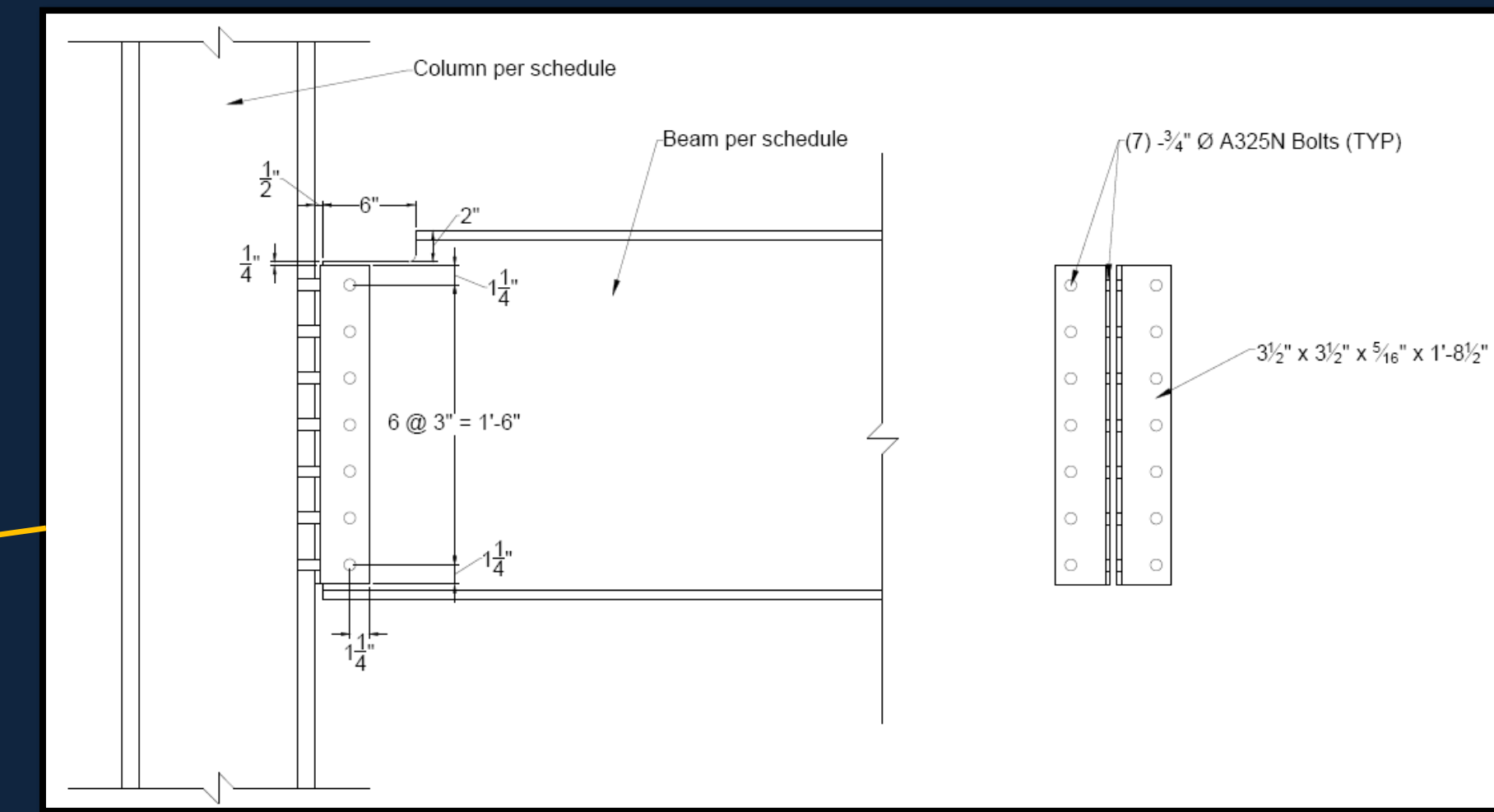
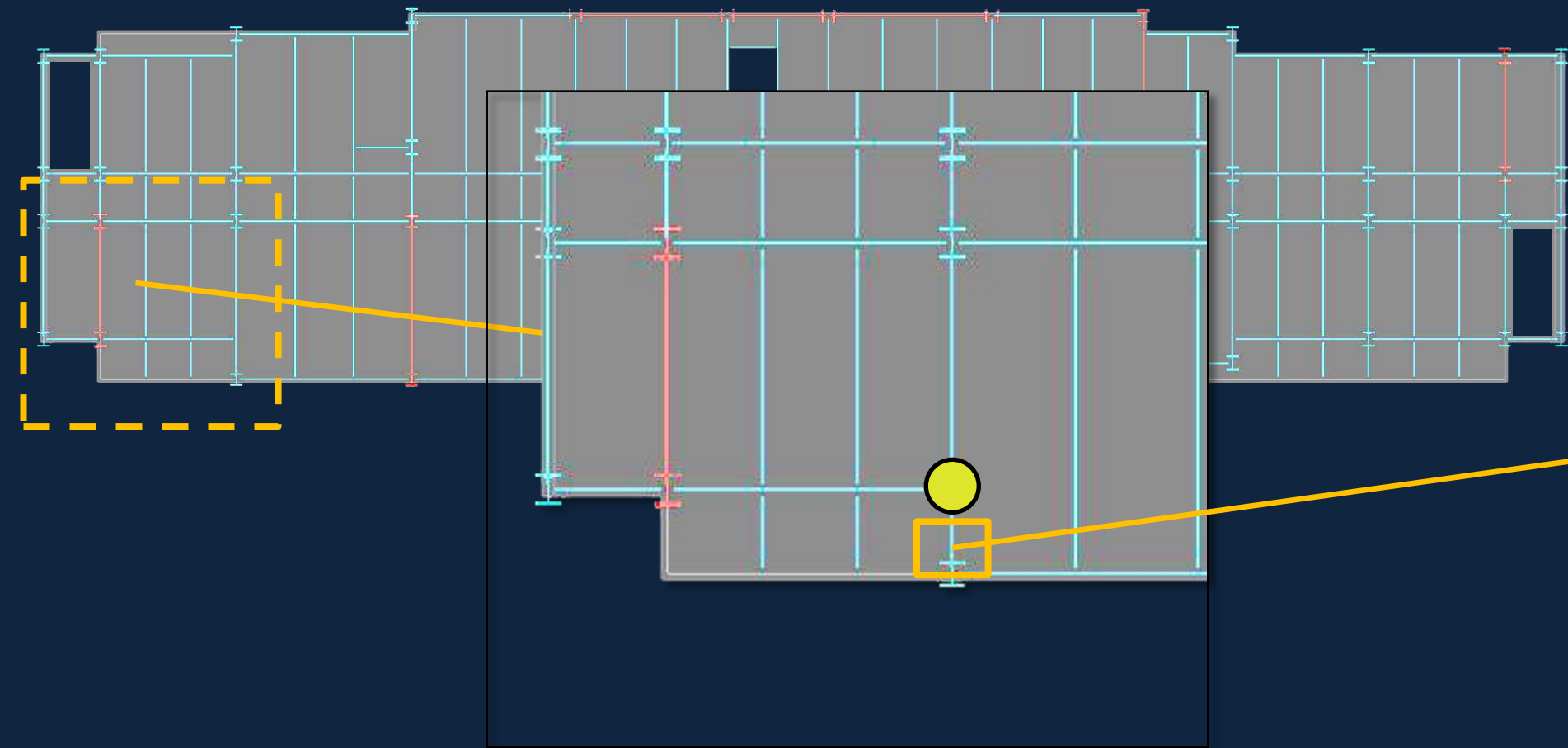
Existing Building

