360

State Street

New Haven • CT • 06510

Structural | Sabrina Duk | T. Boothby

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Presentation *Overview*

- *About* 360 State Street
- *Thesis* Objectives
- *Depth* Study – Structural Design
  - Alternative Framing System: Staggered Trusses to Traditional Steel Framing
- *Breadth* Study – Building Envelop Design
  - Precast, Aluminum, & Glass Façade to All Glass Façade
- *Breadth* Study – Cost & Schedule Comparison
  - Viability of Proposed Framing Systems & Alternative Façade
- *Conclusions*
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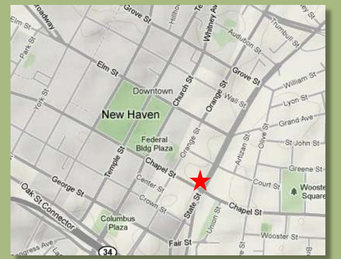
About 360 State Street

Project Team

- Owner/Architect: Becker + Becker Associates
- Structural Engineer: DeSimone Consulting Engineers
- General Contractor: Suffolk Construction

Building Information

- Location: New Haven, Connecticut
- Size: 700,000 gsf (32 Stories)
- Development Cost: $180 million
- Construction: Sept 2008 – Oct 2010



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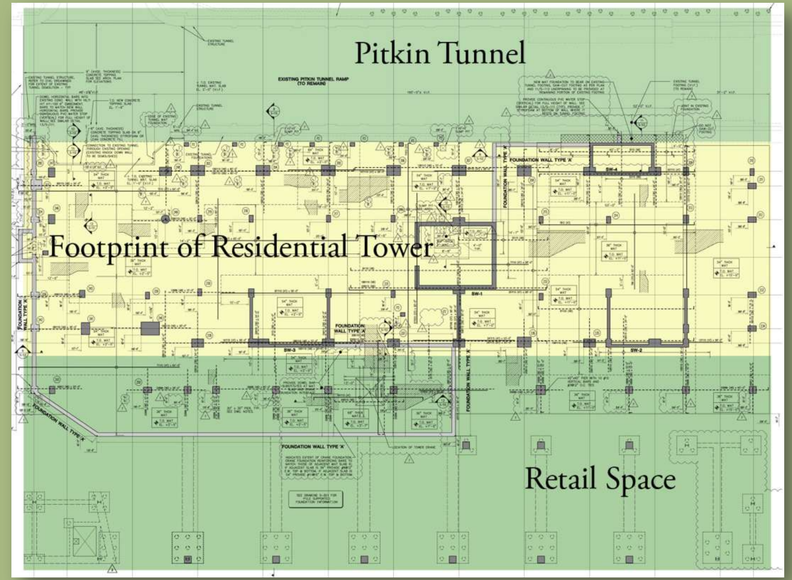
About 360 State Street

Architecture

- 2 Retail Units, 500 Parking Spaces, 500 Apartment Units + Amenities
- Precast Concrete & Aluminum Panel Façade with Glazing, Ornamentation
- Rooftop Gardened Terrace
- Outdoor Pool & Patio

Sustainable Features

- LEED Platinum Certification
- Local & Recycled Building Materials
- 400kW Fuel Cell
- Geothermal Walls, High Performance Windows, & Elevators that Recapture their own Energy



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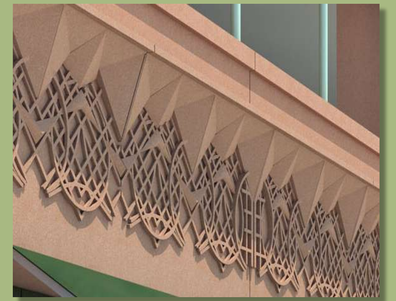

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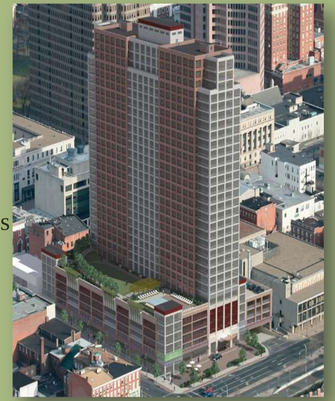
Thesis Objectives

