

# Whiteland Village

Mary Longenecker  
Structural Option  
Senior Thesis  
August 7, 2007

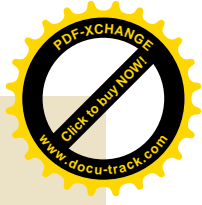
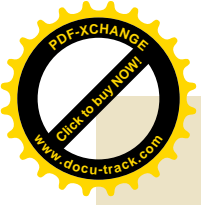


# Outline

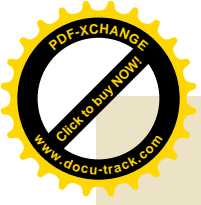


Whiteland Village

- Introduction
- Criteria for Redesign
- Lateral Redesign
  - Staggered Truss
  - Partially Restrained Composite Connections
- Construction Management Issues
- Existing Envelope Analysis
- Conclusions



**Whiteland Village**



# Retirement Community

Exton, Pennsylvania

1,320,000 sq. ft.

\$100-150 million

Design-Build

Dates of Construction

Nov. 2006 - Nov. 2008

Architects:

Dever Architects (Residences)

HLM Design (Commons)

Structural Engineers:

Baker, Ingram & Associates

Construction Managers:

Paul Risk Associates, Inc.

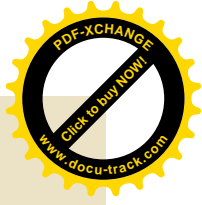
HVAC:

Madsen, Inc.

Electrical:

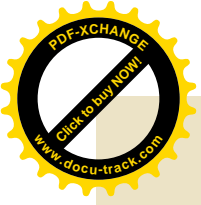
Meadow Valley Electric

**Whiteland Village**

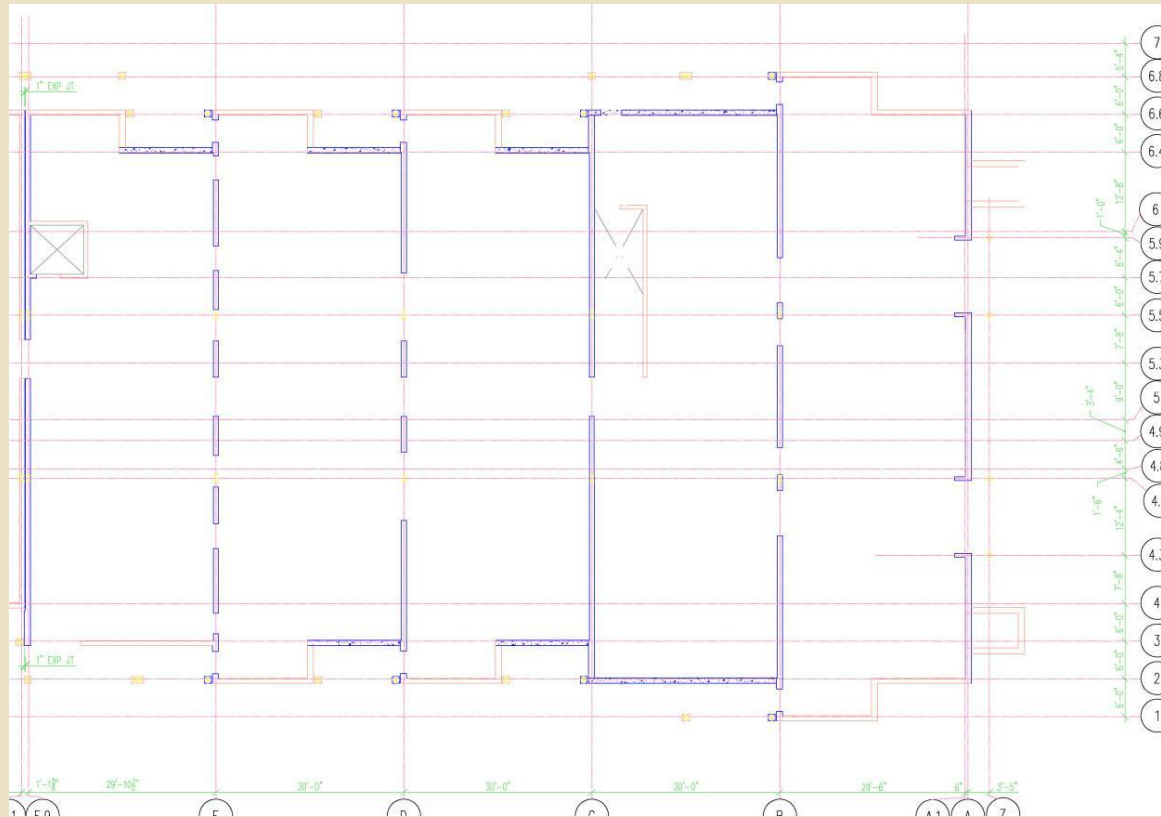


# Existing Systems

- HVAC
  - Central Exhaust System using Energy Wheel
  - Chilled Water Cooling
  - Gas Hot Water Heating
- Fire Protection
  - Wet Sprinkler System
- Electrical
  - 208Y/120V from (1) 5kV Transformer
  - Onsite Co-generation Plant

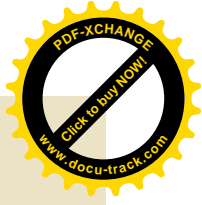
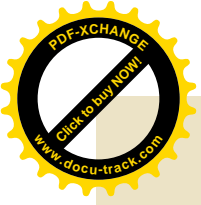


# Existing Structural System

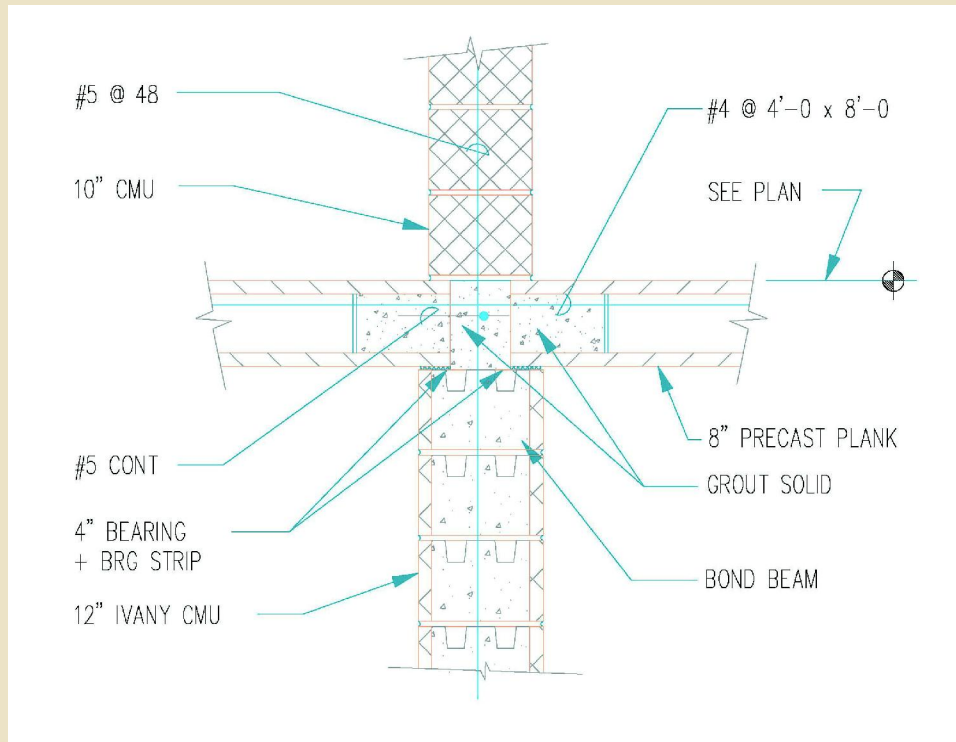


- Lateral System
  - 10" CMU Shearwalls
  - 10" Thick Concrete Shearwalls

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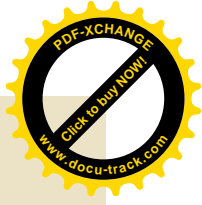
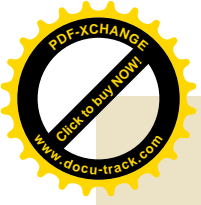


