# La Jolla Commons Phase II Office Tower

San Diego, California

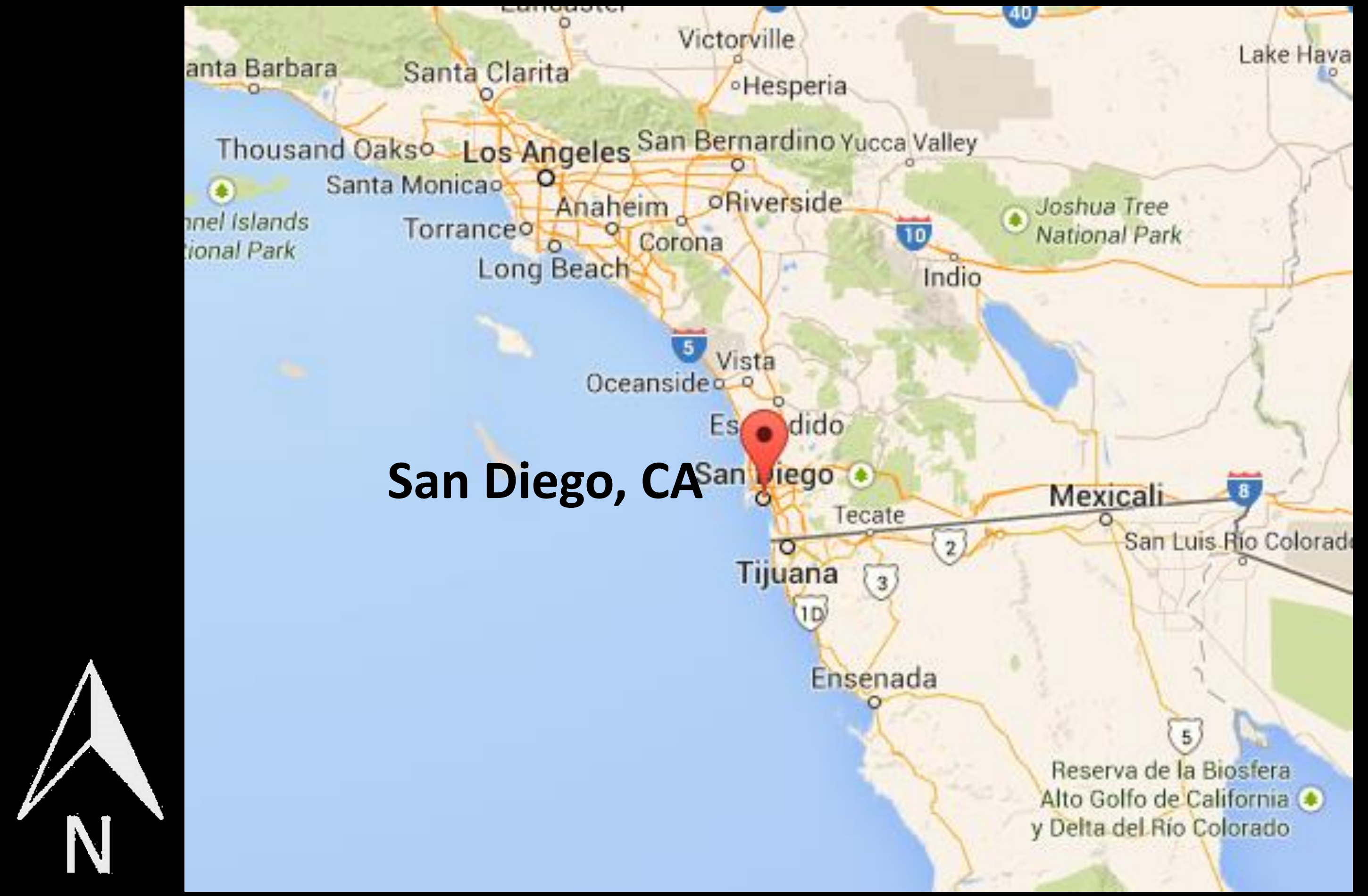
Alyssa Stangl | Structural Option
Faculty Advisor | Dr. Hanagan

*Photos Provided Courtesy of HINES*

- **Building Introduction**
- Design Scenario and Proposed Solution
- Gravity Redesign
  - Preliminary Vibrations and Layout
  - Beam and Column Designs
  - Final Vibrations Analysis
- Lateral Redesign
  - Layout
  - Moment Frames
  - Shear Walls
- Architecture Breadth
- Construction Breadth
- Conclusions

# Building Introduction

- Location | San Diego, California – SDC D
- 13 Stories + Penthouse | 198’ – 8”
- 2 Levels | Underground parking
- 462,301 GSF
- Design-Bid-Build
- Construction Dates | April 2012 – May 2014
- Building Cost | $78,000,000



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# Project Team

- **Owner** | Hines
- **Tenant** | LPL Financial
- **Architect** | AECOM
- **Structural Engineer** | Nabih Youssef Associates

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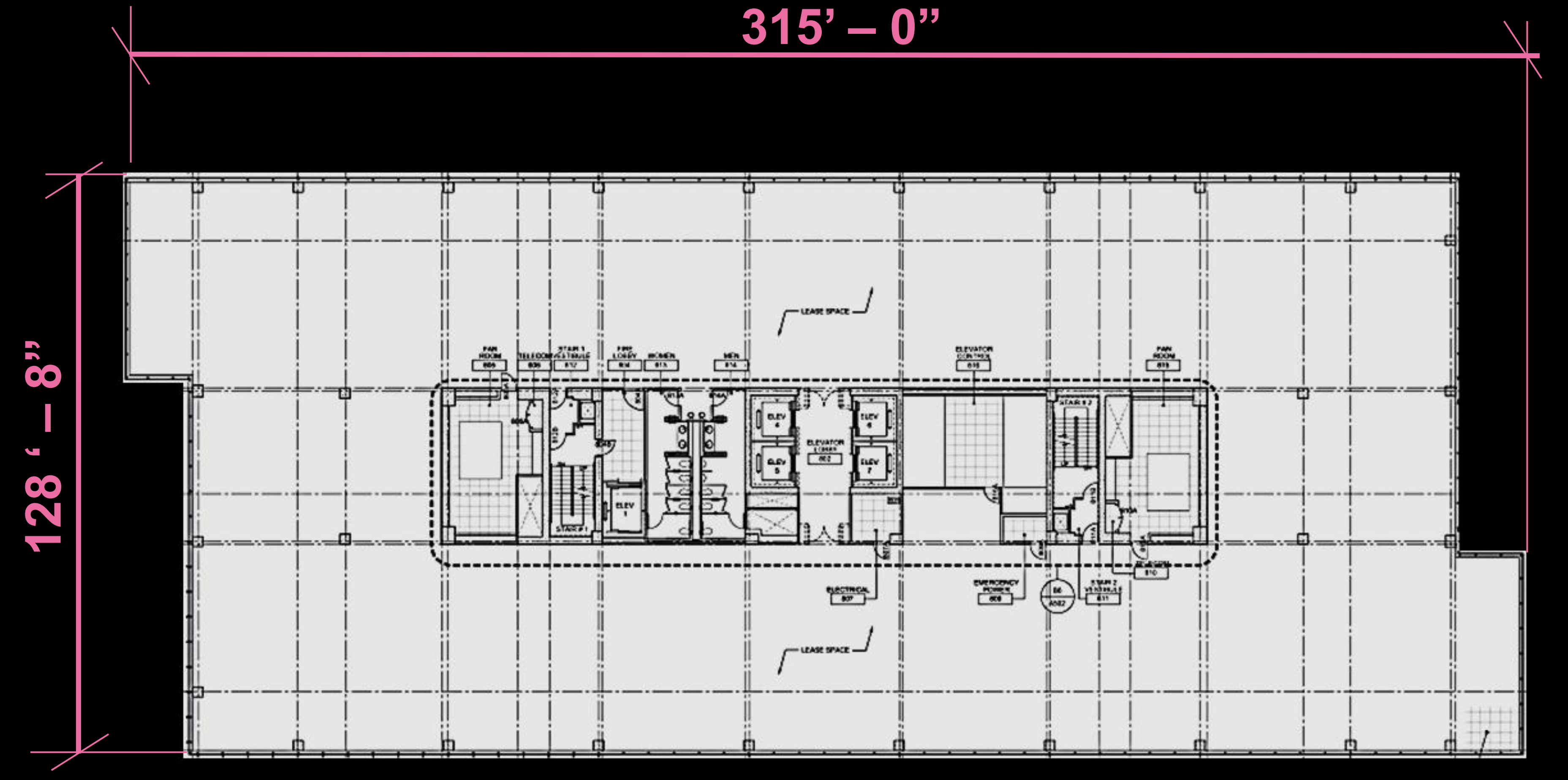
# Architectural Overview

- Large open floor plans
- Office use only
- Similar architecture to LJC Tower I
- 198'-8" height limited by FAA
- LEED-CS Gold & NetZero

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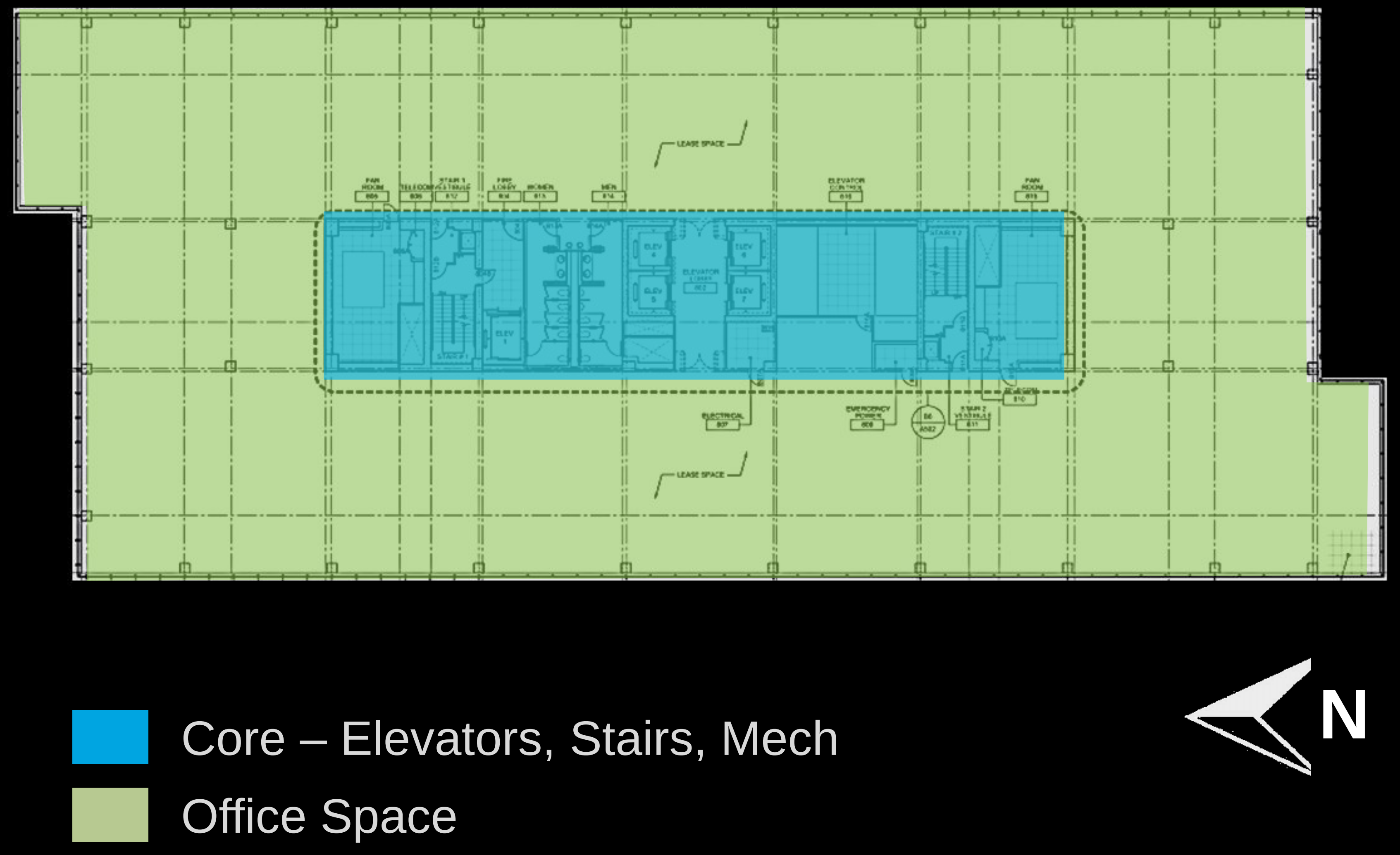

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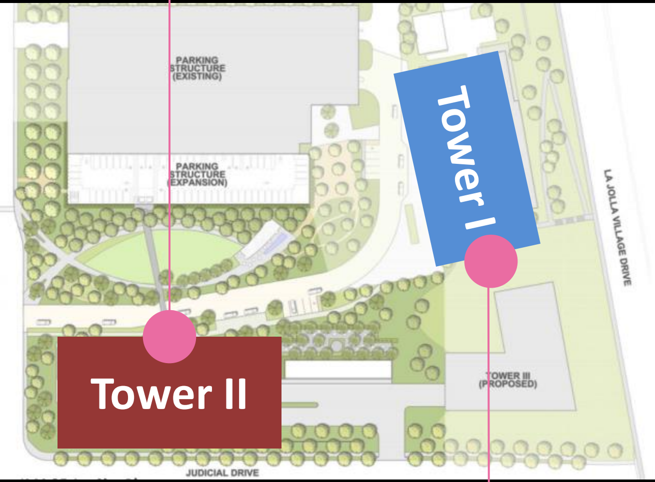


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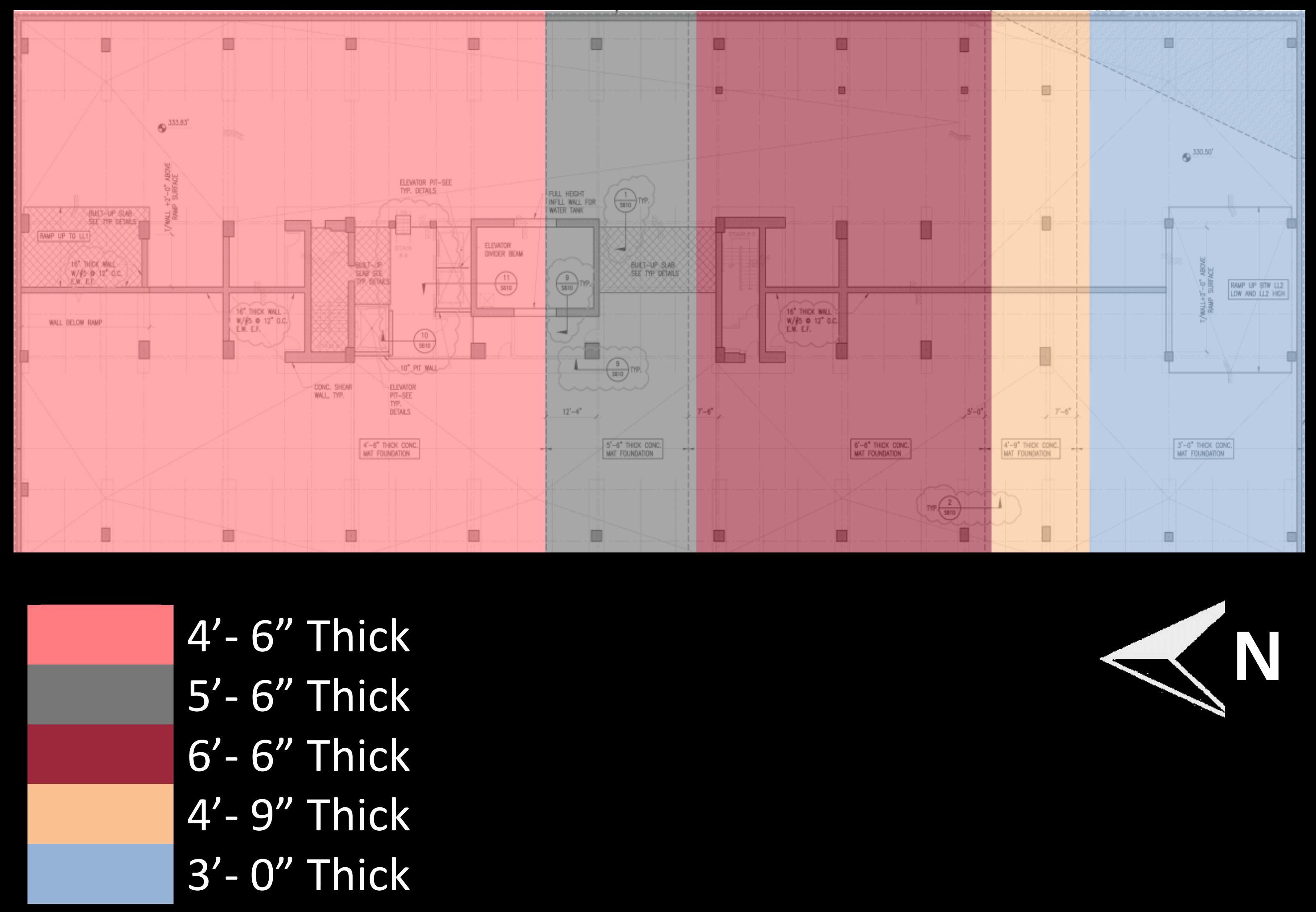
# Existing Structural Overview

- **Gravity System**
  - **Mat foundation**
  - Floor System
- Lateral System
  - Shear Walls
  - Collectors

*Image from Project Documents Provided Courtesy of HINES*



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# Existing Structural Overview

- **Gravity System**
  - Mat foundation
  - **Floor System**
    - Two-Way, Flat Plate Concrete Slab
    - 10" – 14" Thickness
    - 18" Spandrel Beam
- Lateral System
  - Shear Walls
  - Collectors

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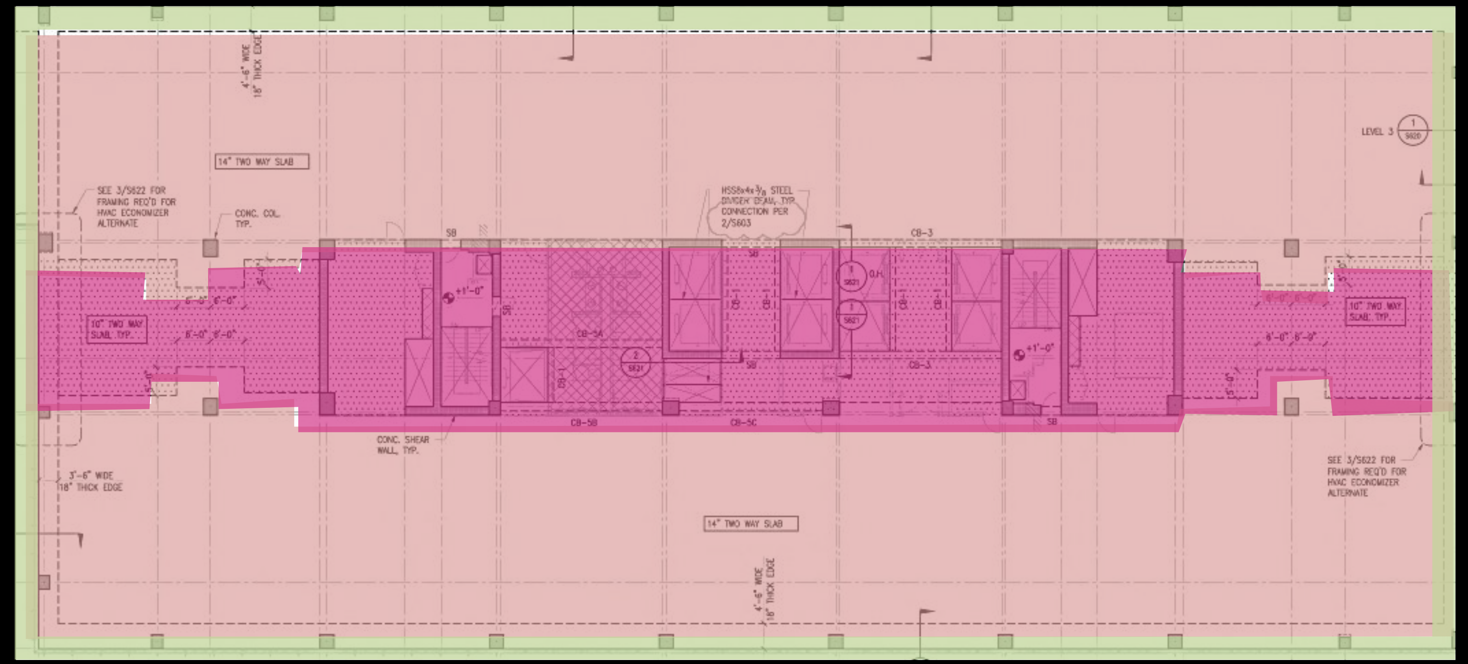

18" Thick Spandrel Beam
10" Thick Core Slab
14" Thick Slab

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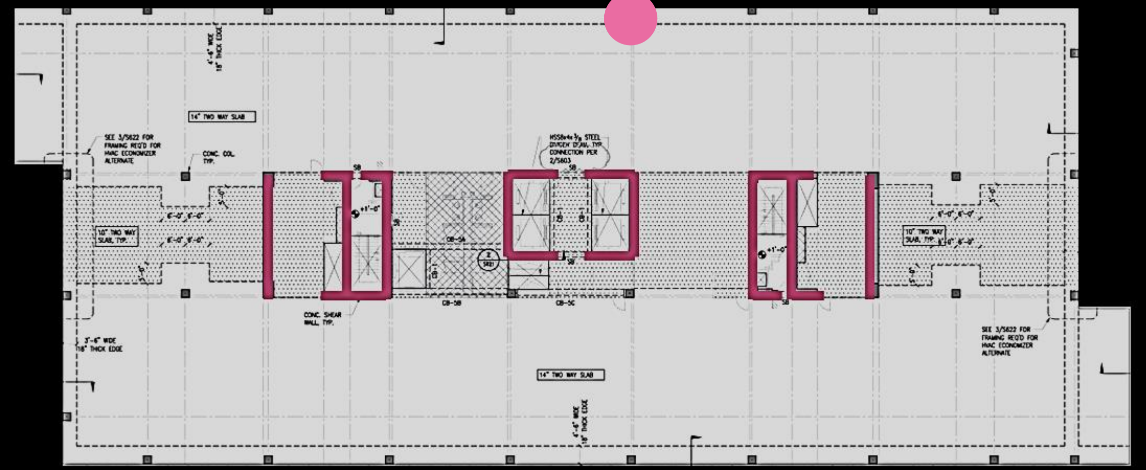
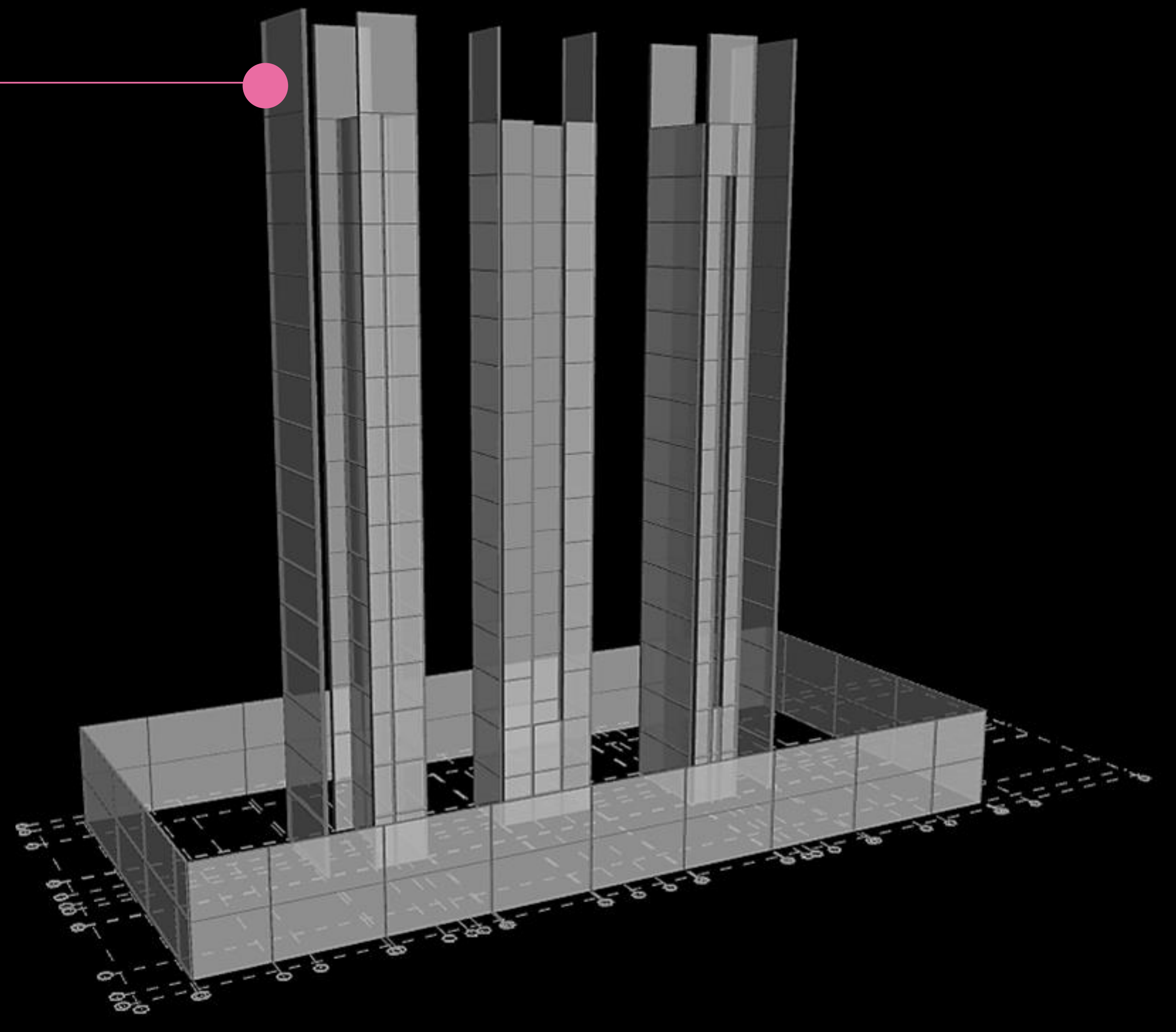
# Existing Structural Overview