Overall Project Goals

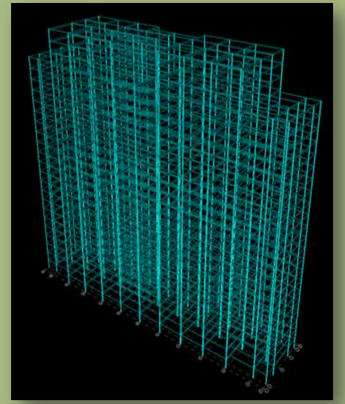
- Longevity & Durability of Structure
- Viable Alternative Solutions
- Conscious, Sustainable Design Decisions
- Maintain Architectural Floor Plans
- Focus on Upper (26) Stories



Structural Depth

- Originally Designed as Cast-In-Place Concrete Structure
- Contractors Not Able to Provide Competitive Cost & Schedule
  - New York vs. New Haven
- Redesigned to Staggered Steel Trusses in 8 Weeks

Proposal: Design Alternative Framing for Gravity & Lateral Systems



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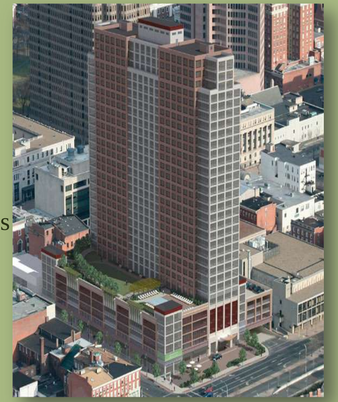

Breadth #1

- Building Envelop Study
- Proposal: Alternative Glass Façade
- High Performance

Breadth #2

- Cost & Schedule Analysis
- Proposal: Compare Viability of Designs
- Viability of Designs

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Depth Study Structural Design

An Alternative Framing Solution

- Provide a Preliminary Design for the Gravity & Lateral Systems using a more Traditional Steel Framing System
- Compare Existing & Proposed Systems to Determine the Ideal Solution

Structural Design Goals

- Increase Strength & Rigidity with additional Structural Elements
- Minimize Floor Depth by Shortening Span Lengths
- Decrease Overall Building Weight
- Optimize Lateral System & Foundation

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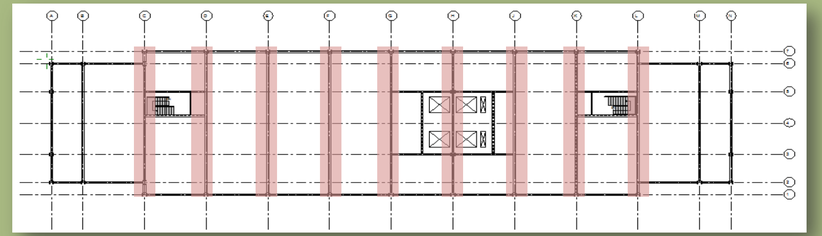
Existing Gravity System

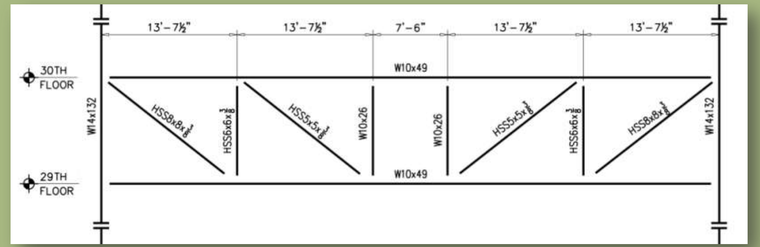


Typical Residential Floor Plan

(9) Staggered Steel Truss Frames @ 23’ – 8” o.c.