Problem Statement

Proposed Solution

**Redesign | Gravity**

Conclusion



# HOTEL N.E.U.S.

## LATERAL

Building Overview

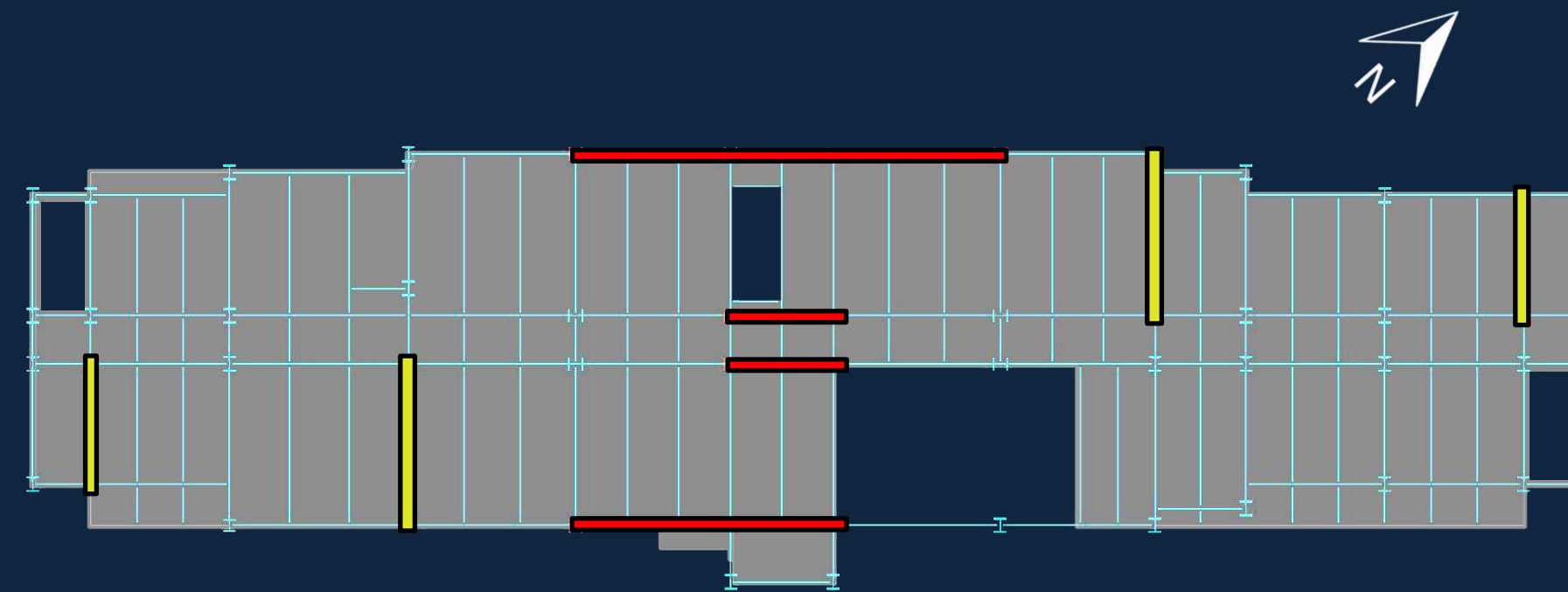
Existing Building

Problem Statement

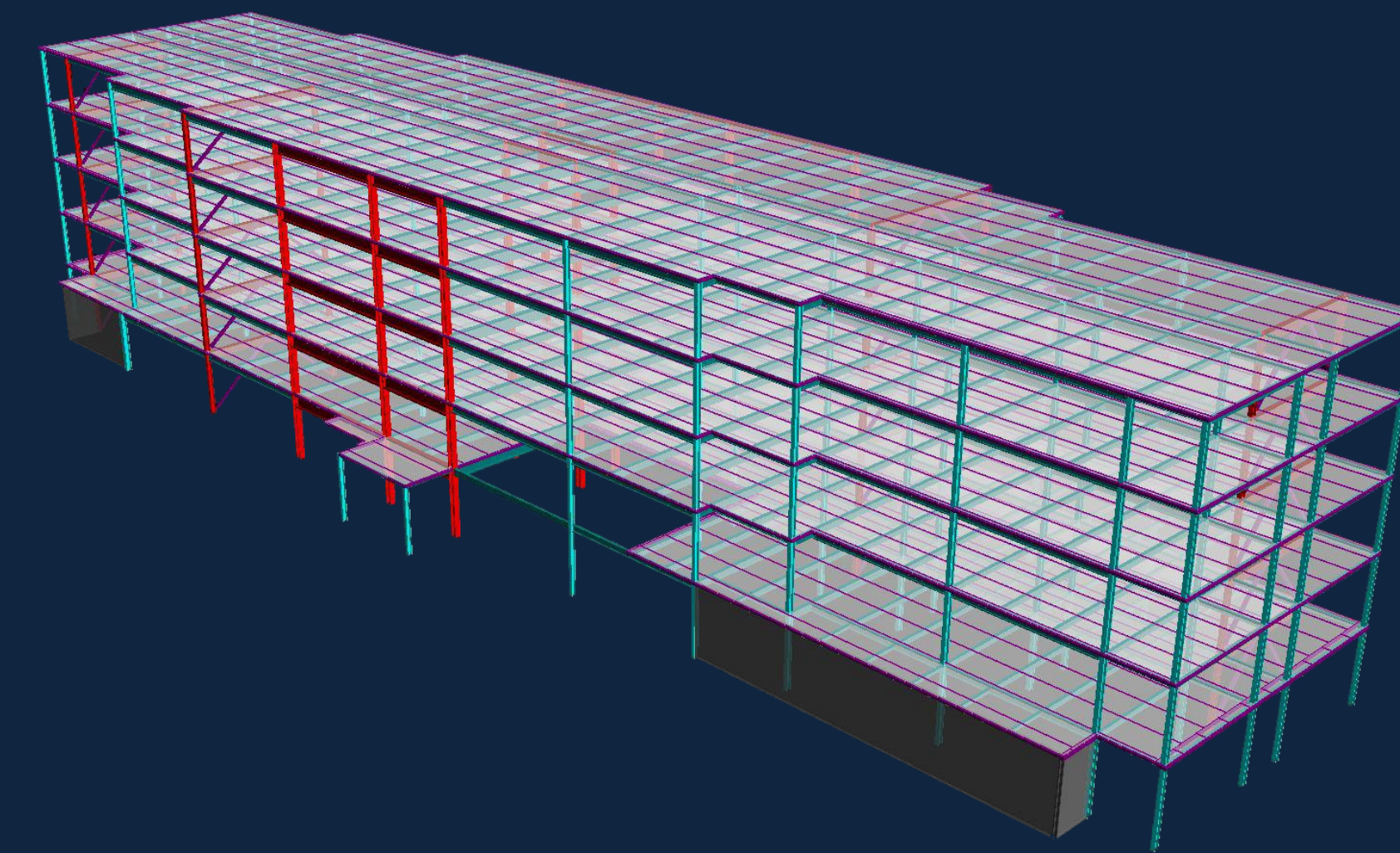
Proposed Solution

**Redesign | Lateral**

Conclusion



— Braced Frame  
— Moment Frame

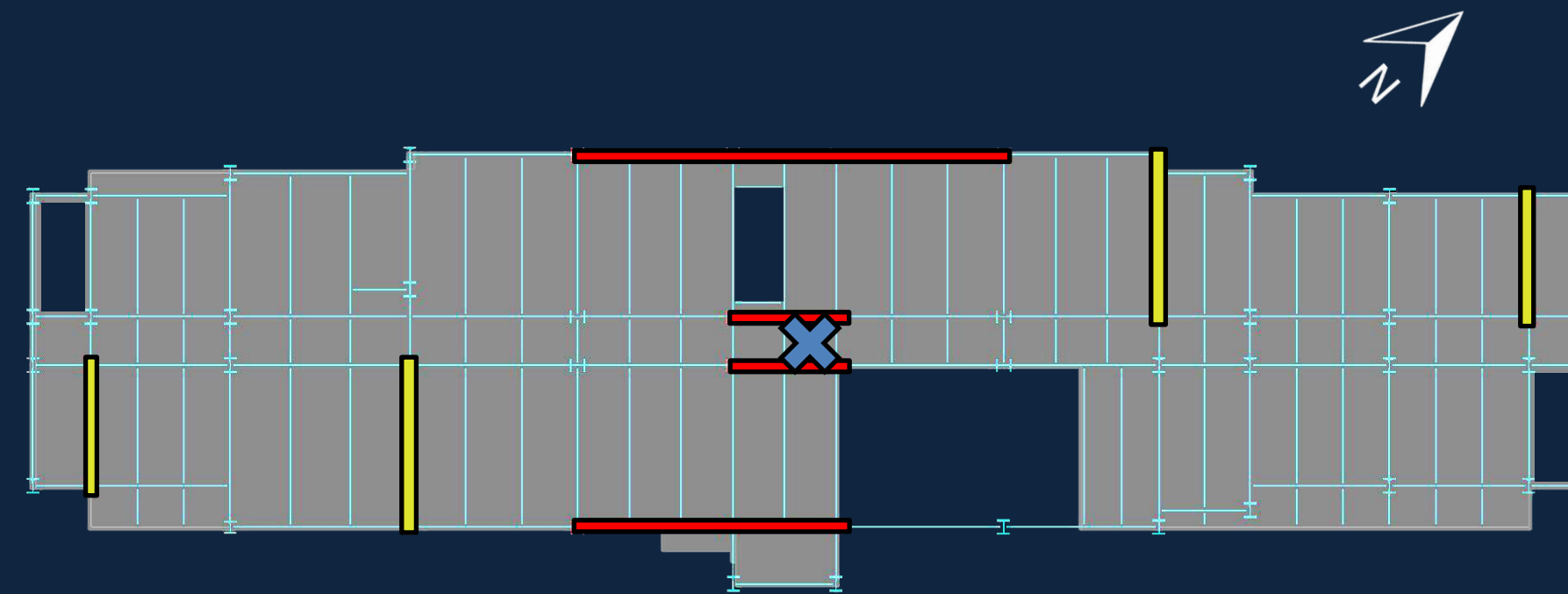


# HOTEL N.E.U.S.

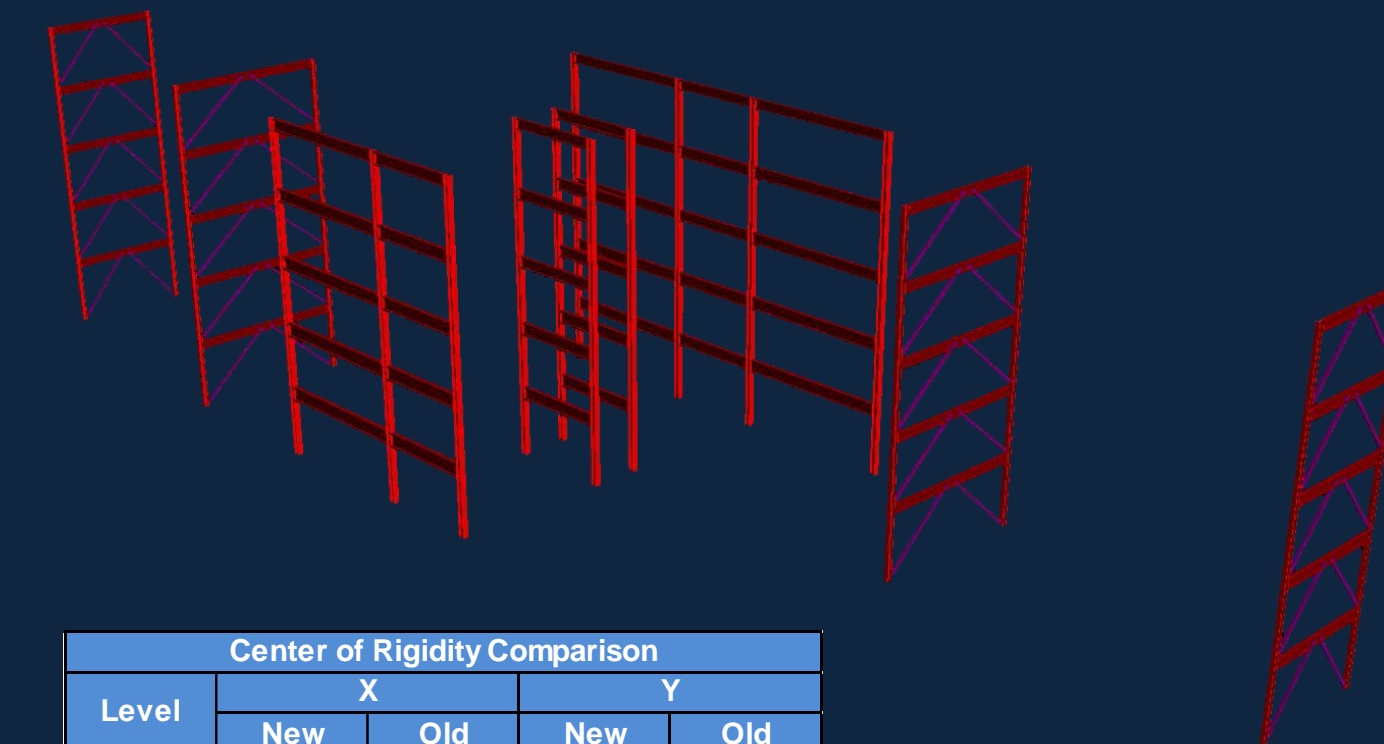
## LATERAL

## CENTER OF RIGIDITY

- Building Overview
- Existing Building
