# Hershey Research Park Building One


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Structural Option
Senior Thesis 2013
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# Presentation Outline

- Building Introduction
- Existing Conditions
- Structural Depth – Structural Redesign
- Breadth One – Sustainability
- Breadth Two – Mechanical
- Conclusion
- Comments


Site Master Plan

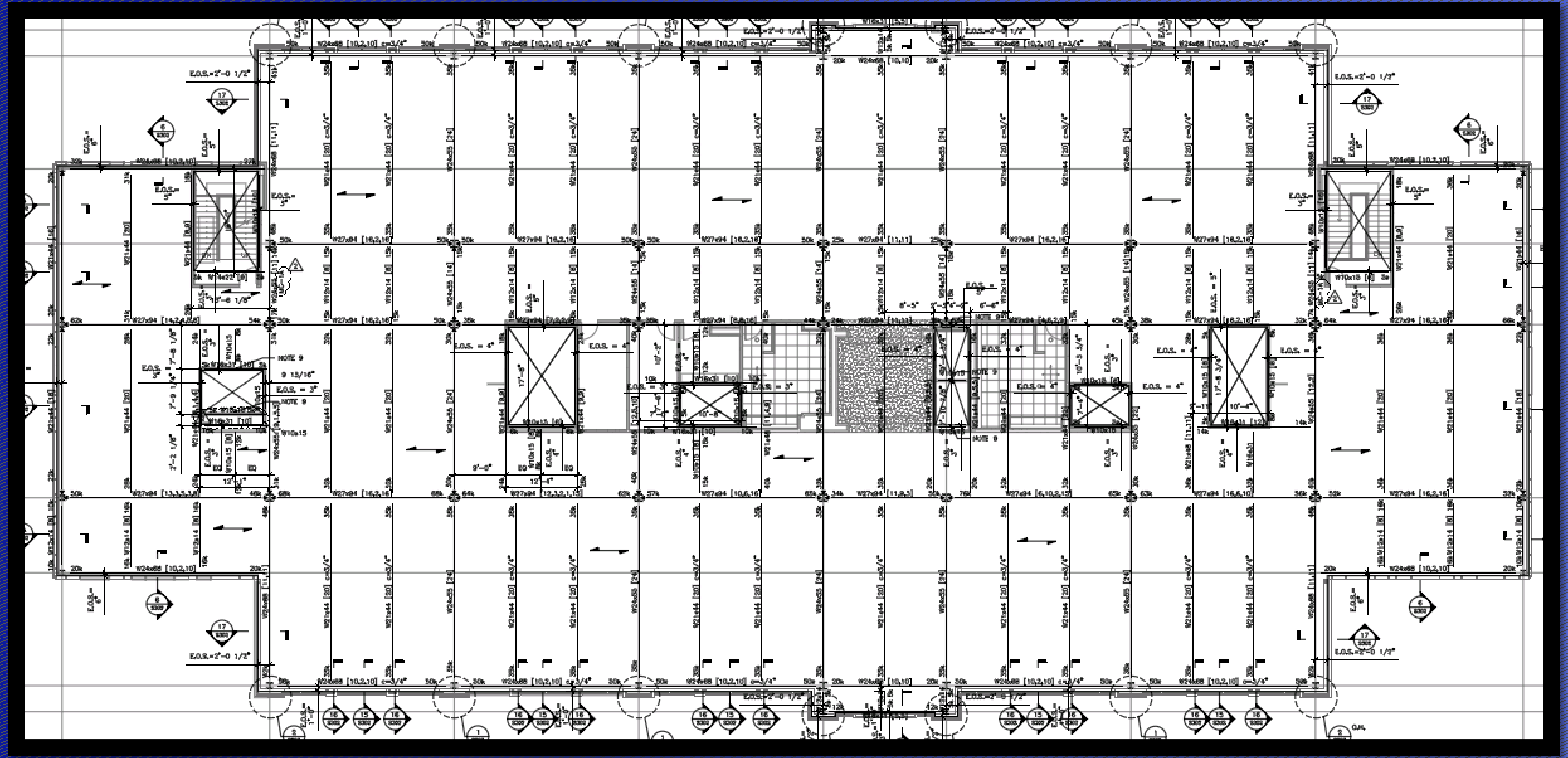
# Building Introduction

- Hershey, PA
- Research Facility
- 80,000 square feet
- Three Stories, 50 feet tall
- Construction started in April 2006
- Opened in May 2007
- $10.7 Million

# Project Team

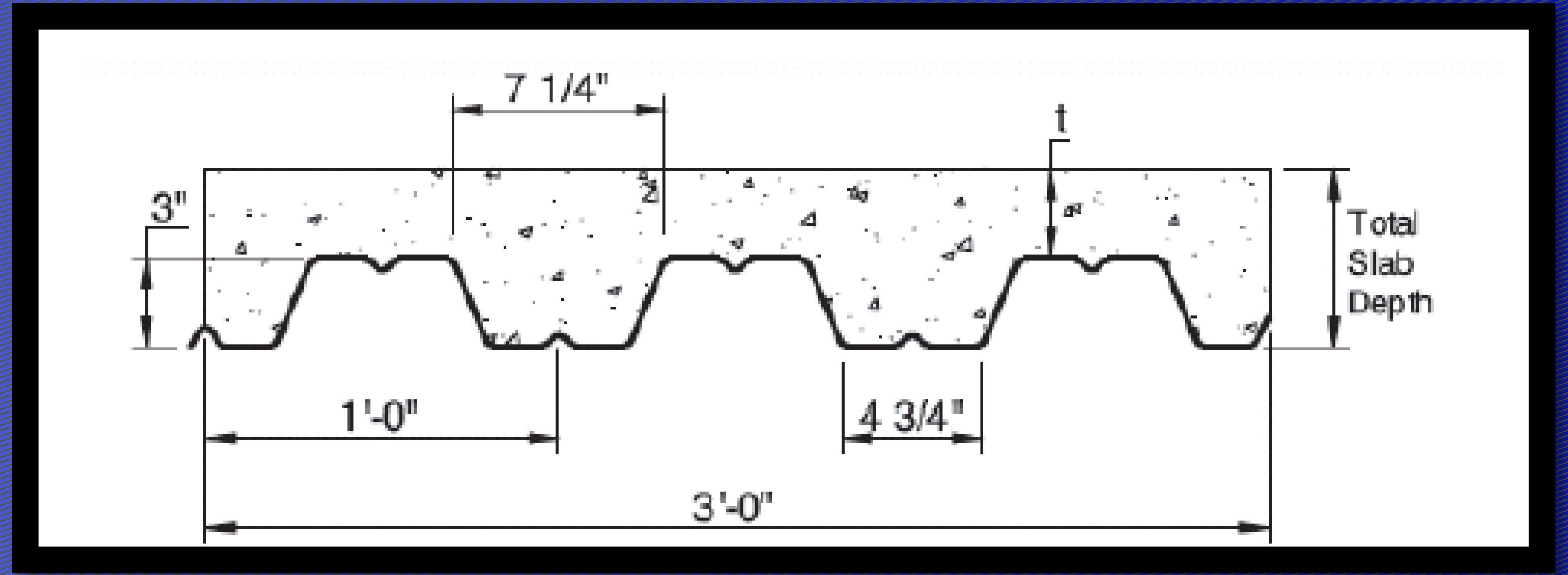
- Owner: Wexford Technology, LLC
- Architect: Ayers/Saint/Gross Inc.
- Engineers: Brinjac Engineering
- Construction Mangers: Whiting – Turner Construction

# Existing Structural System



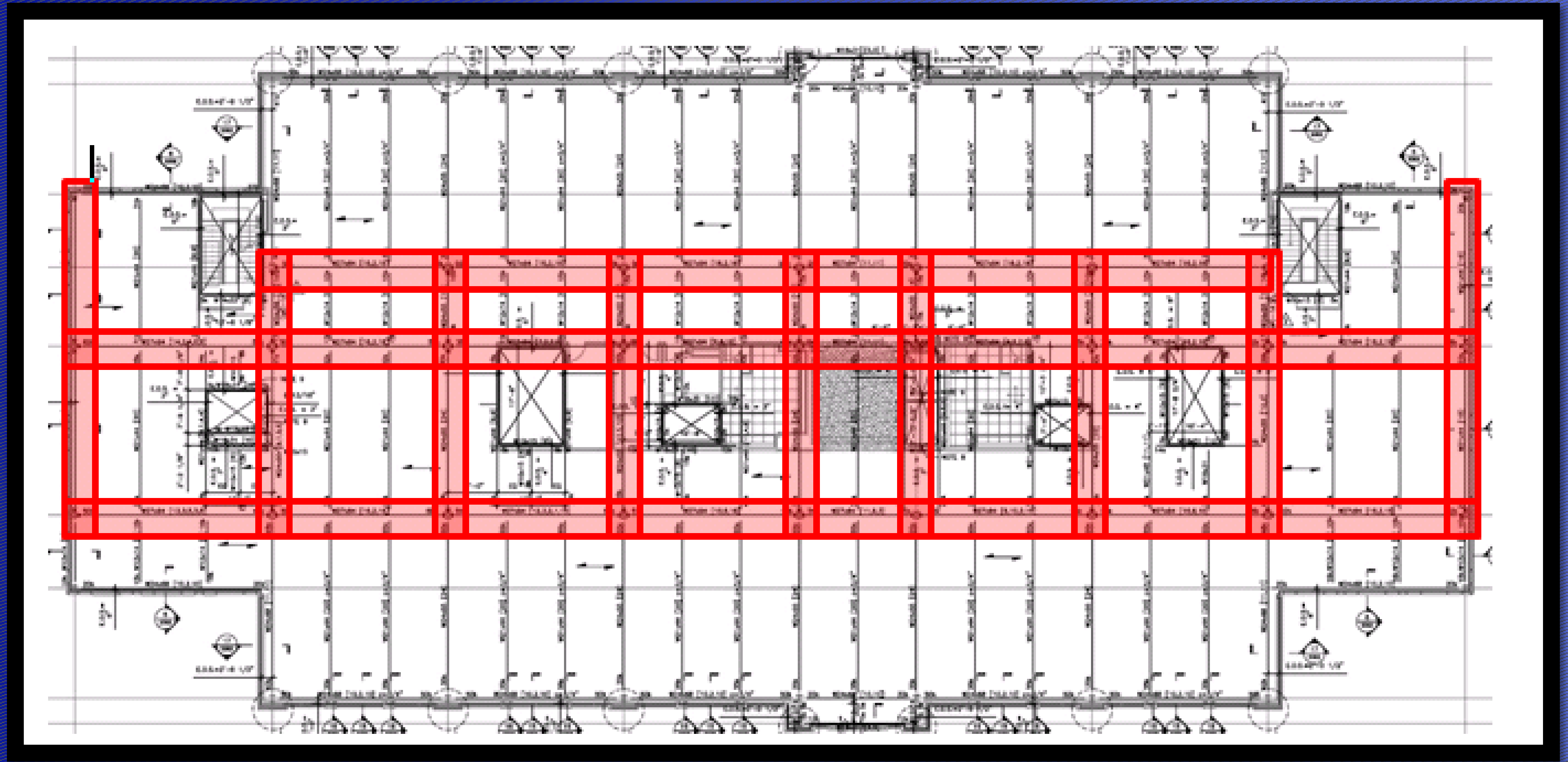
Typical Floor Frame

- Steel Moment Frame
- Composite Metal Deck
  - Vulcraft 3VLI18
- Piers with Concrete Caps