# Existing Structural System



- Floor System
  - 8" Untopped Hollow Core Precast Plank
  - Spanning 30 ft.
  - Can be considered a rigid diaphragm

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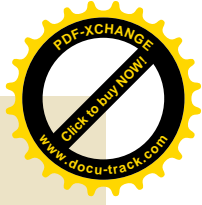


# Alternate Design Considerations

- Ease of future renovations
- Maximum 1'-8" structural depth
- Constructability
- Cost
- Floor vibration
- Fire protection

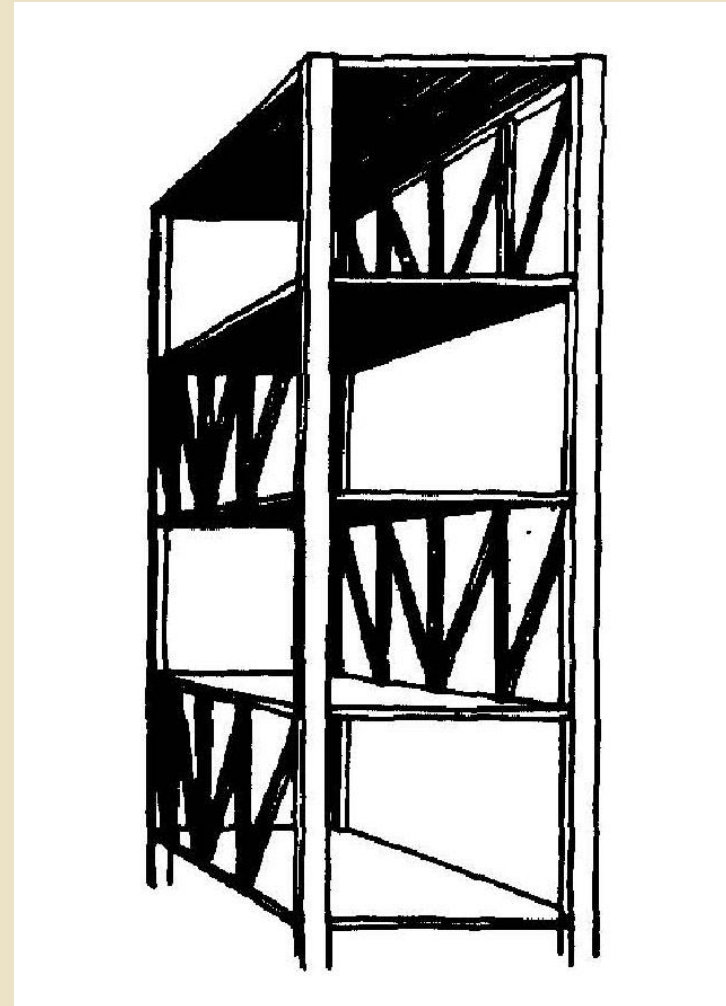
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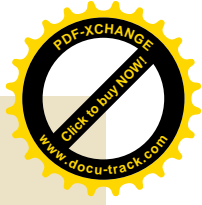
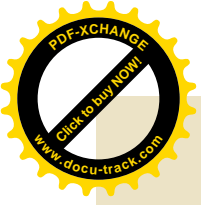


# Staggered Truss

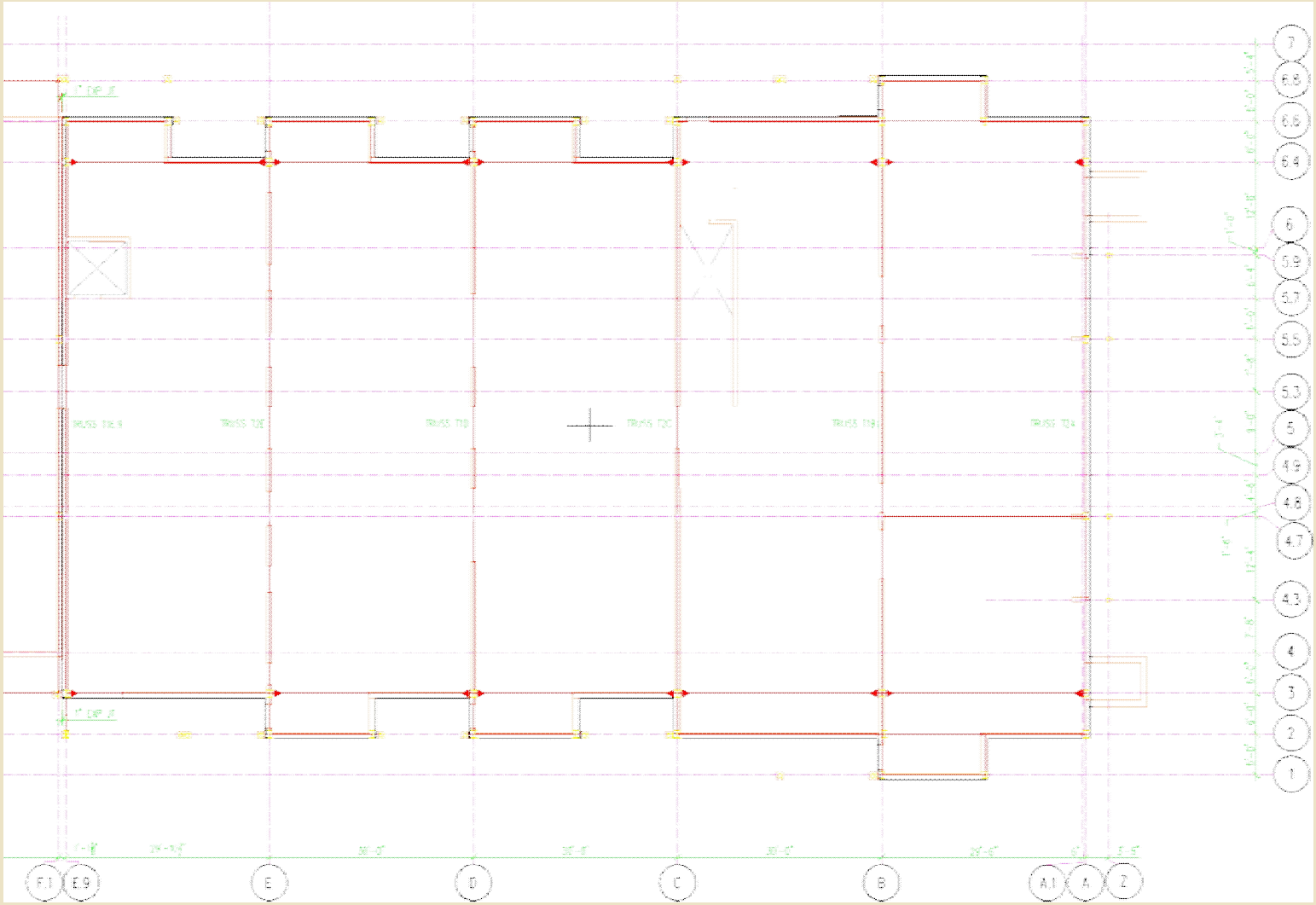
- Full story trusses
  - Span transverse width
  - Alternate floors
- Advantageous in long and narrow buildings