- Problem Statement
- Proposed Solution
- Redesign | Lateral**
- Conclusion



— Braced Frame  
— Moment Frame



Center of Rigidity Comparison				
Level	X		Y	
	New	Old	New	Old
5	123.59	161.57	2.28	-5.05
4	123.64	160.71	1.72	-4.5
3	123.68	159.13	1.95	-3.51
2	123.7	156.28	2.09	-1.72
1	123.69	151.16	2.71	1.37

\*For the Y direction, 0 is centerline

# HOTEL N.E.U.S.

# LATERAL

# BRACED FRAMES

Building Overview

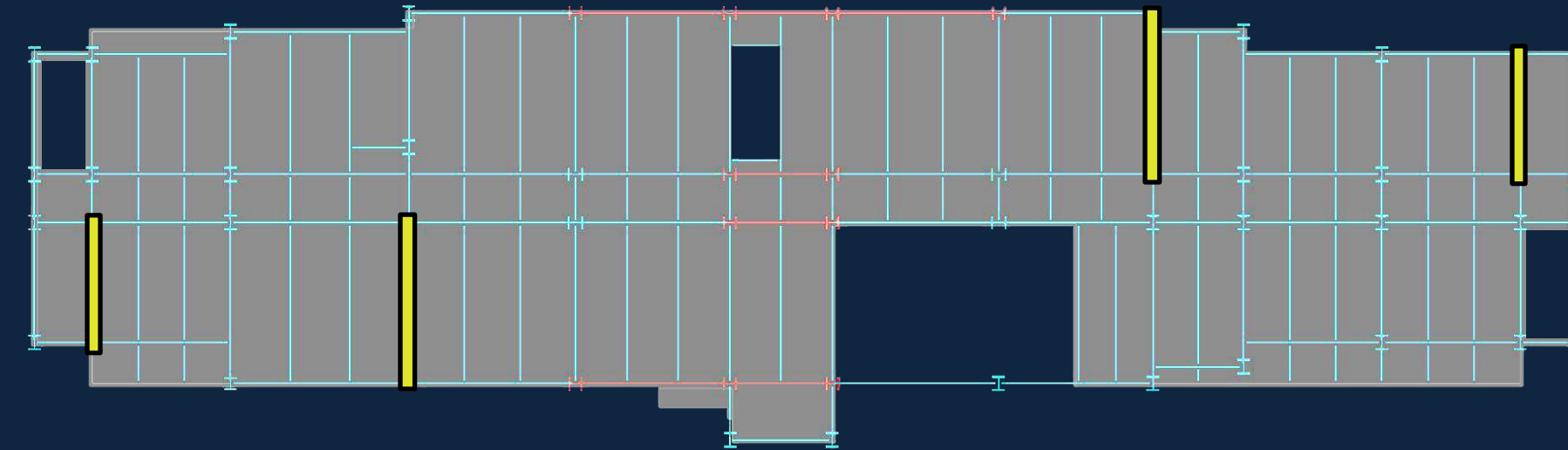
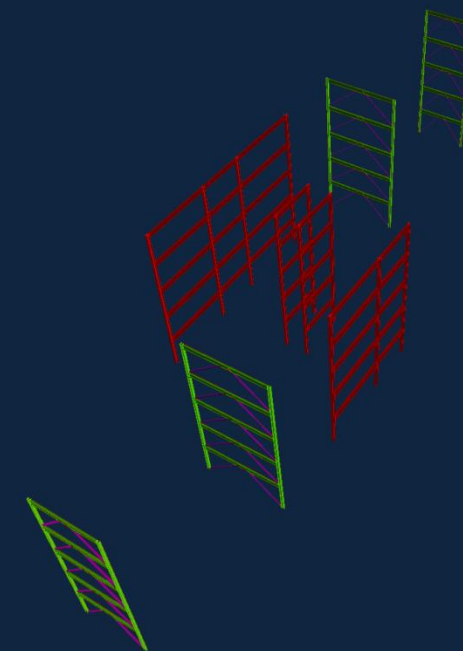
Existing Building