W12x53 Spandrel Beams + Floor Opening Framing

8” Hollow Core Plank Floor System w/ Topping



Typical Truss Framing

Exterior Columns: W14x120 thru W14x505 – Splices also Staggered

Typical W10x Top & Bottom Chords - HSS Diagonals

Vierendeel Panel for Corridor Opening

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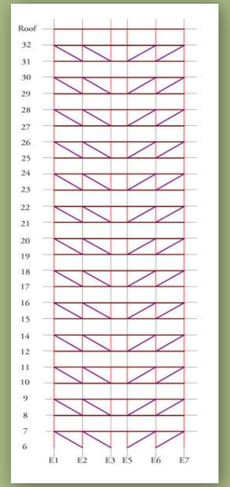
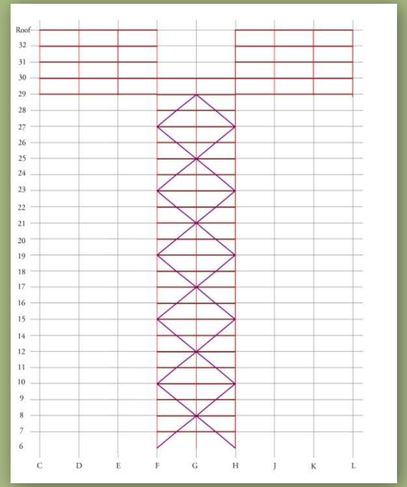
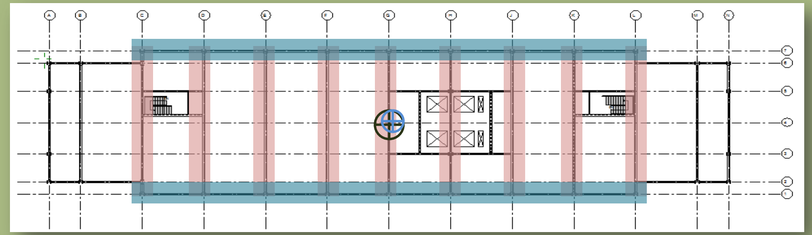
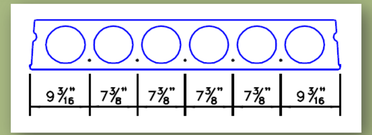
Existing Lateral System









(9) Staggered Steel Truss Frames @ 23’ – 8” o.c.

(2) X – brace Frames w/ 5 –Story Moment Frame (120 Connections)

8” Hollow Core Plank as Rigid Diaphragm

Center of Mass is Slightly off from Center of Rigidity

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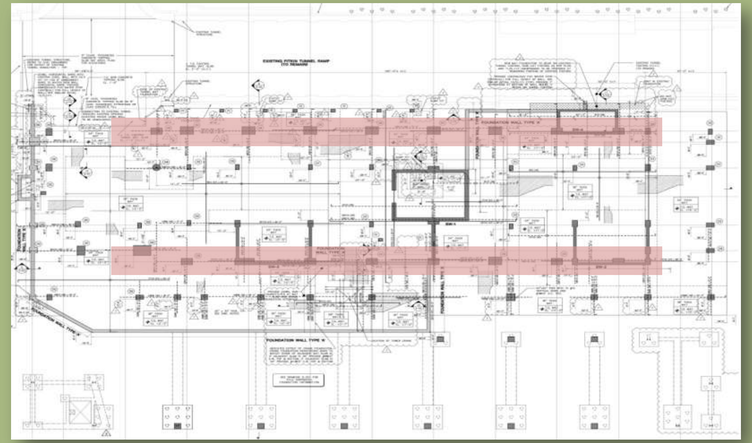
Existing Framing Systems



- 36” to 68” Mat Slab Foundation w/ 8,000 psi Concrete
- 4.5 TSF Bearing Capacity
- Bear onto Concrete Columns
- Gravity Loads 2.81 TSF Bearing
- Overall Building Weight: 90, 757 kips
- 3244 Structural Members

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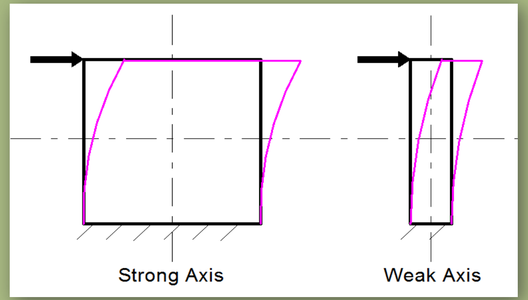
Design Considerations