Deck Cross Section

# Existing Structural System



Lateral Frame

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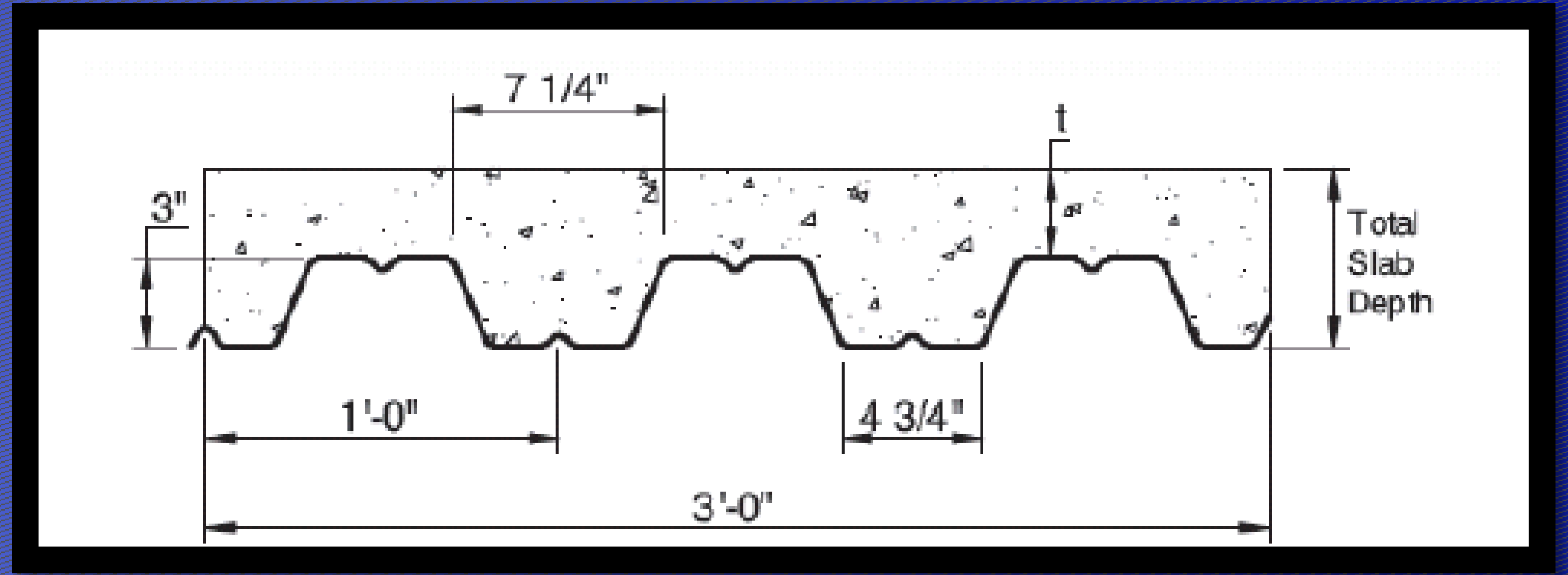


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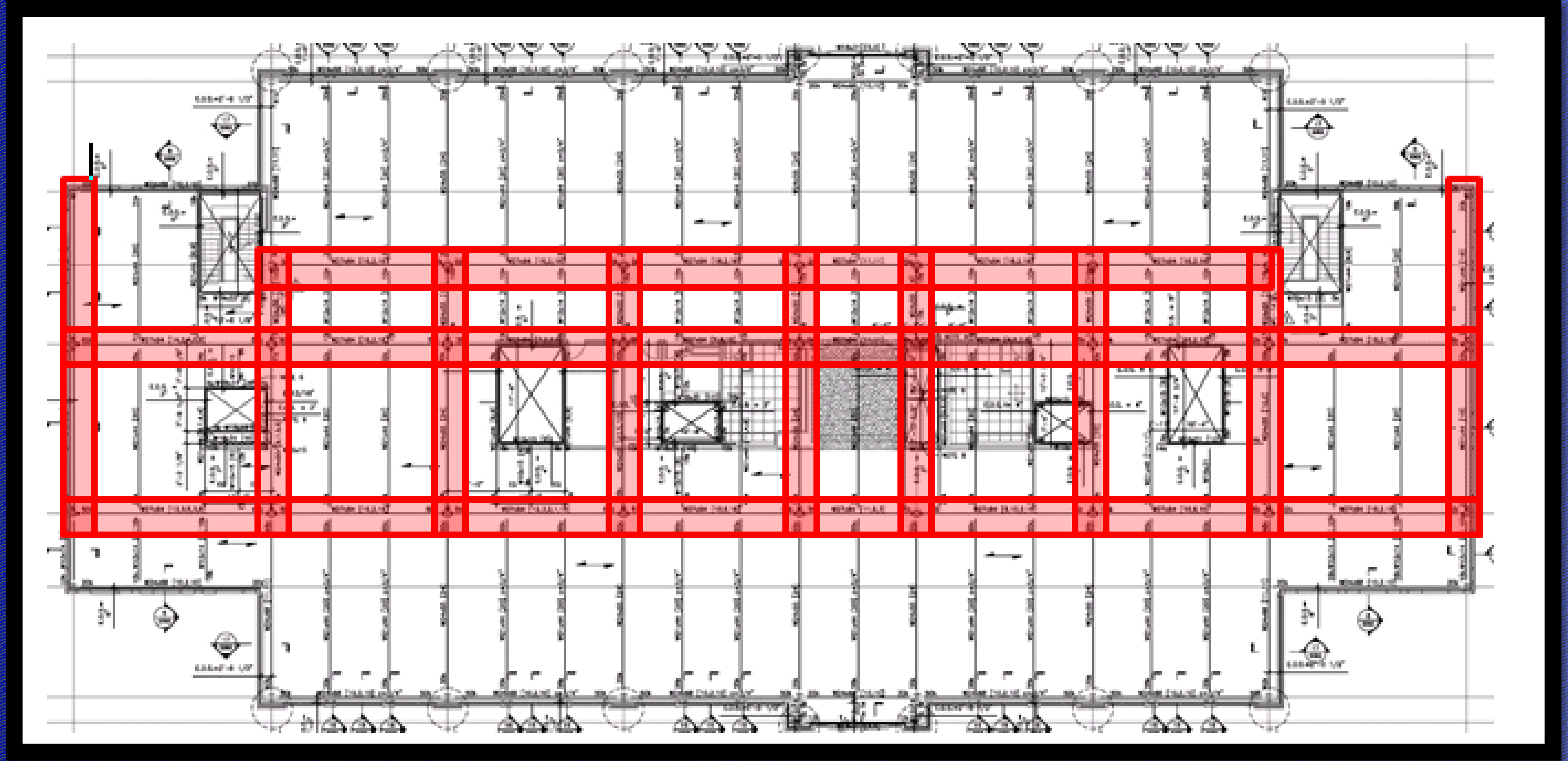
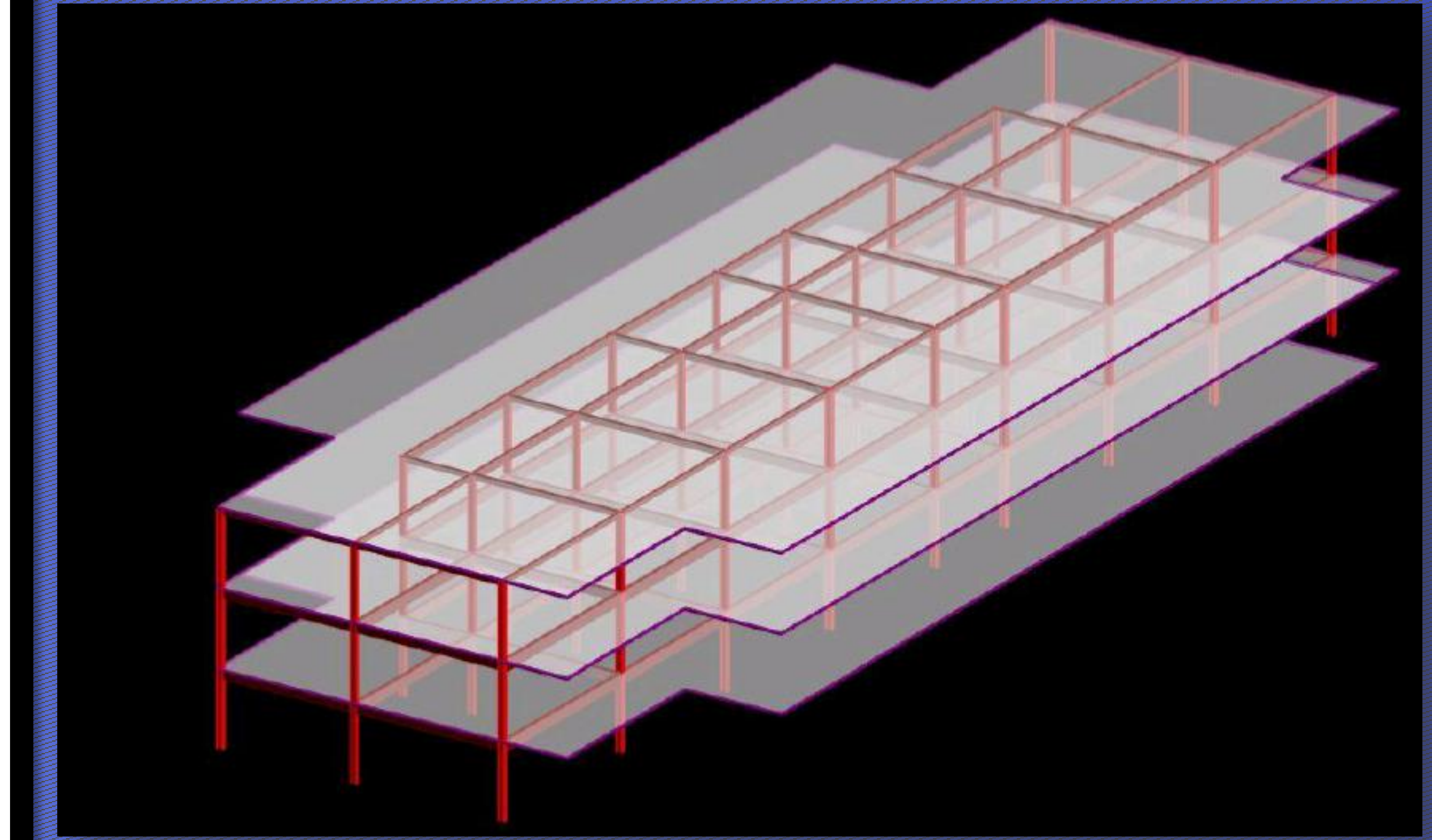
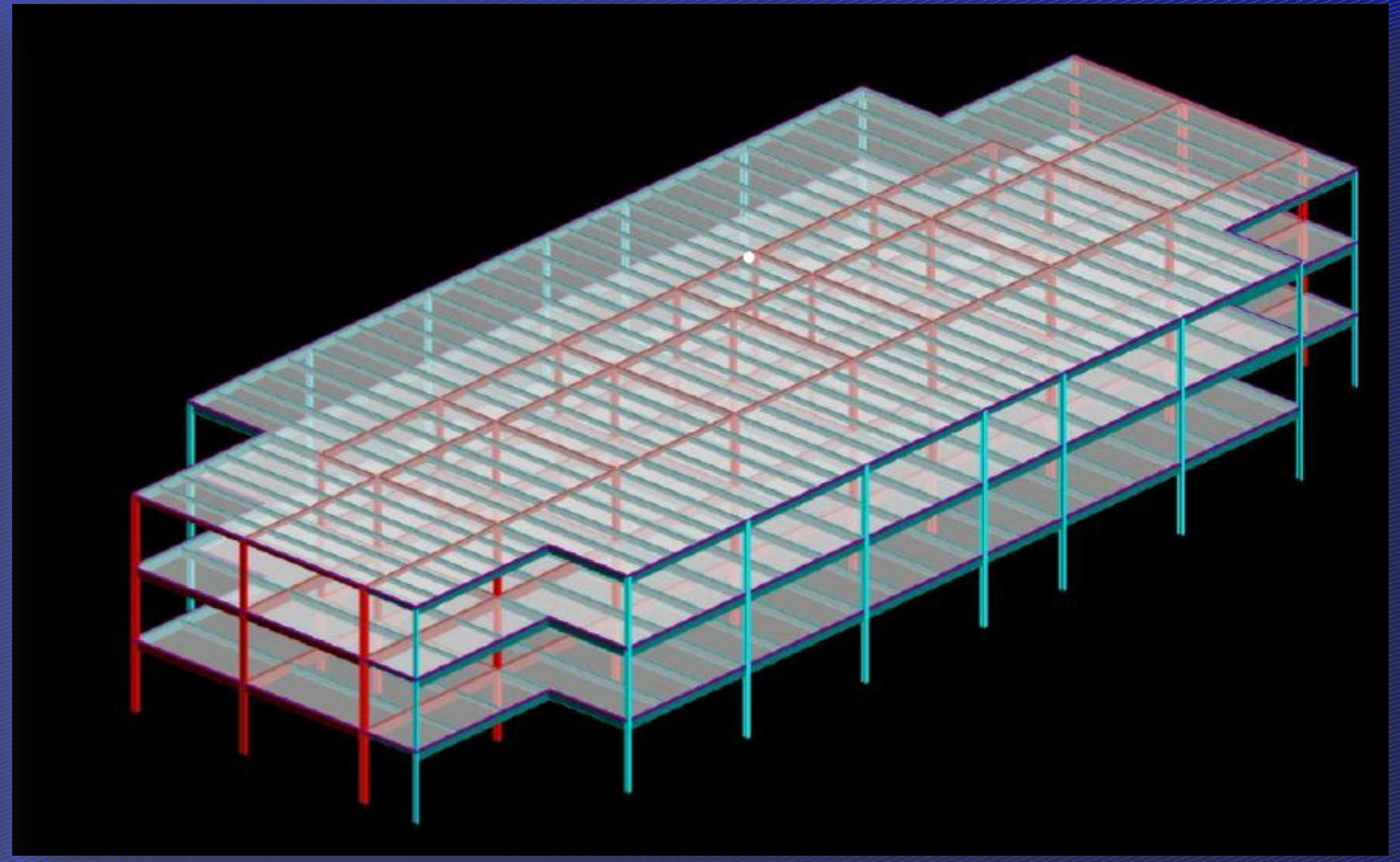