Problem Statement

Proposed Solution

**Redesign | Lateral**

Conclusion



- Replace shear walls in short direction
  - One brace spans swimming area
- $R = 3.25$



# HOTEL N.E.U.S.

# BRACED CONNECTION

# BRACED FRAMES

Building Overview

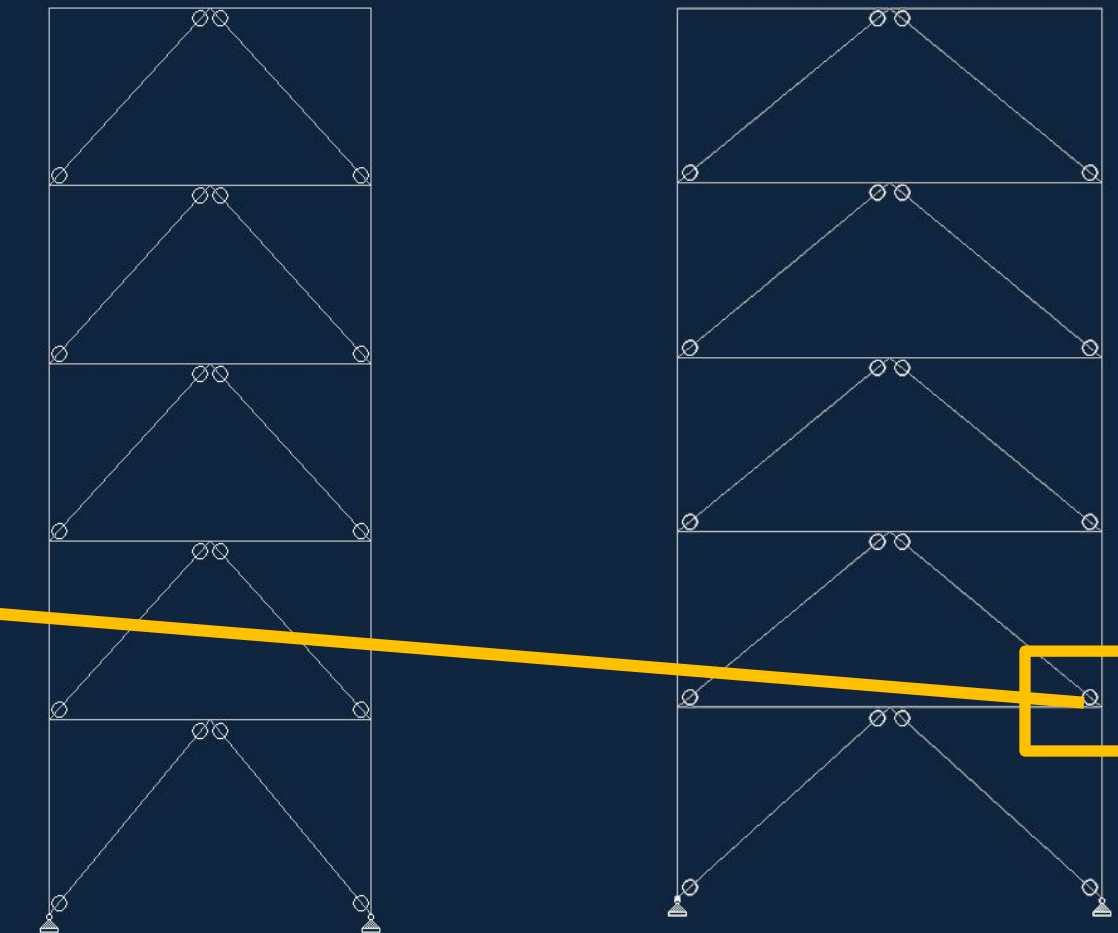
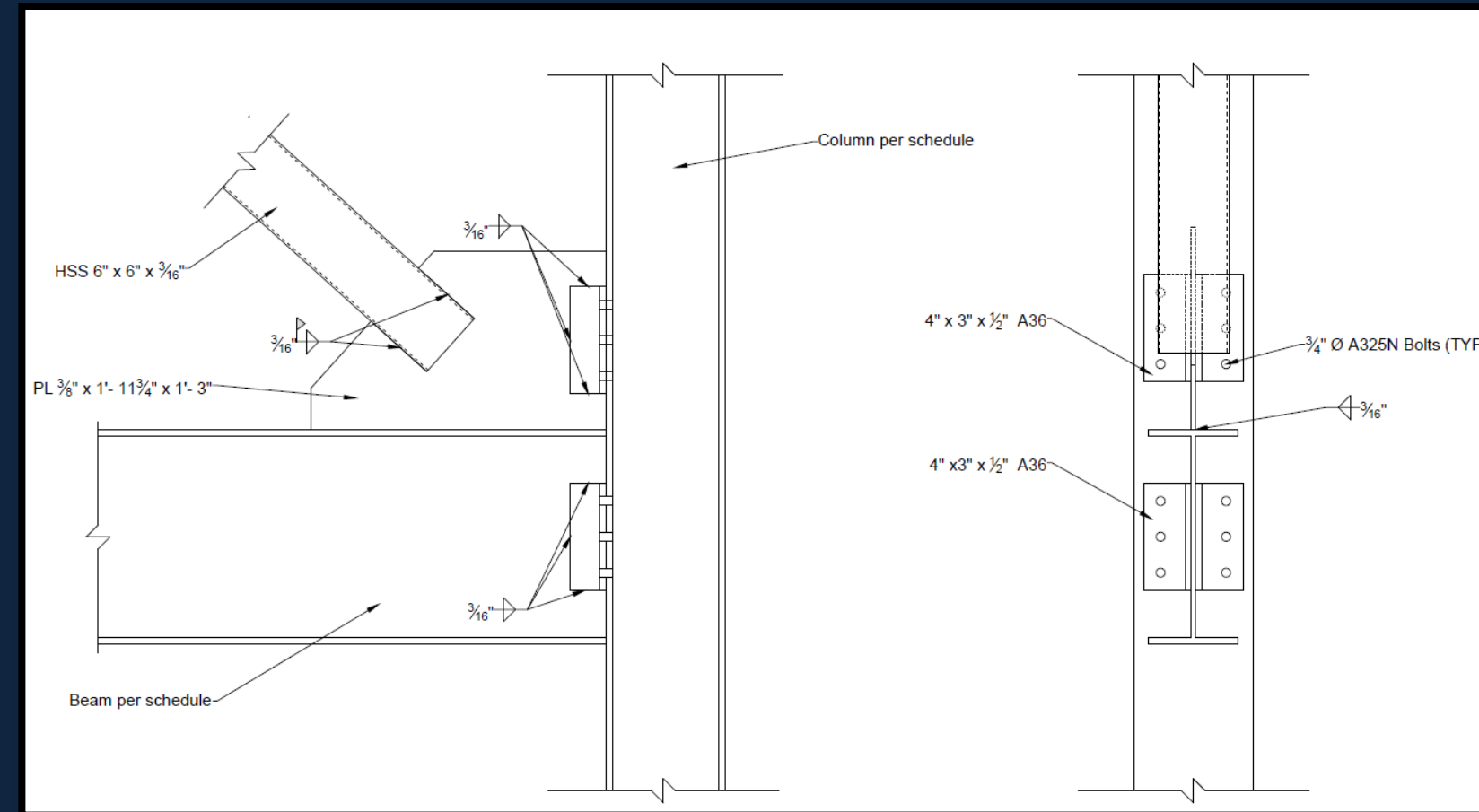
Existing Building