- Gravity System
  - Foundation
  - Floor System
- Lateral System
  - **Shear Walls**
    - Existing Torsional Irregularity
  - Collectors





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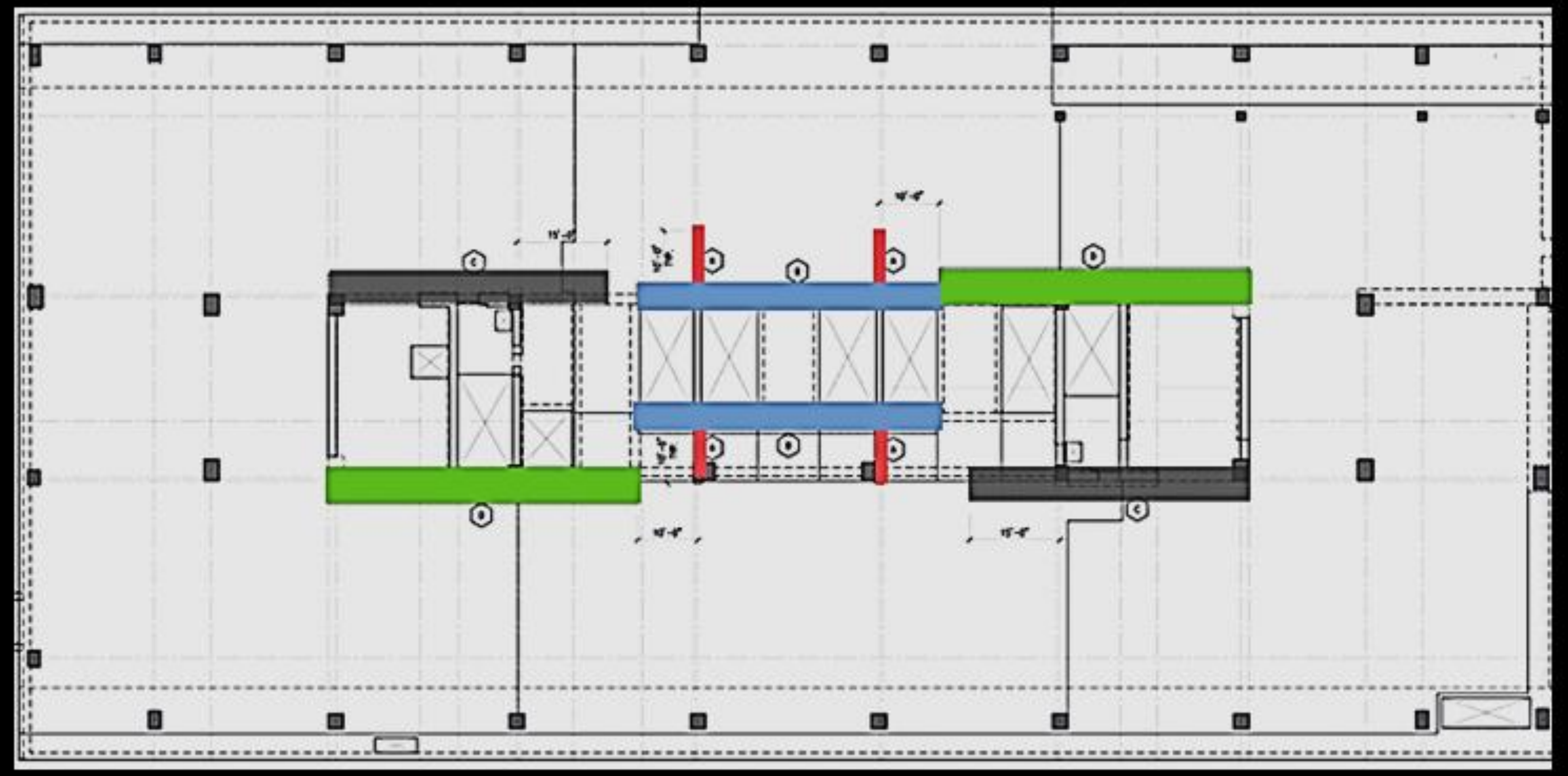
# Existing Structural Overview

- Gravity System
  - Foundation
  - Floor System
- **Lateral System**
  - Shear Walls
  - **Collectors**
    - N-S Direction at Lower Levels

*Image from Project Documents Provided Courtesy of HINES*



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# La Jolla Commons Office Tower



## Design Scenario

- Redesign the building in steel
- Modify lateral system to eliminate existing torsional irregularity
- Determine Impact
  - Architecture
  - Serviceability – Walking induced vibrations
  - Cost and schedule

## Proposed Solution

- Use original column locations
- Determine configuration of composite steel beams to control vibrations
- Add steel moment frames to building perimeter to control torsion
- Determine floor-to-ceiling height impact
- Compare costs and schedules

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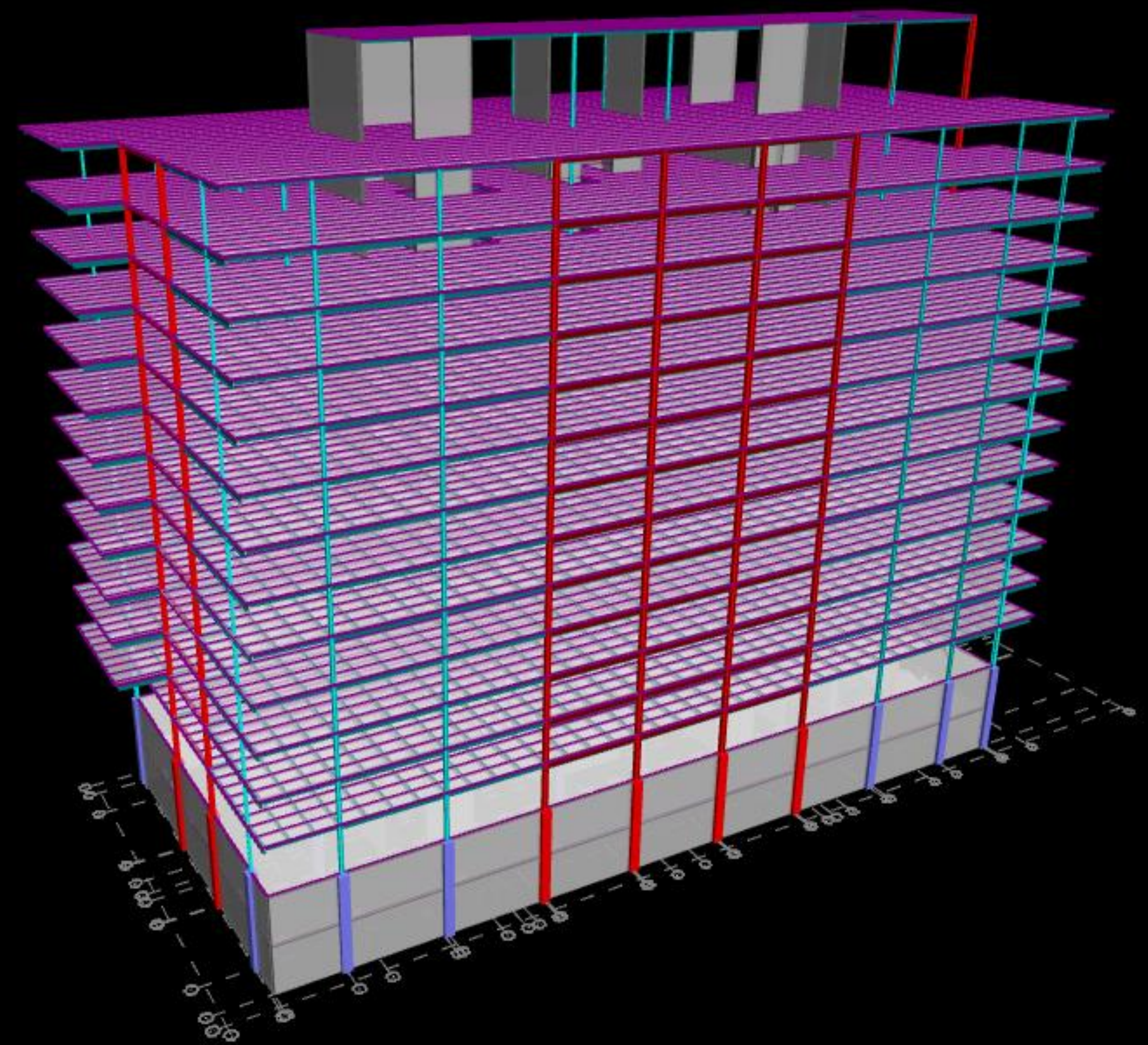
## Gravity Redesign



# La Jolla Commons Office Tower



# Preliminary Vibrations Analysis

- Vibrations due to human excitation
- Control peak acceleration of the bay

Design Selection:

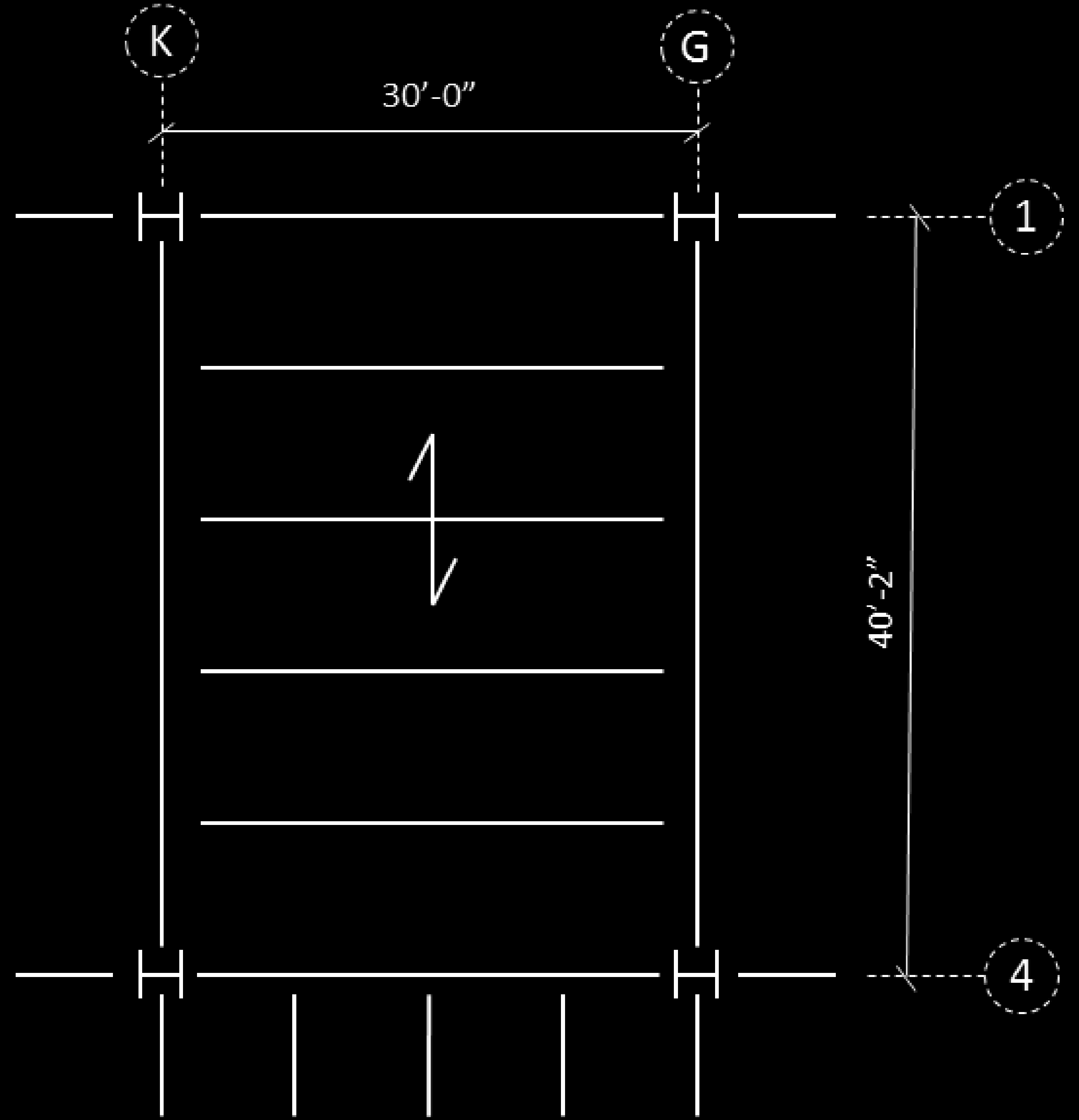
- 1.5VLR20
- 4.25” LW Topping
- 7.5’ – 8’ beam spacing

Source: *The Preliminary Assessment for Walking-Induced Vibrations in Office Environments* by Dr. Linda Hanagan and Taehoo Kim

| Deck Configuration for Vibration Control | |
|---|---|
| Concrete Strength | 3000 psi |
| Steel Grade | 50 |
| Deck Type | 1.5VLR20 |
| Topping (in) | 4.25 |
| LW/NW? | LW |
| Total Slab Thickness (in) | 5.75 |
| Class | 4 |
| Select C1 | 0.413 |
| Select C2 | 0.019 |
| Evaluate C1 + C2 | 0.432 |
| C1 + C2 < 0.5? | GOOD |

# Gravity System Layout

- Which direction to span infill beams?
  - **Short**
  - Long
- Long Direction Selected



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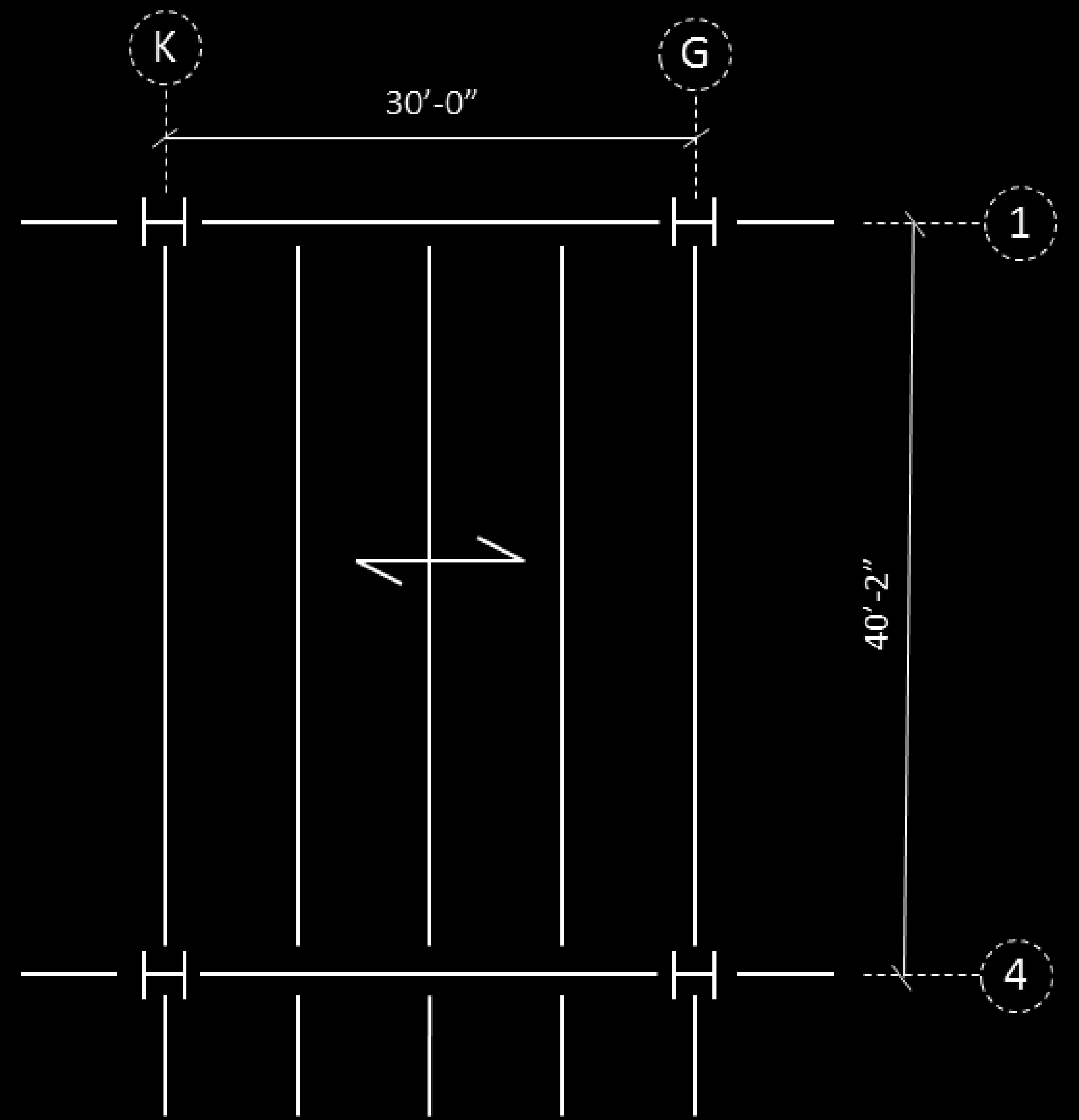

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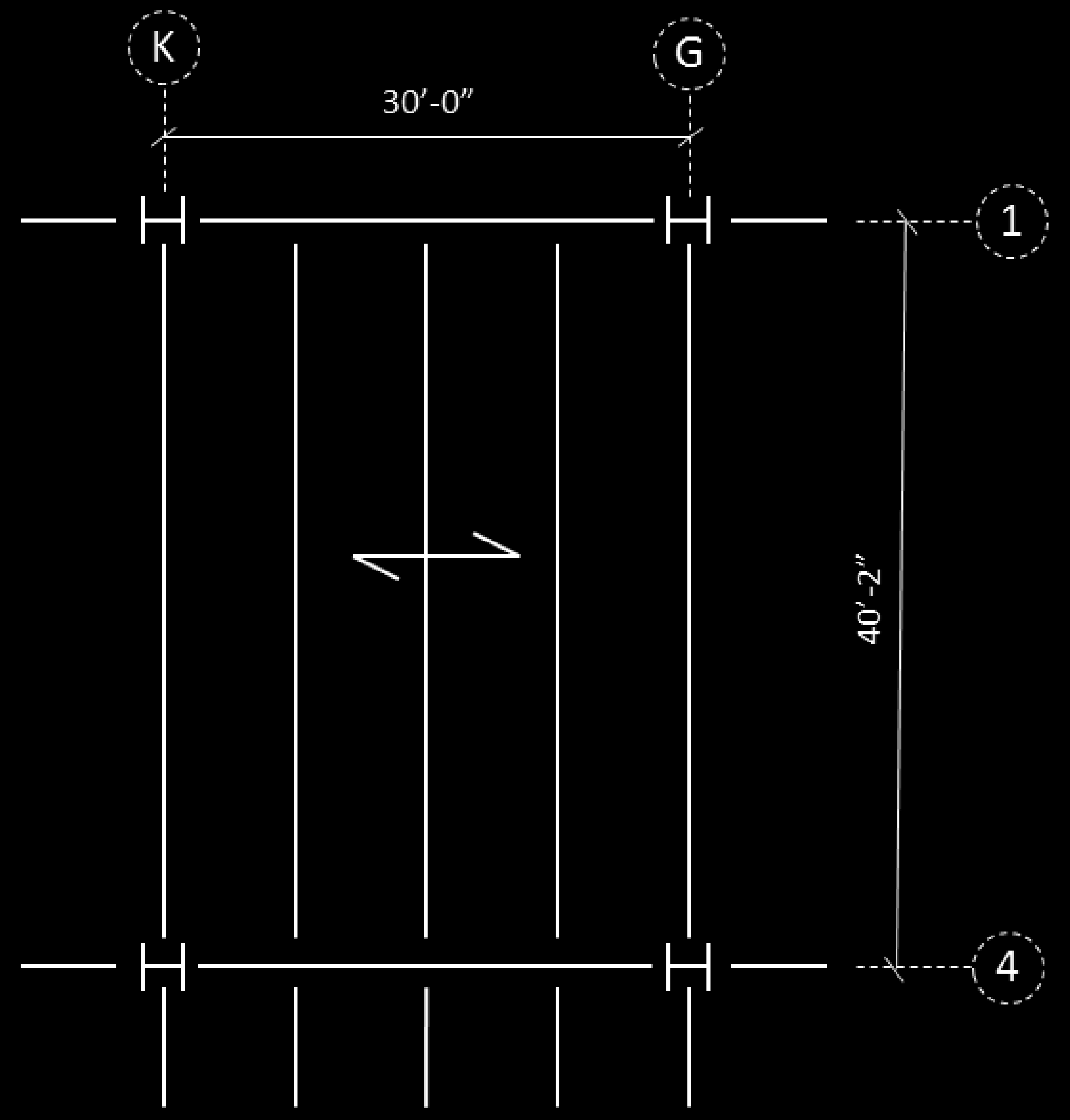
# Gravity System Layout

- Which direction to span infill beams?
  - Short
  - Long
- **Long Direction Selected**

**Infill Beam Comparison**

| | Steel Weight (lbs) | Number of Members |
|---|---|---|
| Long Direction | 212936 | 155 |
| Short Direction | 179608 | 225 |