Lateral Frame



RAM Model - Lateral Frame



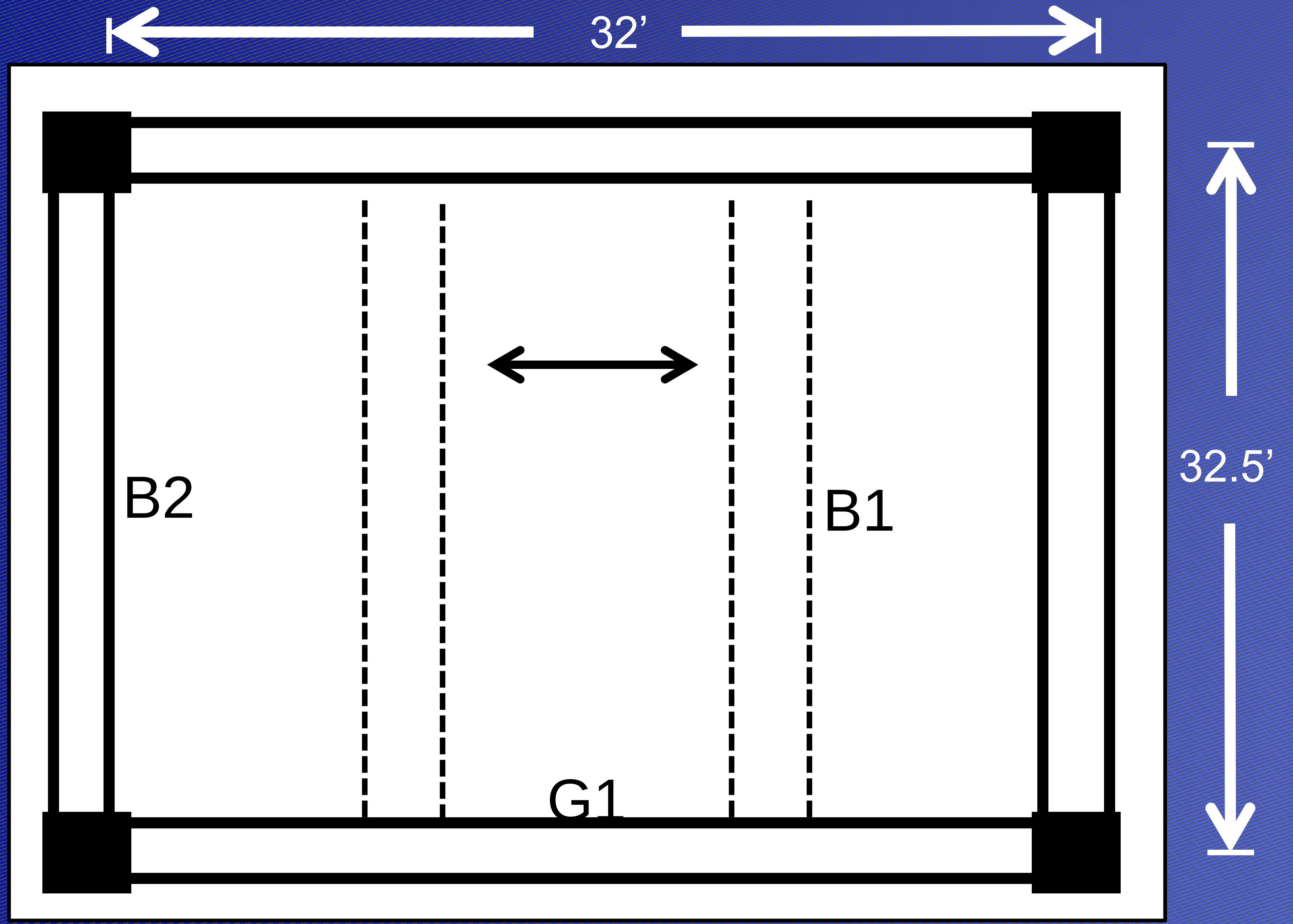
RAM Model – Existing Structure

# Structural Depth

- System Redesign
  - Steel to Concrete
  - One Way Slab with Beams
- Lateral Design
  - Concrete Moment Frame
- Goals
  - Design an adequate system
  - Cost effective and easy to construct

# Thesis Breadths

- Breadth One – Sustainability
- Breadth Two – Mechanical
- Goals
  - LEED Certification through the addition of green roof
  - More energy efficient