Problem Statement

Proposed Solution

**Redesign | Lateral**

Conclusion



# HOTEL N.E.U.S.

# LATERAL

# MOMENT FRAMES

Building Overview

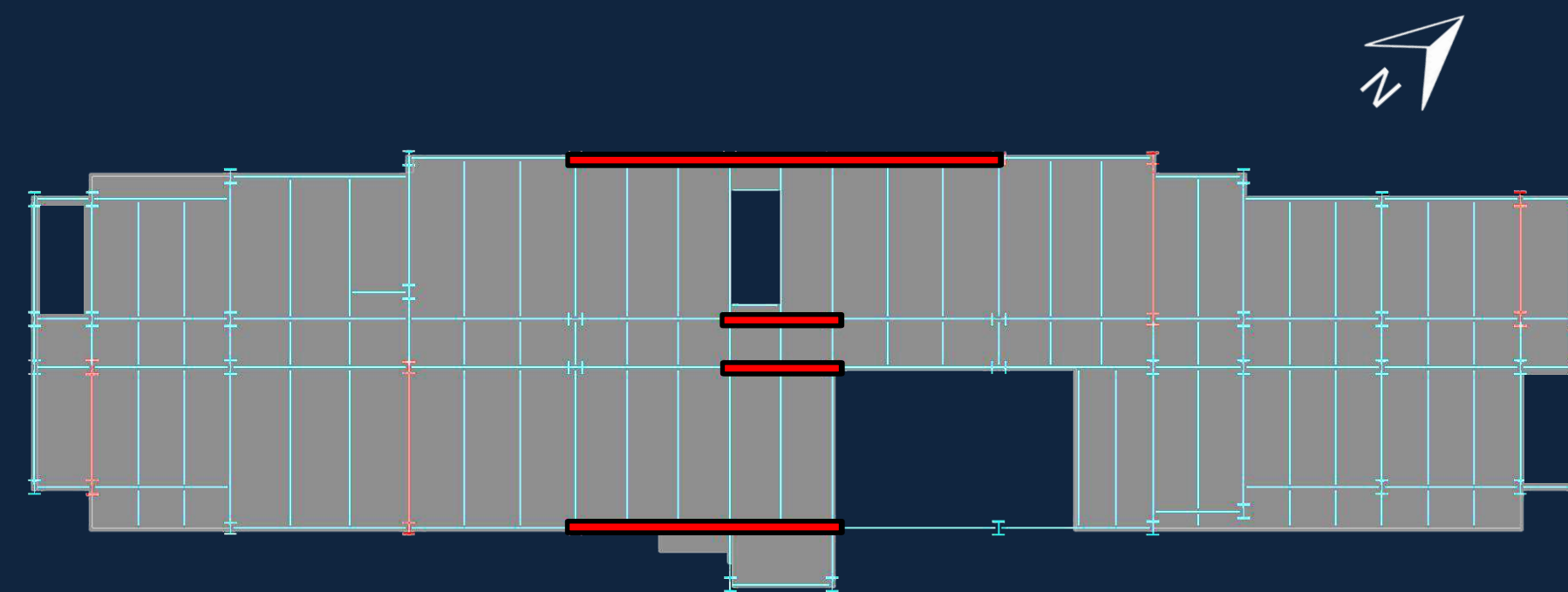
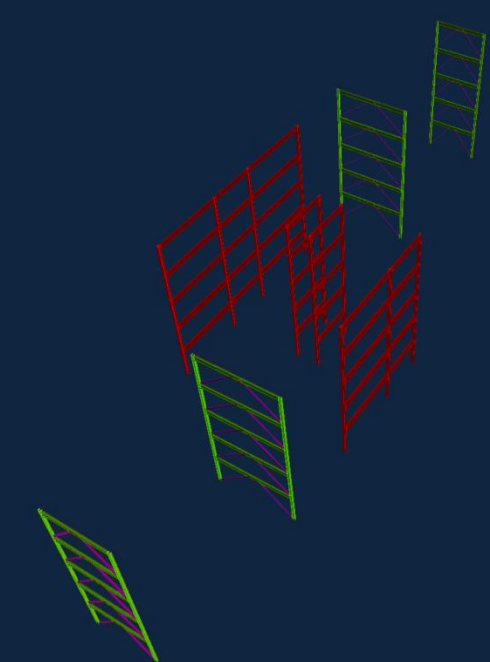
Existing Building