Geometry

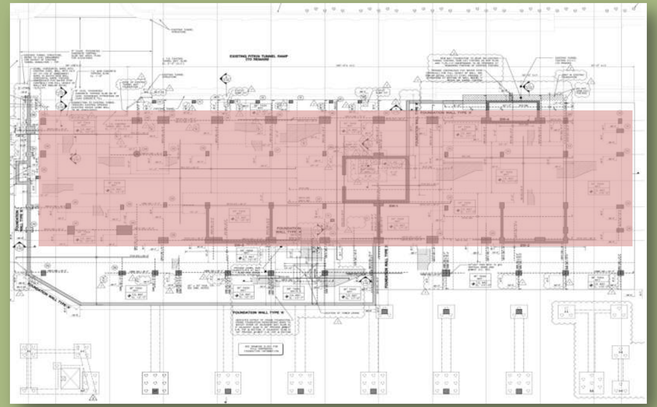
Residential Tower 62’ x 260’

Steel Column Orientation



Foundation Columns

Locations for Bearing



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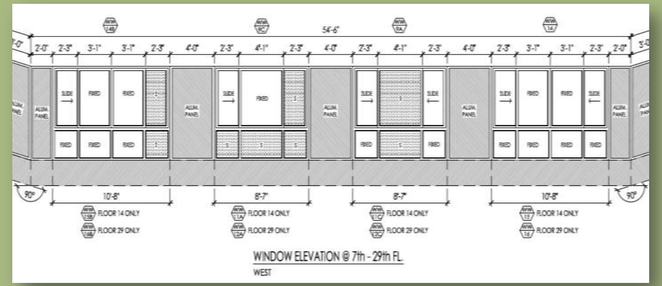
Design Considerations

Gridlines

Façade Placement on East/West Face

Interior Wall Locations



Window Obstructions

Interference w/ Façade Aesthetic

Note:

- Only Changing Framing
- Maintaining HCP Floor System

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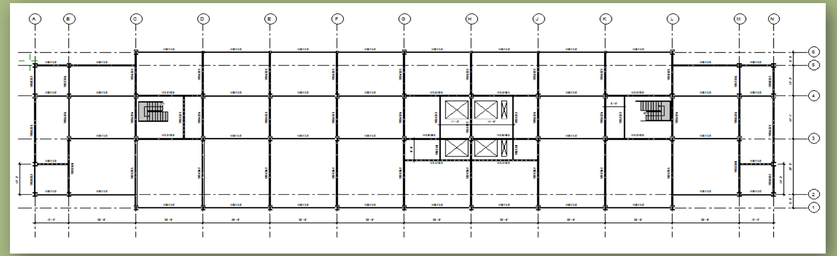
Proposed Gravity System



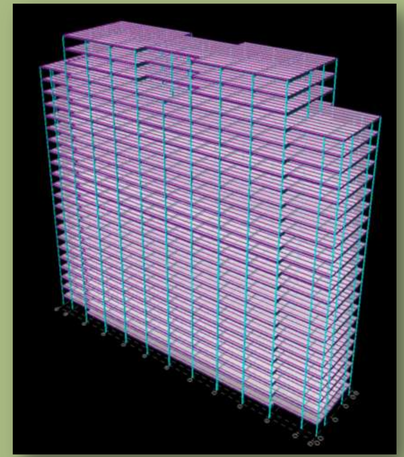
Typical Residential Floor Plan

(4) Rows of Columns – W10x33 thru W10x68

Maintained 23’ – 8” Spacing due to Apartment Units

Beams – W8x10 thru W24x55

Deflections: l/360 ≥ 1.0”



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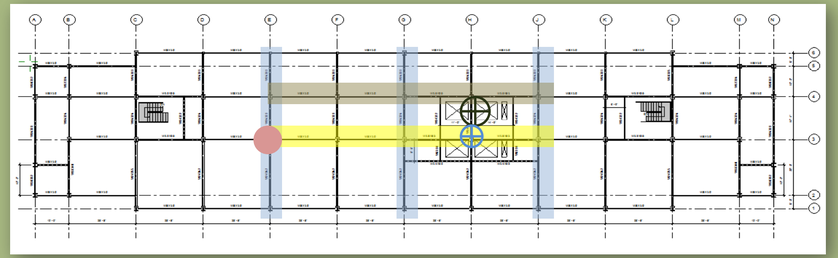
Proposed Lateral System