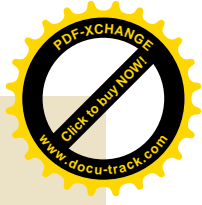
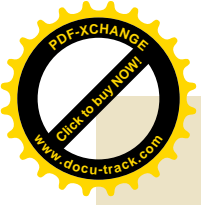
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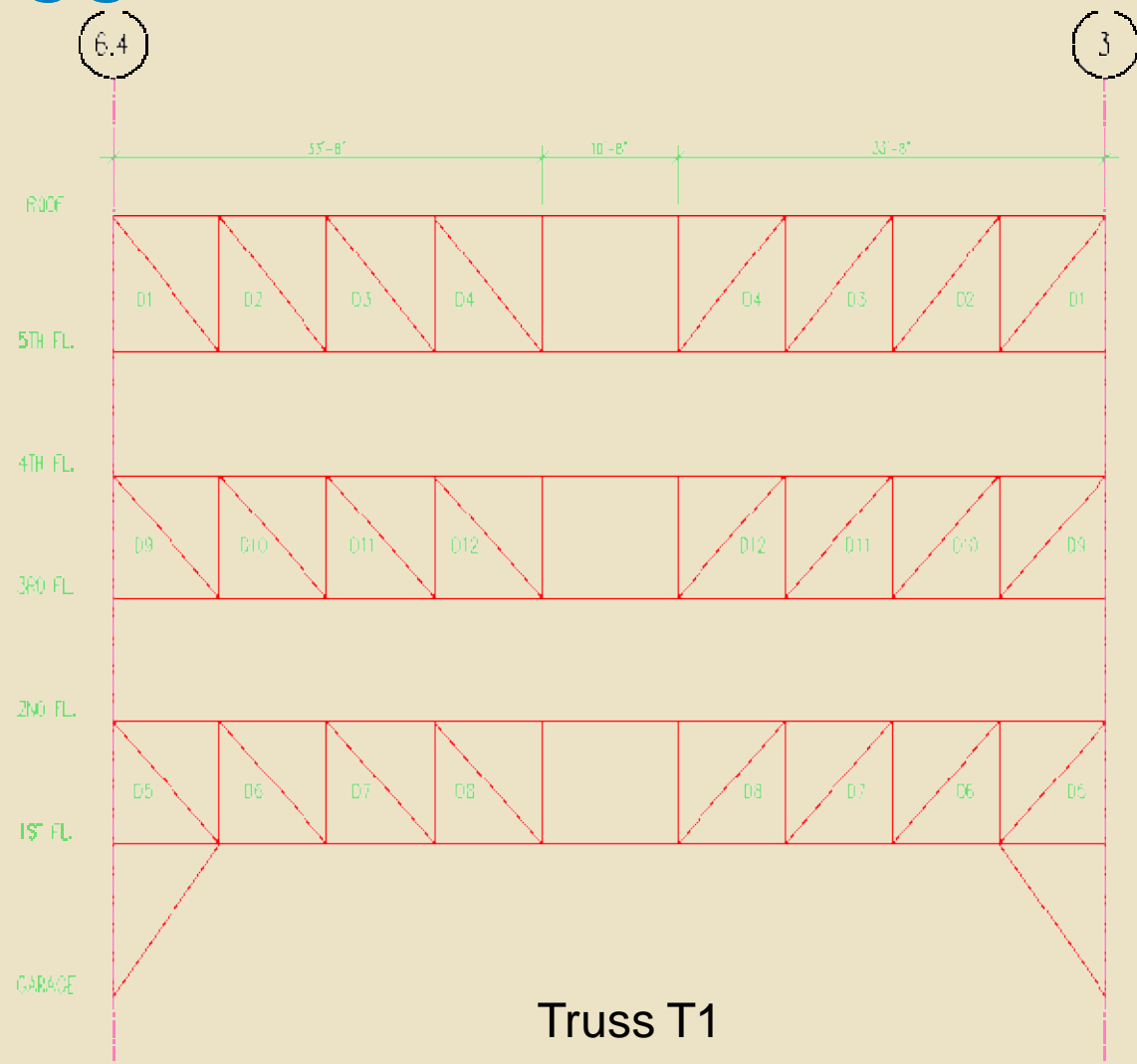
# Staggered Truss Alternate



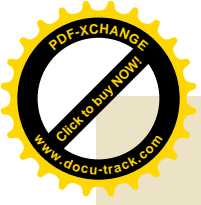
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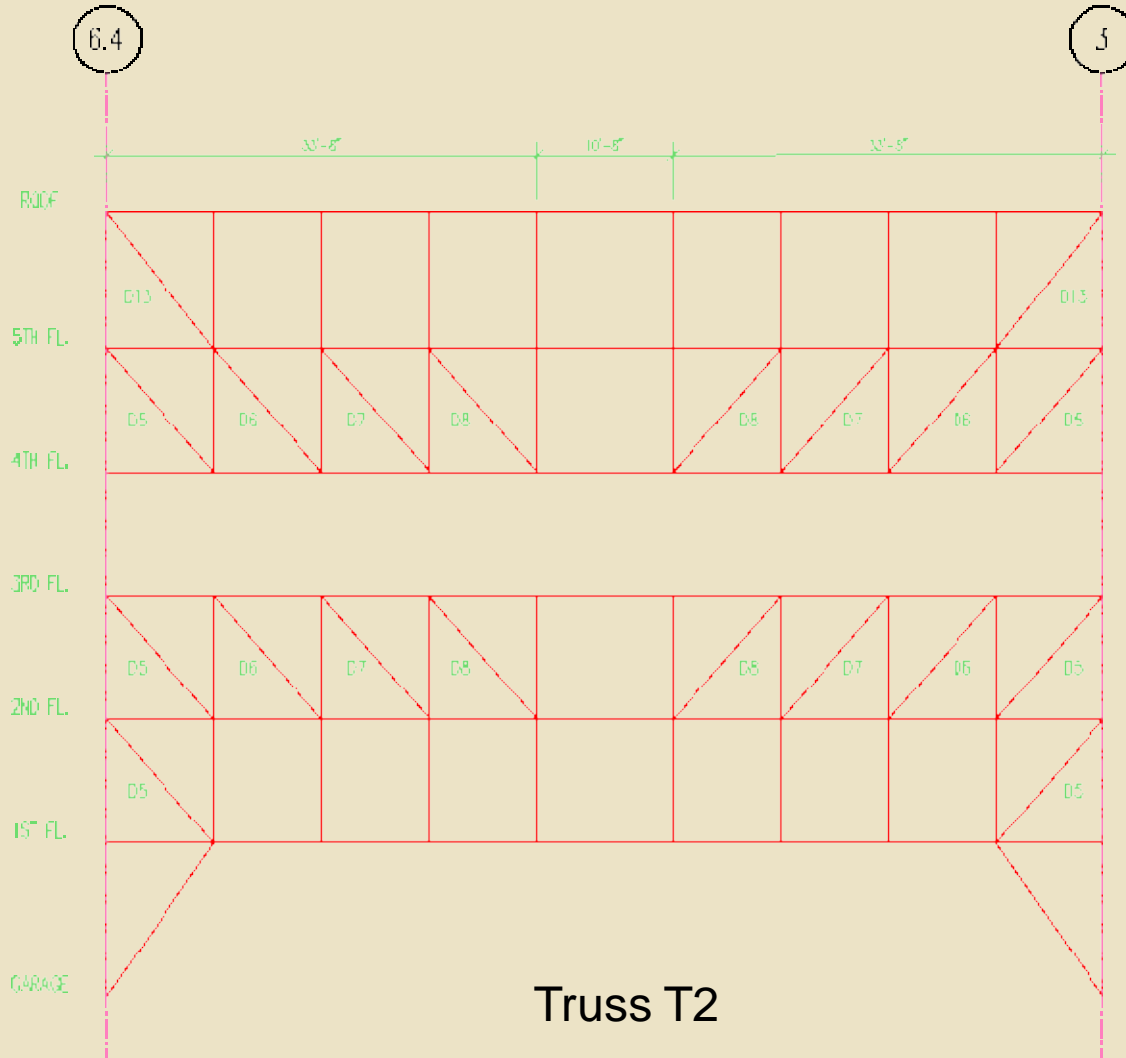
# Staggered Truss Alternate



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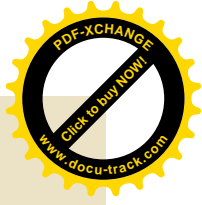