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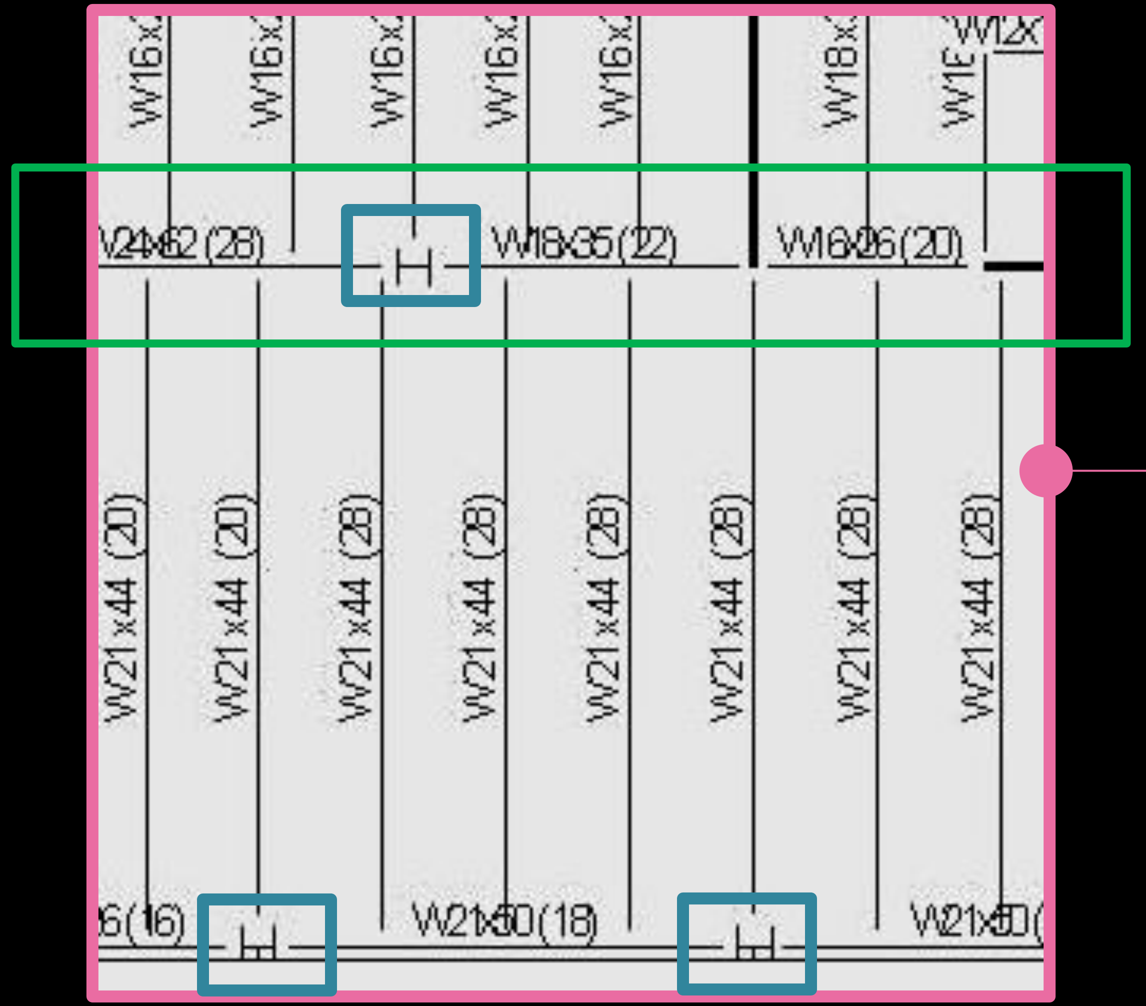
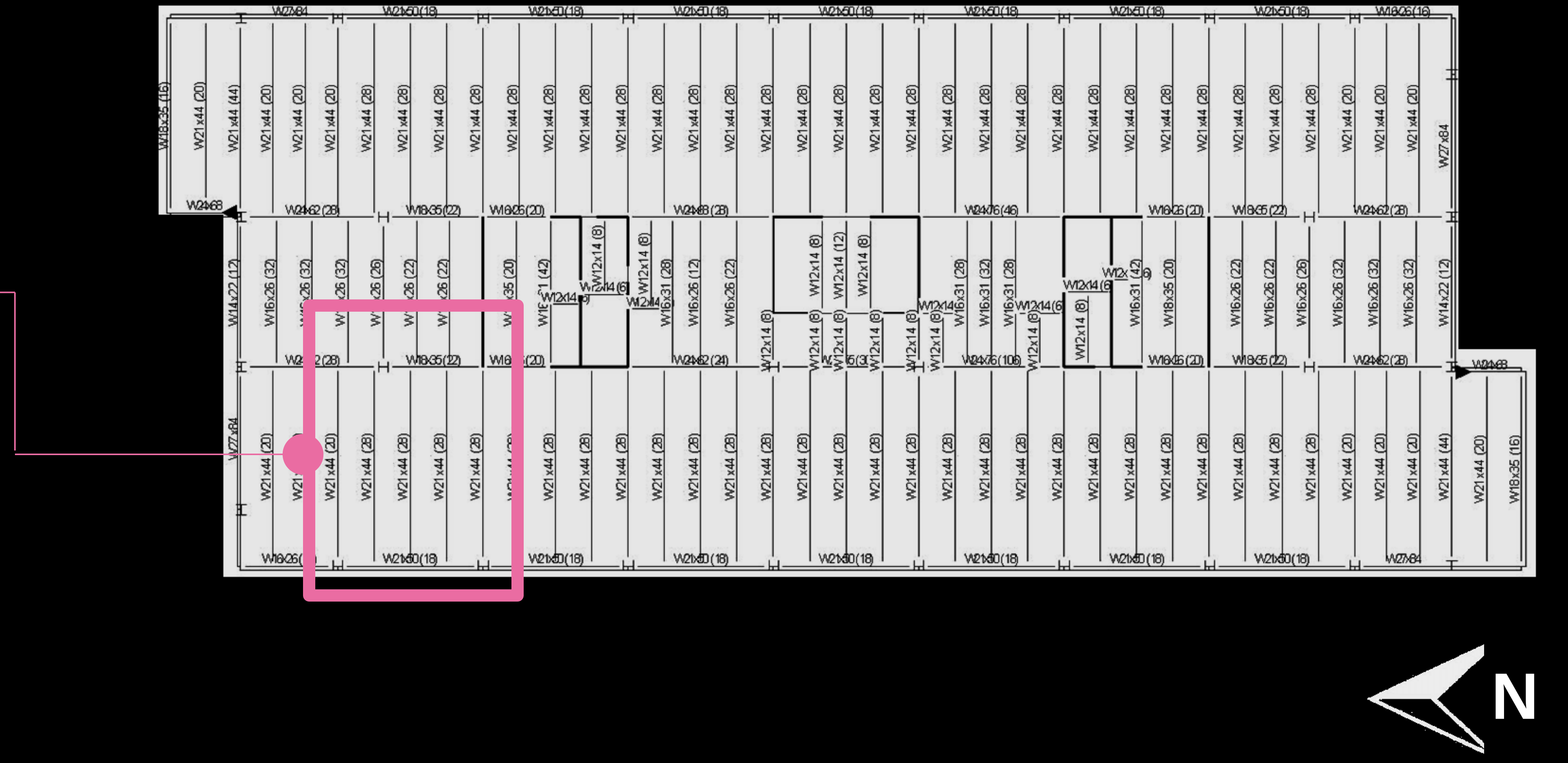
## Gravity System Layout

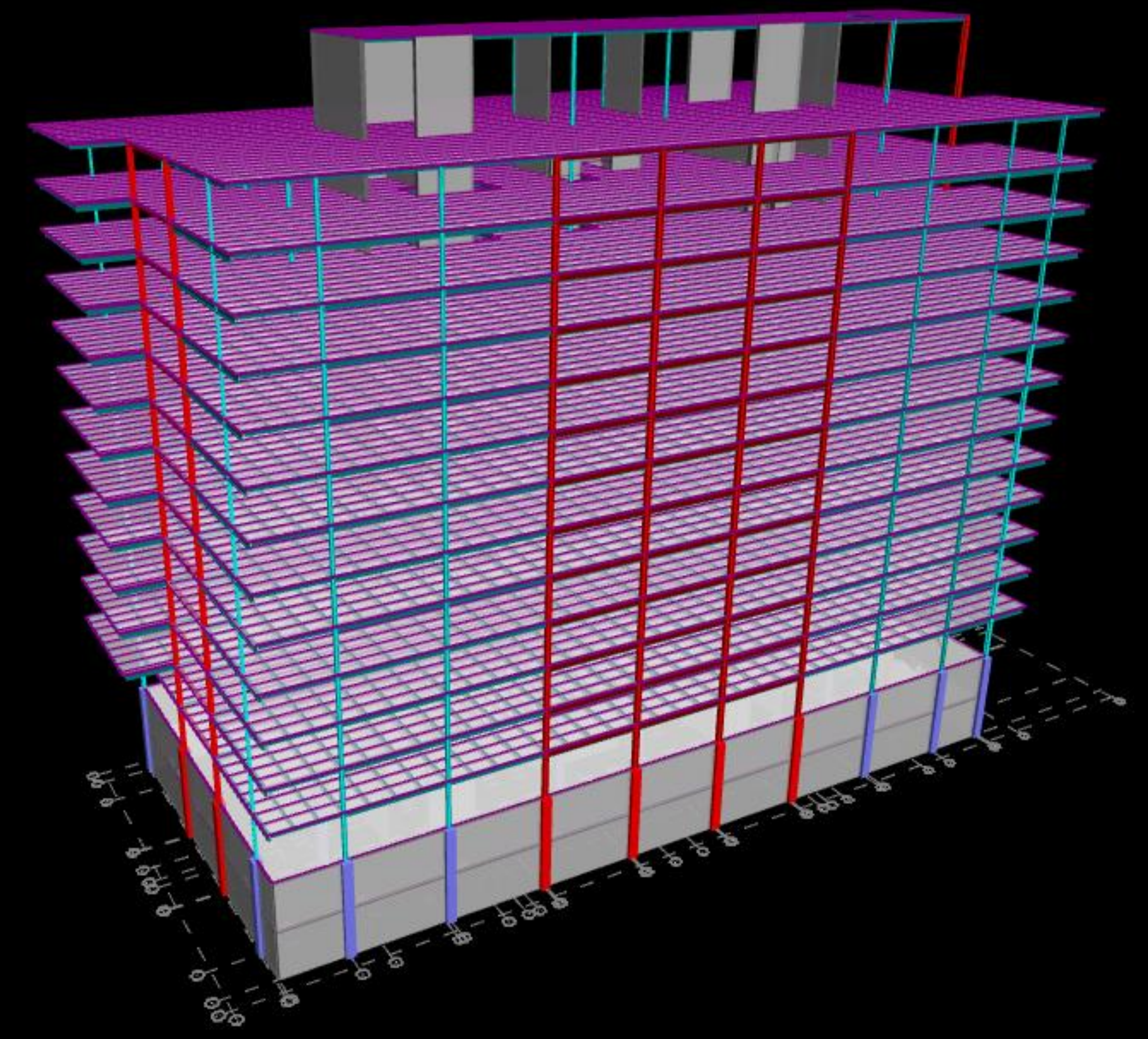


# RAM Gravity Model

- RAM SS used to develop gravity designs
  - Composite steel beams
  - Steel columns
- Several designs verified by hand calculations

| Gravity Loads | | |
|---|---|---|
| | Dead (PSF) | Live (PSF) |
| Core | 90 | 250 |
| Lease Space | 90 | 80 |



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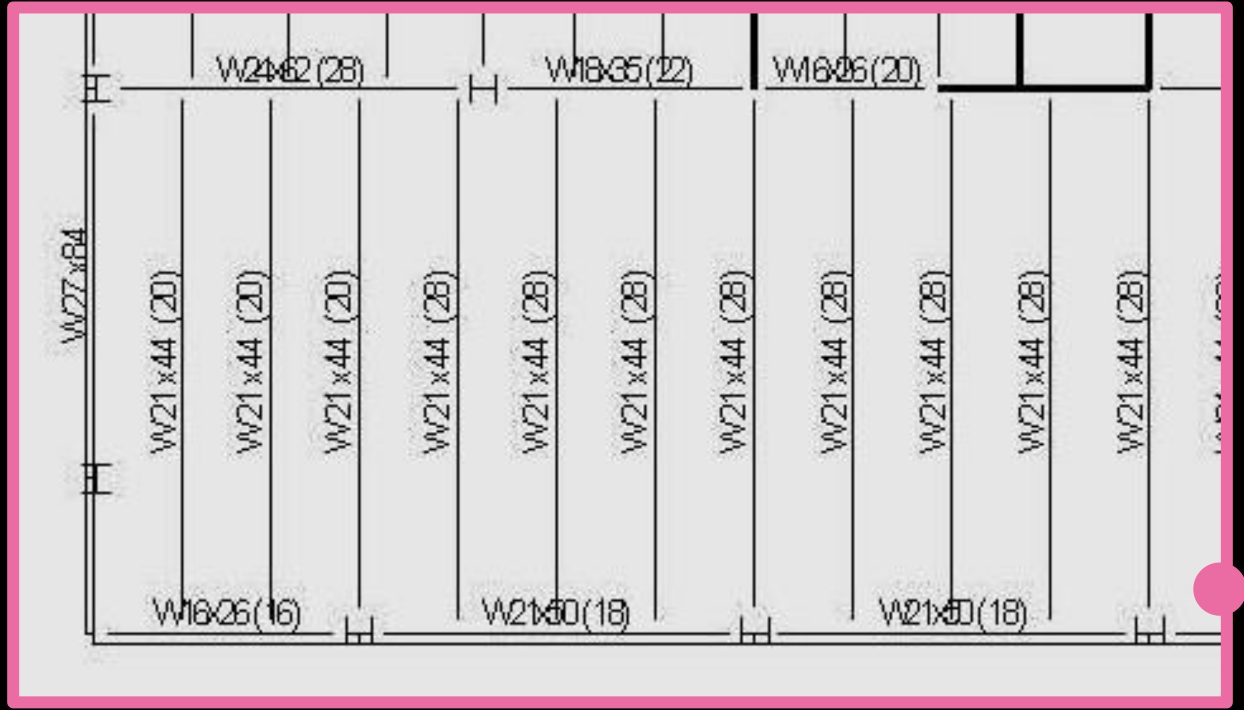
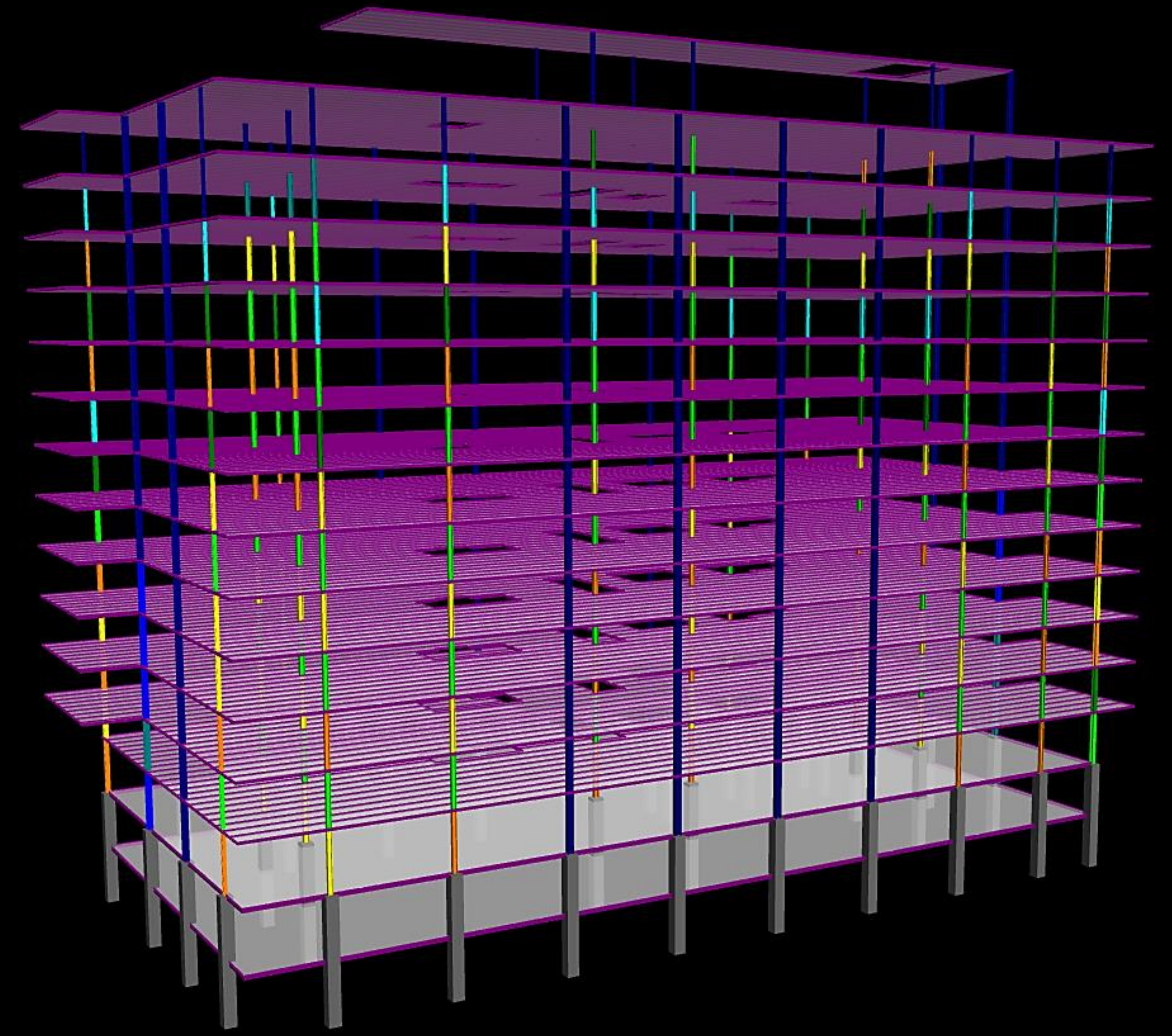
# Beam Designs

- Common Member Sizes:
  - W21x44 (28) infill exterior bays
  - W24x62 (32) infill interior bays
  - W21x50 (18) exterior girder




# Column Designs

- Spliced every 2 stories
- Each column line has consistent column depth



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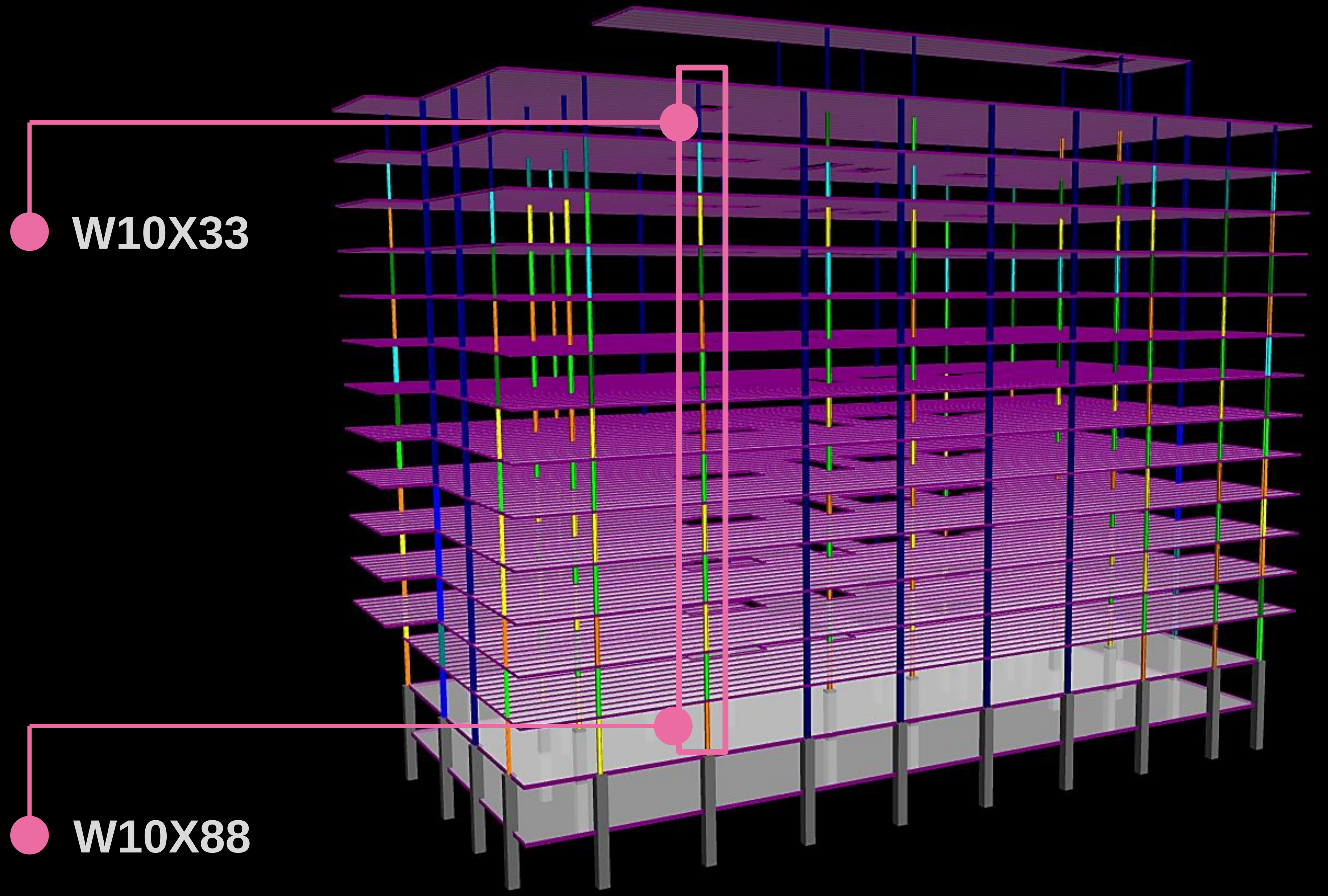
# Column Designs

- Spliced every 2 stories
- Each column line has consistent column depth
  - **Exterior Column Line**



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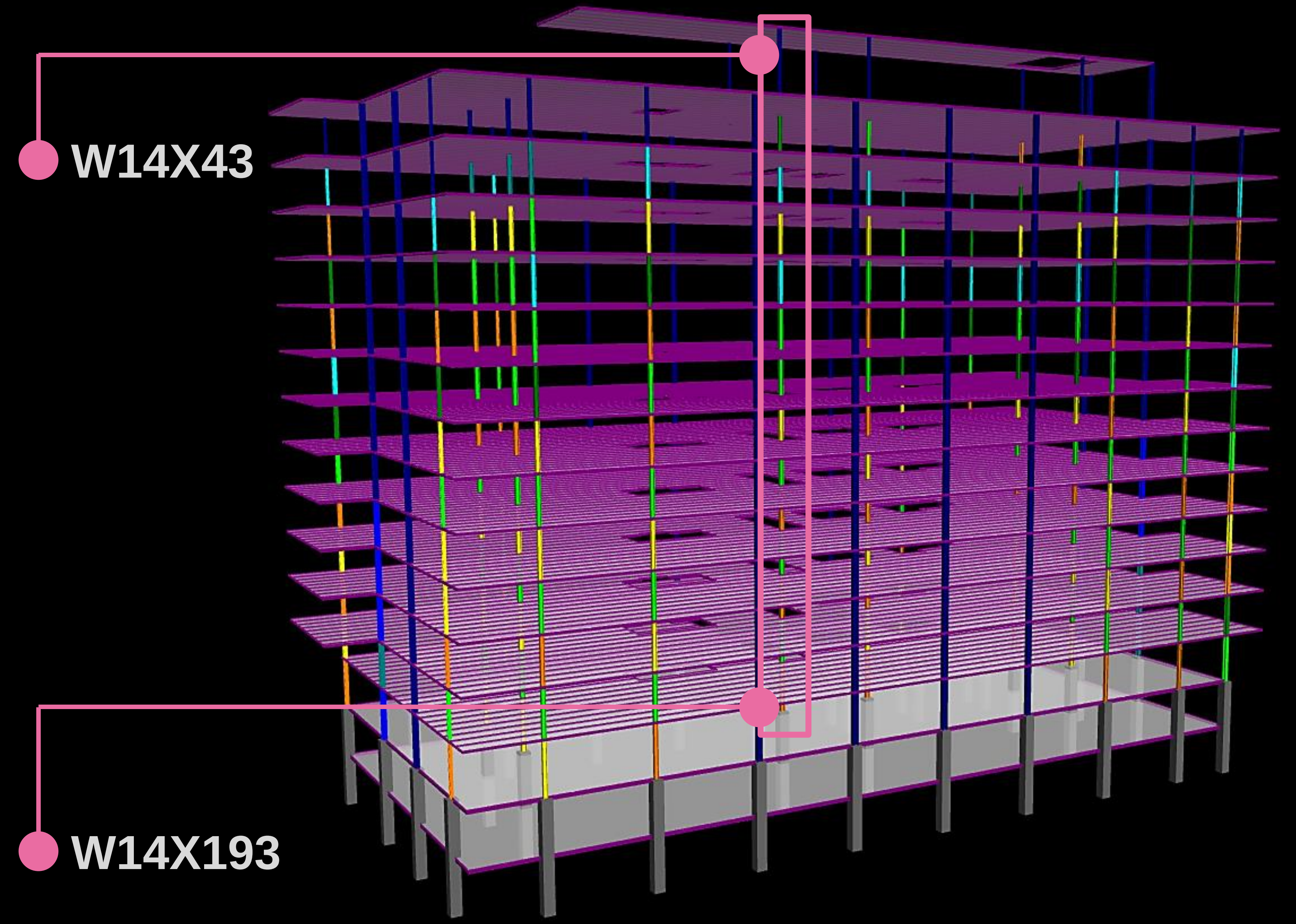
## Column Designs

- Spliced every 2 stories
- Each column line has consistent column depth
  - Exterior Column Line
  - **Interior Column Line**