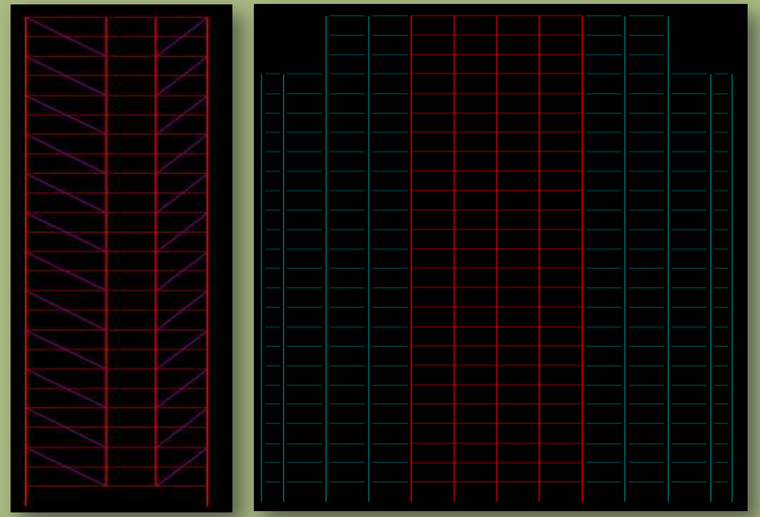
Typical Residential Floor Plan

Critical Column – W14x43 thru W14x176

(3) Frames w/ Diagonal Braces – HSS10x10 & HSS8x8

(1) Moment Frame – W16x31 Beams, 192 Connections

(1) X – Brace Frame – HSS14x14 & HSS10x10



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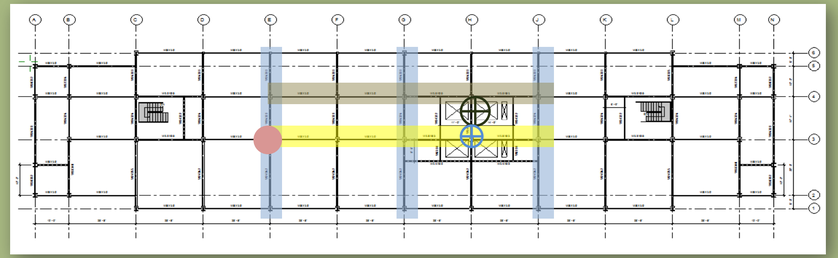

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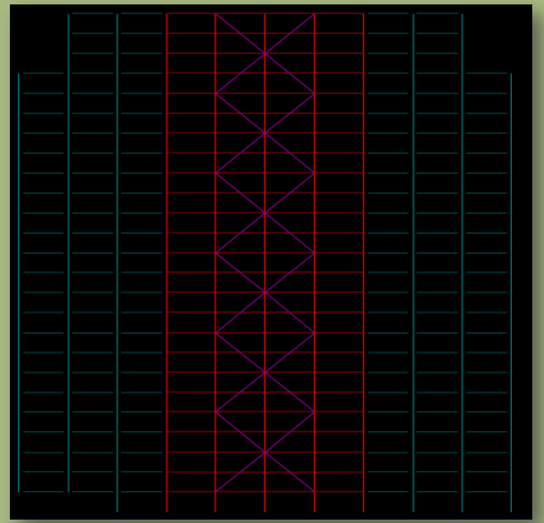

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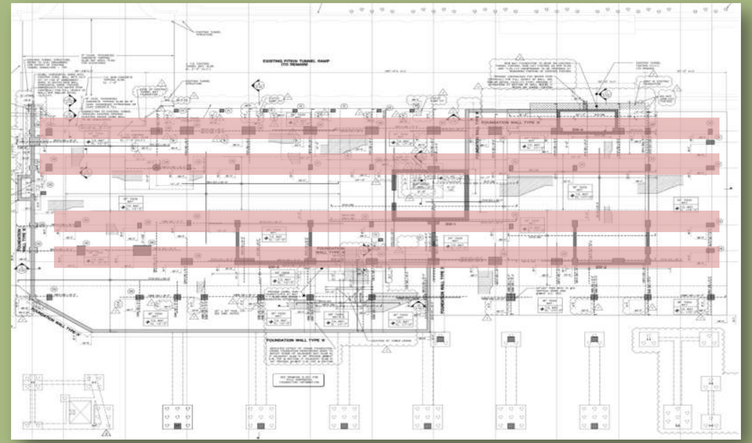
Proposed Framing Systems



