The hub on Chestnut

PHILADELPHIA, PA

Andrew Simone

STRUCTURAL

Architectural Engineering

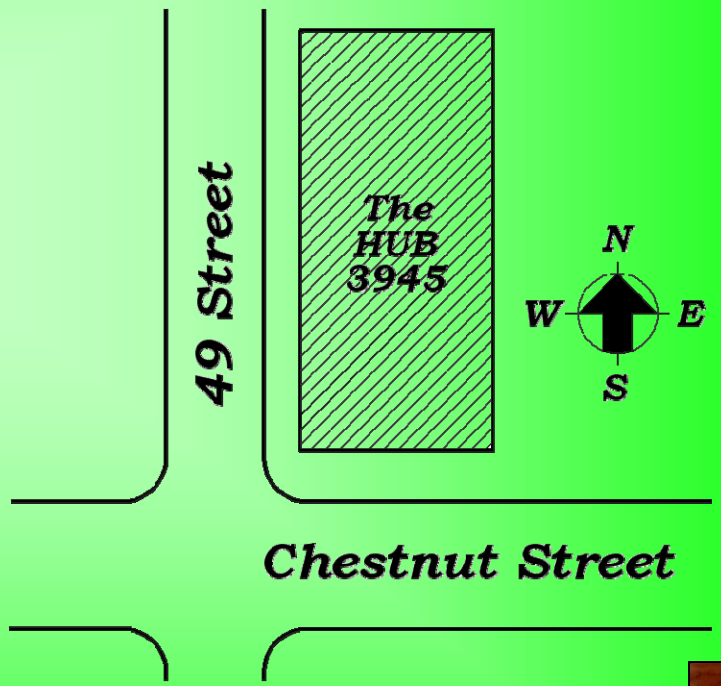
Senior Thesis 2007

Presentation Outline

- Project Description
  - Existing Structural System
    - Proposal
      - Structural Redesign
        - Green Roof Study
          - Construction Breadth
            - Recommendation

Project Overview

- University City Section of Philadelphia
- Nine Levels (Above-Grade)
- 110 Apartment Units
- 3 Levels of Retail
- 68,000 SF (Residential)
- 30,000 SF (Commercial)
- $22.3 Project Cost
- Design-Build Delivery



The HUB on Chestnut
PHILADELPHIA, PA

Architecture

- *Height*
  100’
- *Width*
  68’ (Chestnut Street)
- *Length*
  148’ (40th Street)
- *Footprint*
  11,000 SF

- Mixed-Use Occupancy
- Studio/Multi-Room Style Units
- Double Height Retail Areas
- Exposed Concrete Finishes
- Aluminum Rainscreen System with Corrugated Metal and Wood Veneer Panels
- EPDM Roof System

Project Team

- *Owner*
  Teres Holdings, LLC
- *Architect*
  Piatt Associates (Design)
  Brawer & Hauptman (Project)
- *Structural Engineer*
  O'Donnell & Naccarato
- *CM/General Contractor*
  Domus, Inc
- *Civil Engineer*
  Barton & Martin Engineers
- *Mechanical Engineer*
  AKF Engineers

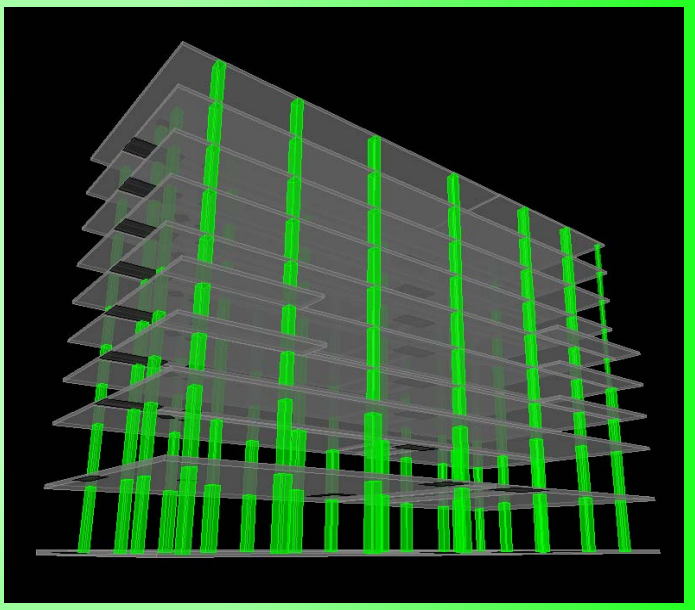
Presentation Outline

- ✓ Project Description
  - o ***Existing Structural System***
    - o Proposal
      - o Structural Redesign
        - o Green Roof Study
          - o Construction Breadth
            - o Recommendation