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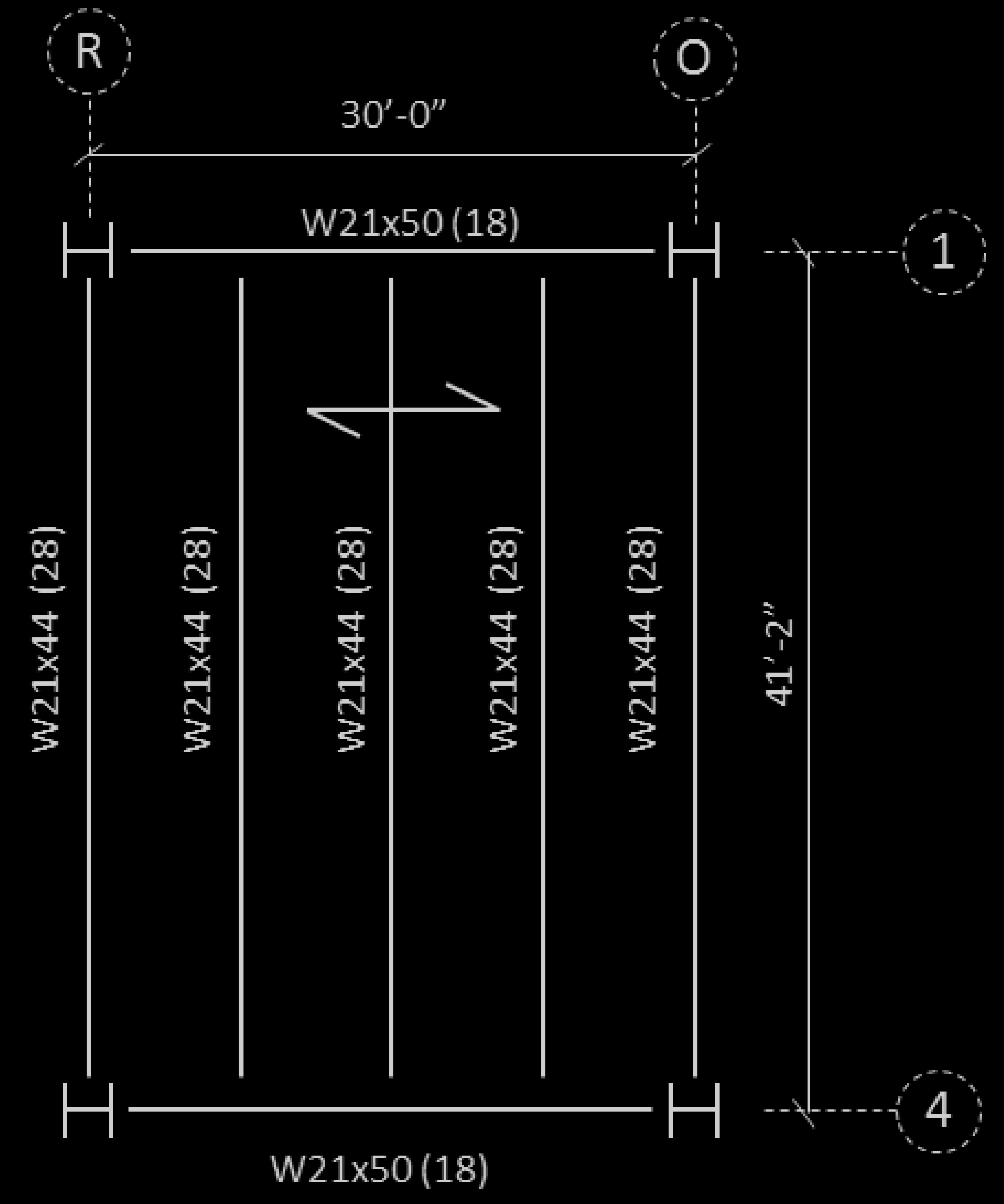
# Final Vibrations Analysis

- AISC *Design Guide 11* analysis on a typical bay for walking induced vibrations
- Determine combined panel weight and natural frequency to determine bay peak acceleration
  - $P_0$ = 65 lb
  - $\beta$ = 0.03
  - $a_0/g$ < 0.5%

From AISC DG 11 – Table 4.1

$$\frac{a_0}{g} \geq \frac{a_p}{g} \rightarrow 0.5\% \geq 0.38\%$$



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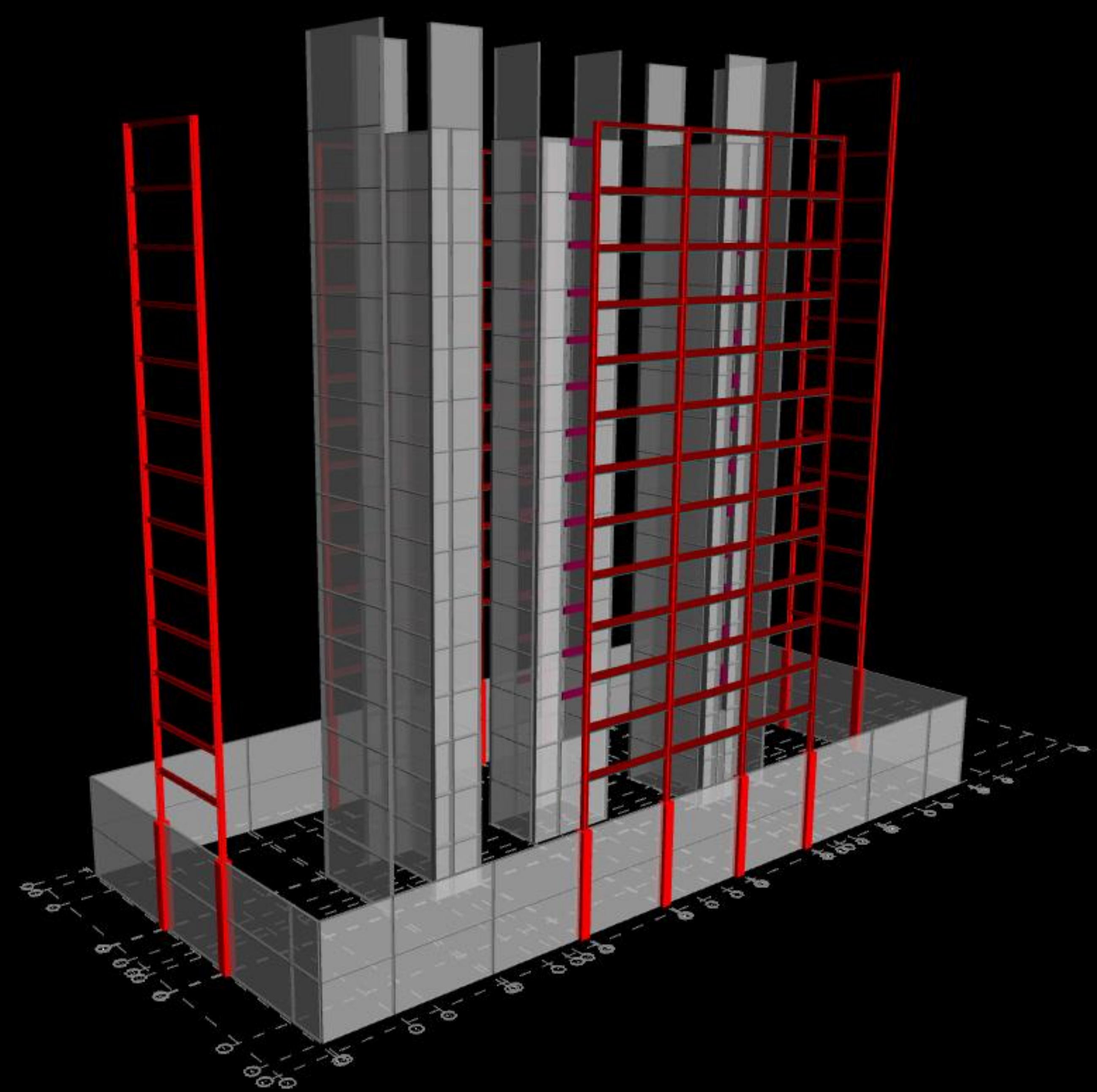
## Lateral Redesign



# Lateral System



- Reduced building weight
  → Seismic loads decreased

- Building height unchanged
  → Wind loads unchanged

- **Seismic controls**

| Base Shear (Kip) | | | | |
|---|---|---|---|---|
| | Wind N-S | Wind E-W | Seismic N-S | Seismic E-W |
| Concrete | 583 | 1615 | 7698 | 7698 |
| Steel | 583 | 1615 | 4935 | 4408 |

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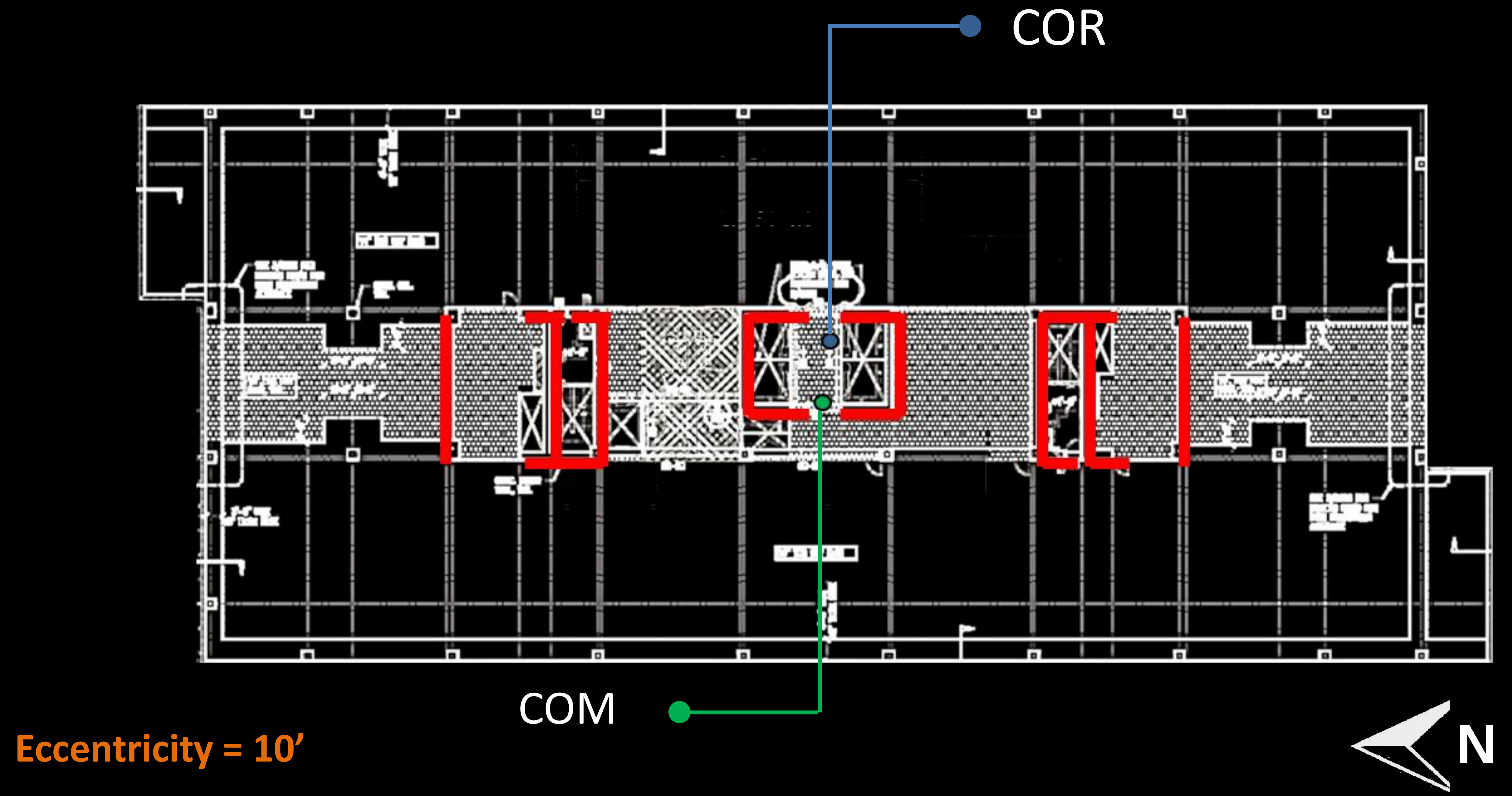
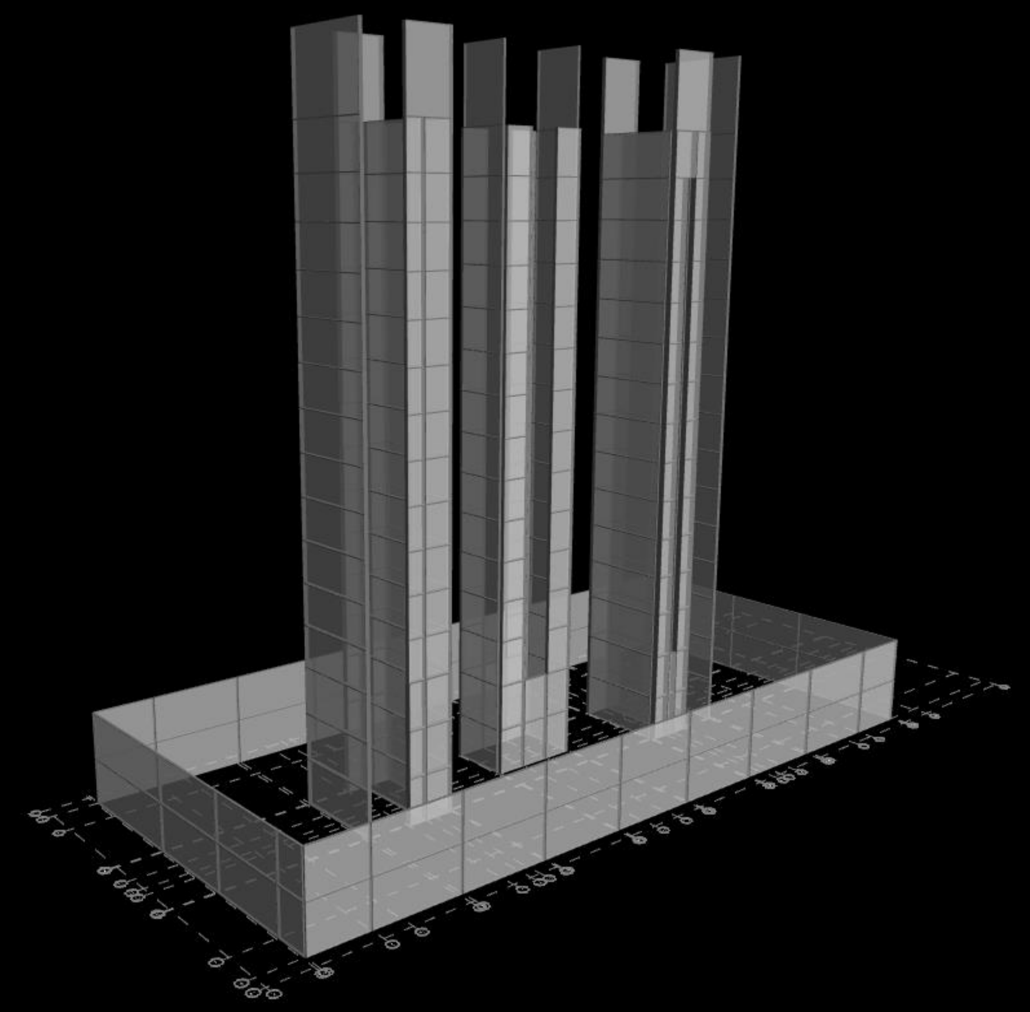
# Existing Lateral System Layout



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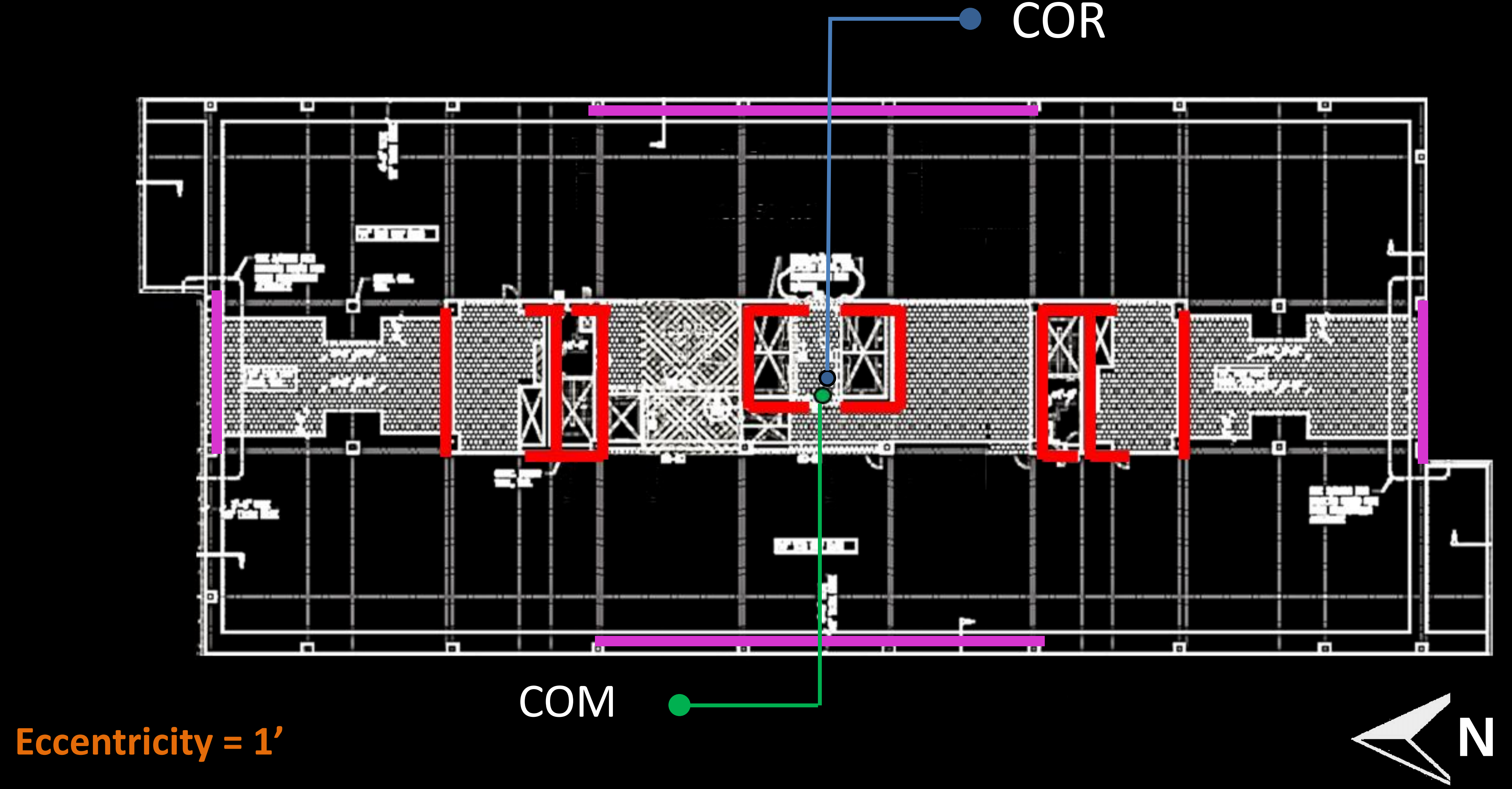
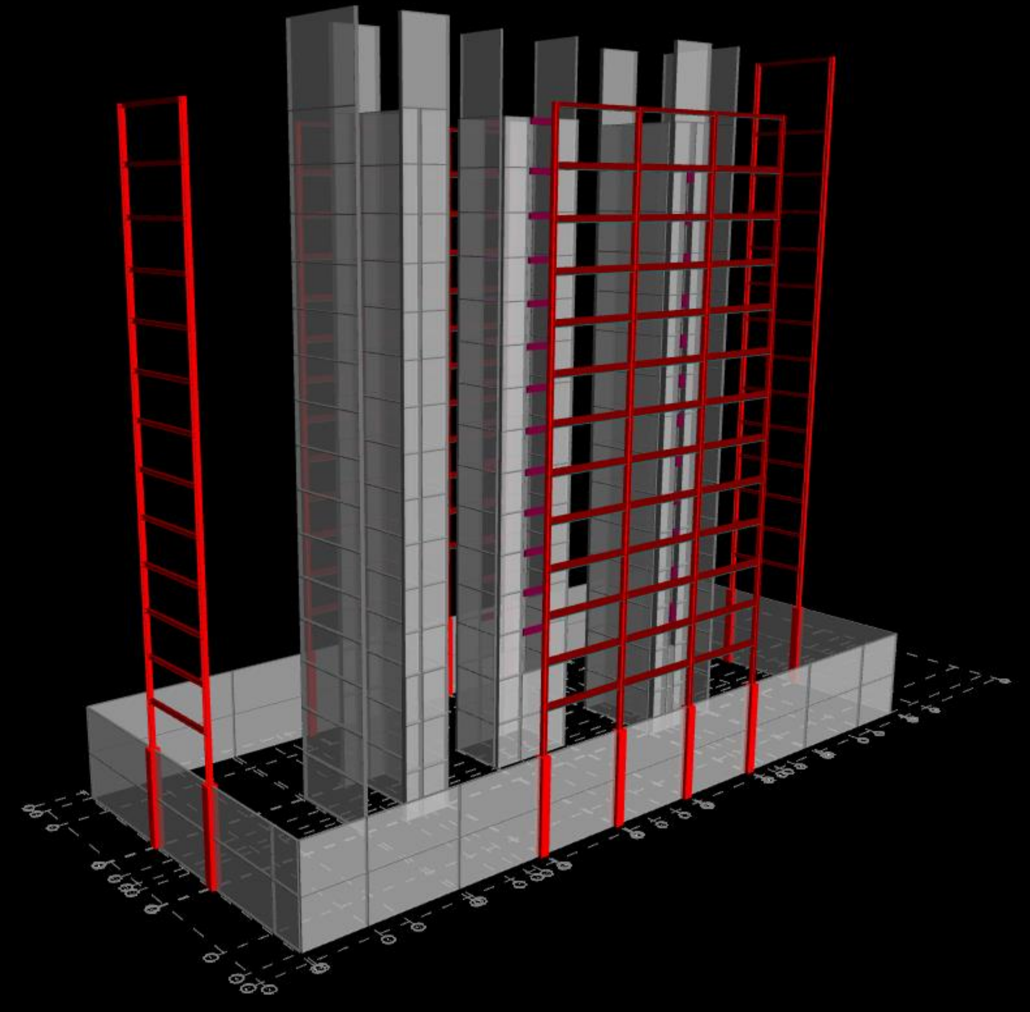
## New Lateral System Layout