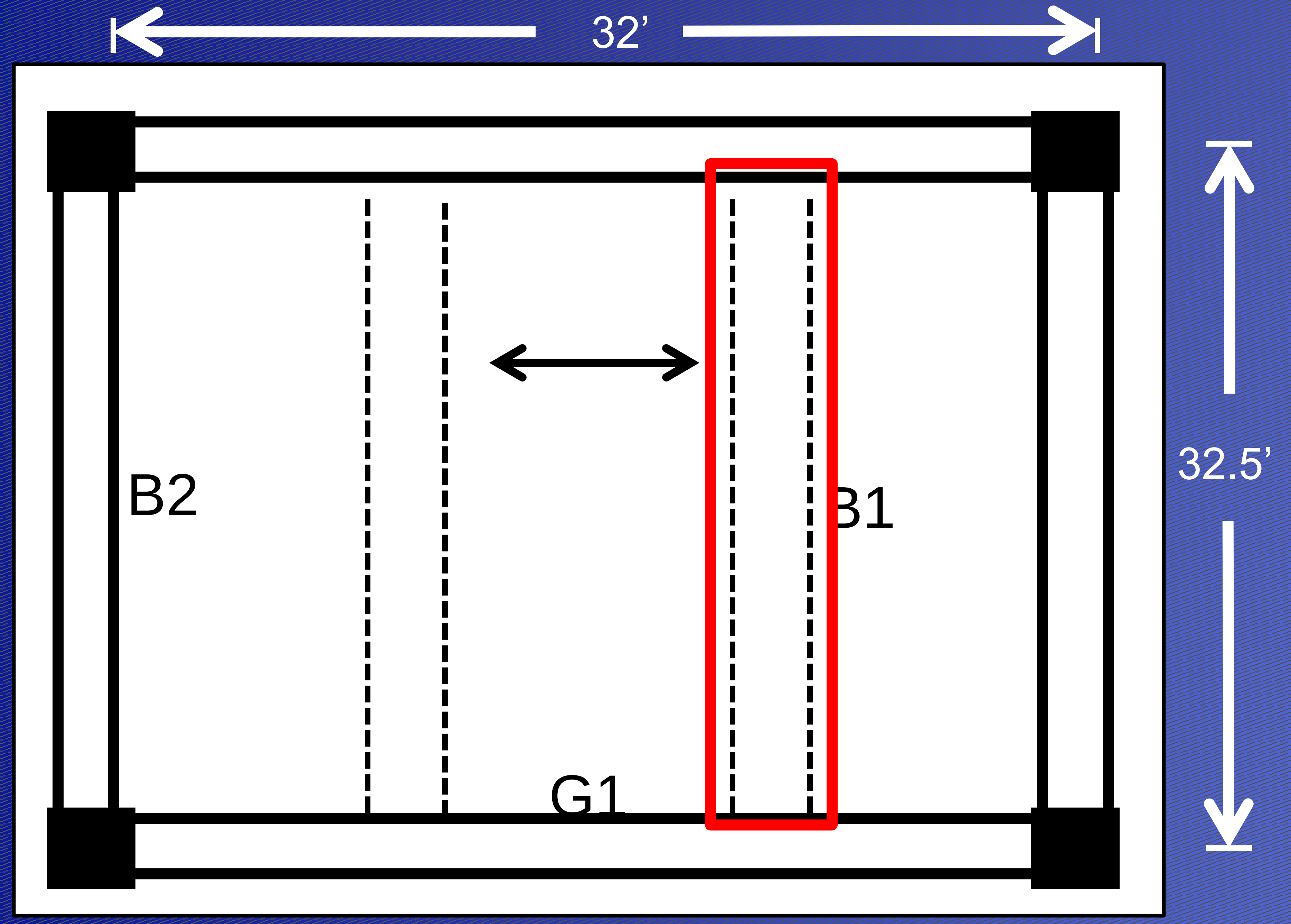
Typical Bay

# Redesign Details

- Controlling Load Combination
  - 1.2D + 1.6L
- Live Load = 100 psf
- Superimposed Dead Load = 25 psf
- Total Load = 190 psf
- Table 9.5(a) of ACI used to help determine beam depths
- As = Mu / 4d

# Slab Design

- Span Length
  - 10.67 ft
- Slab Thickness
  - 5.5 in
- Slab Weight
  - 68.75 psf
- Reinforcement
  - Flexural - # 4 bars @ 12 in OC
  - Transverse - # 4 bars @ 18 in OC

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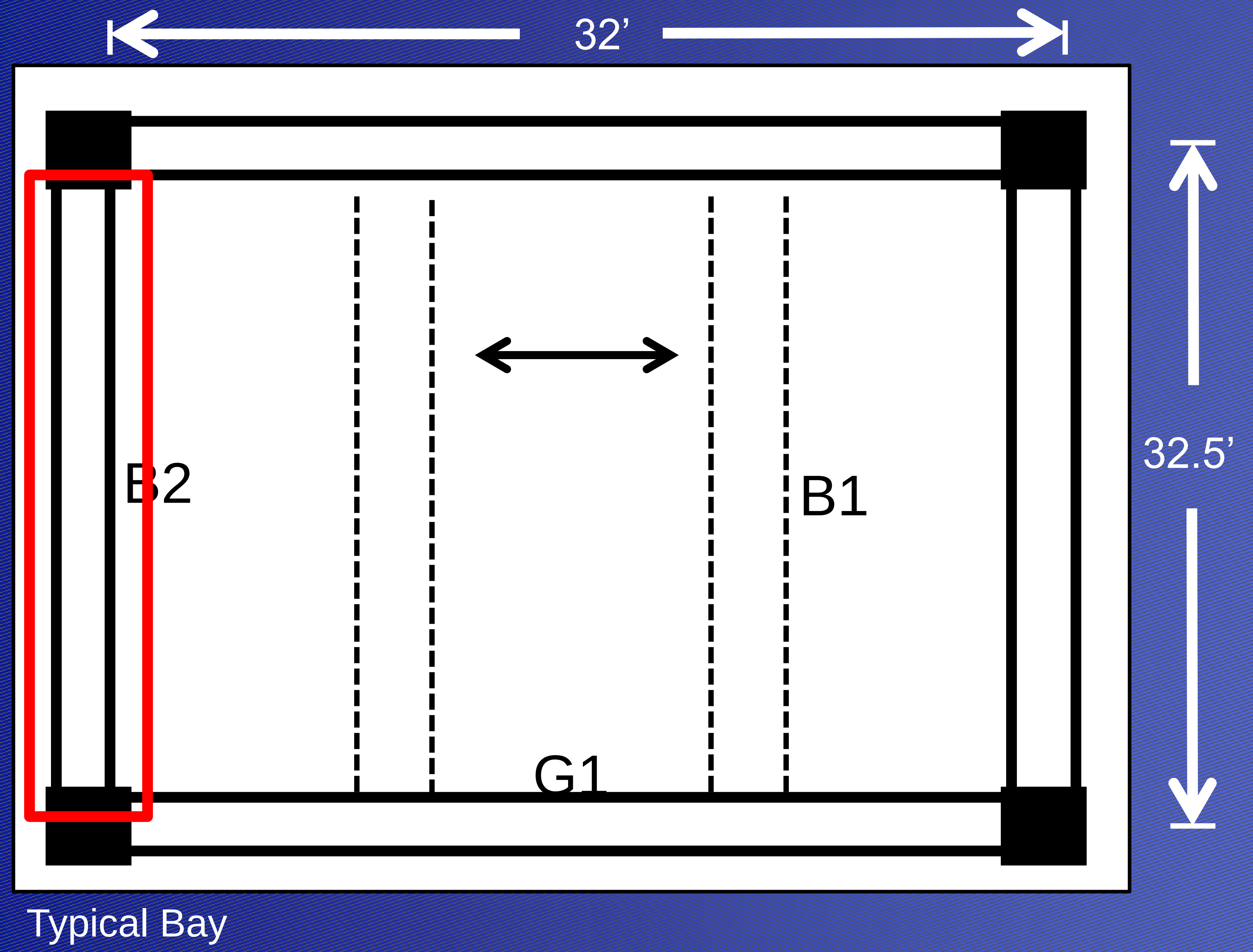
- As = Mu / 4d

# Beam B1 Design

- Span Length
  - 32.5 ft
- Beam Section
  - 16” x 28”
- Mu = 237 k-ft < ΦMn = 264 k-ft
- Vu = 39 k < ΦVn = 78 k
- Reinforcement
  - Exterior Spans – (3) # 7 bars
  - Interior Spans – (4) # 7 bars
  - # 4 Stirrups




# Beam B2 Design

- Span Length
  - 32.5 ft
- Beam Section
  - 20" x 28"
- Mu = 247 k-ft < ΦMn = 267 k-ft
- Vu = 41 k < ΦVn = 88 k
- Reinforcement
  - Exterior Spans – (3) # 7 bars
  - Interior Spans – (4) # 7 bars
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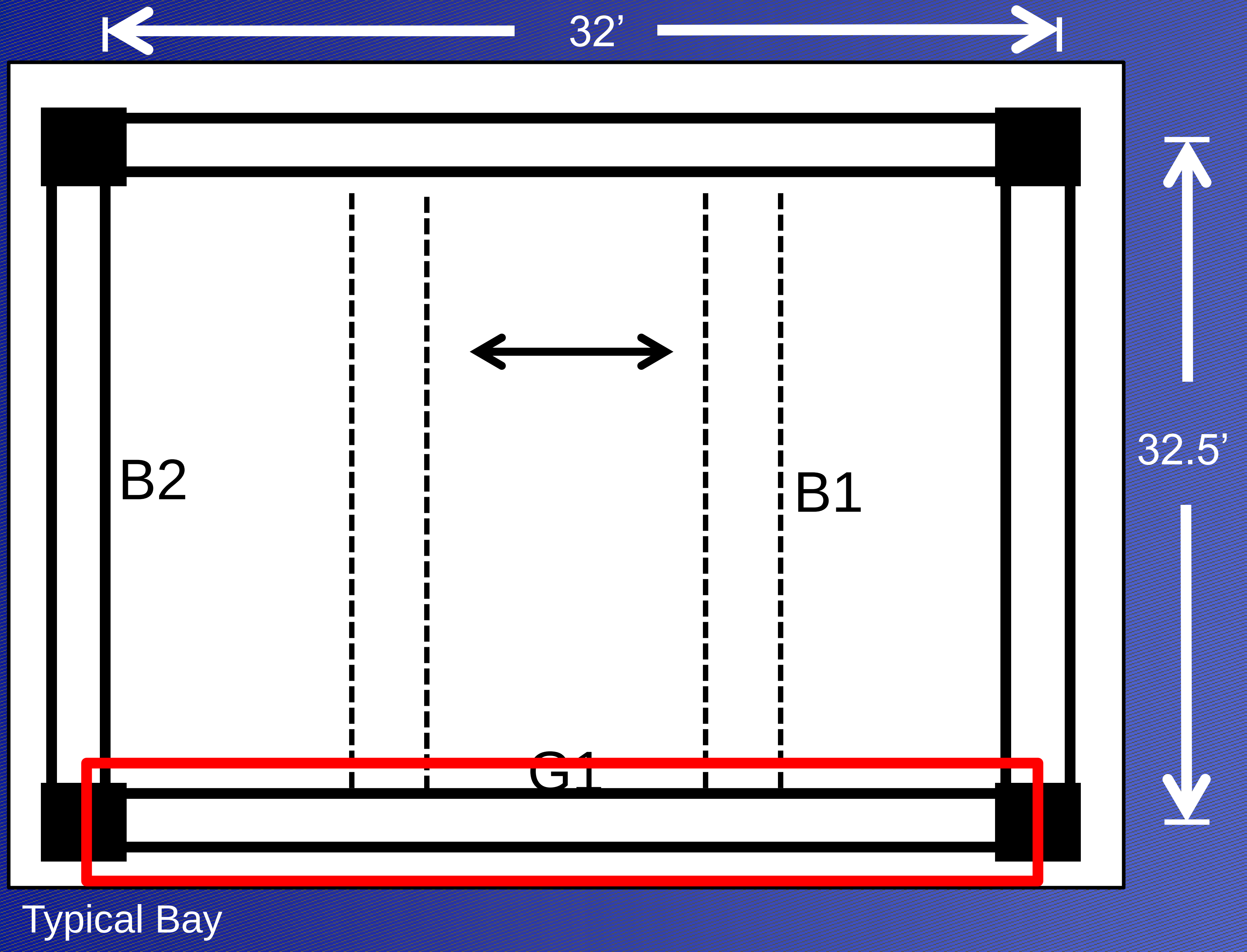