# Staggered Truss Alternate



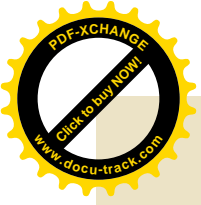
Truss T2

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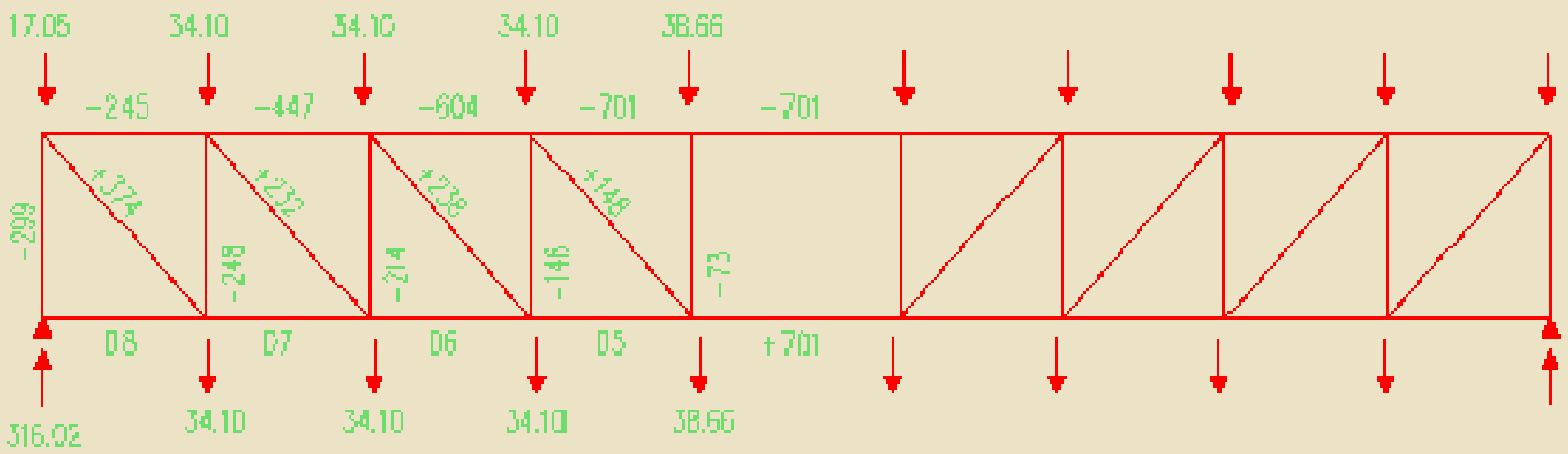


# Staggered Truss Alternate

- Floor System
  - 8” Untopped Hollow-Core Precast Plank
- Design Base Shear = 462 k
  - $R = 3$  for overall system
  - $T = C_u * T_a$

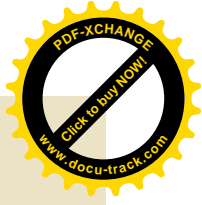
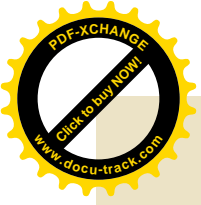


# Staggered Truss Alternate

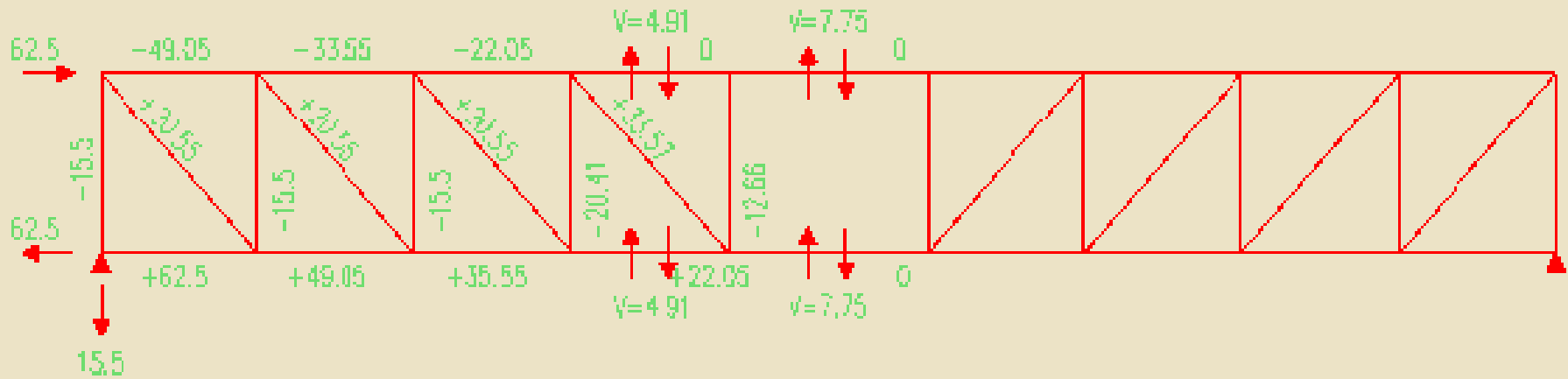


Axial Force in Truss due to Gravity Loads (k)

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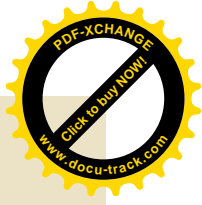
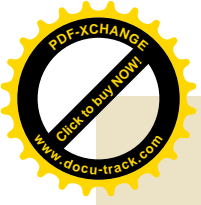


# Staggered Truss Alternate



Axial Force in Truss due to Lateral Loads (k)

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# Staggered Truss Alternate

Columns:

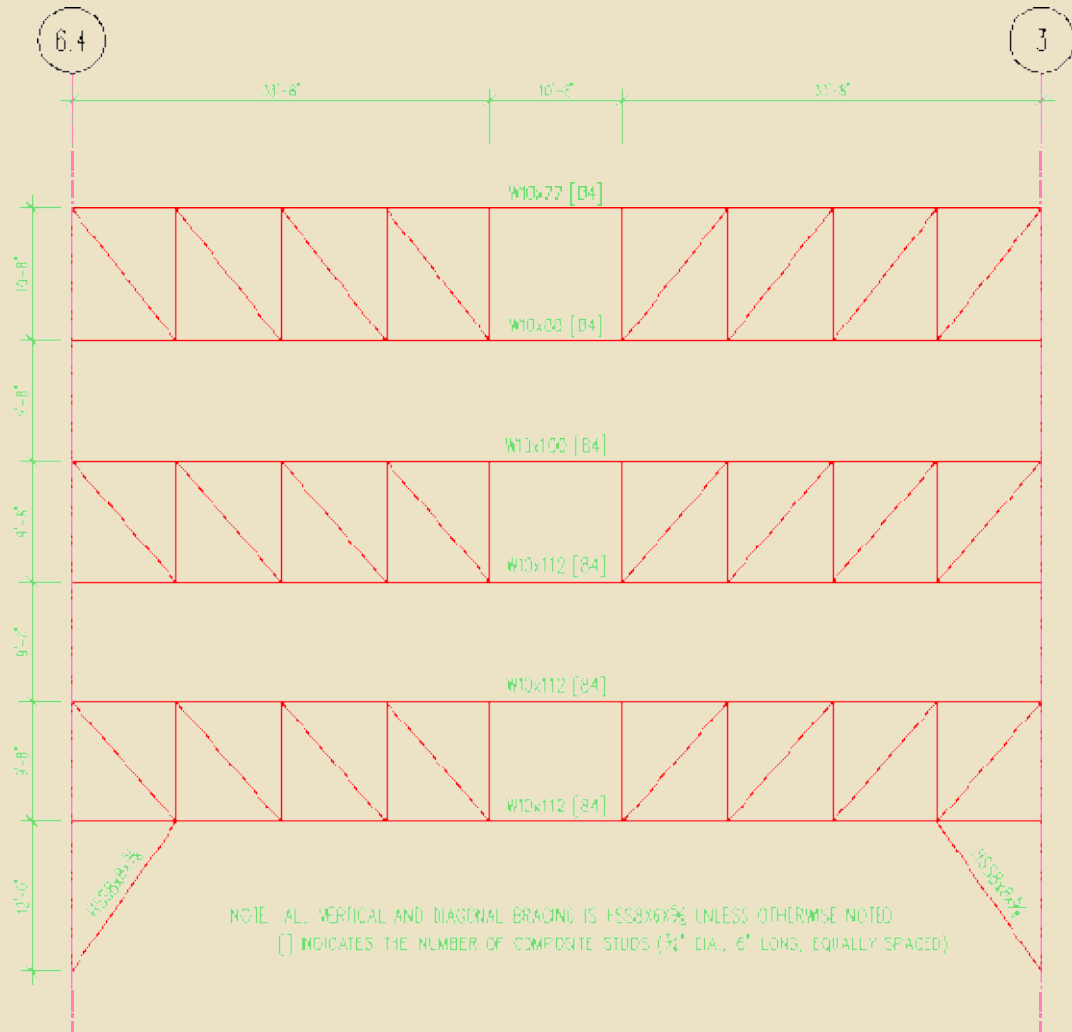
W10x100 A992

Diagonals and Verticals:

HSS 8x6x5/8 A500 GrB

Chords:

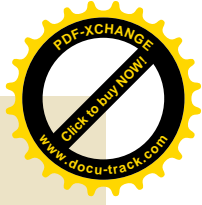
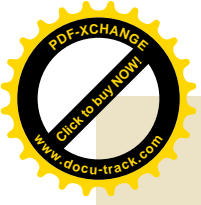
W10x77 to W10x112 A992



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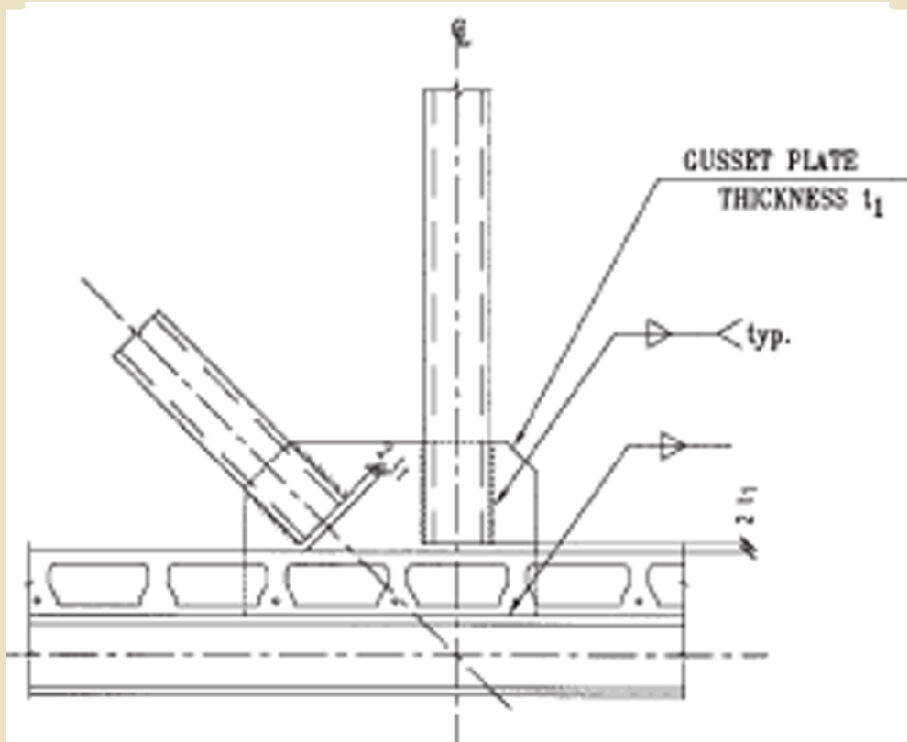
Truss T1





# Staggered Truss Alternate

Slotted HSS to Gusset Plate Connection Details:

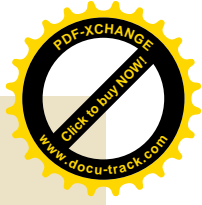
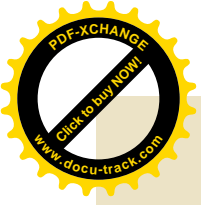


Weld Length: 20"

Width: 3/8"

Plate Thickness: 1/2"

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# Staggered Truss Alternate

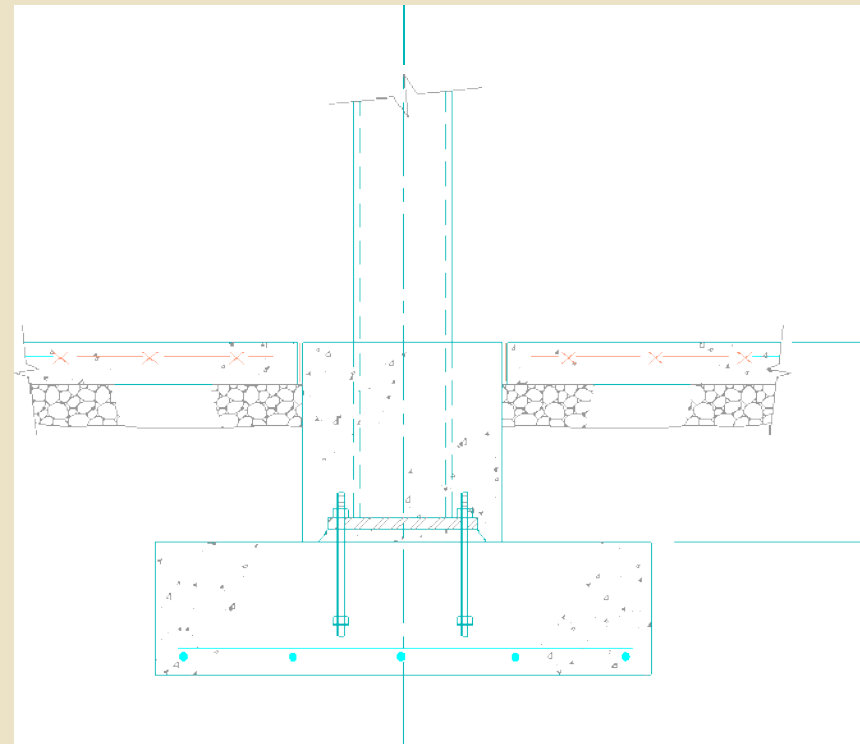
## Foundations

### Truss Columns

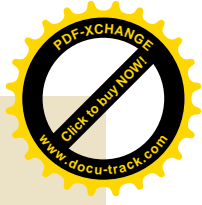
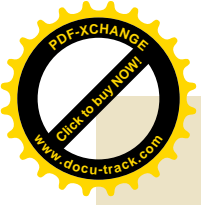
7'x7'x1'-10" spread footing  
with (6) #7 bars ea. way