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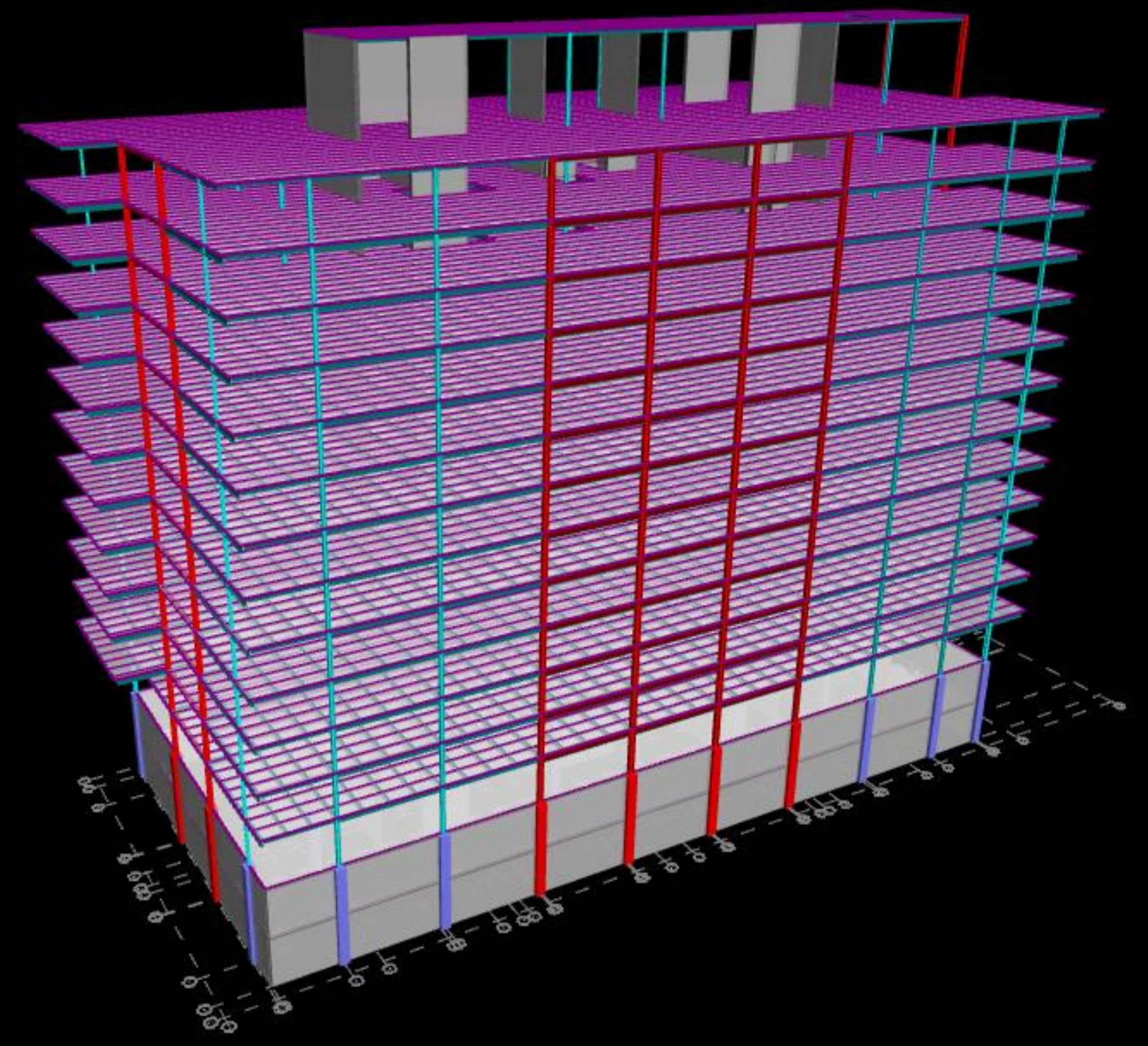
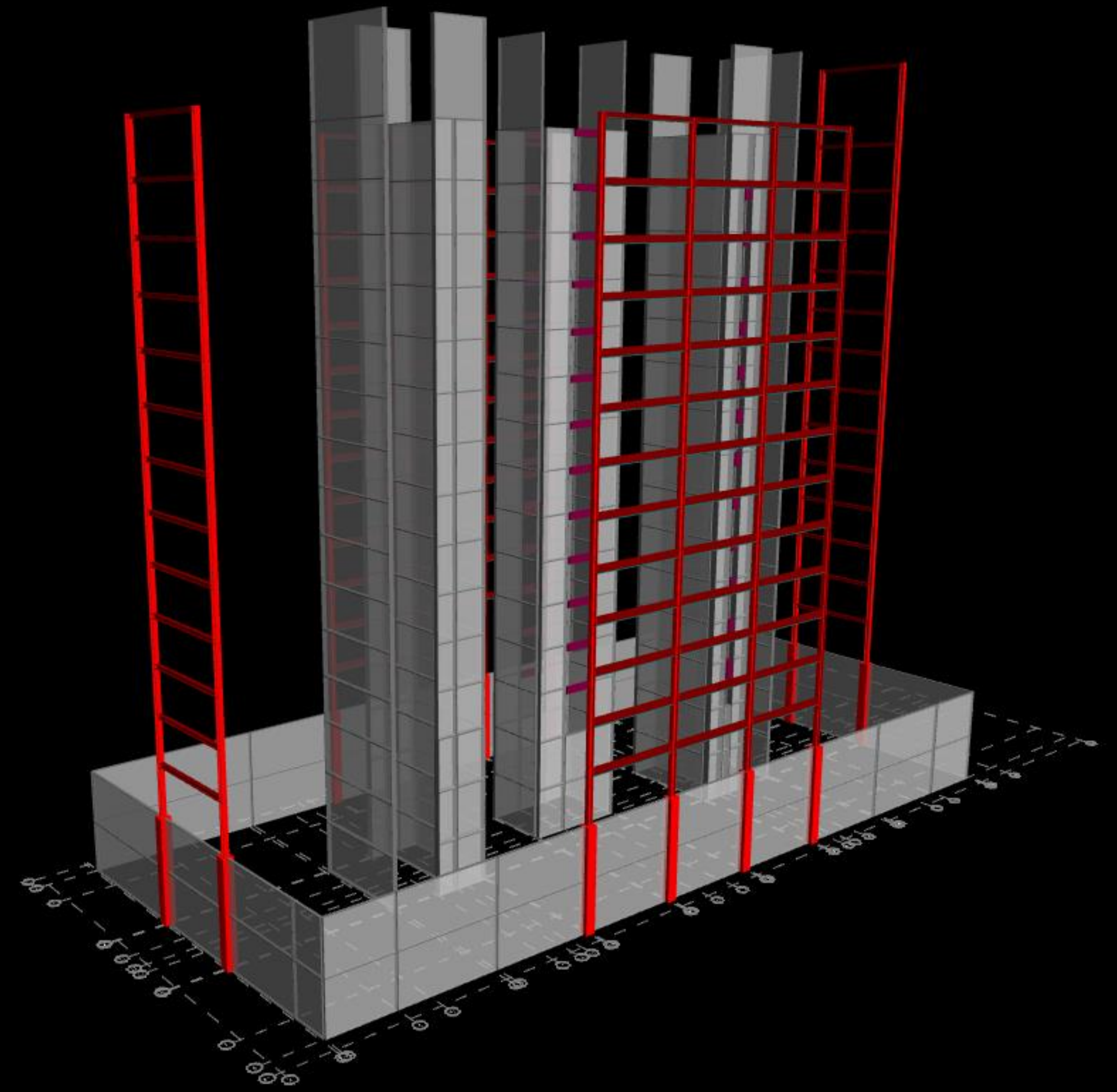
## RAM Model

- Rigid diaphragms
- Wall shell elements neglect out of plane stiffness
- Stiffness reduction based on ACI 318-11
- Panel zone deformations considered
- Base constraints



# Special Moment Frames

- Special moment frames required by ASCE 7-10
  - SDC D
  - 198’ > 65’
- Designed to be “clean column”
  - Strong panel zone
- Strength and joint optimizations for seismic



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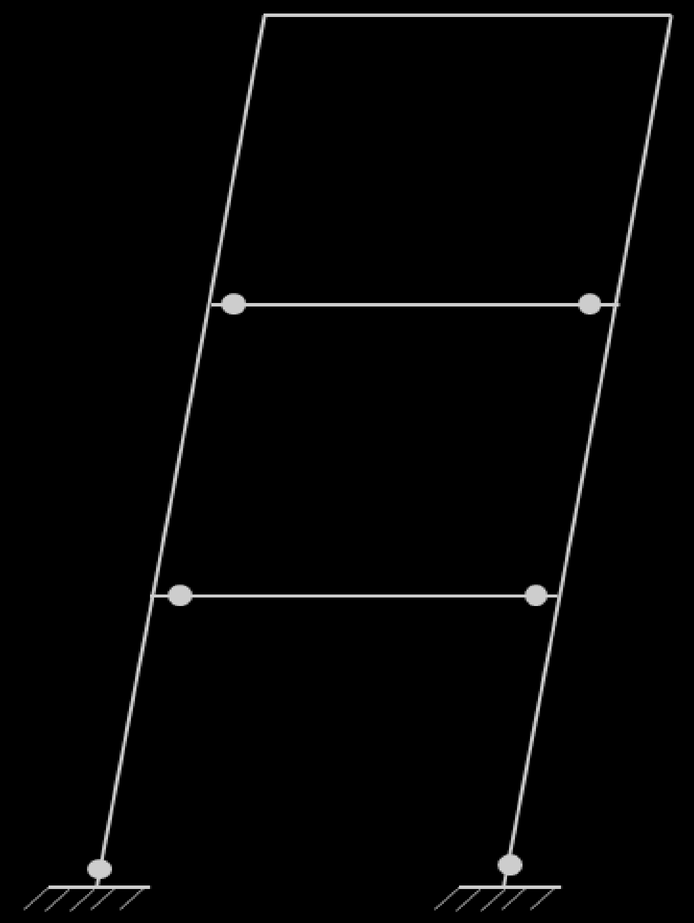
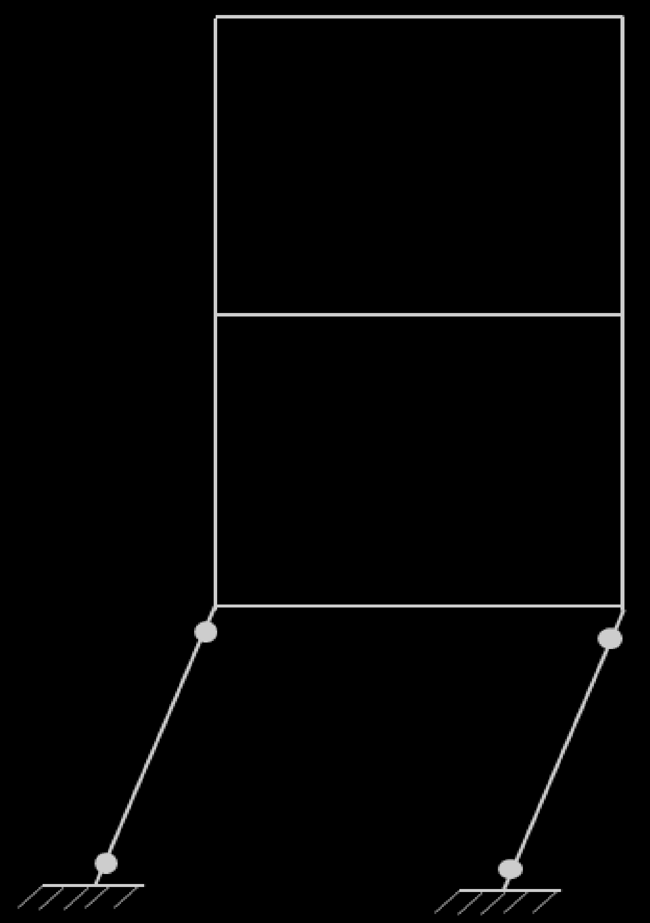
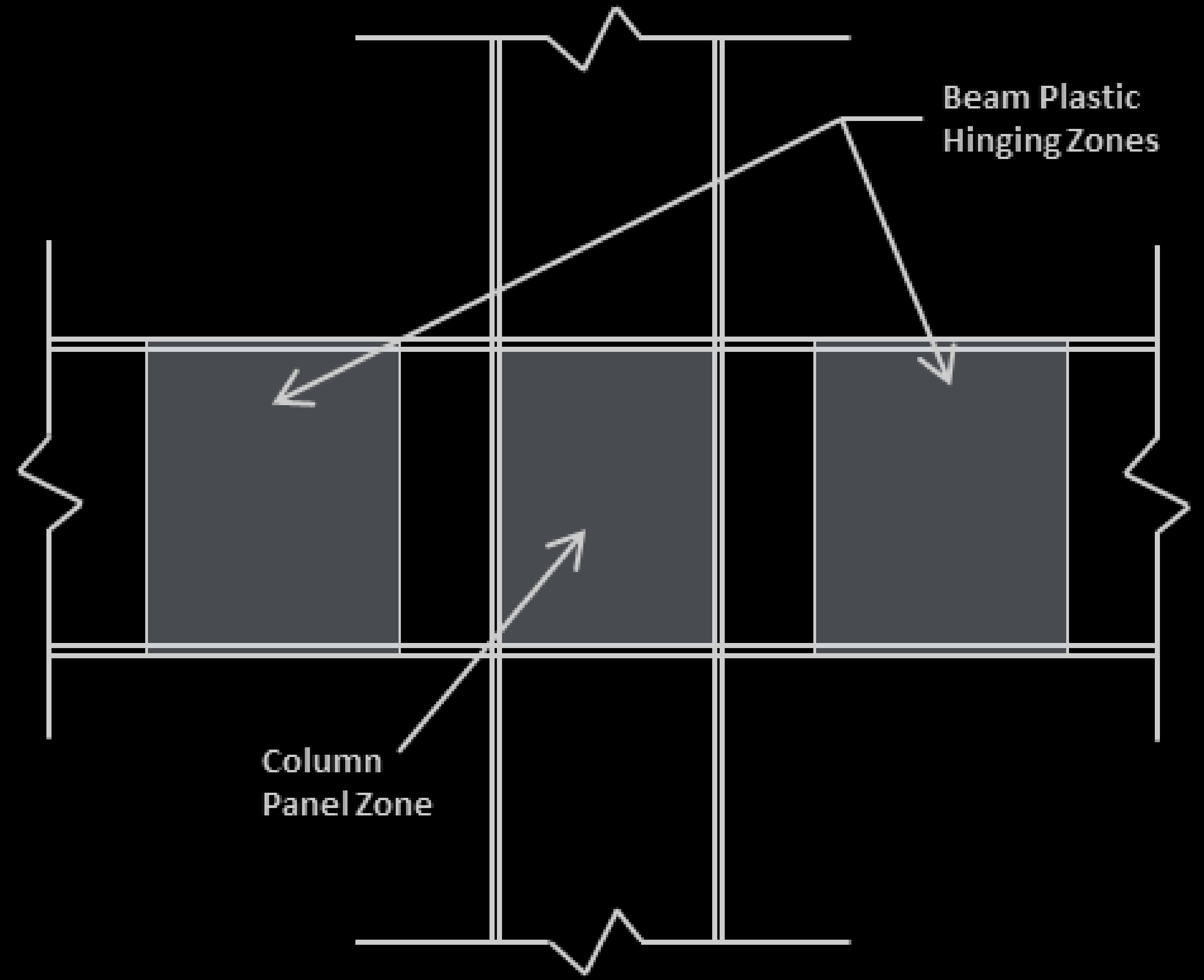
$$\frac{\sum M_{pc}^{*}}{\sum M_{pb}^{*}} > 1.0\ (Provisions\ Eq. E3)$$



Strong Column Weak Beam



Story Mechanism



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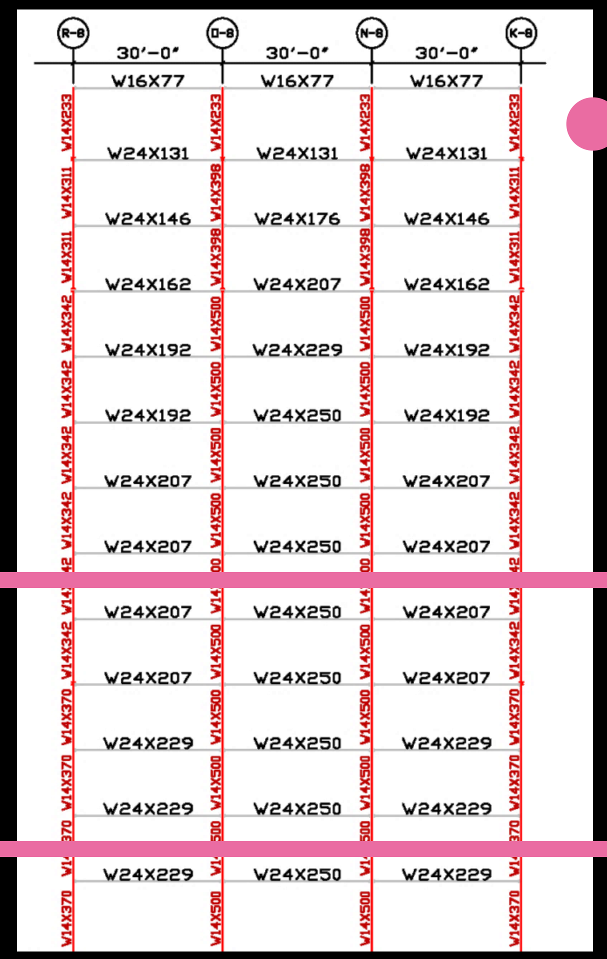
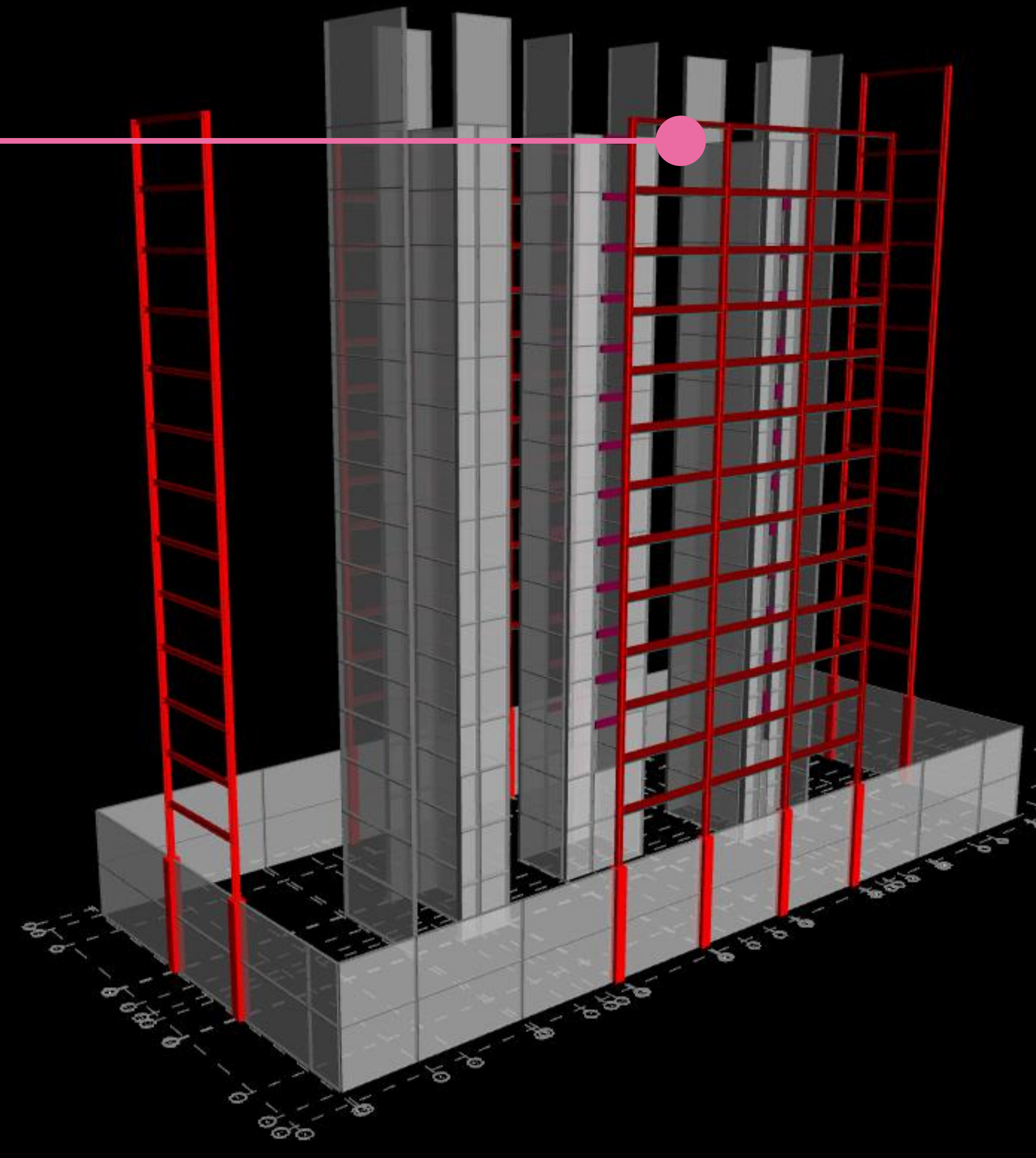
Levels 3-5

FRAME 1





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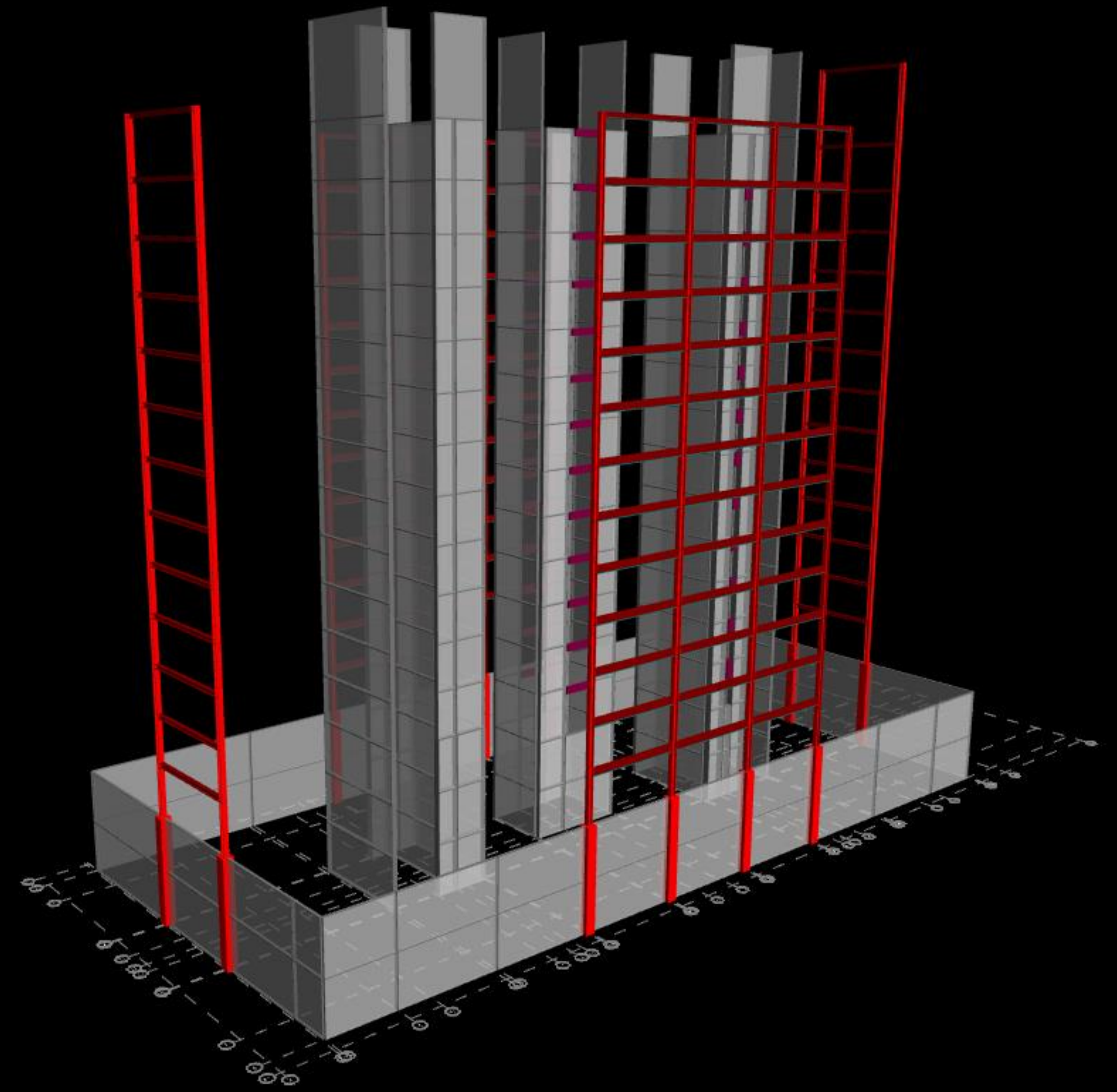
## Special Concrete Shear Walls

- Thickness not reduced to control drift
- Reinforcing redesigned for reduced loads
  - According to ACI 318-11 Ch. 21



# La Jolla Commons Office Tower

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  - **Shear Walls**
- Architecture Breadth
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- Conclusions