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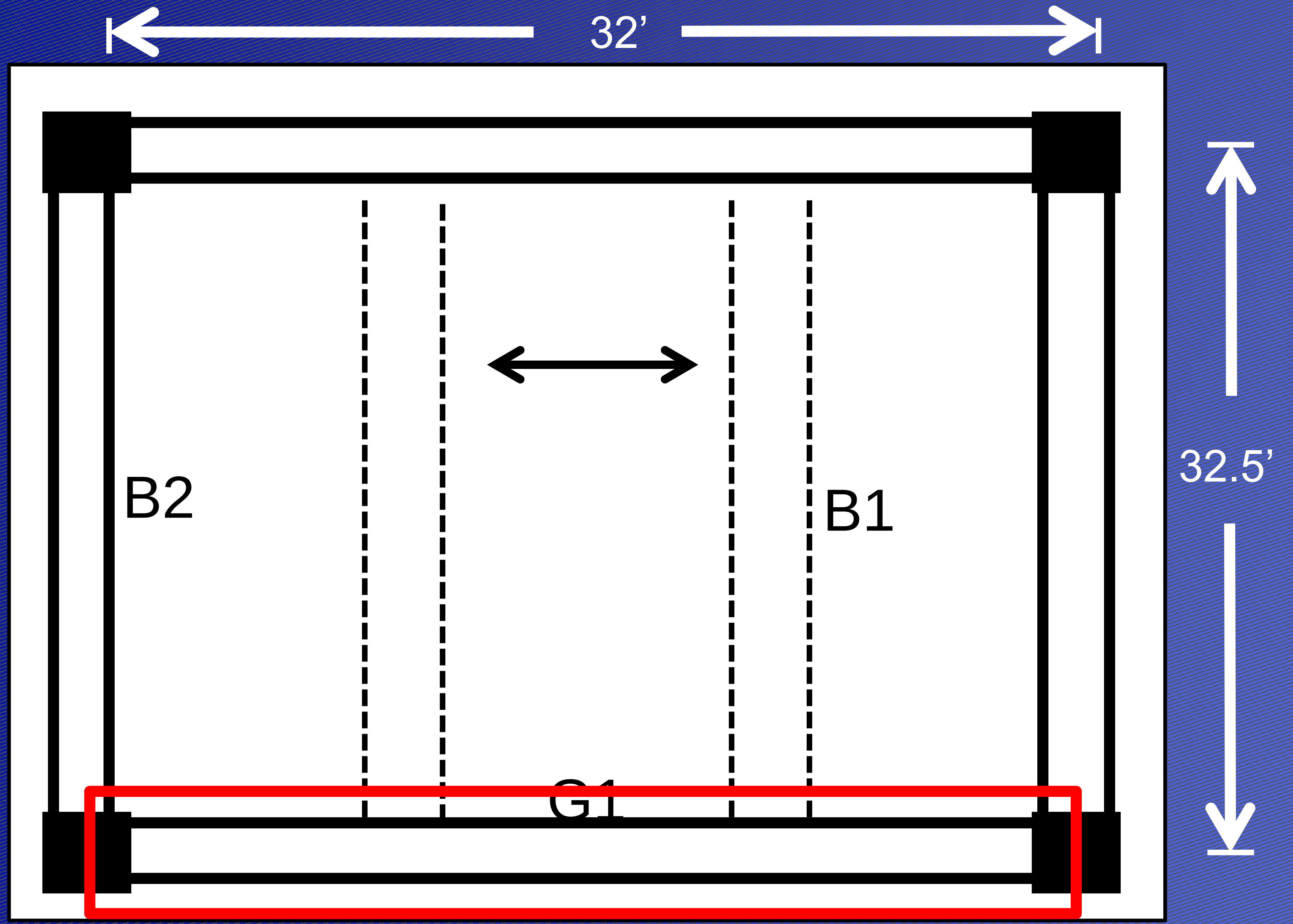
# Girder Design

- Span Length
  - 32 ft
- Beam Section
  - 20" x 28"
- Mu = 302 k-ft < ΦMn = 333 k-ft
- Vu = 47 k < ΦVn = 117 k
- Reinforcement
  - Exterior Spans – (3) # 7 bars
  - Interior Spans – (5) # 7 bars
  - # 4 Stirrups



Typical Bay

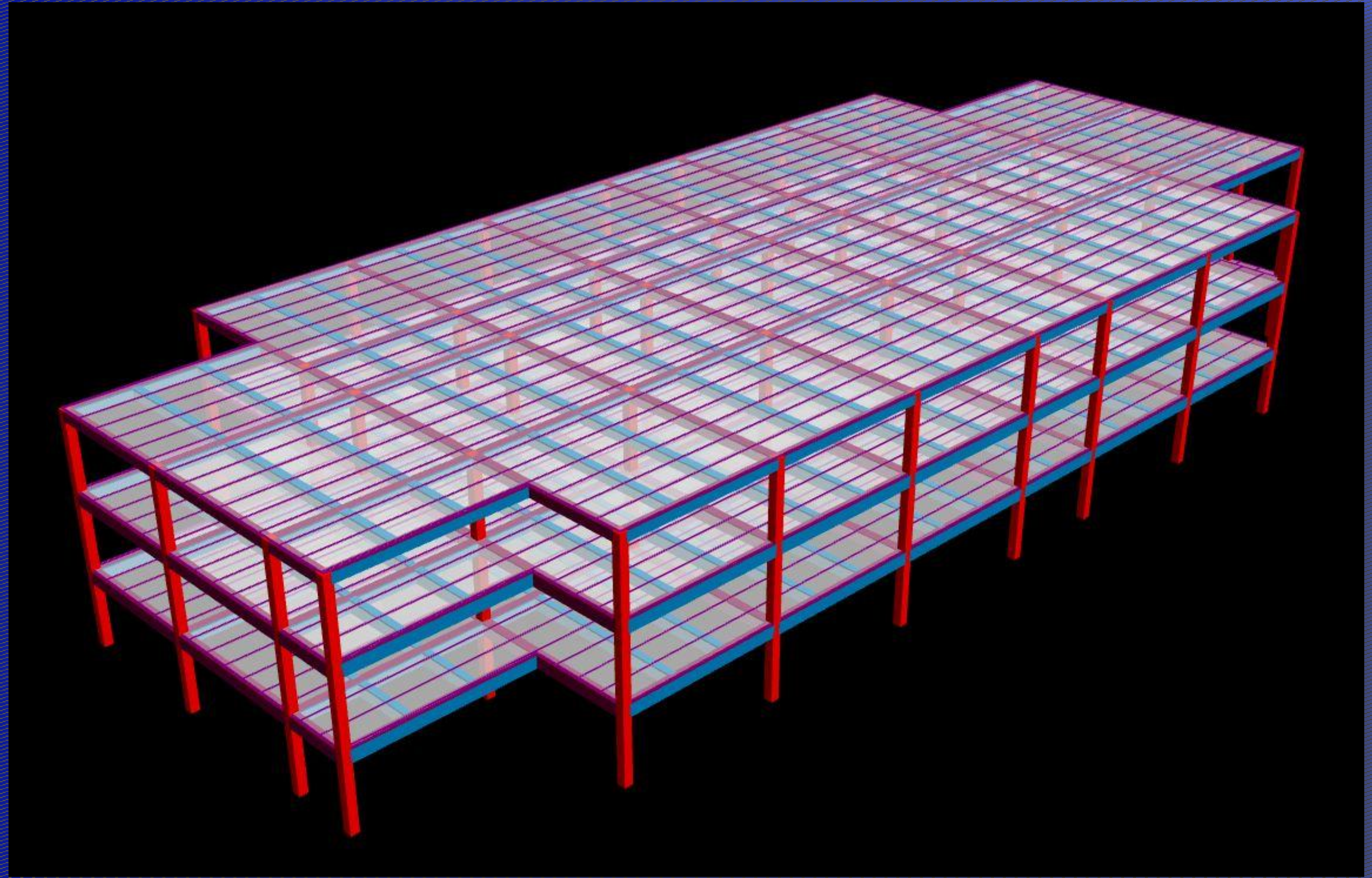
# Column Design

- Column Layout Unchanged
- Simplified Design for Columns
  - Alsamsam and Kamara
- Design Aids based of ACI
- Column Section
  - 20" x 20"
- Reinforcement
  - (12) # 10 bars
- Max Load
  - Pu = 564 kips < ΦPn = 1050 kips