### Gravity Columns

4'x4'x1' spread footing  
with (4) #5 bars ea. way

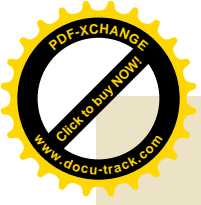


Typical Detail of Column Footing

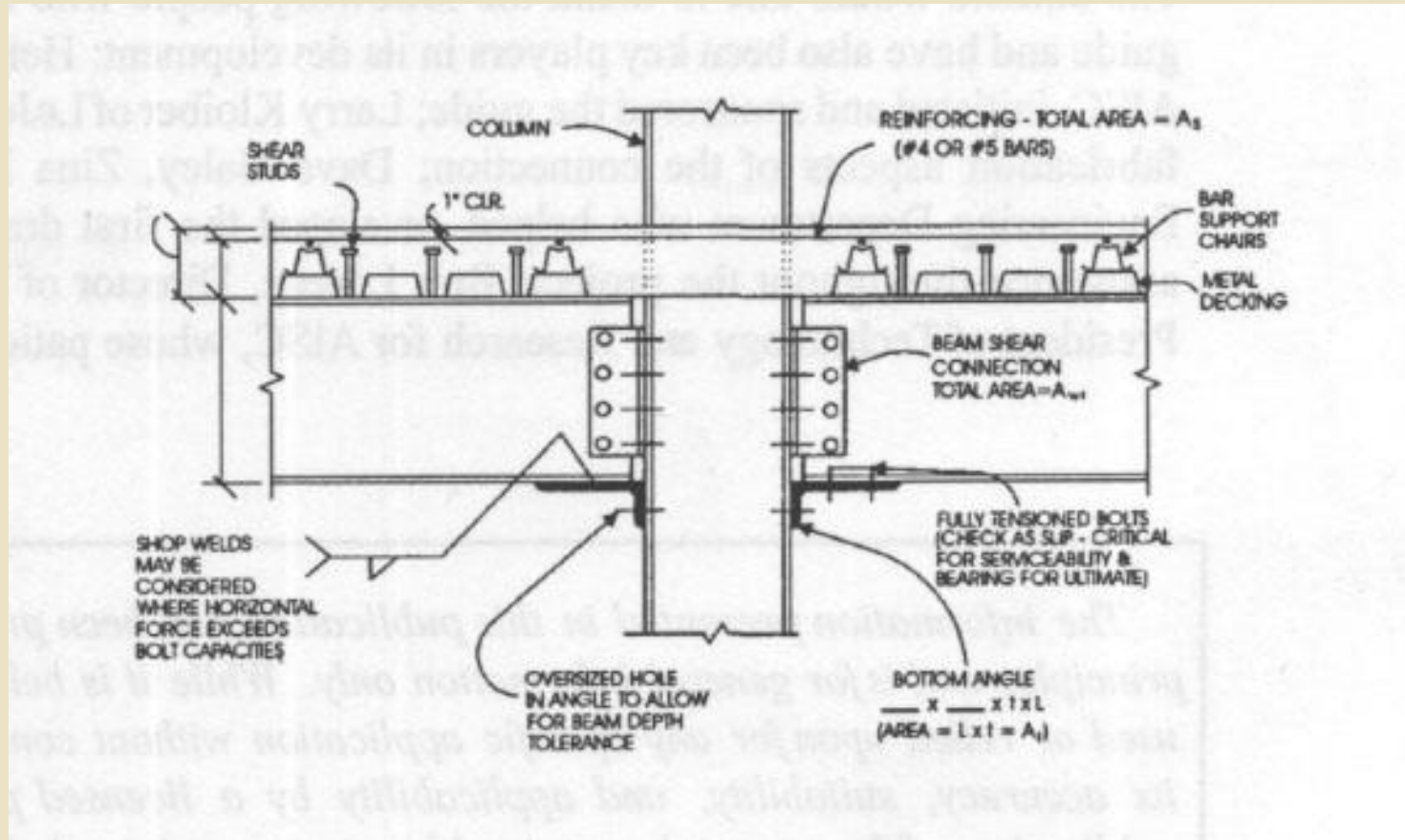


# Partially Restrained Composite Connections

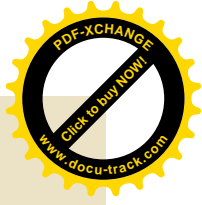
- Type 3 connections
  - Used with steel frame and composite floor
- Reinforcing in the slab used to create top portion of moment connection
- Shear resistance from seat angle at bottom of connection



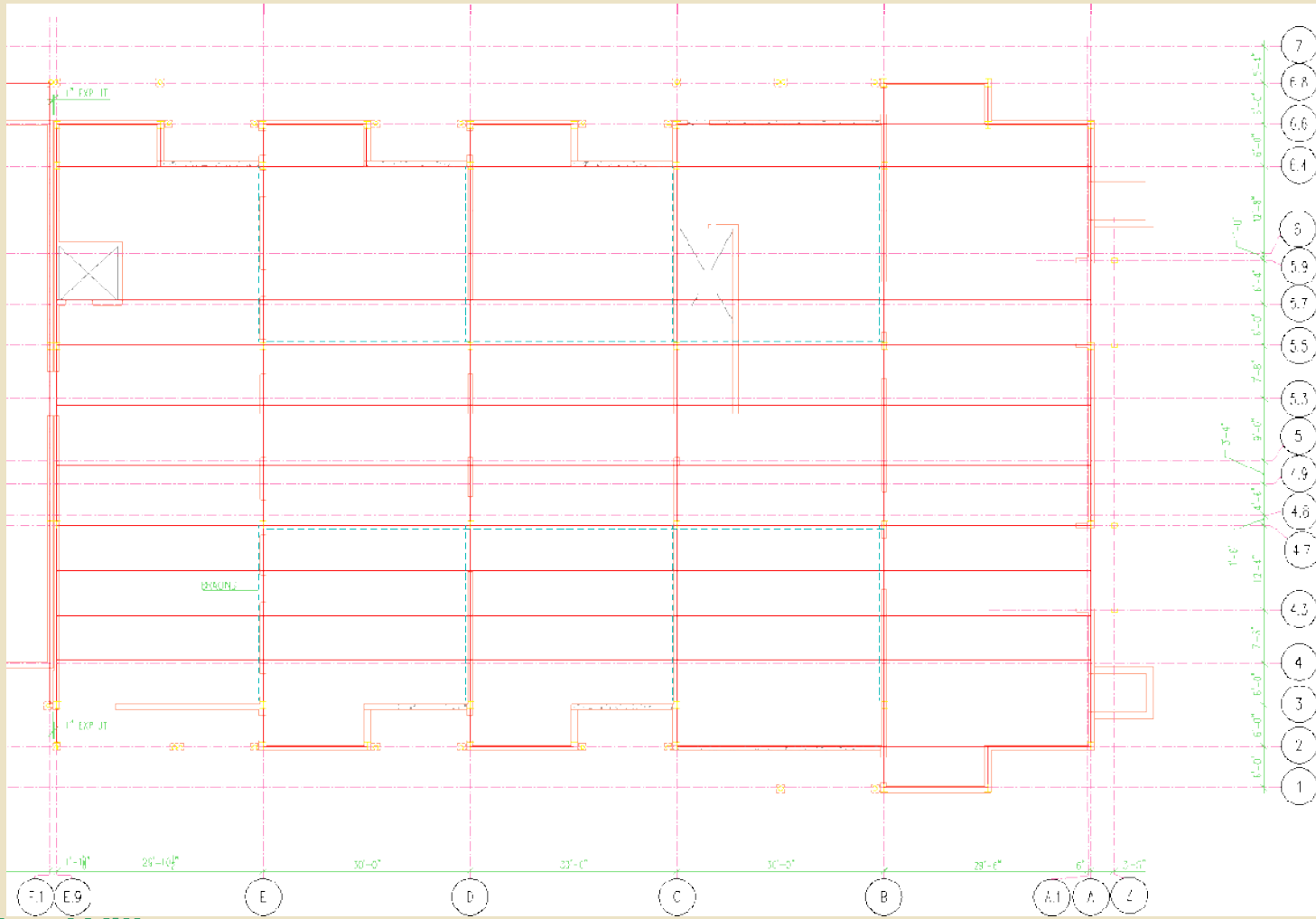
# Partially Restrained Composite Connections



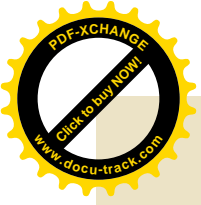
Typical Detail of PRCC



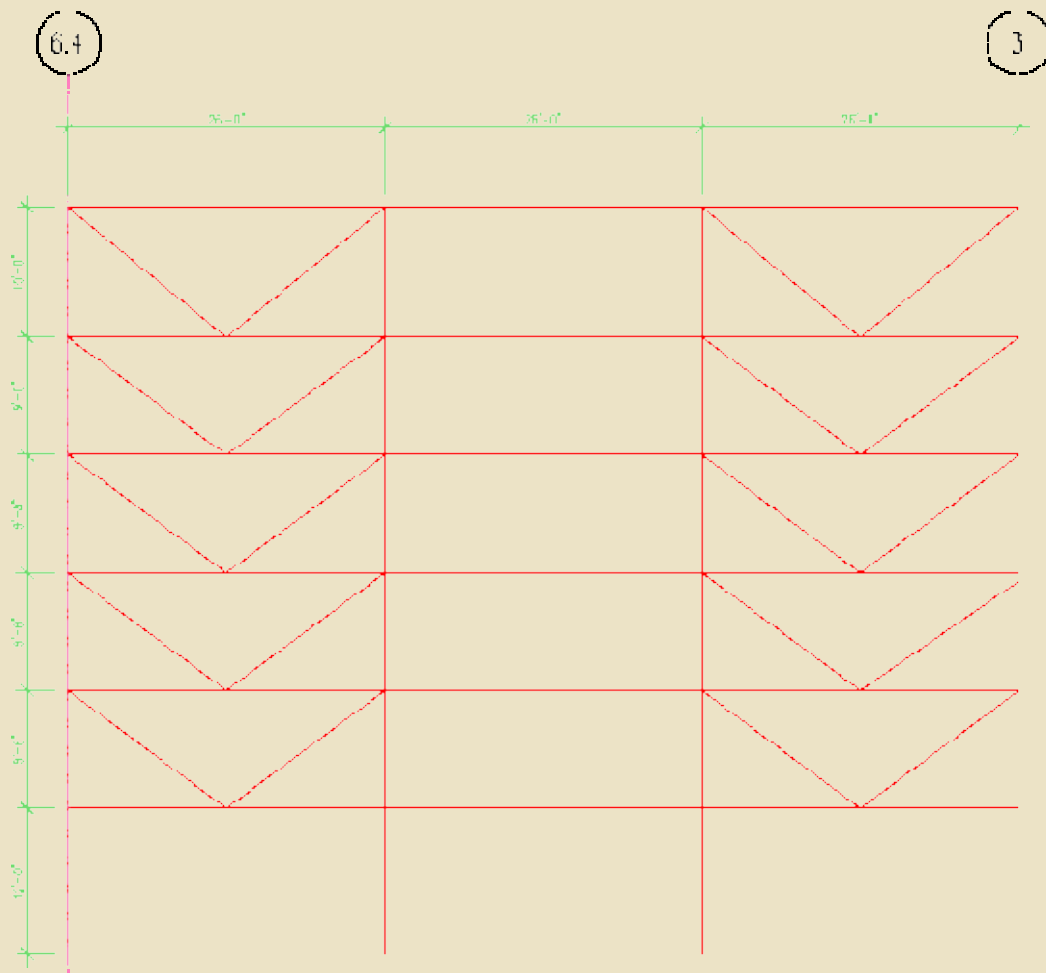
# Partially Restrained Composite Connection Alternate