# Special Concrete Shear Walls

- Shear Wall U Level 2– Reinforcing redesign
  - 7000 PSI NW Concrete, 18" Thick

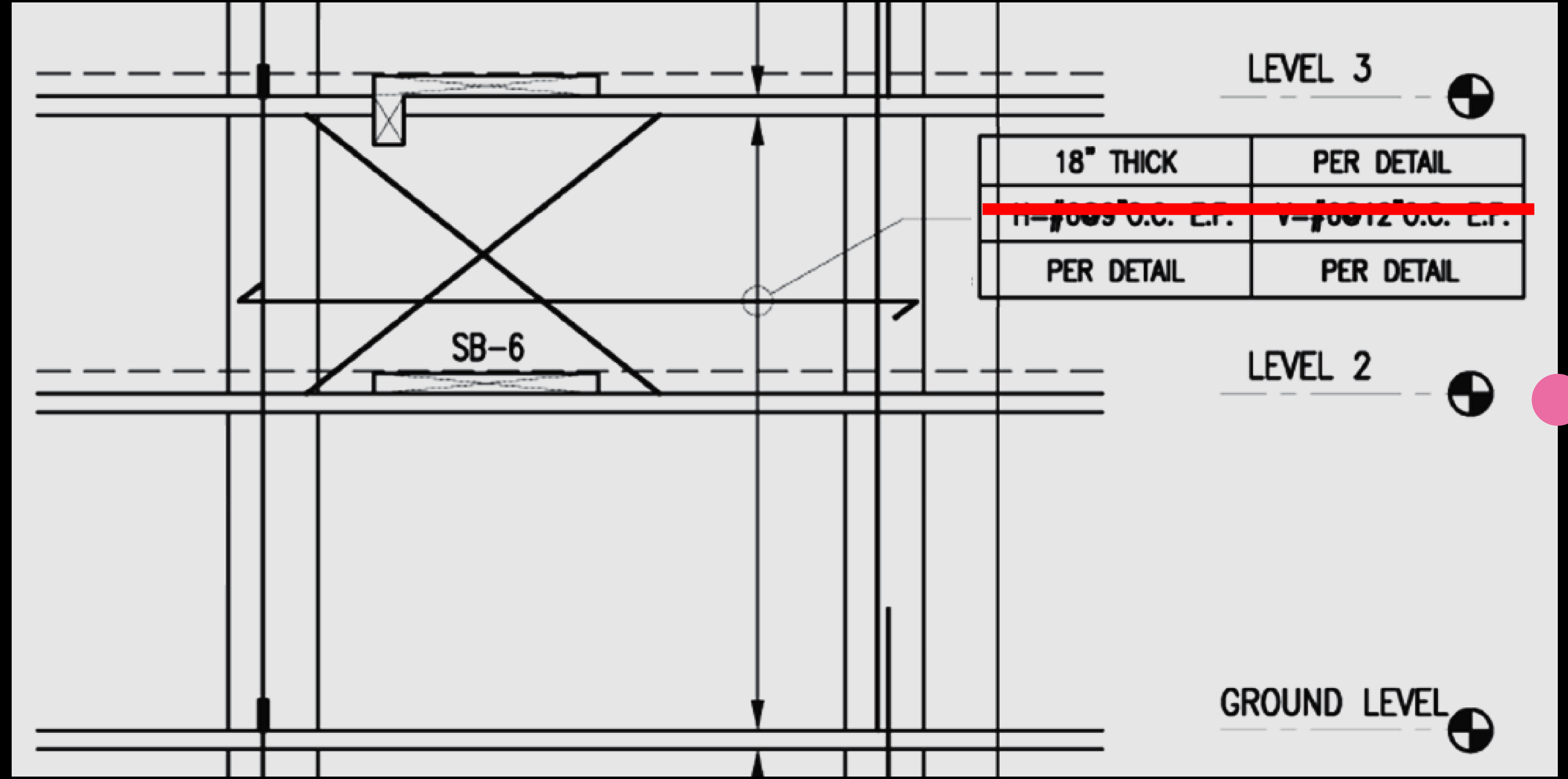
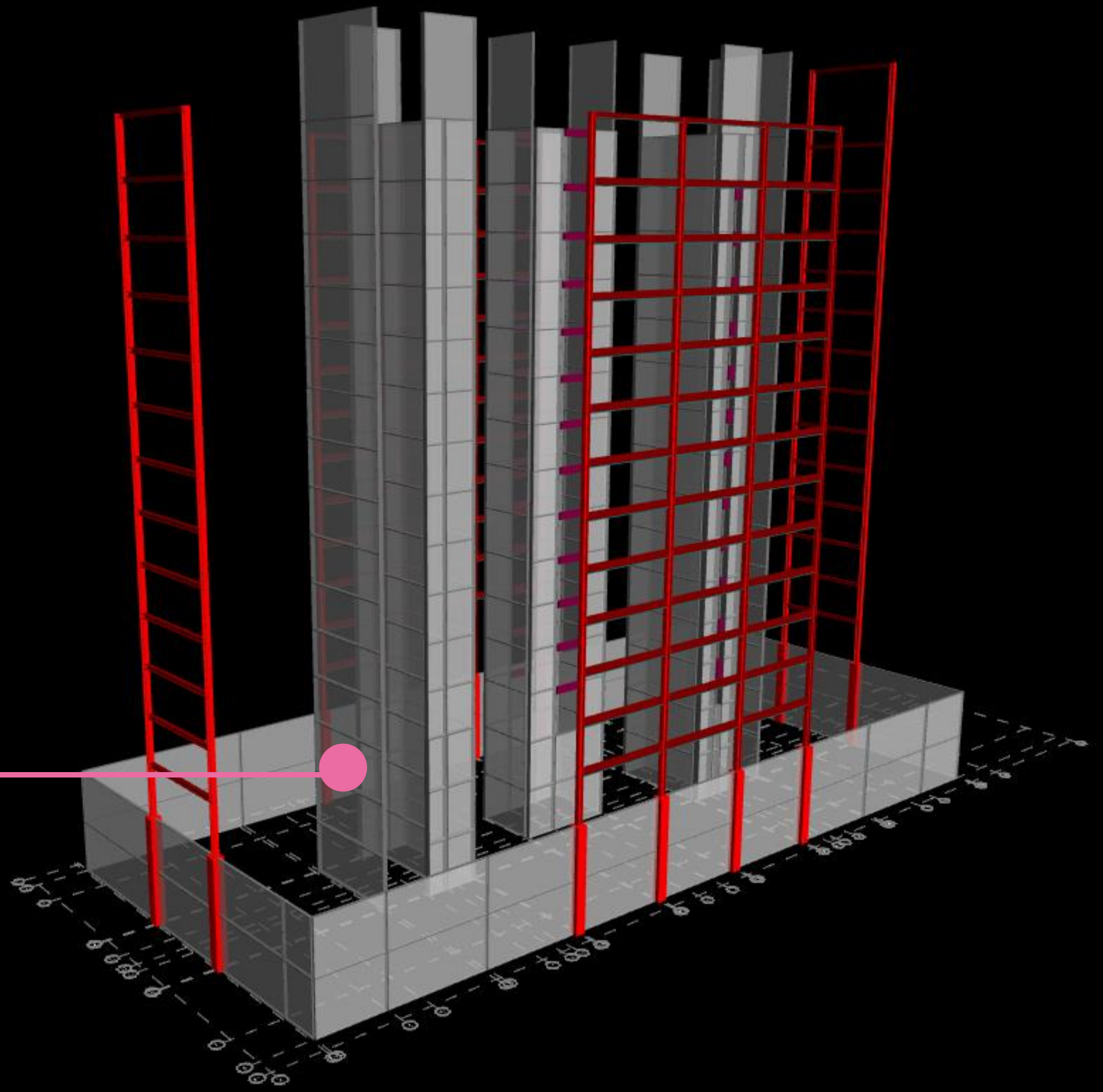



*Image from Project Documents Provided Courtesy of HINES*

**H = #6 @ 9" O.C.**
**V = #6 @ 9" O.C.**
**One curtain only**



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## Architecture Breadth

*Photo Provided Courtesy of HINES*

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# Floor-to-Ceiling Height

- Building height limited to 198’-8” by FAA
- Steel creates a deeper structural system than concrete
- Loss of floor-to-ceiling space


*Photo Provided Courtesy of HINES*

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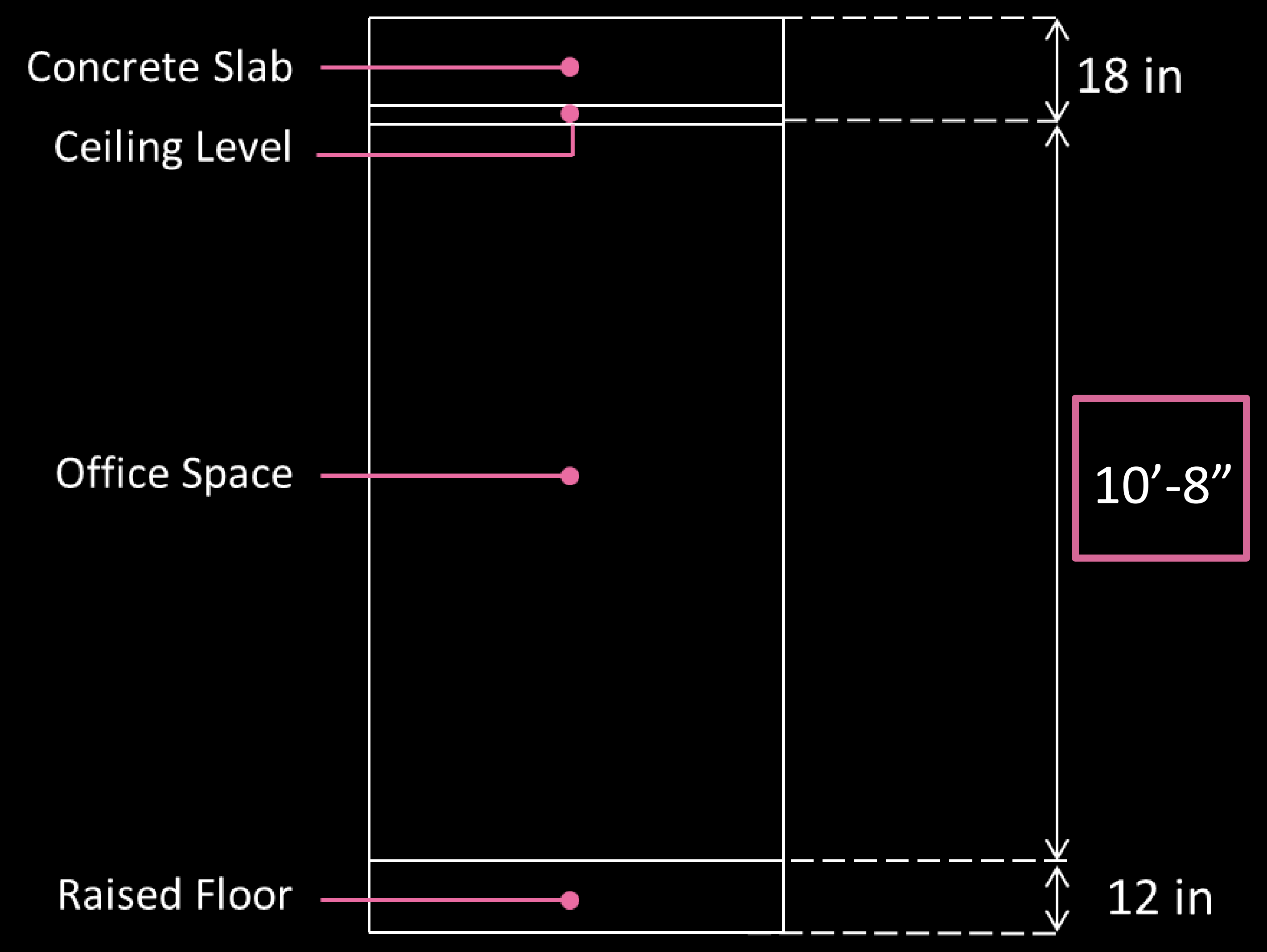
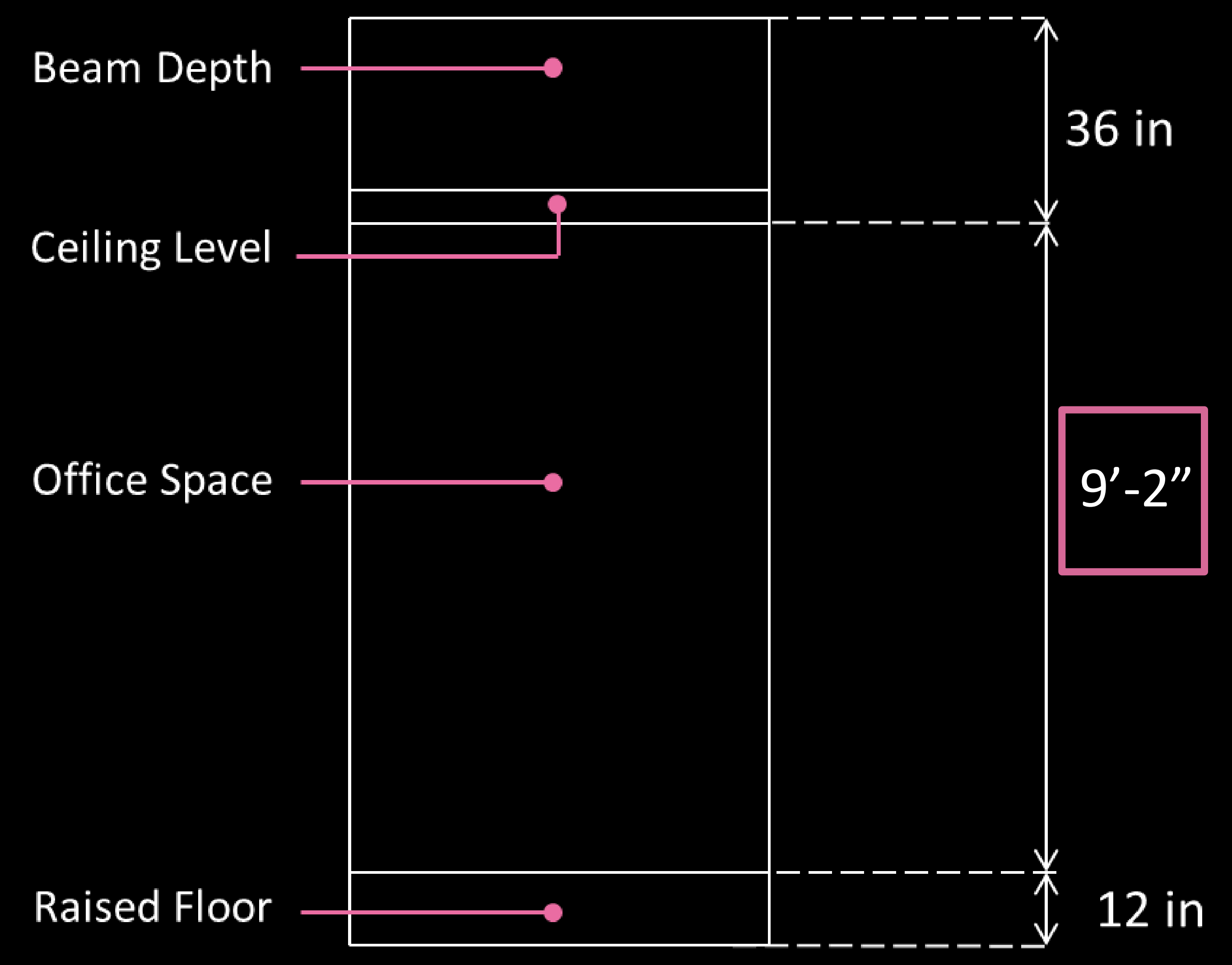
## Floor-to-Ceiling Height

**1'-6" Decrease in floor-to-ceiling height**



Concrete



Steel

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## Construction Breadth

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# Concrete System Cost

- Cost information provided by Hines
- Concrete chosen because it was cheaper than steel system
- Approximately $61 per SF

| Original Concrete Structure Cost Summary | |
|---|---|
| Cost Per SF | $ 61.46 |
| Structural Square Footage | 462,301 SF |
| % General Conditions | 14% |
| Total Original Structure Cost | $ 28,413,000 |
| General Conditions Cost | $ 3,978,000 |
| Original Structure Cost w/ out General Conditions | $ 24,435,000 |

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# Steel System Cost

- Based on cost information from RS Means 2009
- Approximately $65 per SF

| Total Steel Structure Cost (2009 RS Means) | |
|---|---|
| Item | Cost |
| Concrete on Metal Deck | $ 3,050,000 |
| Structural Steel Framing | $ 9,052,000 |
| Shear Walls | $ 4,310,000 |
| Foundation Walls | $ 1,929,000 |
| Lower Level Concrete Slabs | $ 2,796,000 |
| Lower Level Concrete Columns | $ 198,000 |
| Mat Foundation | $ 4,055,000 |
| Total Cost | $ 25,391,000 |
| Final Modified Cost | $ 30,072,000 |

# Cost Comparison

- 23 % Increase in cost for steel system
- Validates original decision by designers to design structure in concrete

| Final Cost Comparison | |
|---|---|
| Original Concrete Structure Cost | $ 24,435,000 |
| New Steel Structure Cost | $ 30,072,000 |
| % Increase in Cost | 23% |

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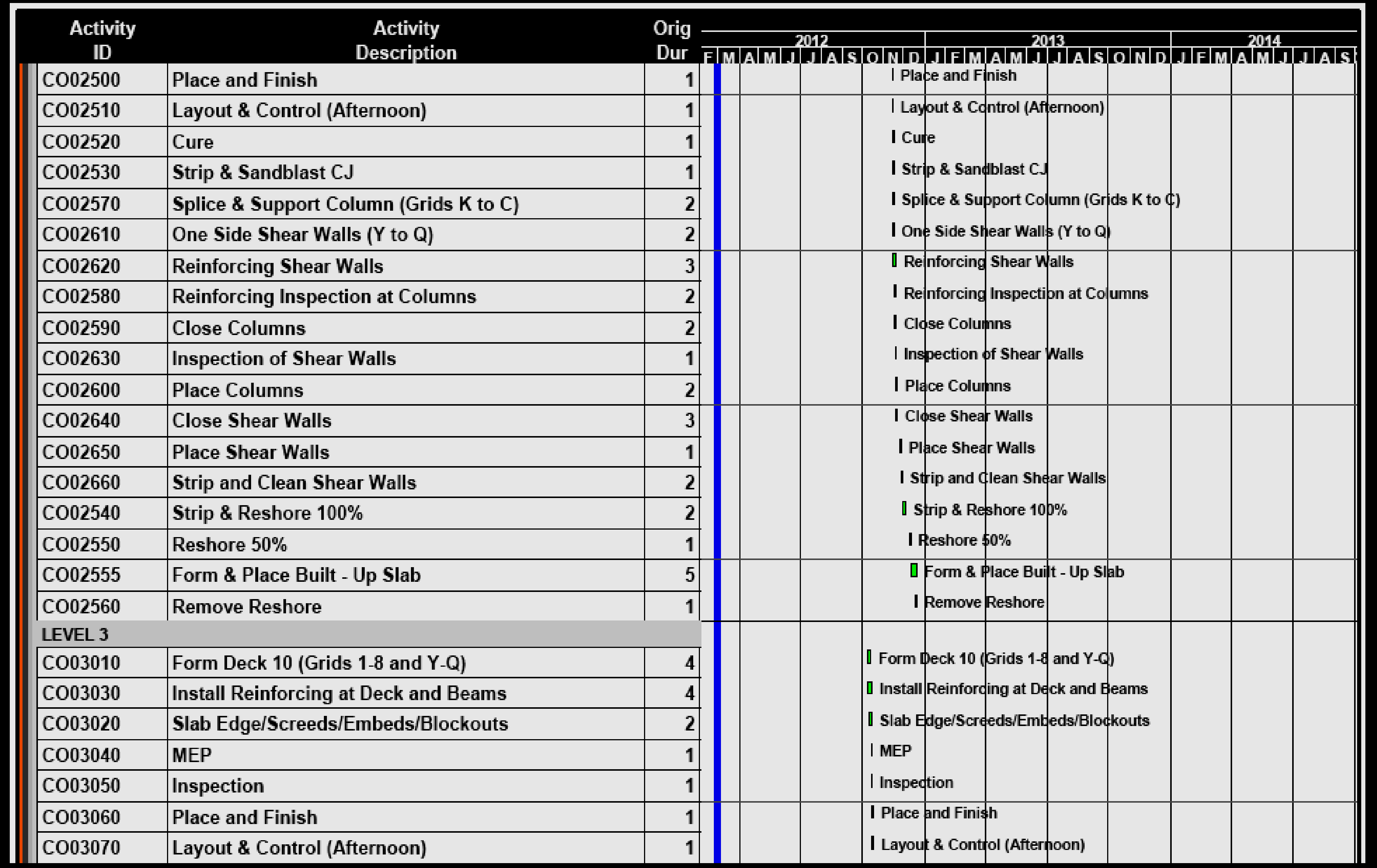
# Concrete System Schedule

- Schedule information provided by Hines
- Superstructure duration | 240 days



| Activity ID | Activity Description | Orig Dur |
|---|---|---|
| CO02500 | Place and Finish | 1 |
| CO02510 | Layout & Control (Afternoon) | 1 |
| CO02520 | Cure | 1 |
| CO02530 | Strip & Sandblast CJ | 1 |
| CO02570 | Splice & Support Column (Grids K to C) | 2 |
| CO02610 | One Side Shear Walls (Y to Q) | 2 |
| CO02620 | Reinforcing Shear Walls | 3 |
| CO02580 | Reinforcing Inspection at Columns | 2 |
| CO02590 | Close Columns | 2 |
| CO02630 | Inspection of Shear Walls | 1 |
| CO02600 | Place Columns | 2 |
| CO02640 | Close Shear Walls | 3 |
| CO02650 | Place Shear Walls | 1 |
| CO02660 | Strip and Clean Shear Walls | 2 |
| CO02540 | Strip & Reshore 100% | 2 |
| CO02550 | Reshore 50% | 1 |
| CO02555 | Form & Place Built - Up Slab | 5 |
| CO02560 | Remove Reshore | 1 |
| LEVEL 3 | | |
| CO03010 | Form Deck 10 (Grids 1-8 and Y-Q) | 4 |
| CO03030 | Install Reinforcing at Deck and Beams | 4 |
| CO03020 | Slab Edge/Screeds/Embeds/Blockouts | 2 |
| CO03040 | MEP | 1 |
| CO03050 | Inspection | 1 |
| CO03060 | Place and Finish | 1 |
| CO03070 | Layout & Control (Afternoon) | 1 |

*Image Extracted from Project Schedule Provided Courtesy of HINES*

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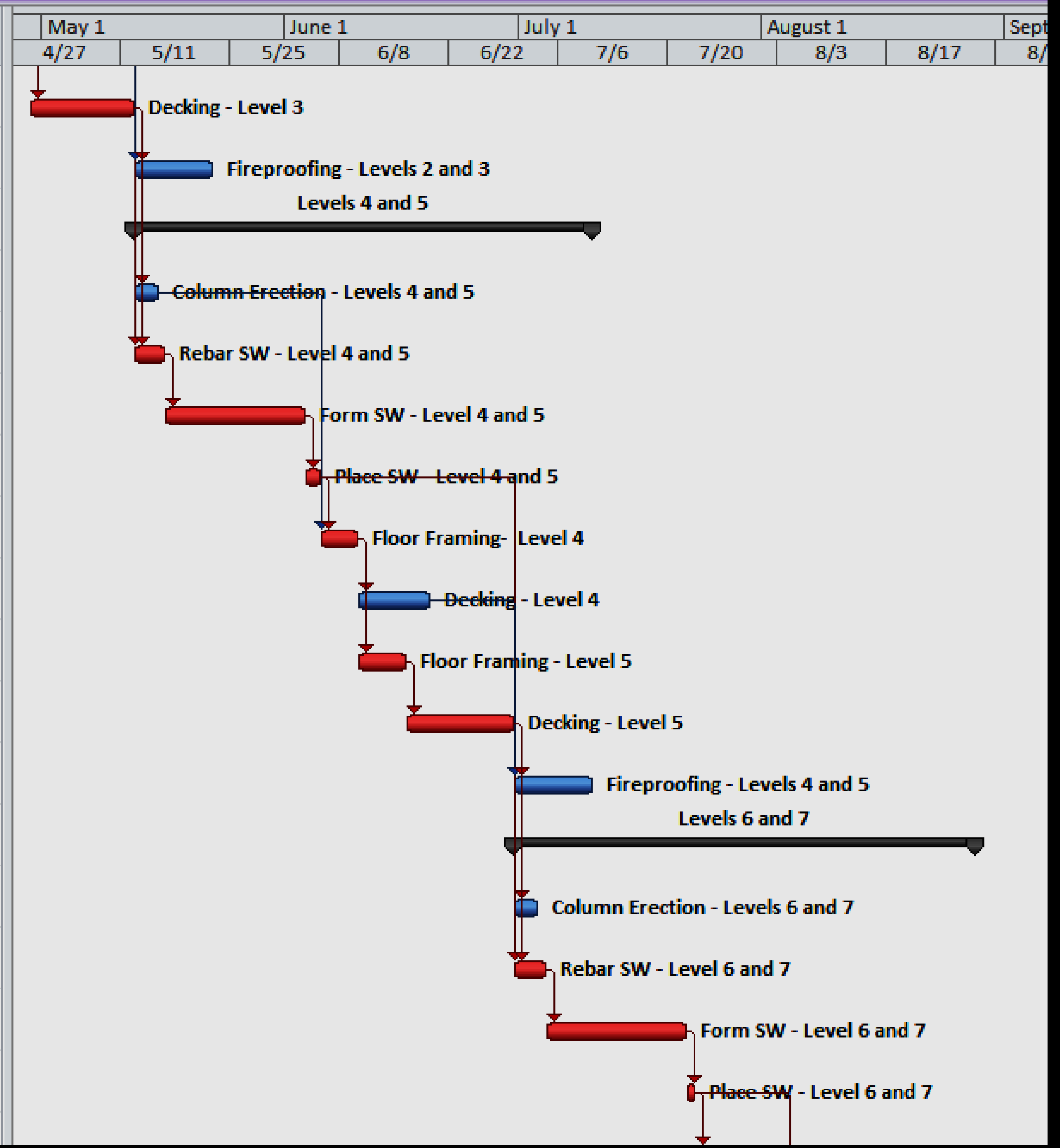
# Steel System Schedule