# Girder Design

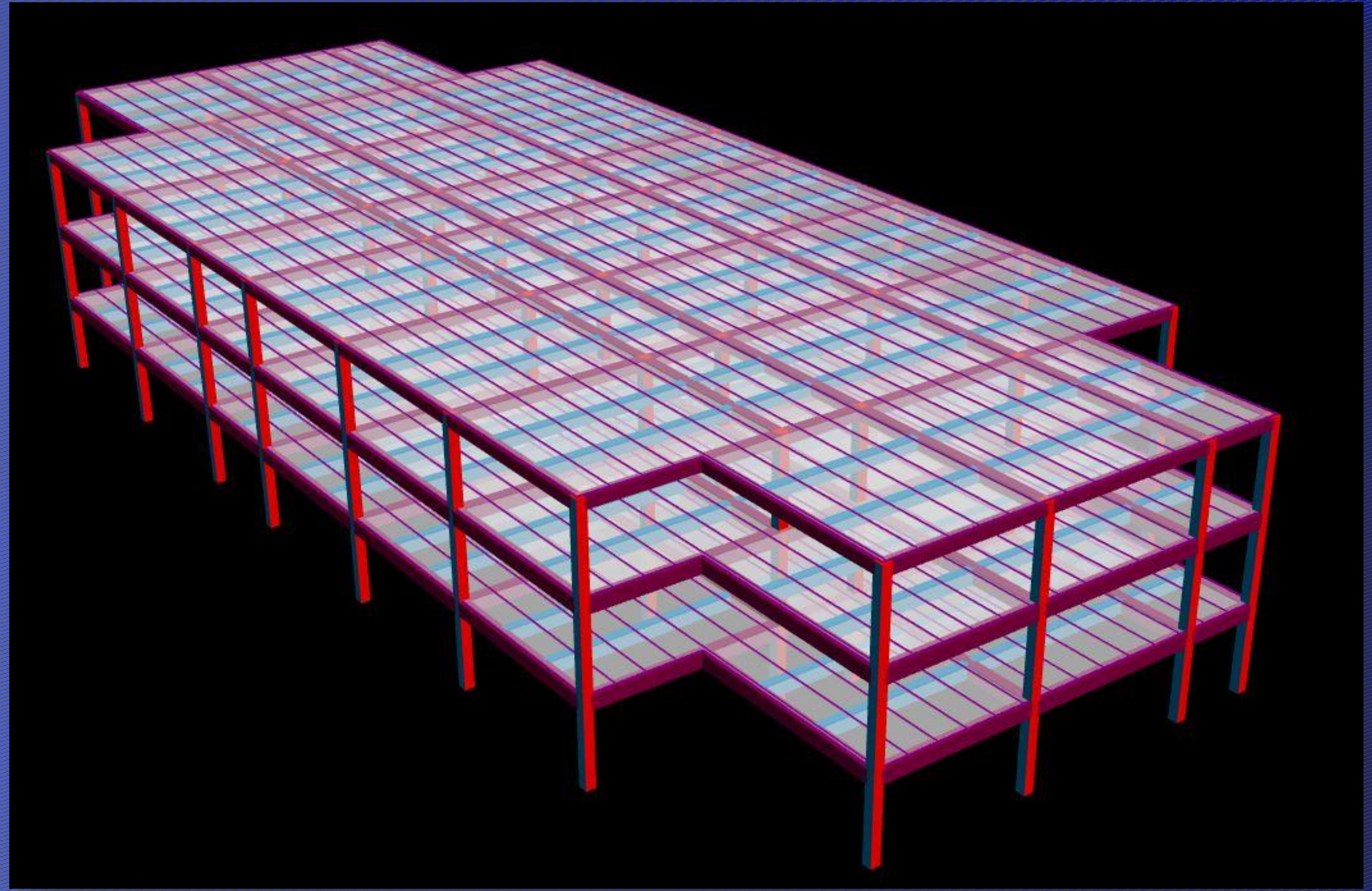
- Span Length
  - 32 ft
- Beam Section
  - 20" x 28"
- Mu = 302 k-ft < ΦMn = 333 k-ft
- Vu = 47 k < ΦVn = 117 k
- Reinforcement
  - Exterior Spans – (3) # 7 bars
  - Interior Spans – (5) # 7 bars
  - # 4 Stirrups

# Lateral Redesign



RAM Structural Model

- Concrete Moment Frame
- No addition lateral resisting needed
- Analysis done using RAM Structural System
- Controlling Load Cases
  - Wind – 1.2 D + 1.0 L + 1.0 W
  - Seismic – 1.2 D + 1.0 L + 1.0 E



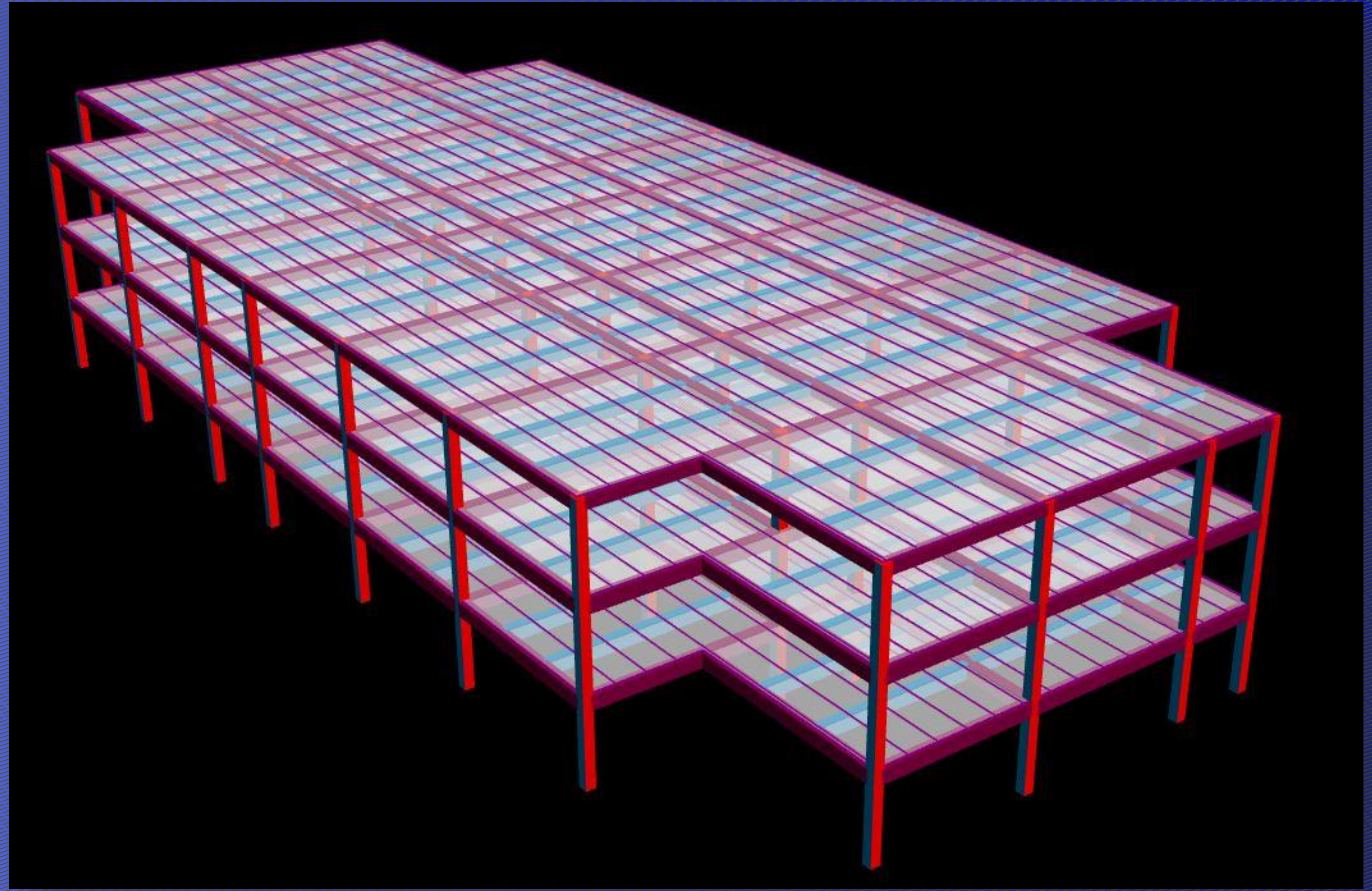
RAM Structural Model

# Serviceability

| Controlling Wind Load Case 1.2D+1.0L+1.0W | | | | | |
|---|---|---|---|---|---|
| **Floor** | X Deflection (in) | Y Deflection (in) | X Drift (in) | Y Drift (in) | Allowable Drift (in) |
| **Roof** | 0.059 | 0.02152 | 0.0124 | 0.01 | 0.44 |
| **3rd** | 0.04666 | -0.01148 | 0.0231 | 0.0066 | 0.44 |
| **2nd** | 0.0236 | -0.00485 | 0.0236 | 0.0049 | 0.44 |
| **Total** | | | 0.0591 | 0.0215 | |

# Wind Loads

- ASCE 7 – 10
- Load Combination
  - 1.2 D + 1.0 L + 1.0 W
  - Wind Case One
- Max Story Drift
  - H/400