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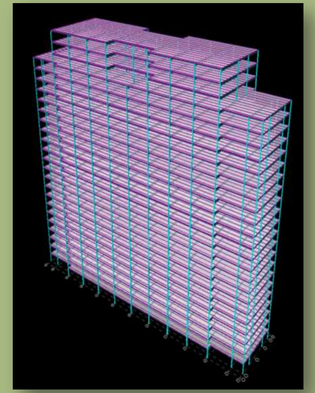

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Breadth Study

Building Envelop Design

- Provide Alternative Façade to Typical Glass & Masonry
- Increase Efficient Thermal Performance

Existing Façade

Precast Architectural Panels & Aluminum Panels + Chicago Style Windows

1” Tempered Glass, Low Emittance

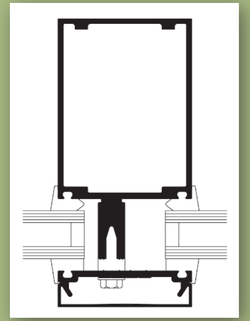
Proposed Façade

1600 Wall System 3 from Kawneer

Prefabricated Curtain Wall

6” deep Aluminum Mullions w/ IsoStrut Thermal Break

1” Glass – Tempered & Spandrel



Description	Overall U - Value	Heat Loss (BTU/hr)	Heat Loss (Watt/hr)	Cost per year for one typical apartment unit
Existing	0.12	1350	396	$611.92
Proposed	0.07	811	238	$367.77

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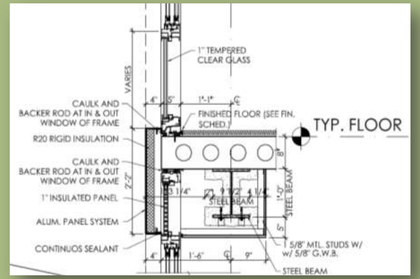
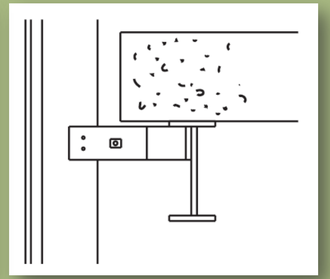
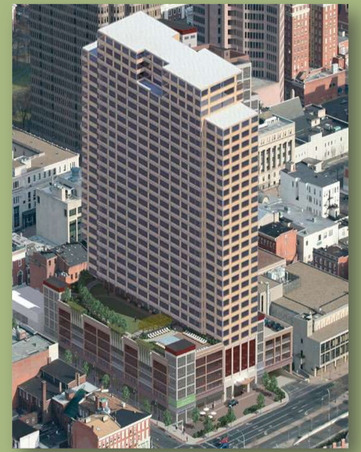


Existing



Proposed

Existing



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Breadth Study

Cost & Schedule Comparison

- Compare Existing & Proposed Systems
- Determine Viability of Structural Design

Description	Framing	Installation	Façade	Installation
Existing	**$9,519,102.44**	102 days	$ 12,718,645.80	Variable
Proposed	**$9,838,923.74**	116 days	$3,641,877.96	Variable

Description	Material O &P	Labor O & P	Equipment O &P	Total O &P	Overall Total
Staggered Trusses	$35.39	$ 6.24	$3.21	$ 44.84	$2,285,091.24
8” Hollow Core Planks	$14.60	$2.01	$0.65	$17.26	$7,234,011.20
Aluminum & Glazing	$68.48	$12.13	$ -	$80.61	$12,718,645.80
Traditional Steel	$35.39	$6.24	$3.21	$ 44.84	$2,604,912.54
Spandrel Glass	$22.28	$7.97	$ -	$ 30.25	$2,863,707.00
Tempered Glass	$10.33	$2.00	$ -	$ 12.33	$778,170.96

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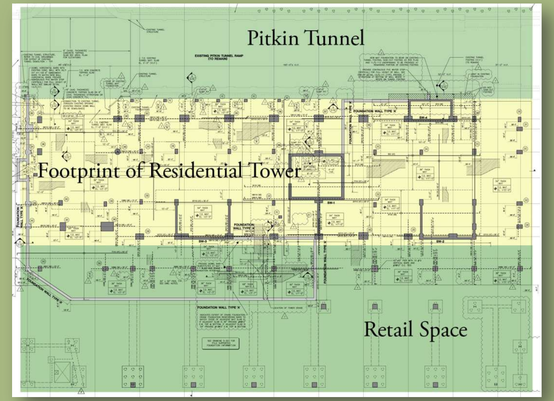
Breadth Study