- Schedule produced in Microsoft Project
- Durations from RS Means 2009
- Superstructure duration | 230 days

| | Task Name | Duration |
|---|---|---|
| 9 | Decking - Level 3 | 9.8 days |
| 10 | Fireproofing - Levels 2 and 3 | 8 days |
| 11 | **Levels 4 and 5** | **42.1 days** |
| 12 | Column Erection - Levels 4 and 5 | 3 days |
| 13 | Rebar SW - Level 4 and 5 | 4 days |
| 14 | Form SW - Level 4 and 5 | 12 days |
| 15 | Place SW - Level 4 and 5 | 1.5 days |
| 16 | Floor Framing- Level 4 | 2.8 days |
| 17 | Decking - Level 4 | 7.5 days |
| 18 | Floor Framing - Level 5 | 4 days |
| 19 | Decking - Level 5 | 9.8 days |
| 20 | Fireproofing - Levels 4 and 5 | 8 days |
| 21 | **Levels 6 and 7** | **43.3 days** |
| 22 | Column Erection - Levels 6 and 7 | 3 days |
| 23 | Rebar SW - Level 6 and 7 | 4 days |
| 24 | Form SW - Level 6 and 7 | 12 days |
| 25 | Place SW - Level 6 and 7 | 1.5 days |
| 26 | Floor Framing - Level 6 | 4 days |



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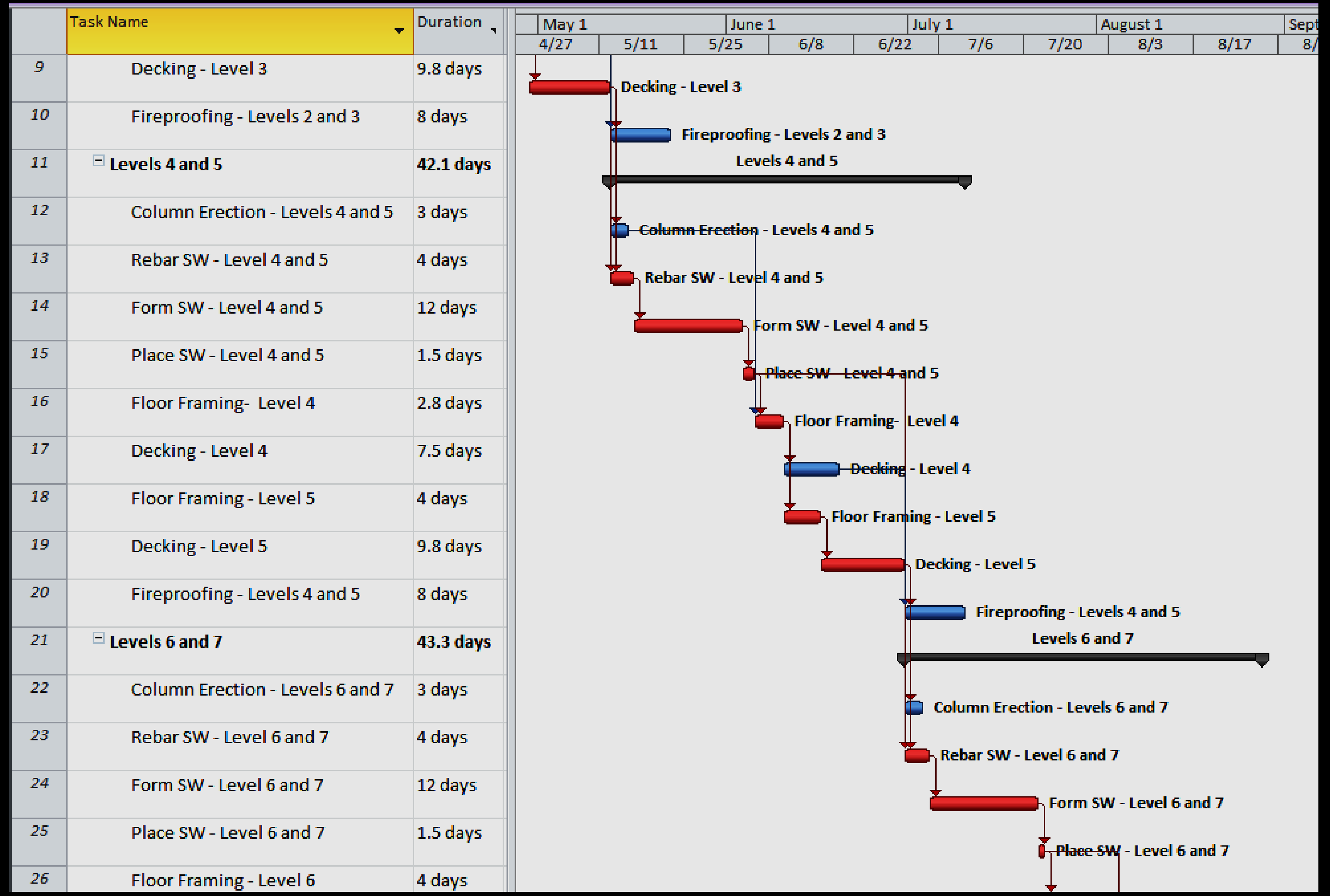
# Schedule Comparison

- Only 2 weeks time savings
- Not worth the 23% cost increase
- If time savings were more significant, cost increase may have been offset



# La Jolla Commons Office Tower



# Conclusions

- Designed a feasible steel gravity system with vibration reducing characteristics
- Designed special steel moment frames
- Eliminated torsional irregularity
- Reduced floor-to-ceiling heights
- Increased cost for steel structure is not offset by reduction in project schedule

*Photo Provided Courtesy of HINES*

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# Acknowledgements


*Special Thanks to:*

Hines

Nabih Youssef Associates

AE Faculty | especially Dr. Linda Hanagan & Prof. Sustersic

Benjamin Barben

My loving family, boyfriend, friends, and classmates


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**Questions and Comments?**

*Photo Provided Courtesy of HINES*

# La Jolla Commons Office Tower

## Appendix Slides

- Architecture Breadth
- Dual Systems Check
- Shear Wall Modeling
- Lateral System Verification
- Model Verification
- Vibrations Analysis

# Architecture Breadth

Appendix List

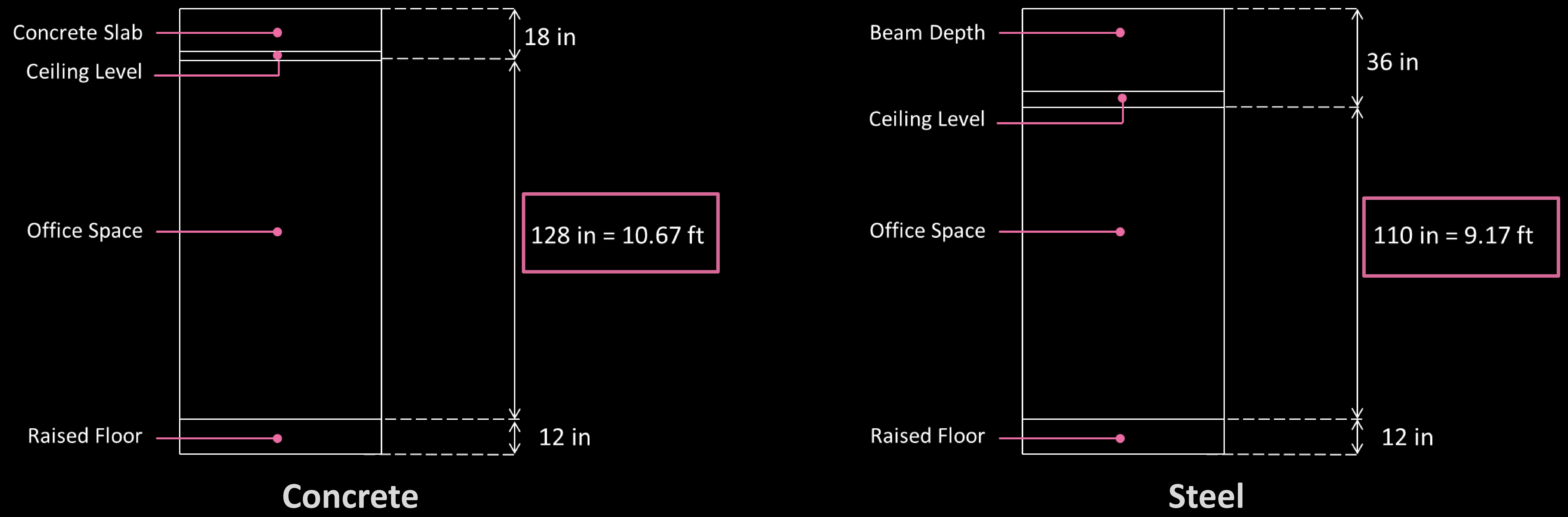
# Floor-to-Ceiling Height

- Building height limited to 198’-8” by FAA
- Steel creates a deeper structural system than concrete
- Loss of floor-to-ceiling space


Appendix List

# La Jolla Commons Office Tower

## Floor-to-Ceiling Height




**1'-6" Decrease in floor-to-ceiling height**

Appendix List

# Fire Protection Breadth

| Required Fire-Resistance Ratings | | |
|---|---|---|
| **Element** | Construction Type | Required Rating (hours) |
| **Primary Floor Framing Members** | Type 1B | 2 |
| **Secondary Floor Framing Members** | Type 1B | 2 |
| **Structural Columns** | Type 1A | 3 |

Appendix List

**TABLE 601**
**FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)**

| BUILDING ELEMENT | TYPE I | | TYPE II | | TYPE III | | TYPE IV | TYPE V | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | A[d] | B | A[d] | B | HT | A[d] | B |
| Primary structural frame[g] (see Section 202) | 3[a] | 2[a] | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Bearing walls<br>Exterior[f, g]<br>Interior | <br>3<br>3[a] | <br>2<br>2[a] | <br>1<br>1 | <br>0<br>0 | <br>2<br>1 | <br>2<br>0 | <br>2<br>1/HT | <br>1<br>1 | <br>0<br>0 |
| Nonbearing walls and partitions<br>Exterior | | | See Table 602 | | | | | | |
| Nonbearing walls and partitions<br>Interior[e] | 0 | 0 | 0 | 0 | 0 | 0 | See Section 602.4.6 | 0 | 0 |
| Floor construction and associated secondary members (see Section 202) | 2 | 2 | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Roof construction and associated secondary members (see Section 202) | $1^1/_2$[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | HT | 1[b,c] | 0 |

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.

e. Not less than the fire-resistance rating required by other sections of this code.

f. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

g. Not less than the fire-resistance rating as referenced in Section 704.10

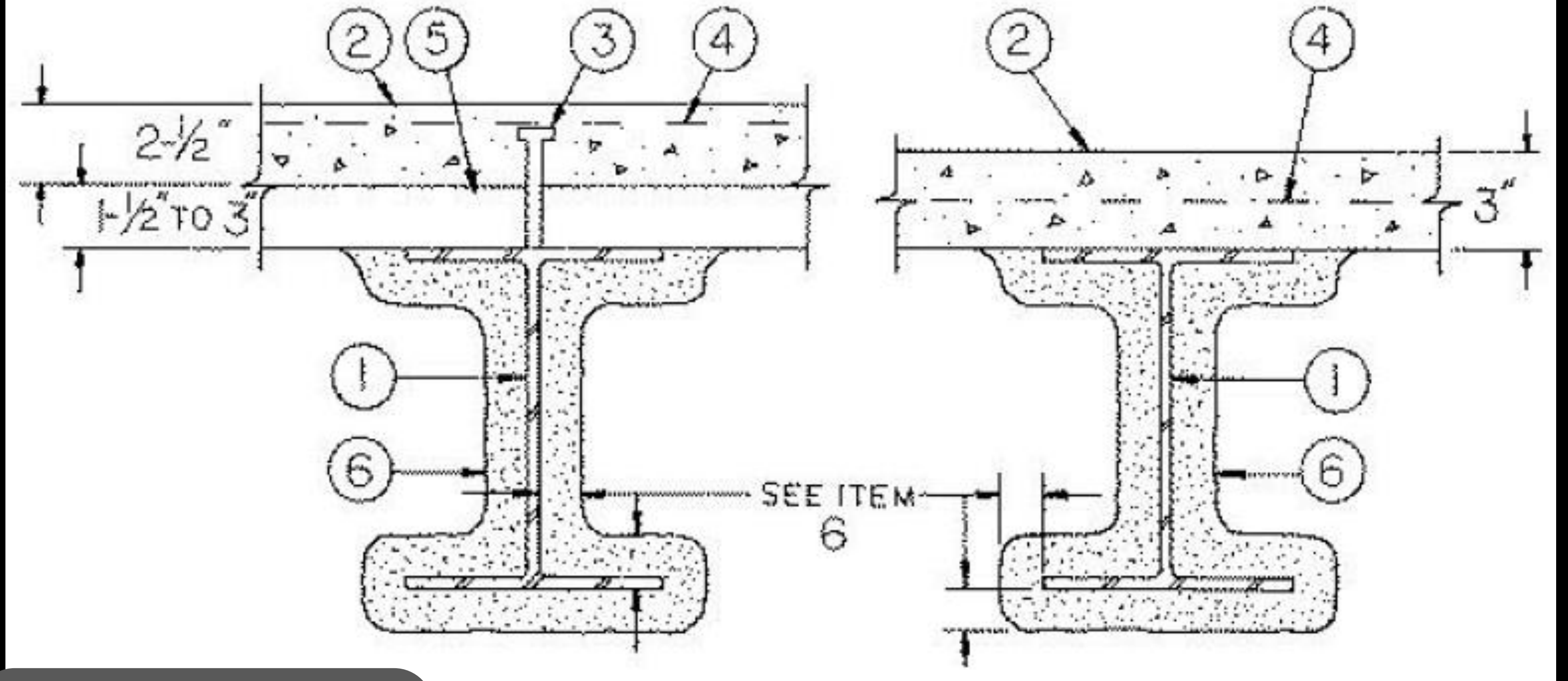
# La Jolla Commons Office Tower

# Fire Protection Breadth

**Design No. N708**

February 08, 2014

**Restrained Beam Ratings — 1, 2, 3 and 4 Hr.**
**Unrestrained Beam Ratings — 1, 1-1/2, 2, 3 and 4 Hr.**
**Load Restricted for Canadian Applications — See Guide BXUV7**




Appendix List

1.5” of SFRM

$$h_2 = h_1 \, [(W_1 / D_1) + 0.60] \, / \, [(W_2 / D_2) + 0.60]$$

**(Equation 7-17)**

where:

$h$ = Thickness of sprayed fire-resistant material in inches.

$W$ = Weight of the structural steel beam or girder in pounds per linear foot.

$D$ = Heated perimeter of the structural steel beam in inches.

Subscript 1 refers to the beam and fire-resistant material thickness in the *approved* assembly.

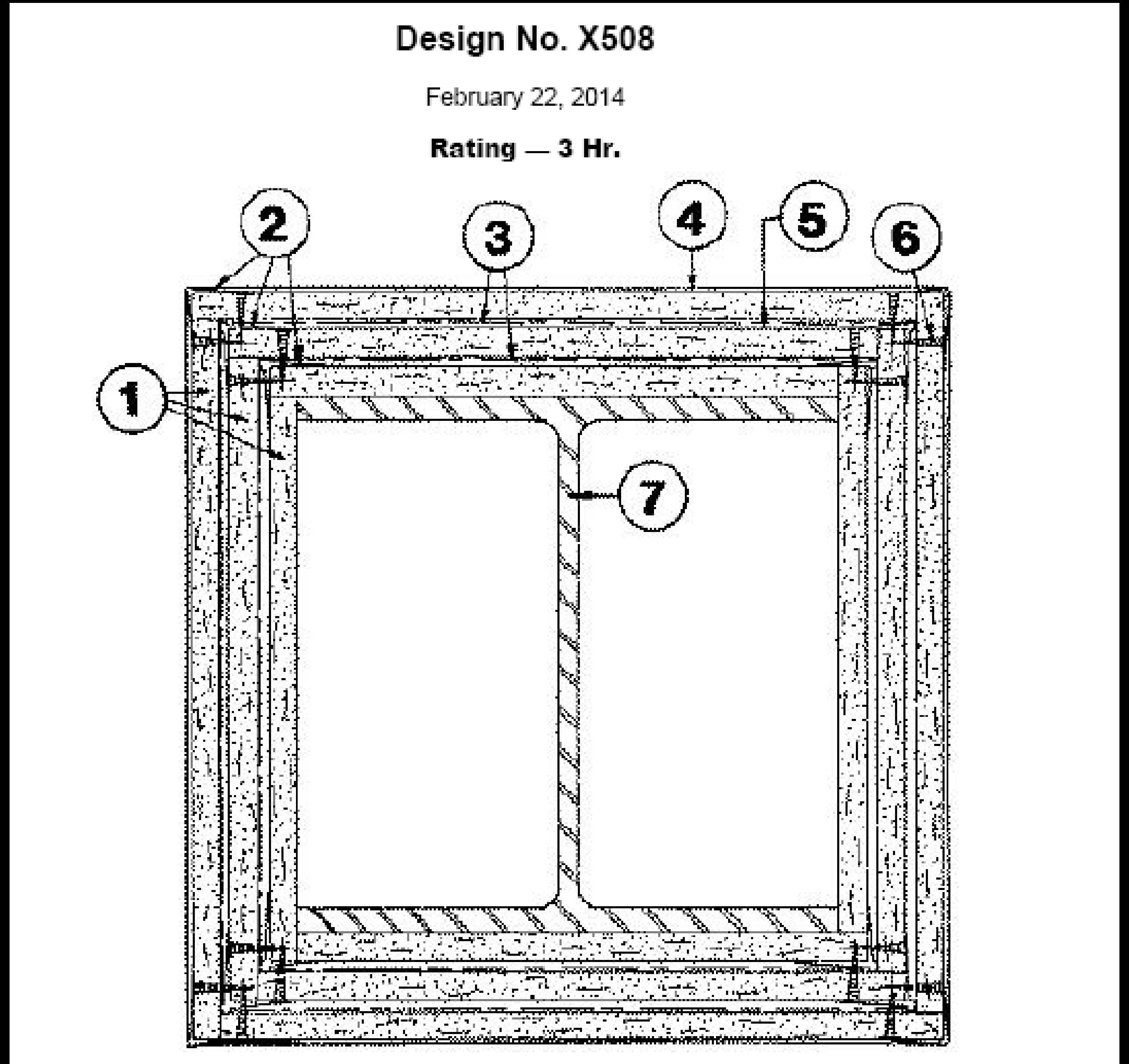
| Required Spray Fireproofing Thickness | | | | | |
|---|---|---|---|---|---|
| <u>722.5.2.2.1 Requirements</u> | | | | | |
| Min W/D for Substitute Beam: | 0.37 | OK | | | |
| Min Thickness of Protection: | 0.375 | in | | | |
| Unrestrained/restrained? | Unrestrained (to be conservative) | | | | |
| Min Fire Rating: | 1 hour | | | | |
| Required Fire Rating: | 2 hour | | | | |
| Minimum Beam Size: | W12x14 | | | | |
| Heated Perimeter: | 0.405 | | | | |
| Assembly Tested | Min Beam Size | h1 | W1/D1 | W2/D2 | h2 |
| N708 | W8x28 | 1.00 | 0.819 | 0.405 | 1.412 |

# La Jolla Commons Office Tower

# Fire Protection Breadth

1. The outer layer must be 5/8 inches thick. The inner layers will be 5/8 inch thick wall board as well. The wallboard is installed without any horizontal joints. 1 inch long self-drilling screws shall be spaced as required for the installation of the first layer of wall board.
2. 28 MSG galvanized metal corner bead
3. 18 SWG annealed wire, space 6 inches from each end and at 1'-9" intervals
4. May be finished with 3/32" thick gypsum veneer plaster. Joints reinforced.
5. Laminated with joint cement.
6. 1 inch long self-drilling screws spaced at 12" center to center
7. Minimum column size of W10X49. 9/16 flange thickness and 5/16 inch web thickness. 14.4 square inch area.

Appendix List



# La Jolla Commons Office Tower

# Fire Protection Breadth

- 4.25 LW topping provided
- Adequate for 2 hour fire resistance between levels

TABLE 707.3.10
FIRE-RESISTANCE RATING REQUIREMENTS FOR FIRE BARRIER ASSEMBLIES OR HORIZONTAL ASSEMBLIES BETWEEN FIRE AREAS

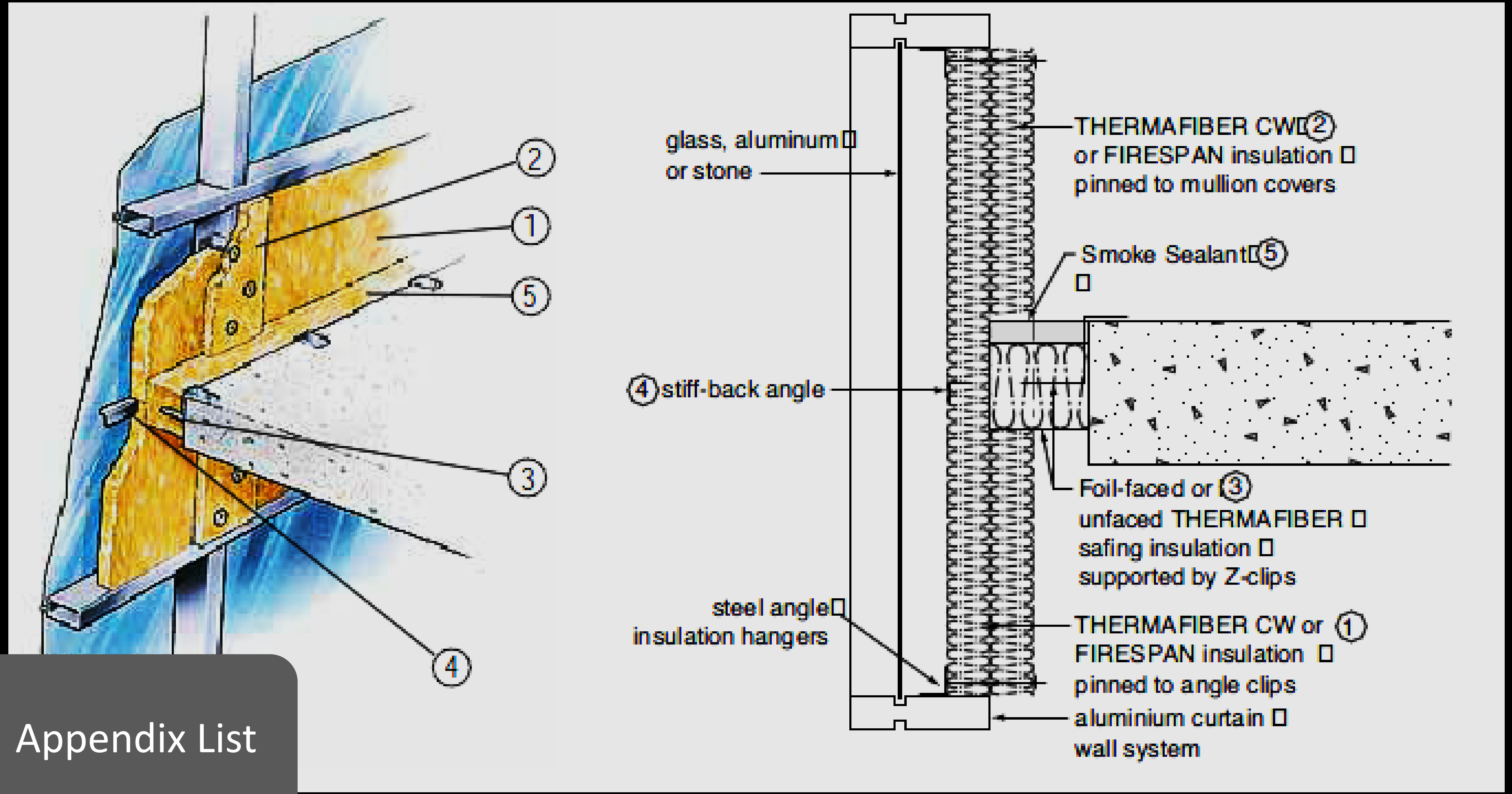
| OCCUPANCY GROUP | FIRE-RESISTANCE RATING (hours) |
|---|---|
| H-1, H-2 | 4 |
| F-1, H-3, S-1 | 3 |
| A, B, E, F-2, H-4, H-5, I, M, R, S-2 | 2 |
| U | 1 |

| Restrained Assembly Rating | Type of Protection | Concrete Thickness & Type (1) |
|---|---|---|
| 2 Hr. (continued) | Sprayed Fiber | 2" NW&LW |
| | | 2 1/2" NW&LW |
| | | 2 1/2" LW |
| | | 2 1/2" NW |
| | | 3 1/4" LW |
| | Unprotected Deck | 3 1/4" LW |
| | | 4 1/2" NW |