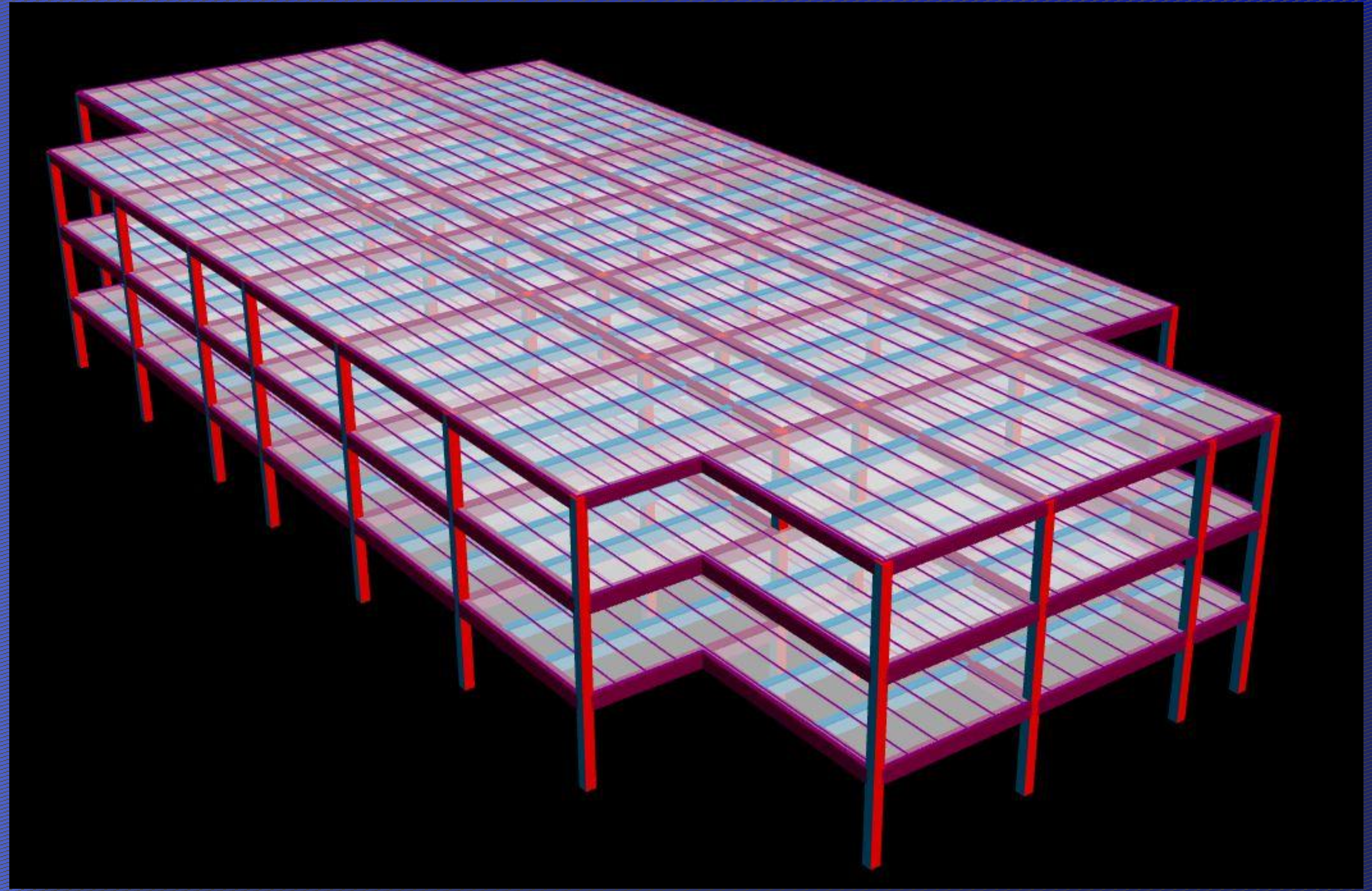
RAM Structural Model

# Serviceability

| Controlling Seismic Load Case 1.2D+1.0L+1.0E | | | | | |
|---|---|---|---|---|---|
| **Floor** | X Deflection (in) | Y Deflection (in) | X Drift (in) | Y Drift (in) | Allowable Drift (in) |
| **Roof** | 0.51621 | -0.019 | 0.1492 | 0.0008 | 2.64 |
| **3rd** | 0.36698 | -0.00981 | 0.2005 | 0.0059 | 2.64 |
| **2nd** | 0.16647 | -0.00424 | 0.1664 | 0.0045 | 2.64 |
| **Total** | | | 0.5161 | 0.0112 | |

# Seismic Loads

- ASCE 7 – 10
- Load Combination
  - 1.2 D + 1.0 L + 1.0 E
- Max Story Drift
  - 0.015 x H
- Design Variables
  - Seismic Design Category = “D”
  - R = 3.0
  - I = 1.25

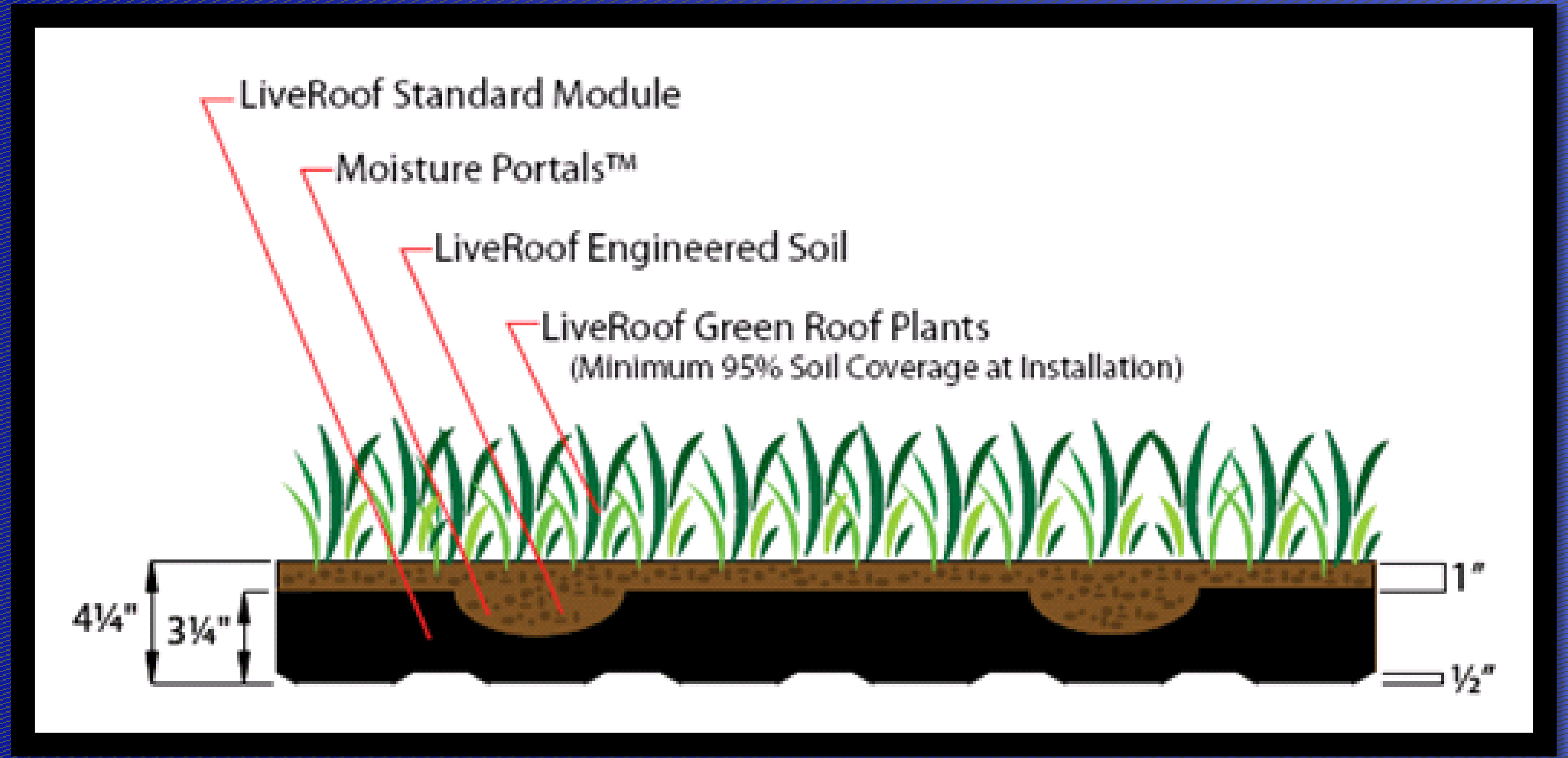


RAM Structural Model

# Sustainability Breadth

- Main goal is to achieve LEED certification through the addition of a green roof
- Owners Future Plans – LEED Certification for all buildings
- Two different green roofs were compared
  - LiveRoof
  - TectaGreen
- Roof Structure
  - Extra 35 psf on Roof

# Sustainability Breadth

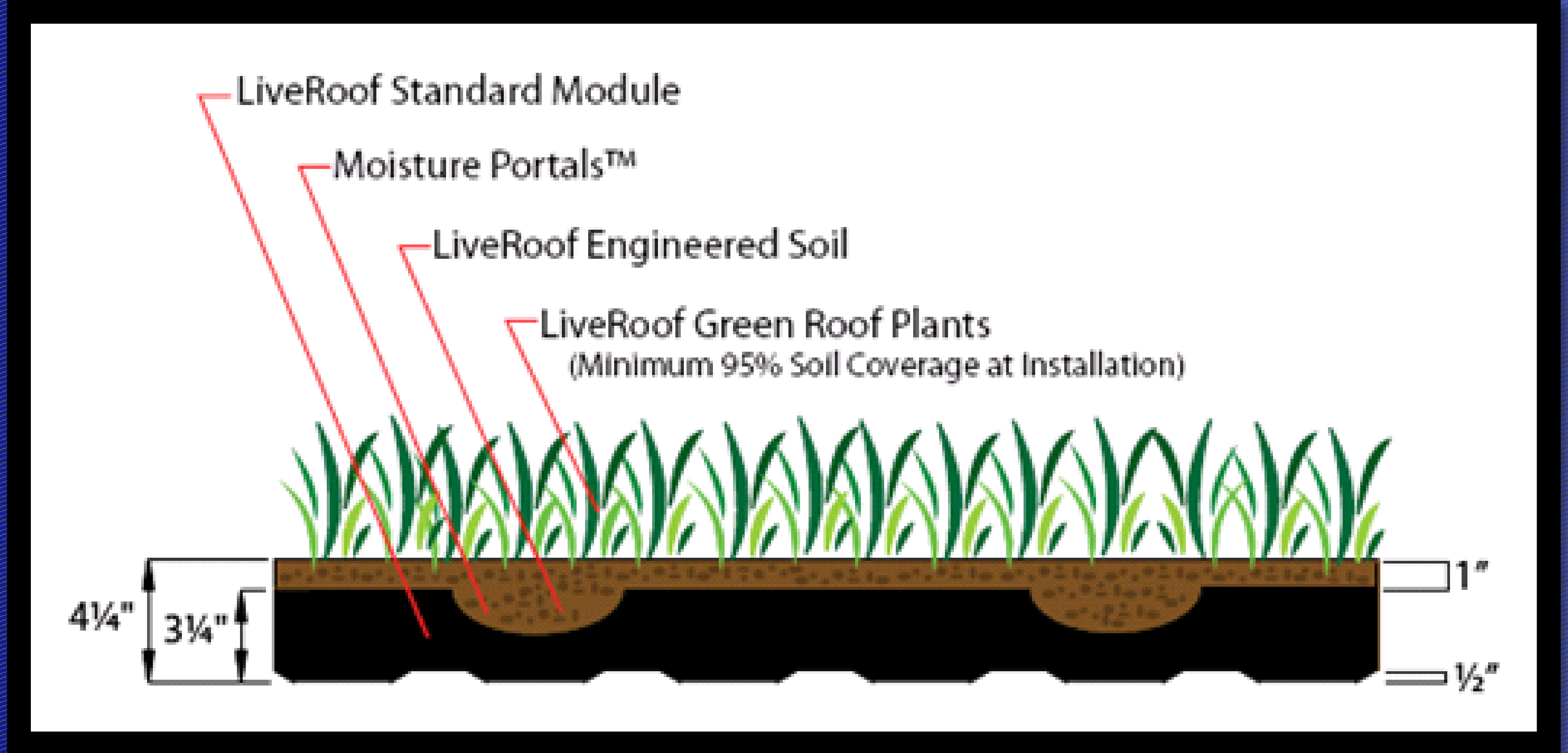


LiveRoof  Green Roof Design Detail

- Both designs have similar advantages and disadvantages
- The LiveRoof system was chosen as the better choice
- Standard Module
- Possible of obtaining over 20 LEED credits
- Optimized Energy Performance – Mechanical Breadth

| LiveRoof System | | |
|---|---|---|
| **LEED Category** | Credit Abbreviation | Credits Possible |
| **Protect or Restore Habitat and Maximum Open Space** | SS 5.1/5.2 | 1 each (2 total) |
| **Storm Water Design** | SS 6.1/6.2 | 1 each (2 total) |
| **Heat Island Effect** | SS 7.1/7.2 | 1 each (2 total) |
| **Water Efficient Landscape** | WE 1.1/1.2 | 2/4 (6 total) |
| **Optimized Energy Performance** | EA 1.1-1.19 | 1 each (19 total) |
| **Construction Waste Management** | MR 2 | 1 to 2 |
| **Recycled Content** | MR 4.1/4.2 | 1 to 2 |
| **Regional Materials** | MR 5.1/5.2 | 1 to 2 |
| **Rapidly Renewable Materials** | MR 6 | 1 |