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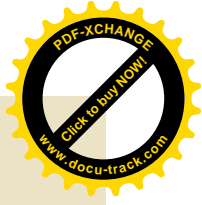
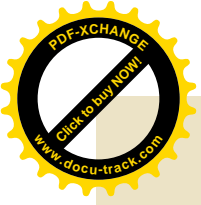


# Partially Restrained Composite Connection Alternate

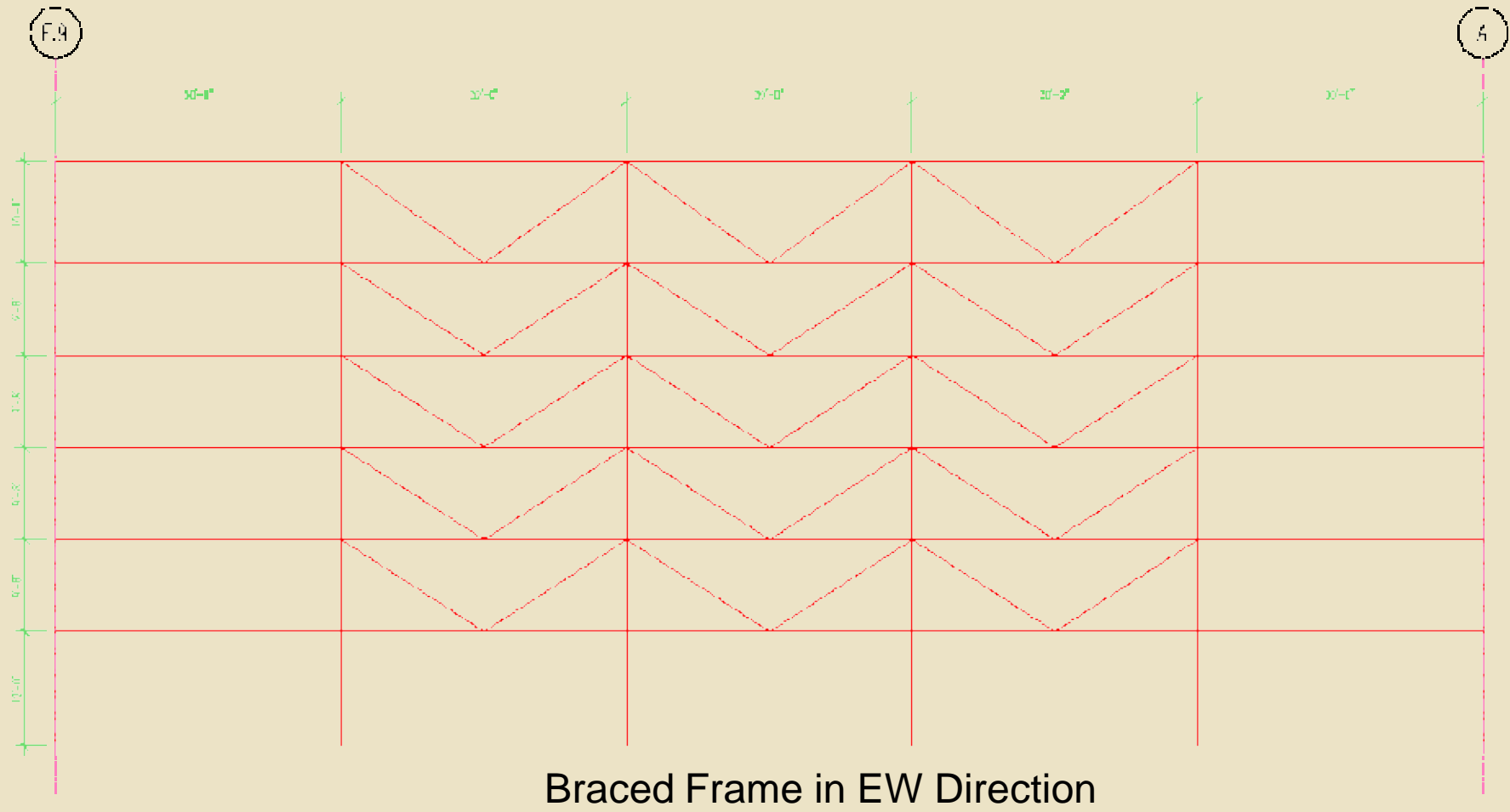


Braced Frame in NS Direction

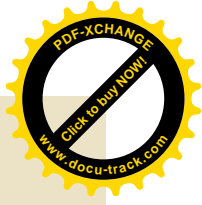
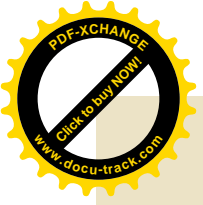
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# Partially Restrained Composite Connection Alternate



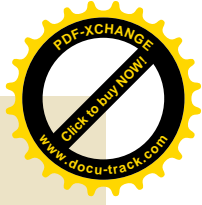
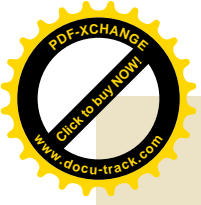
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# Partially Restrained Composite Connection Alternate

- Floor System Determination
  - Using *Floor Vibration Serviceability*
- 1 1/2" Composite Deck with 5.5" Total Slab Thickness
- Design Lateral Load = 431 k
  - $R = 3$
  - $T = C_u * T_a$

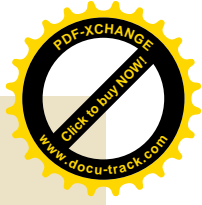
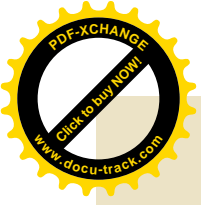




# Partially Restrained Composite Connection Alternate

Frame	Beam Location	Connection	Beam and Studs	Mu (ftk)	I <sub>LB</sub> (in <sup>4</sup> )
NS	Typ Bay Floor	PIN-PIN	W21x44 (14)	397	1420
EW	Int. Bay Floor	PIN-PIN	W16x40 (16)	277	886
	Ext. Bay Floor	PIN-PIN	W16x40 (16)	277	886

- Analysis determined PRCC type connections not warranted in braced frame layout
- Structural depth greater than 1'-8" limit
- Condominium layouts would require changes to allow for bracing



# Construction Management Issues

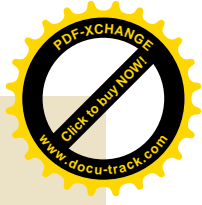
- Existing Lateral System Cost:  
\$363,000
- Staggered Truss System Cost:  
\$610,000
- Existing system more labor-intensive

Material	Total Cost
CMU Walls	106236
Conc Walls	63120
Scaffold	60255
Conc Ftgs	43285
Total	272896
Adjusted Total	362618

Existing Lateral System Cost

Material	Total Cost
STL Cols	36786
Fireproofing	40582
HSS Bracing	96941
STL Beams	279590
Conc Ftgs	5356
Total Cost	459255
Adjusted Total	610246