Appendix List

# La Jolla Commons Office Tower

# Fire Protection Breadth

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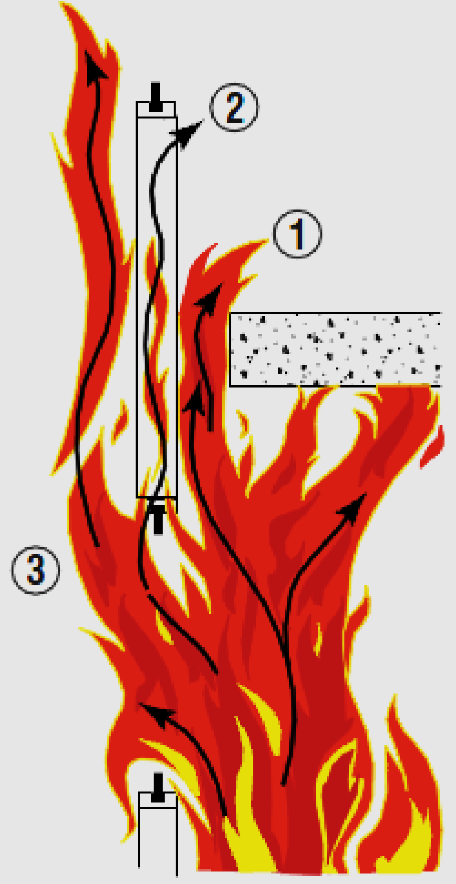
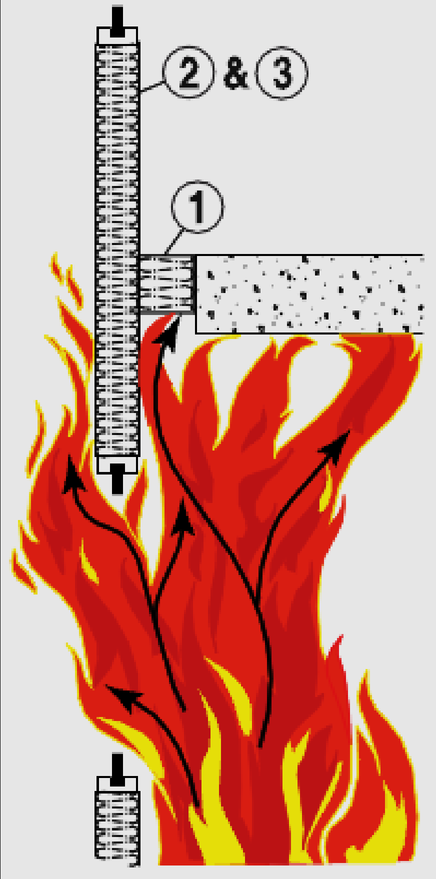



Spread of fire
(unprotected)

**In an unprotected curtain wall, or in one protected with low-melt glass fiber insulation, there are three ways in which fire can spread from floor to floor.**

1. Through the space between the slab edge and the curtain wall.
2. Through the window head mullion and then up through the cavity of the curtain wall.
3. Out through the broken vision glass and back in through the curtain wall.




THERMAFIBER Fire Containment
(protected)

**THERMAFIBER Life-Safety Fire Containment Products compartmentalize fire, preventing it from spreading from the floor of origin up to the floor above by:**

1. Filling the slab-edge/curtain wall gap with Thermafiber Safing Insulation
2. Protecting the vertical mullions
3. Providing a vertical barrier to fire using Thermafiber Curtain Wall or FireSpan Insulation

# Shear Wall Modeling

Appendix List

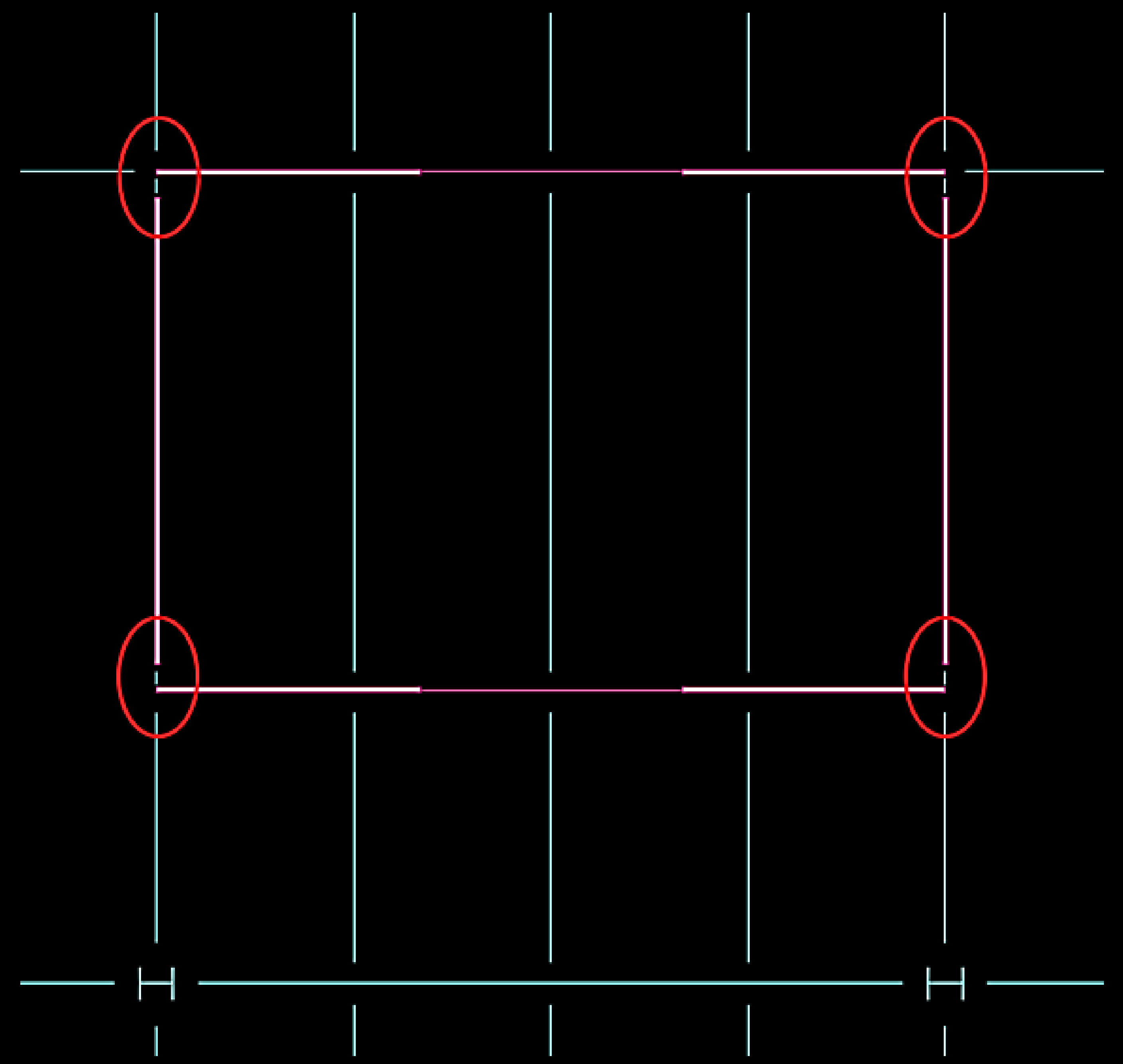
RAM
A Bentley Solutions Center

Bentley

Appendix List

# Shear Wall Modeling Method

- Shell elements connected at nodes caused an irregular distribution of torsional forces within the wall core
- Bentley suggested disconnecting the shear walls and adding gravity framing elements to eliminate a "framing tables" error
- Does not count on flanged walls to take out of plane loads or to help in flexure
- Eliminated odd torsionally anomaly



# Model Verification

Appendix List

# Model Verification

| Model Verification Summary | | |
|---|---|---|
| | % Error X-Direction | % Error Y-Direction |
| **Center of Mass** | 0.284% | 1.265% |
| **Center of Rigidity** | 2.813% | 1.681% |
| **Floor Mass** | 11% | |
| **Seismic Loads** | 15% | |
| **Wind Loads** | 0.25% | 3.31% |
| **2D Analysis** | 10 - 20 % | |

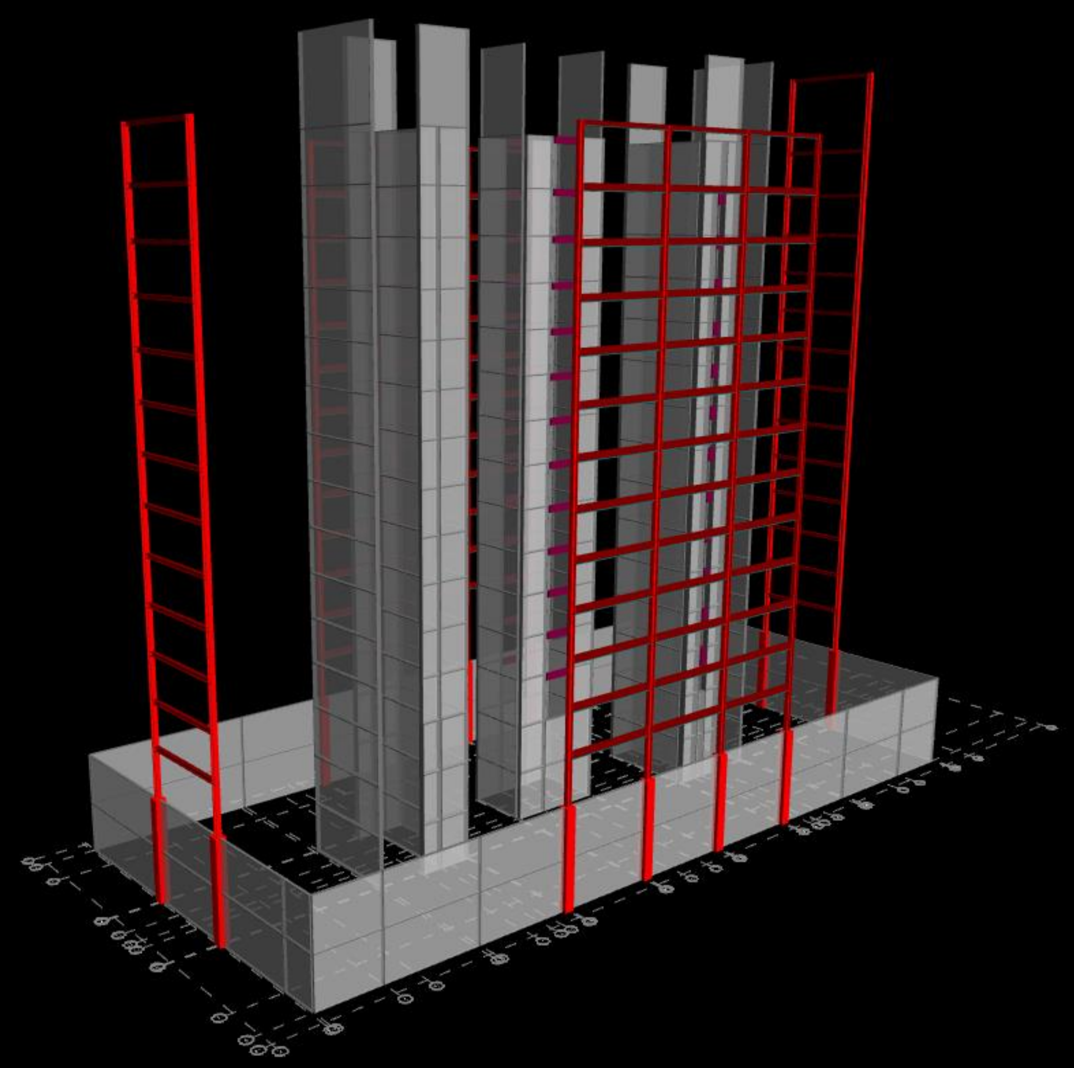
Appendix List

# Dual System Check

Appendix List

# La Jolla Commons Office Tower

# Dual System Check



| Dual System Check | | | |
|---|---|---|---|
| **X-Direction Direct Shear** | | | |
| Item | Shear (kip) | % of Total Shear | Dual System? |
| Frame 1 | 595.21 | 18.27% | No |
| Frame 2 | 643.37 | 19.74% | No |
| Shear Walls | 2020.00 | 61.99% | - |
| Total Shear | 3258.58 kip | | |
| | | | |
| **Y-Direction Direct Shear** | | | |
| Item | Shear (kip) | % of Total Shear | Dual System? |
| Frame 3 | 35.61 | 1.18% | No |
| Frame 4 | 32.41 | 1.08% | No |
| Shear Walls | 2941.00 | 97.74% | - |
| Total Shear | 3009.02 kip | | |

Appendix List

# Lateral System Verification

Appendix List

# La Jolla Commons Office Tower

# Lateral System Verification

- Drifts for wind and seismic were verified to meet code and industry standard requirements (Cd=5, R=6)
- Torsional analysis was performed at each story under the different seismic load cases and found to no longer have an irregularity
- Stability coefficients were verified
- Overturning moment was checked under the controlling load case

Appendix List

| Wind Displacement Determination | | | | |
|---|---|---|---|---|
| Load Case | X - Deflection (in) | Y - Deflection (in) | L/400 (in) | Pass/Fail? |
| Wind_ASCE710_1_X | 1.91 | 0.00 | 5.940 | Pass |
| Wind_ASCE710_1_Y | 0.00 | 2.11 | 5.940 | Pass |
| Wind_ASCE710_2_X+E | 1.43 | -0.01 | 5.940 | Pass |
| Wind_ASCE710_2_X-E | 1.43 | 0.01 | 5.940 | Pass |
| Wind_ASCE710_2_Y+E | 0.01 | 1.68 | 5.940 | Pass |
| Wind_ASCE710_2_Y-E | -0.01 | 1.49 | 5.940 | Pass |
| Wind_ASCE710_3_X+Y | 1.43 | 1.58 | 5.940 | Pass |
| Wind_ASCE710_3_X-Y | 1.43 | -1.58 | 5.940 | Pass |
| Wind_ASCE710_4_X+Y_CW | 1.07 | 1.11 | 5.940 | Pass |
| Wind_ASCE710_4_X+Y_CCW | 1.08 | 1.27 | 5.940 | Pass |
| Wind_ASCE710_4_X-Y_CW | 1.07 | -1.26 | 5.940 | Pass |
| Wind_ASCE710_4_X-Y_CCW | 1.08 | -1.10 | 5.940 | Pass |

# La Jolla Commons Office Tower

- Drifts for wind and seismic were verified to meet code and industry standard requirements (Cd=5, R=6)
- Torsional analysis was performed at each story under the different seismic load cases and found to no longer have an irregularity
- Stability coefficients were verified
- Overturning moment was checked under the controlling load case

Appendix List

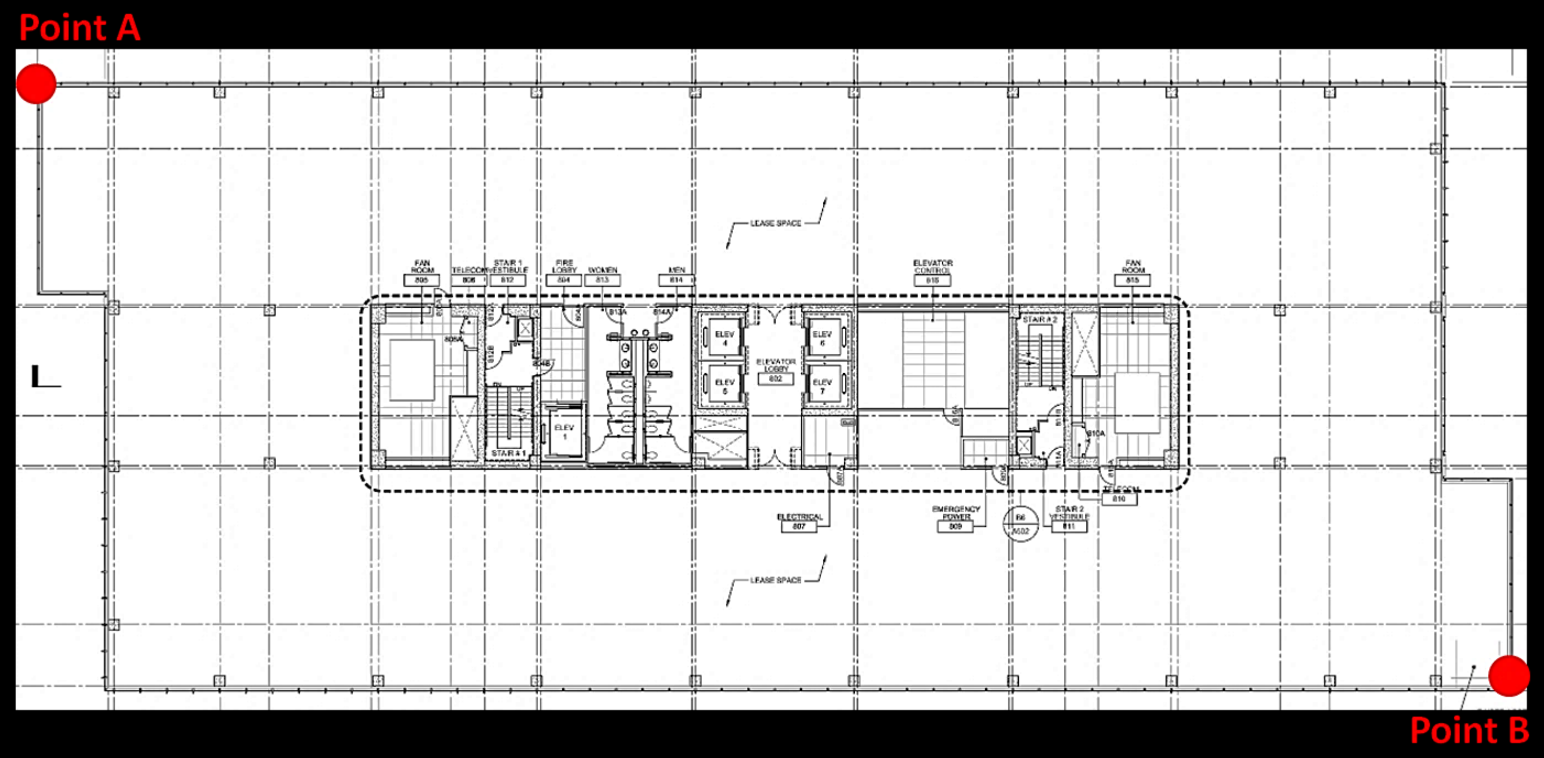
| Seismic Story Drift Check | | | | | | |
|---|---|---|---|---|---|---|
| **Level** | Level Height (ft) | $C_d*\delta_x$ | | Allowable Drift (in) | Pass/Fail? | |
| | | X-Direction | Y-Direction | | X-Direction | Y-Direction |
| **PH Roof** | 24.33 | 5.15 | 2.04 | 5.839 | Pass | Pass |
| **PH** | 14.5 | 3.08 | 1.22 | 3.480 | Pass | Pass |
| **13** | 14 | 2.83 | 1.02 | 3.360 | Pass | Pass |
| **12** | 14 | 2.87 | 1.01 | 3.360 | Pass | Pass |
| **11** | 14 | 2.89 | 1.00 | 3.360 | Pass | Pass |
| **10** | 14 | 2.89 | 0.97 | 3.360 | Pass | Pass |
| **9** | 14 | 2.85 | 0.93 | 3.360 | Pass | Pass |
| **8** | 14 | 2.76 | 0.88 | 3.360 | Pass | Pass |
| **7** | 14 | 2.62 | 0.82 | 3.360 | Pass | Pass |
| **6** | 14 | 2.41 | 0.74 | 3.360 | Pass | Pass |
| **5** | 14 | 2.13 | 0.64 | 3.360 | Pass | Pass |
| **4** | 14 | 1.76 | 0.53 | 3.360 | Pass | Pass |
| **3** | 14 | 1.29 | 0.40 | 3.360 | Pass | Pass |
| **2** | 15 | 0.78 | 0.27 | 3.600 | Pass | Pass |
| **Overall Displacement=** | | 36.32 | 12.46 | | | |

# La Jolla Commons Office Tower

# Lateral System Verification

- Drifts for wind and seismic were verified to meet code and industry standard requirements (Cd=5, R=6)
- Torsional analysis was performed at each story under the different seismic load cases and found to no longer have an irregularity
- Stability coefficients were verified
- Overturning moment was checked under the controlling load case

Appendix List




| Check for Torsional Irregularities X Direction | | | | | |
|---|---|---|---|---|---|
| Level | $\delta_A$ | $\delta_B$ | $\delta_{avg}$ | $\delta max$ | Does a torsional irregularity exist? |
| PH | 0.6268 | 0.6269 | 0.63 | 0.6269 | No |
| Level 13 | 0.5762 | 0.5764 | 0.58 | 0.5764 | No |
| Level 12 | 0.5846 | 0.5847 | 0.58 | 0.5847 | No |
| Level 11 | 0.5887 | 0.5888 | 0.59 | 0.5888 | No |
| Level 10 | 0.5877 | 0.5878 | 0.59 | 0.5878 | No |
| Level 9 | 0.5788 | 0.5789 | 0.58 | 0.5789 | No |
| Level 8 | 0.5614 | 0.5615 | 0.56 | 0.5615 | No |
| Level 7 | 0.5320 | 0.5321 | 0.53 | 0.5321 | No |
| Level 6 | 0.4901 | 0.4902 | 0.49 | 0.4902 | No |
| Level 5 | 0.4330 | 0.4331 | 0.43 | 0.4331 | No |
| Level 4 | 0.3582 | 0.3582 | 0.36 | 0.3582 | No |
| Level 3 | 0.2116 | 0.2637 | 0.24 | 0.2637 | No |

# La Jolla Commons Office Tower

# Lateral System Verification

- Drifts for wind and seismic were verified to meet code and industry standard requirements (Cd=5, R=6)
- Torsional analysis was performed at each story under the different seismic load cases and found to no longer have an irregularity
- Stability coefficients were verified
- Overturning moment was checked under the controlling load case

Appendix List

| Building Resisting Moment | | |
|---|---|---|
| Worst Case Resistance - Y Direction | | |
| Total Building Weight = | 82296 | kip |
| Moment Arm = | 57.5 | ft |
| Factory of Safety= | 0.67 | |
| $M_{resisting}$ = | 3170446 | ft-k |

| Worst Case Moment for Building Overturning | |
|---|---|
| Seismic Y Direction - Load Case: Y + YET | |
| 381110 | ft-k |

| Check Overturning | | |
|---|---|---|
| Worst Case Resistance - Y Direction | | |
| Overturning Moment = | 381,110 | ft-kip |
| Resisting Moment = | 3,170,446 | ft-kip |
| Okay? | Pass | |

# Vibrations Analysis

Appendix List

# La Jolla Commons Office Tower

## Vibrations Analysis

- LL = 11 PSF
- Superimposed DL = 40 PSF

- Concrete weight = 50 pcf (Lightweight)
- Floor thickness = 5.75”
- 1.5VLR20 with 4.25” LW topping

- $P_0$ = 65lb
- $\beta$ = 0.03
- $a_0/g$ = 0.5%

Appendix List

- Beam Properties:
  - $W_j$ = 153 kip
  - $f_j$ = 4.39 Hz
  - $W_g$ = 205.3 kip
  - $f_g$ = 4.86 Hz

- Combined Mode Properties:
  - $f_n$ = 3.36 Hz
  - $W_{total}$ = 174.5 kip

- $a_p/g$ = 0.38%

- $a_p/g < a_0/g$