Problem Statement

Proposed Solution

**Redesign | Lateral**

Conclusion



- Allows for window and door openings
- Pinned Base
- $R = 3$



# HOTEL N.E.U.S.

# MOMENT CONNECTION

# MOMENT FRAMES

Building Overview

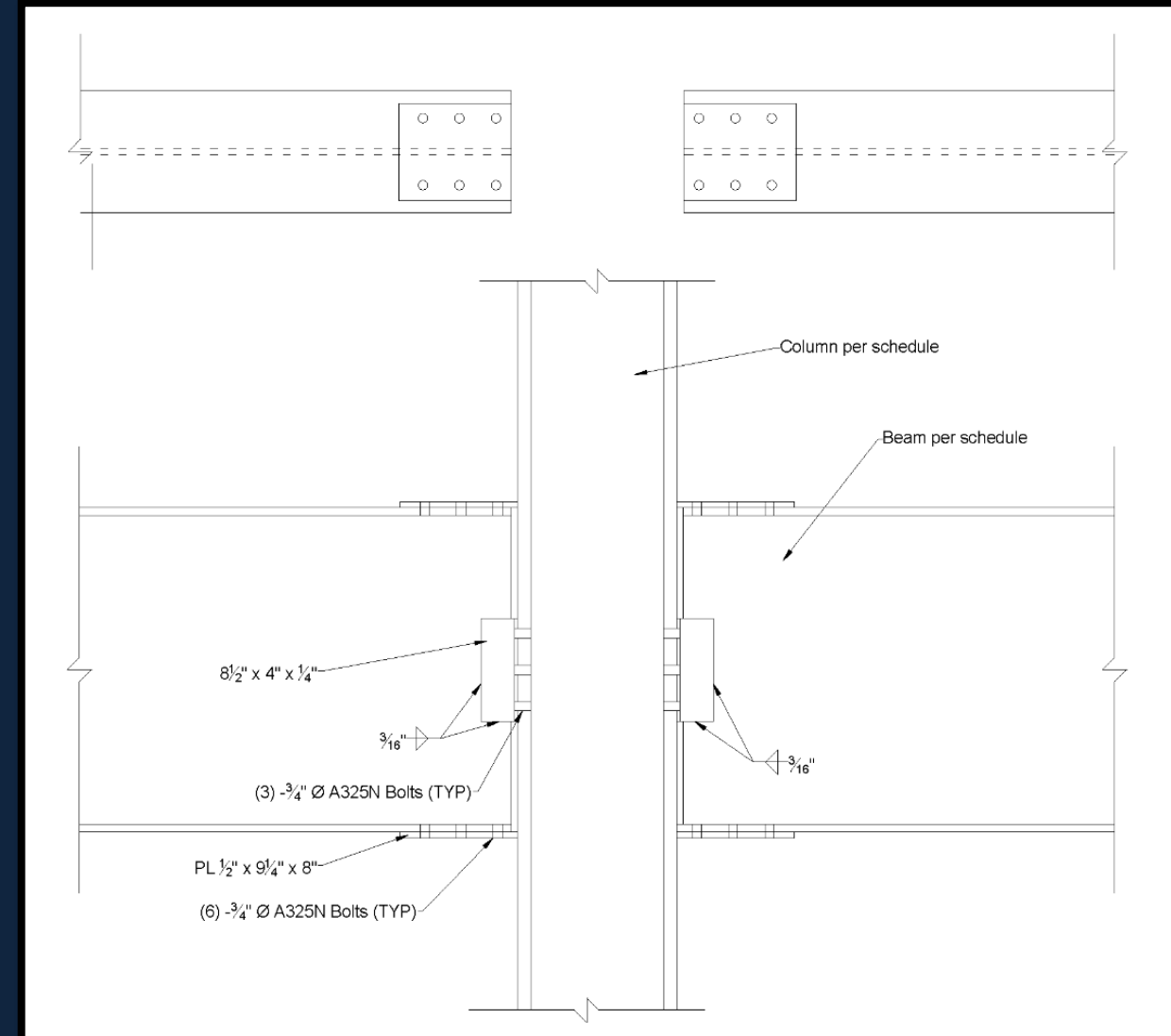
Existing Building

Problem Statement

Proposed Solution

**Redesign | Lateral**

Conclusion



# HOTEL N.E.U.S.

# ARCHITECTURE

# EXISTING STYLES

Building Overview

Existing Building

Problem Statement

Proposed Solution

**Redesign | Arch.**

Conclusion





# HOTEL N.E.U.S.

# ARCHITECTURE

# ELEVATIONS

Building Overview

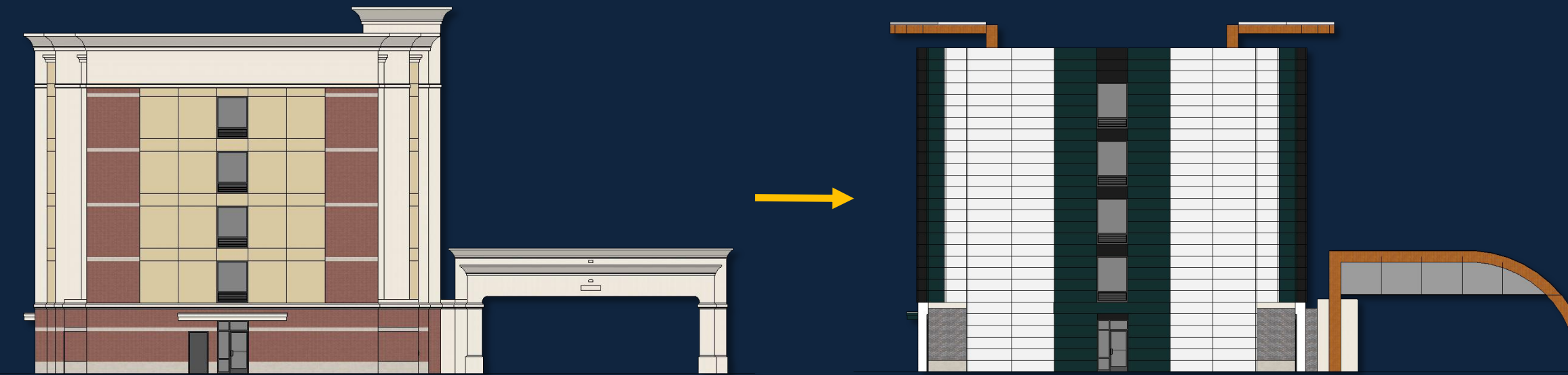
Existing Building

Problem Statement

Proposed Solution

**Redesign | Arch.**

Conclusion



# HOTEL N.E.U.S.

# ARCHITECTURE

Building Overview

Existing Building

Problem Statement

Proposed Solution

**Redesign | Arch.**

Conclusion



- Metal Span Architectural Insulated Panels
  - Grey, Green, and White
- Grey Brick along base
- Roof Awning
- Entryway
  - Tinted Structural Glass

# HOTEL N.E.U.S.

# ENCLOSURE

Building Overview

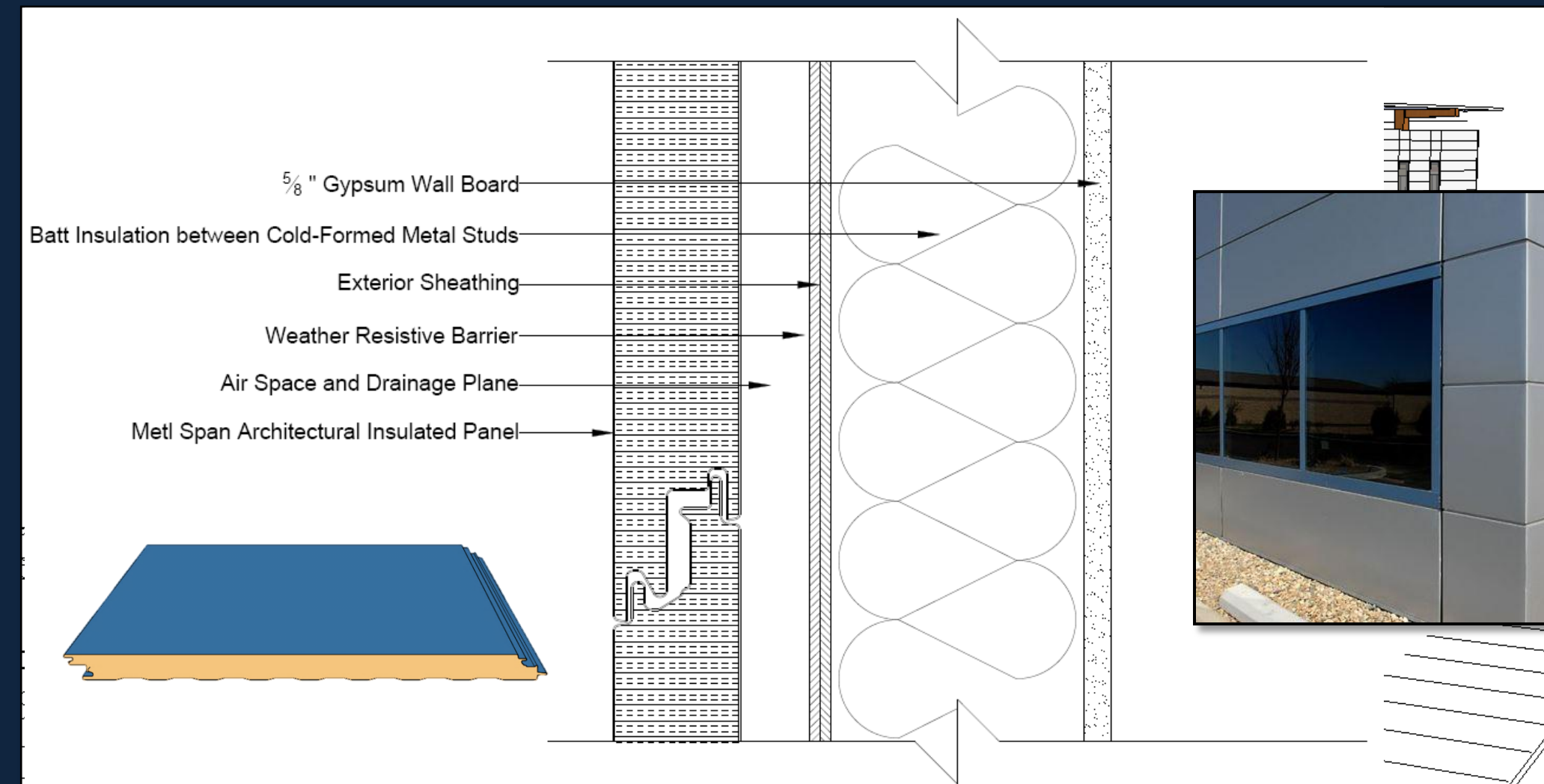
Existing Building

Problem Statement

Proposed Solution

**Redesign | Encl.**

Conclusion



# HOTEL N.E.U.S.

## SUMMARY

## GOALS

Building Overview

Existing Building

Problem Statement

Proposed Solution

Redesign

**Conclusion**

- Gravity system changed from precast plank and masonry walls to **composite steel**
- Lateral system changed from masonry shear walls
  - Short direction- **Braced frames**
  - Long direction- **Moment frames**
- Façade changed from EIFS to **metal panels**

- Maintain floor plan and room sizes ✓
- Locate Braces within partitions ✓
- Limit drift for moment frames ✓
- Keep C.O.R. close to center of building ✓
- Redesign architecture ✓
- Redesign enclosure ✓