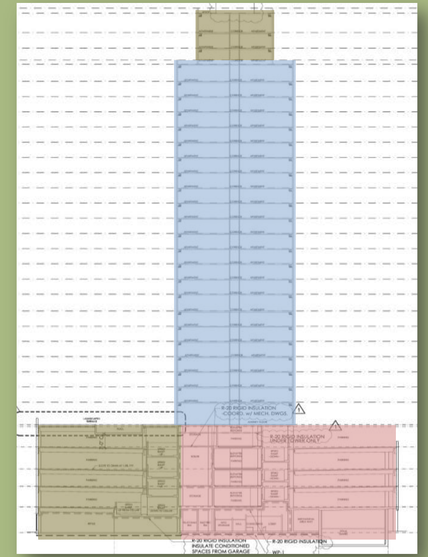
Cost & Schedule Comparison



Phase 1

Phase 2a

Phase 2b



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Conclusions

Were Structural Design Goals Achieved?

✖ Increase Strength & Rigidity with additional Structural Elements

★ Decrease Overall Building Weight

★ Optimize Lateral System & Foundation

	Existing	Proposed
Building Weight	90,757 kips	90,288 kips
# of Structural Members	3,244	3,787
Gravity Loads	Pass	Pass
Lateral Loads	Pass	Pass

Story Drift

$\Delta_{allowable}$ = 7.33”

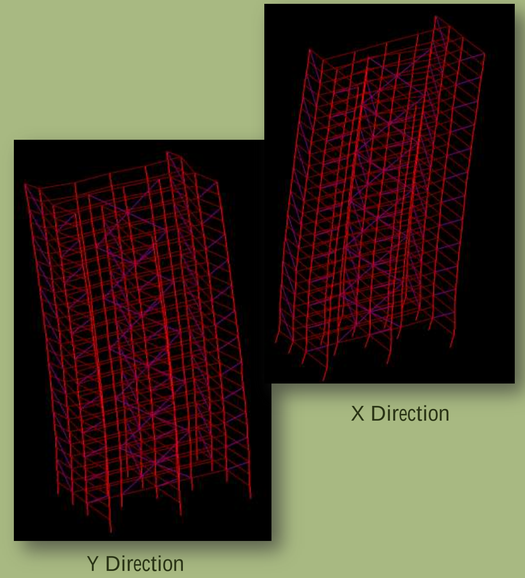
Wind X = 5.50”

Wind Y = 1.50”

$\Delta_{allowable}$ y 40.64”

Seismic X = 26.71”

Seismic Y = 10.93”



X Direction

Y Direction

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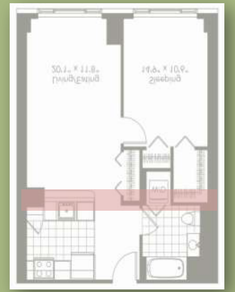
Conclusions

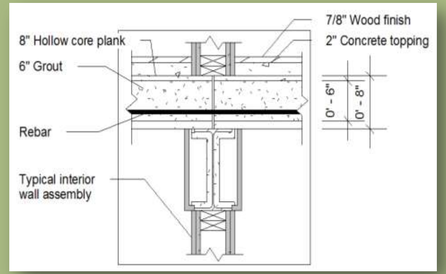
Were Structural Design Goals Achieved?

✖ Minimize Negative Impact on Original Architectural Layout

✖ Minimize Floor Depth by Shortening Span Lengths



Typical Apartment Unit



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Conclusions

Ideal Design Solution for 360 State Street:

Staggered Steel Trusses

- Strong, Durable Structure – Provides Gravity & Lateral Support
- Flexible Architectural Layouts – Large Open Spaces
- Quick Assembly – All Systems Prefabricated
- Minimal Storage Required
- Cost Effective

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Thank You!

Becker + Becker Associates Inc.

DeStefano & Chamberlain Inc.

The Architectural Engineering Faculty

To the AE Class of 2010:

WE DID IT!

Special Thanks to my Family for all the Endless Support

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Q& A