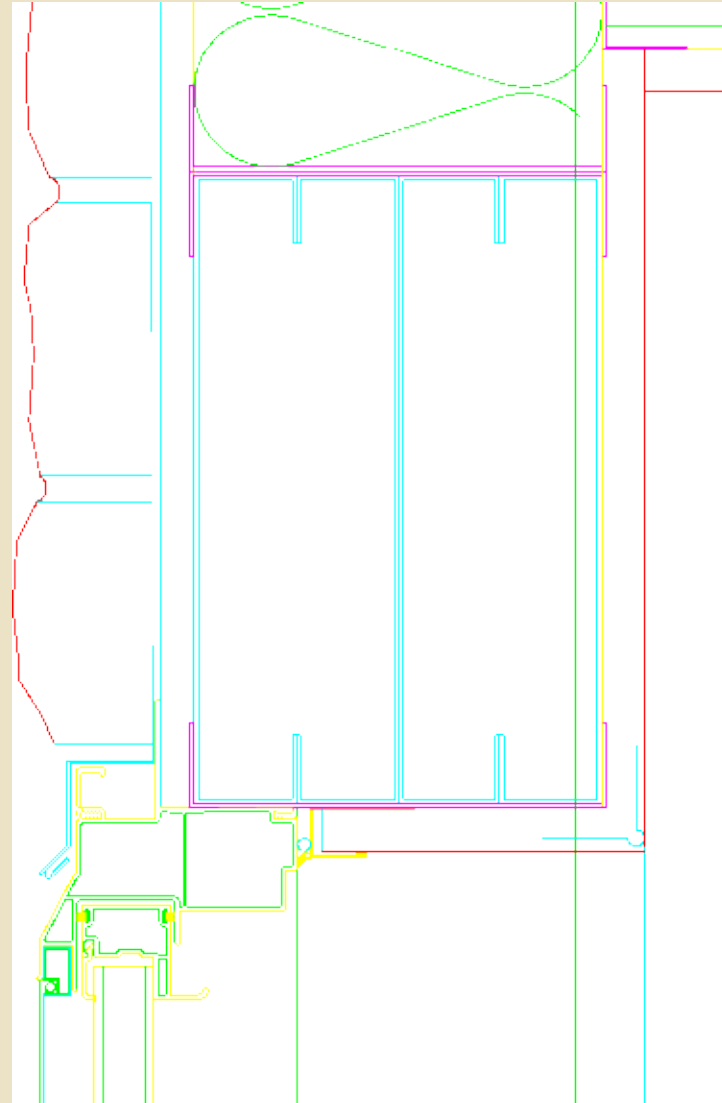
Staggered Truss System Cost



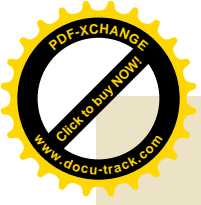
# Existing Envelope Analysis

## Concerns:

- Drainage
- Drip edge
- Moisture Penetration



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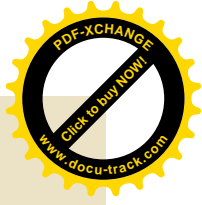


# Existing Envelope Analysis

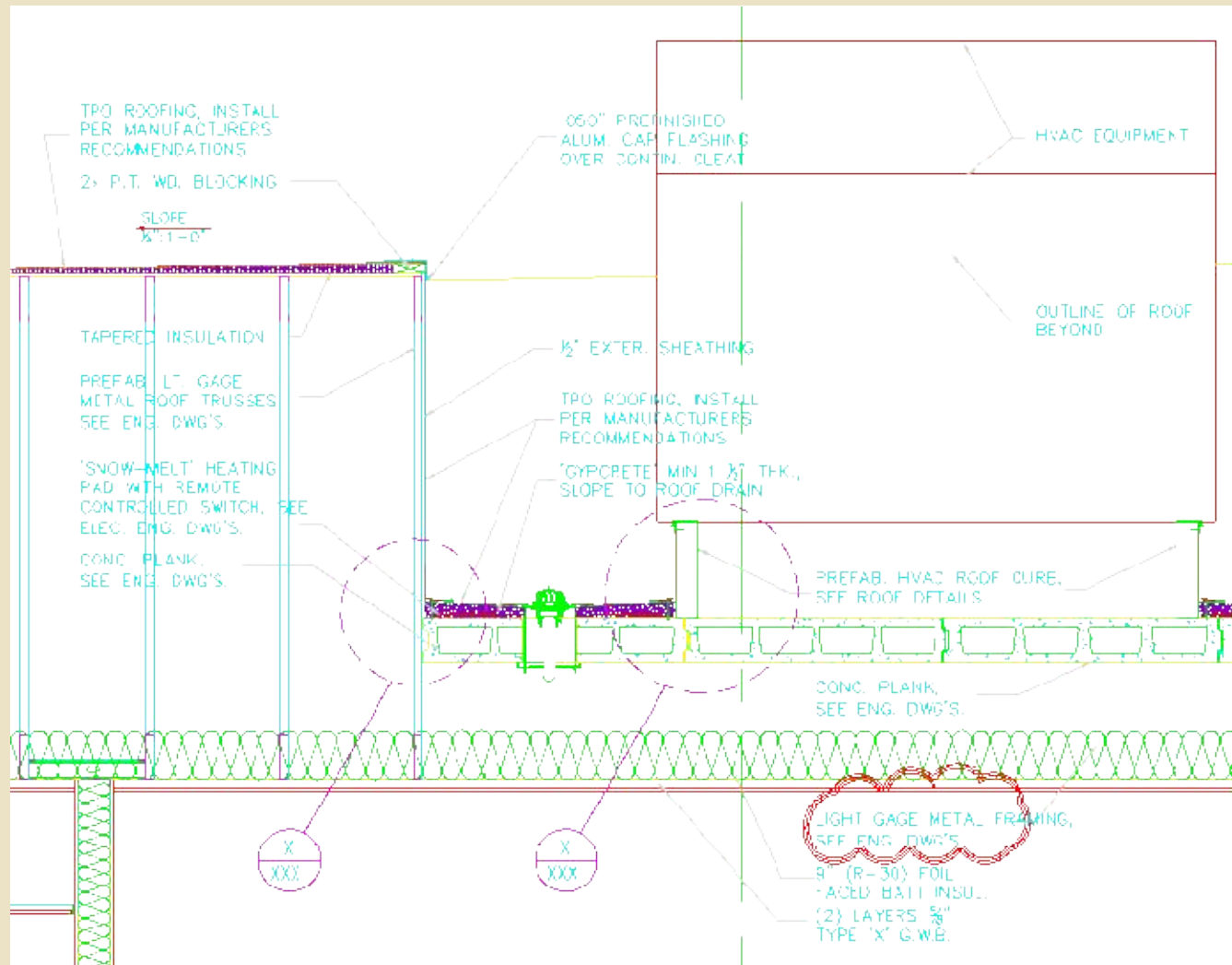


Roof wells for mechanical units

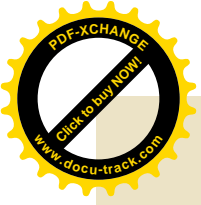
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# Existing Envelope Analysis

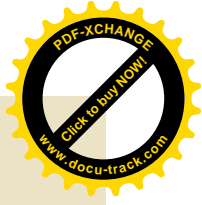
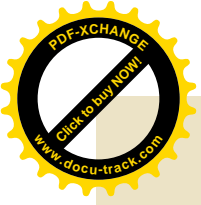


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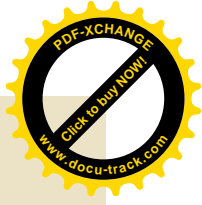
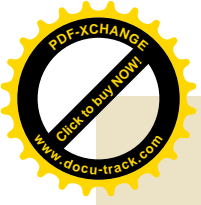
# Existing Envelope Analysis

- Recommendations
  - Add drainage cavity
  - Extend drip edge
  - Keep existing detailing for mechanical wells
  - Onsite checks to ensure detailing complete



# Conclusions

- Staggered truss is a feasible structural alternate
  - Allows for ease of renovation
  - More costly system
- Partially restrained composite connections are not feasible
- Envelope details should be reworked to prevent bulk water penetration



# Acknowledgements

Thanks to the following individuals for their assistance throughout my project:

- Dr. Andres LePage
- Andreas Phelps
- The entire AE Department Faculty and Staff
- Larry Baker and the entire staff of Baker, Ingram & Associates
- John Beers of Paul Risk Associates Inc.
- Partners of Whiteland Village

Special thanks to my friends and family

**Whiteland Village**





# Questions



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