# Sustainability Breadth




LiveRoof Green Roof Design Detail

- Both designs have similar advantages and disadvantages
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- Standard Module
- Possible of obtaining over 20 LEED credits
- Optimized Energy Performance – Mechanical Breadth

LiveRoof Green Roof

# Structural Effects

| Roof Slab Design Details | |
|---|---|
| **Slab Thickness** | 5.5" |
| **Flexural Reinforcement (Top and Bottom)** | # 4 Bars @ 12" |
| **Transverse Reinforcement** | # 4 Bars @ 18" |
| **System Weight** | 68.75 psf |

| Roof Beam Design Details | |
|---|---|
| **Beam Section** | 12"x22" |
| **Flexural Reinforcement (Exterior Spans)** | (3) #7 Bars |
| **Flexural Reinforcement (Interior Spans)** | (2) #10 Bars |
| **Beam Weight** | 206 plf |

| Roof Girder Design Details | |
|---|---|
| **Beam Section** | 18"x22" |
| **Flexural Reinforcement (Midspan)** | (3) #7 Bars |
| **Flexural Reinforcement (Supports)** | (5) #7 Bars |
| **Beam Weight** | 310 plf |

- Roof Loads
  - Roof Live Load – 30 psf
  - Superimposed Dead Load – 25 psf
  - Green Roof – 35 psf
  - Snow Load – 30 psf
- Controlling Load Case
  - 1.2 D + 1.6 Lr
- Total Load – 120 psf

LiveRoof  Green Roof

# Breadth Conclusion

- The addition of a green roof would be helpful
- LEED credits can help for LEED certification
  - Certified: 40 – 49 points
  - Silver: 50 – 59 points
  - Gold: 60 – 79 points
  - Platinum: 80 or more

LiveRoof  Green Roof

# Conclusions

- The existing steel frame is the more feasible structural system for the building
  - Higher floor thickness
  - Longer construction time
- The addition of a green roof would be helpful
  - Possible addition of over 20 LEED Credits
  - LEED Certification
  - Lower energy cost

# Comments
# Or
# Questions?


## Acknowledgements

Wexford Science and Technology, LLC
Brinjac Engineering
Ayers/Saint/Gross Inc.
AE Staff
Advisor: Dr. Linda Hanagan

# Mechanical Breadth

- Main goal was to find the energy saving ability of the green roof
- The more energy the green saves, the better
- More LEED Credits
  - Optimized Energy Performance – Mechanical Breadth
  - Up to 19 Credits Possible

# Mechanical Breadth

| Roof Assembly R - Values | |
|---|---|
| Material | R – Value |
| Concrete Slab (5.5”) | .4125 |
| Insulation | 22 |
| Roof Board | 1.09 |
| Water Proofing Membrane | .12 |
| LiveRoof Standard Green Roof System | 2 |

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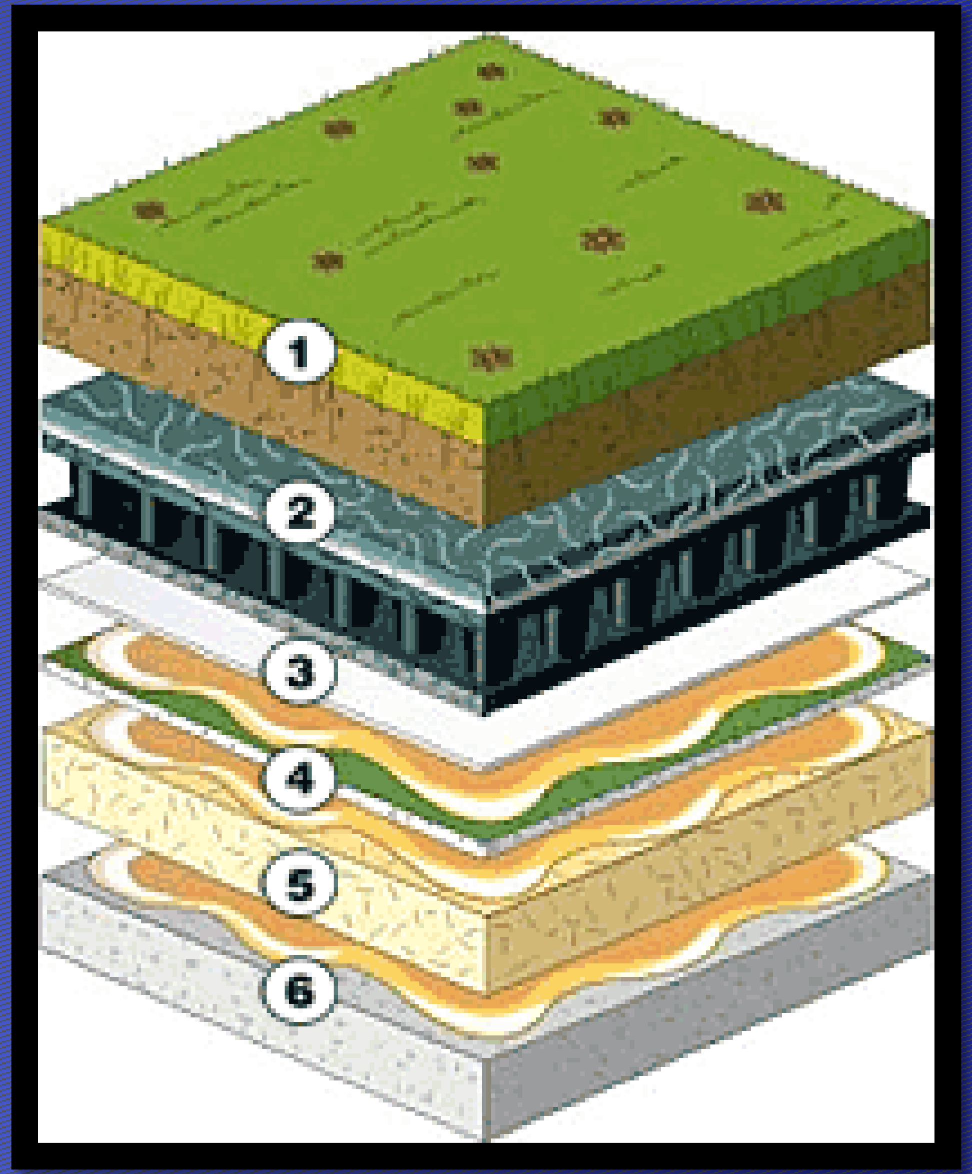

Green Roof Assembly

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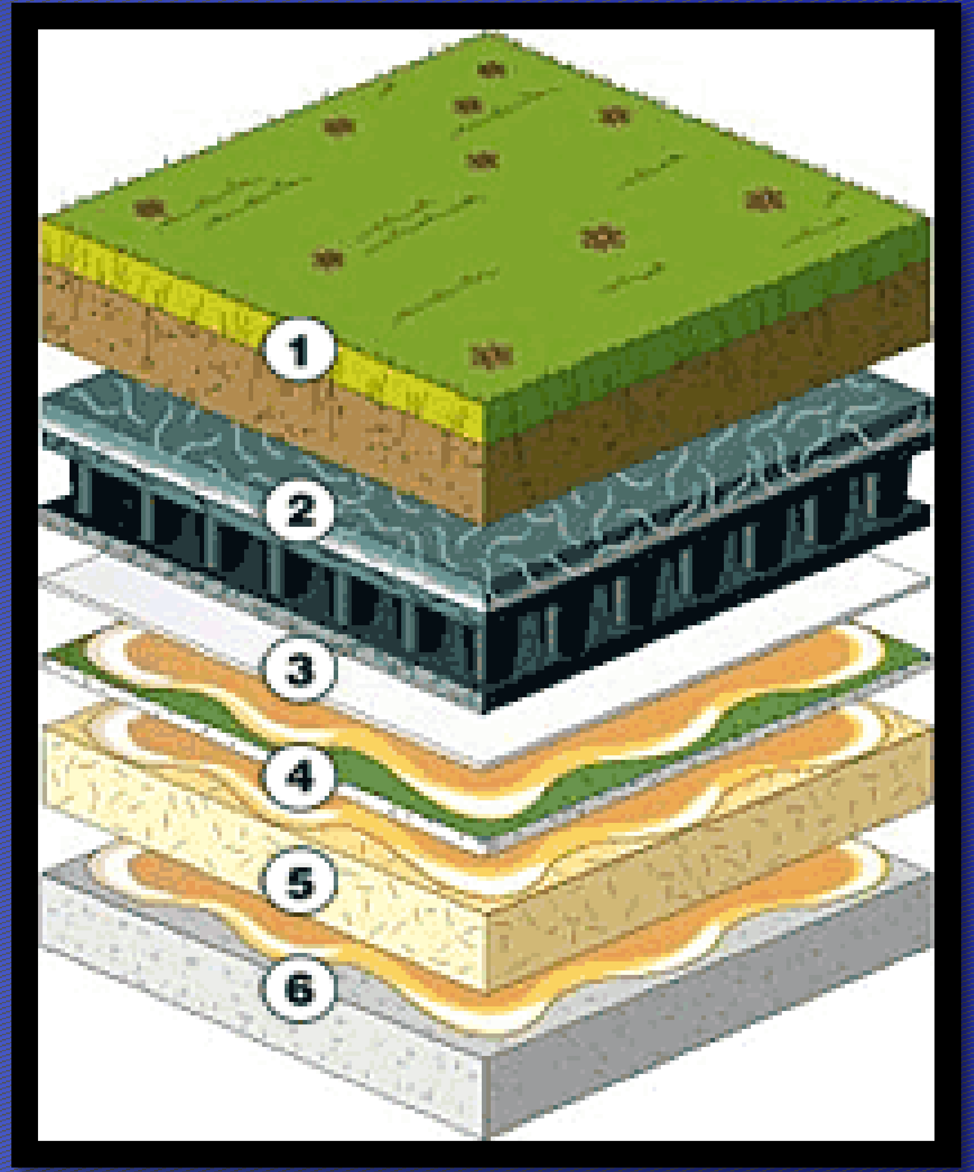
- Energy Saving of 77,375,928 BTU per year
- Additional financial benefits from tax credits
  - Federal – 30% of total cost
- LEED points
  - One Credit from energy reduction



Green Roof Assembly