Existing Structural System

Codes

International Building Code 2003
- ASCE 7 - 02
- ACI 318 - 02



Floor System

Two-Way Flat Slab (Retail)
Post-Tensioning (Residential)

Lateral System

Ordinary Concrete Moment Frame

Foundation

Reinforced Concrete Caissons

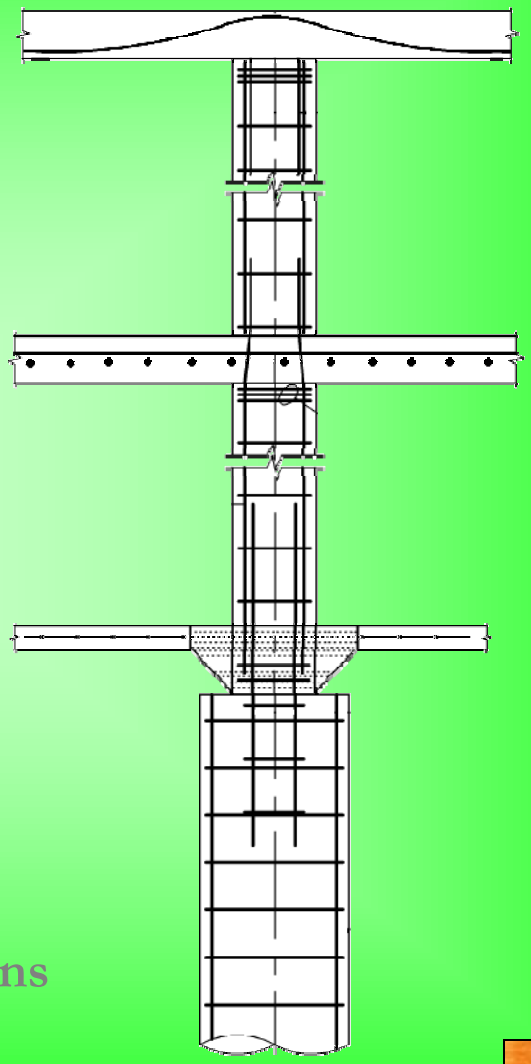
Gravity System

Two-Way Flat Slab (Retail)

- 5,000 PSI Compressive Strength
- 12" Depth
- 25' x 25' (Typical Bay)
- #6 Bars 16" on-center (Typical)

Post-Tensioning (Residential)

- 5,000 PSI Compressive Strength
- 9" Depth
- Span in Both Directions
- ½ Ø, 270 KSI, Low Relation Tendons