# HOTEL N.E.U.S.

# ACKNOWLEDGEMENTS

Building Overview

Existing Building

Problem Statement

Proposed Solution

Redesign

**Conclusion**



*Atlantic Engineering Services:*

Cam Baker

John Schneider

AE Department Faculty

Dr. Thomas Boothby

My family, friends, girlfriend, and God

# THANK YOU

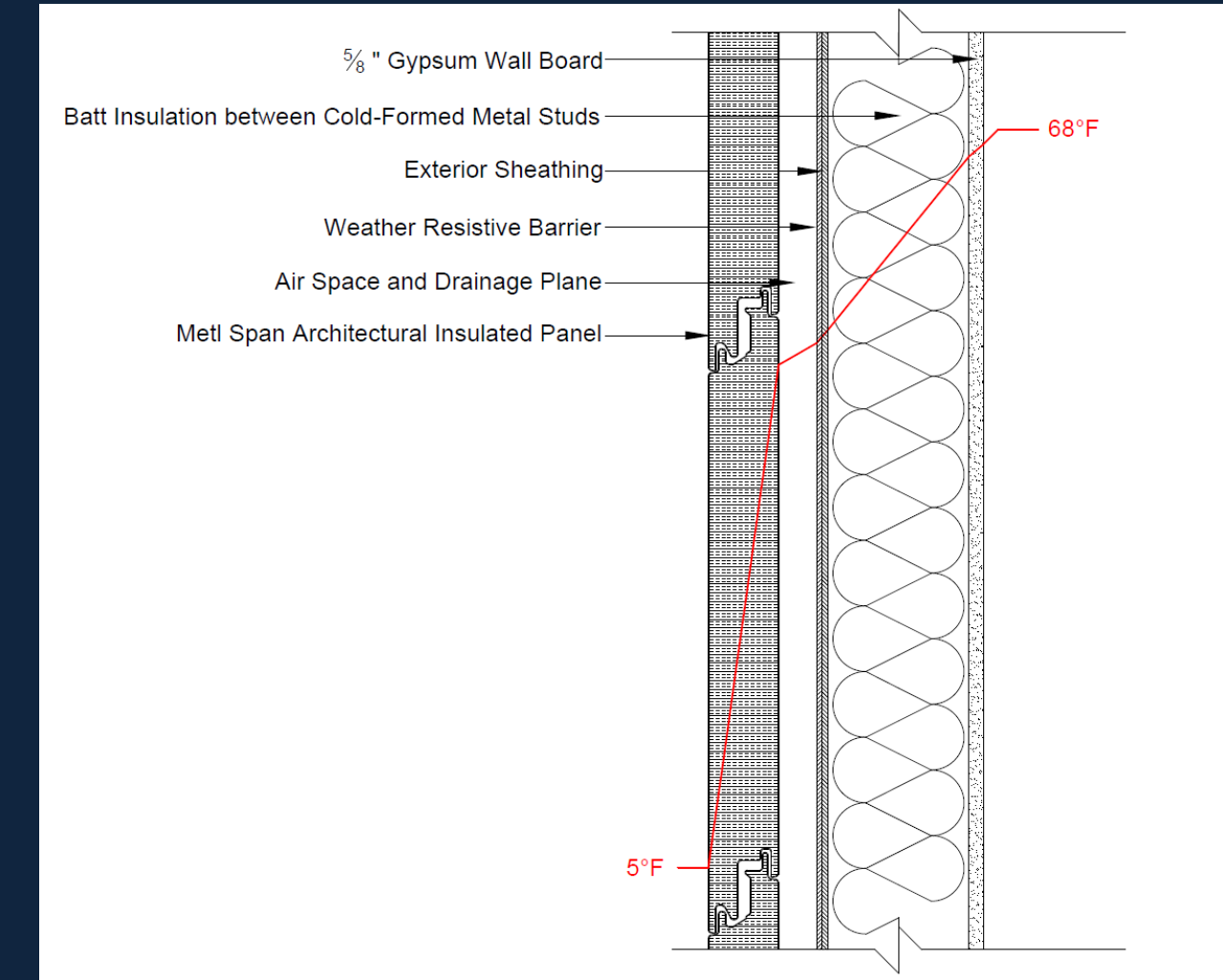
# HOTEL N.E.U.S.

# APPENDIX

# SEISMIC/THERMAL

- Building Overview
- Existing Building
- Problem Statement
- Proposed Solution
- Redesign
- Conclusion**

Seismic Load Data		
Occupancy Category	-	II
Site Class	-	D
Seismic Load Importance Factor	$I_e$	1
Site Class Coefficient	$S_s$	0.125
	$S_1$	0.049
Spectral Response Coefficient	$F_a$	1.6
	$F_v$	2.4
	$S_{DS}$	0.1333
	$S_{D1}$	0.0784
Seismic Design Category	-	B
Long Period Transition Period	$T_L$	12
Response Modification Factor	R	3.25
Fundamental Period (N-S)	$T_a$	0.930
Response Modification Factor	R	3
Fundamental Period (E-W)	$T_a$	1.900

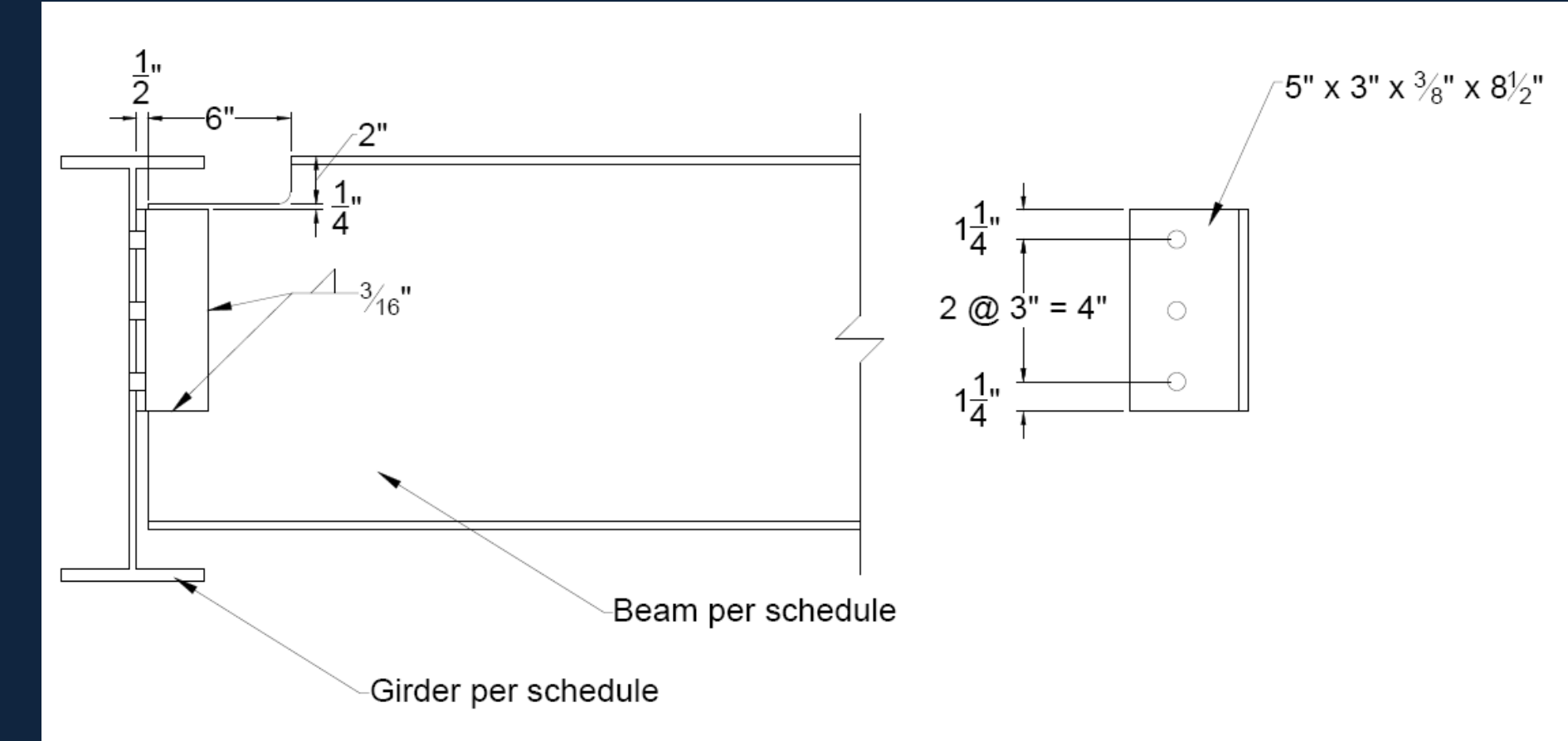
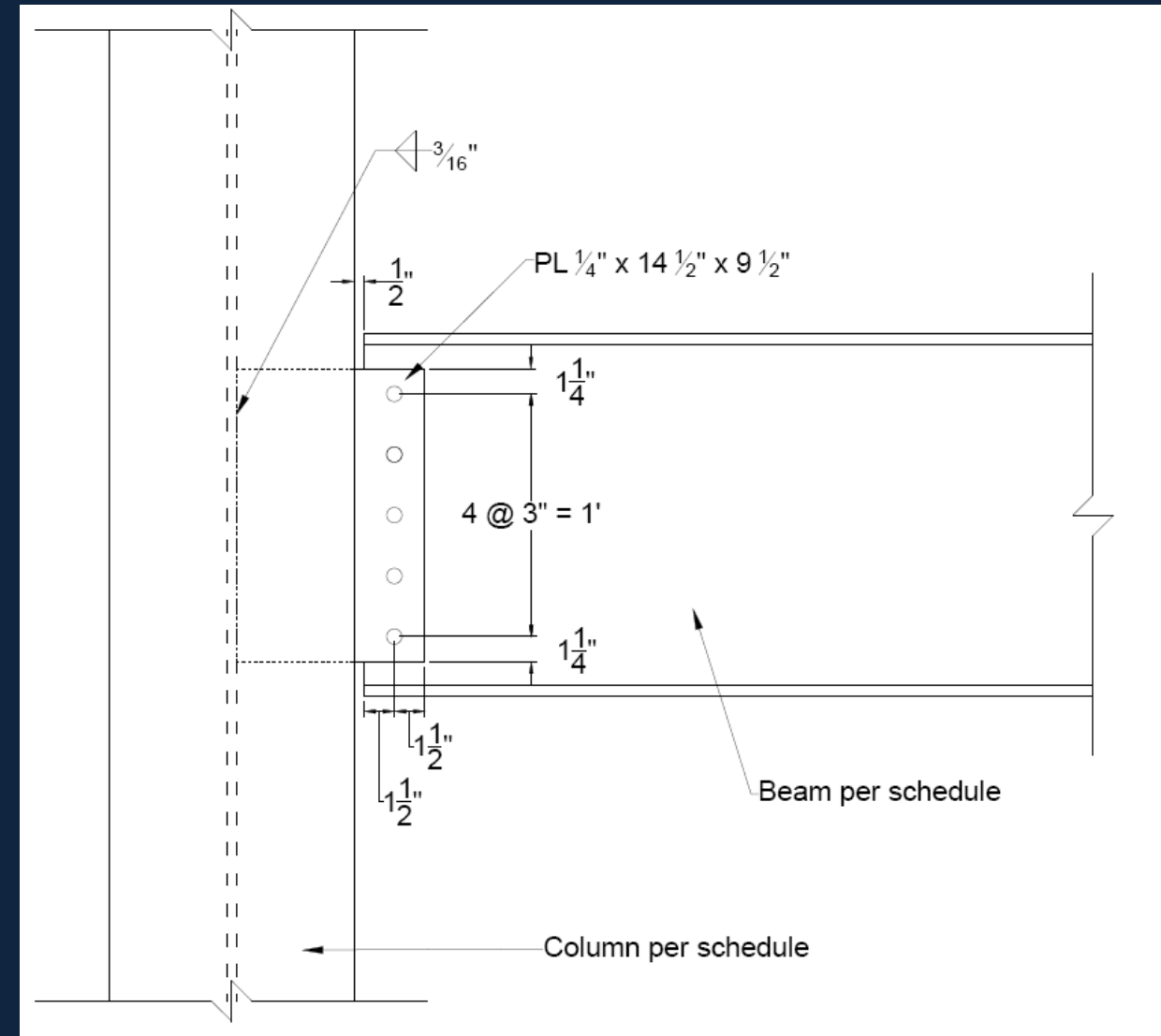


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# APPENDIX

# GRAVITY CONNECTIONS

- Building Overview
- Existing Building
- Problem Statement
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- Redesign
- Conclusion**



# HOTEL N.E.U.S.

# APPENDIX

# LATERAL AND DRIFTS

Building Overview

Existing Building

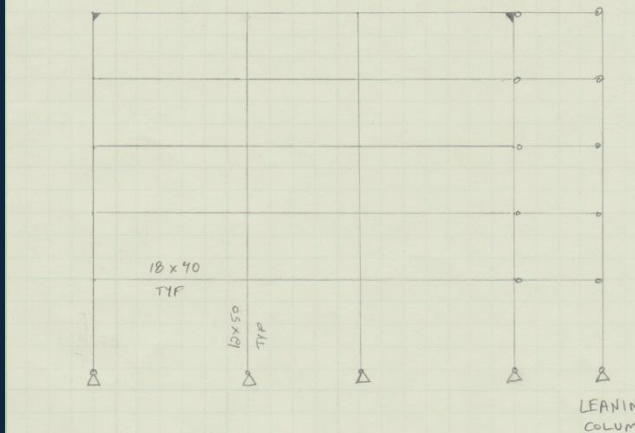
Problem Statement

Proposed Solution

Redesign

**Conclusion**

DIRECT ANALYSIS METHOD  
JORDAN RUTHERFORD



LEANING COLUMN LOADS

FLOOR	DEAD	LIVE
5	995 - 71 = 924	306 - 51.7 k = 254 k
4	1158 - 101 = 1057	545 - 87.3 k = 458 k
3	1158 - 101 = "	545 - " = "
2	1158 - 101 = "	545 - " = "
1	1145 - 101 = "	545 - " = "

DETERMINE  $B_1$

$$P_r = 200 \text{ k}$$

$$P_{ce} = \frac{\pi^2 EI}{(KL)^2} = \frac{\pi^2 (0.8)(29000 \text{ ksi})(1580 \text{ in}^4)}{[(1.0)(10)(10)]^2} = 15238 \text{ k}$$

$$B_1 = \frac{C_m}{1 - \frac{P_r}{P_{ce}}} = \frac{1}{1 - \frac{200}{15238}} = 1.016$$

DETERMINE  $B_2$

$$P_{story} = 7238 \text{ k}$$

$$R_n = 1 - 0.15 \frac{P_{MF}}{P_{story}} = 1 - \frac{(240 + 200 + 158 + 200)}{7238} = .98$$

$$P_{story} = R_n \frac{HL}{\Delta} = \frac{.98(140 \text{ k})(10)(10)}{.73} = 54880$$

$$B_2 = \frac{1}{1 - \frac{200}{54880}} = 1.15 < 1.5 \text{ METHOD OK } \checkmark$$

ANALYZE AN INT. COL BY DIRECT ANALYSIS METHOD  
ASSUME  $B_2 < 1.7$ , REDUCED STIFFNESS  
CONTROLLING LOAD COMBO:  $1.2D + 0.5L_p + 0.5S_p = 1.6W$   
FIRST ORDER ANALYSIS w/ REDUCED STIFFNESS  $F_u = 240 \text{ k}$   $\Delta_m = 0.33$   $M_u = 135 \text{ ft-k}$   
TRIB AREA =  $(97')(13.39') = 1293 \text{ ft}^2$   
LOAD TO FRAME =  $(63 \text{ psf})(1293 \text{ ft}^2) = 81.5 \text{ k}$   
 $(200 \text{ psf})(97') = 19.4 \text{ k}$  DEAD  
 $(60 \text{ psf})(1293 \text{ ft}^2) = 77.6 \text{ k}$   
 $(100 \text{ psf})(97') = 9.7 \text{ k}$  LIVE  
 $(55 \text{ psf})(1293 \text{ ft}^2) = 71 \text{ k}$  ROOF DEAD  
 $(40 \text{ psf})(1293 \text{ ft}^2) = 51.7 \text{ k}$  SNOW

AMPLIFIED AXIAL LOAD:

$$P_r = P_u + B_2 P_{e1} = 240 + 1.15(0) = 240 \text{ k}$$

$$P_y = A F_y = 42.7(50) = 2135$$

$$\frac{\alpha P_r}{P_y} = \frac{1.0(240)}{2135} = .112 < .5 \therefore r_b = 1.0$$

$$P_c = 1750 \text{ k @ } 10'$$

$$\frac{P_r}{P_c} = \frac{240}{1750} = .137 < .2 \text{ HI-1b}$$

Floor	Displacement		Drift		Allowable Displacement (in)
	X direction (in)	Y direction (in)	X direction (in)	Y direction (in)	
5	0.54924	0.63710	0.04477	0.10257	1.68
4	0.50447	0.53453	0.05847	0.12077	1.35
3	0.44600	0.41376	0.07073	0.13321	1.02
2	0.37527	0.28055	0.08812	0.13653	0.69
1	0.28715	0.14402	0.28715	0.14402	0.36

Floor	Seismic Drift and Displacement						Allowable Drift (in)
	Displacement			Drift			
	X direction (in)	Cd	Total	Y direction (in)	Cd	Total	
5	1.19952	3.00	3.59856	0.5272	3.25	1.7134	2.64
4	1.09567	3.00	3.28701	0.4378	3.25	1.4229	2.64
3	0.94893	3.00	2.84679	0.3257	3.25	1.0584	2.64
2	0.77525	3.00	2.32575	0.2030	3.25	0.6598	2.64
1	0.58089	3.00	1.74267	0.0863	3.25	0.2804	2.88



# HOTEL N.E.U.S.

# APPENDIX

# FOOTING GRAPHS

- Building Overview
- Existing Building
- Problem Statement
- Proposed Solution
- Redesign
- Conclusion**