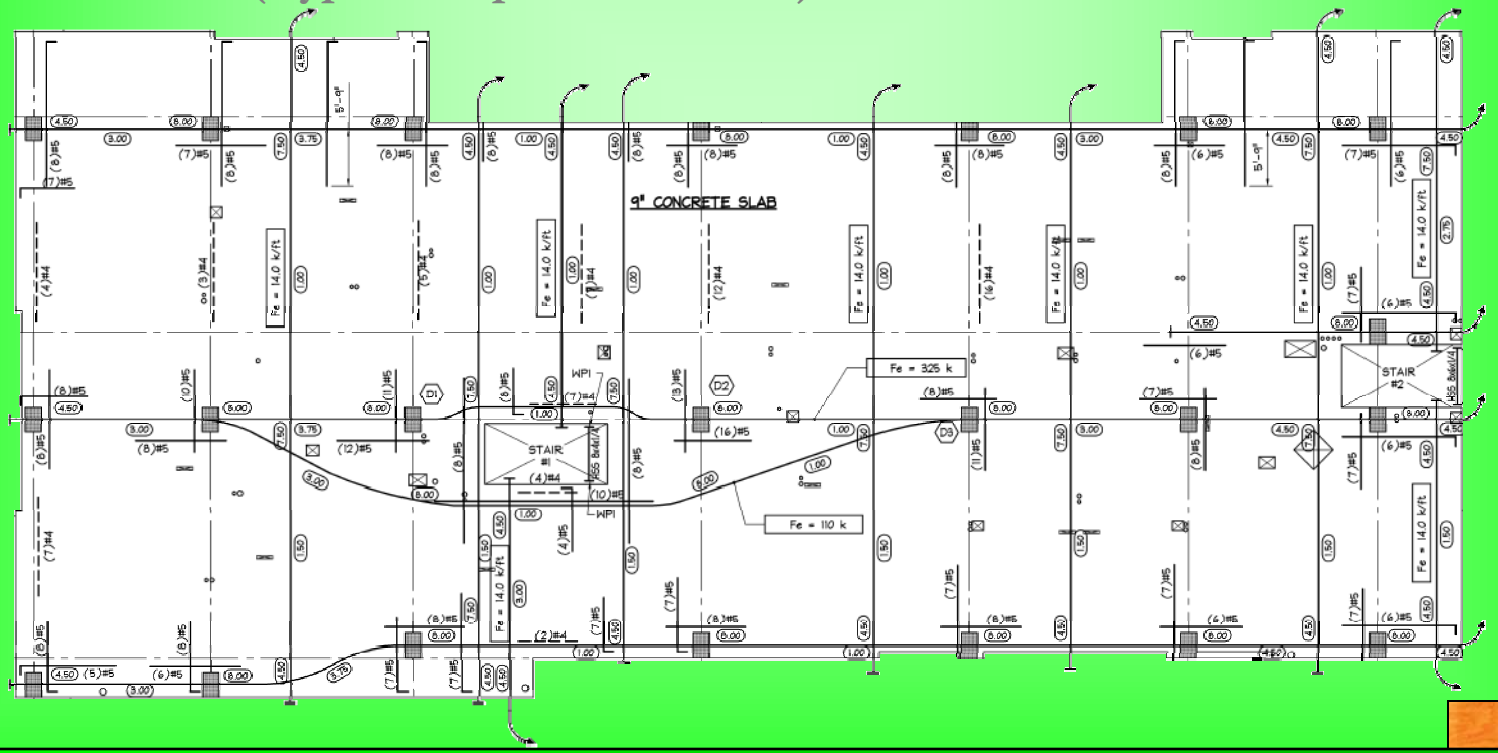


The HUB on Chestnut

PHILADELPHIA, PA

Caissons

- 5,000 PSI Compressive Strength
- 3’-6” to 4’-6” Ø
- (10) #10 Bars 18” Spiral Tie
- 45’ (Typical Depth to Bedrock)



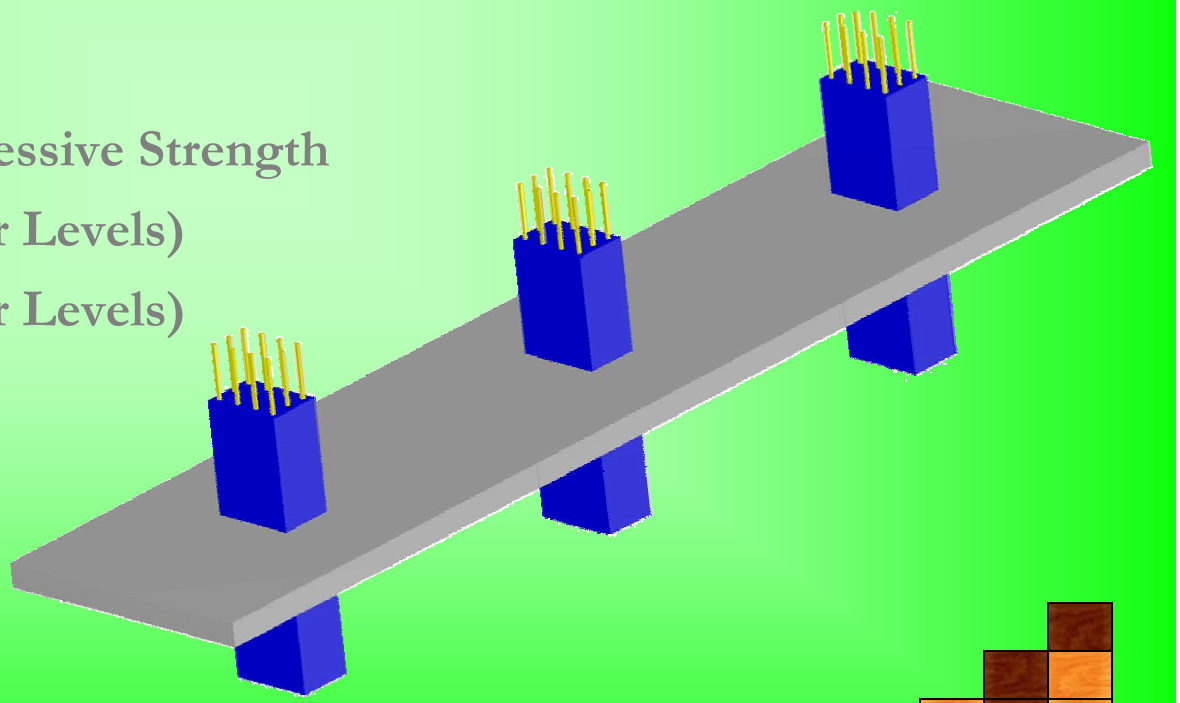
Lateral System

Ordinary Concrete Moment Frame

- Column Geometry and Slab Reinforcement

Columns

- 5,000 PSI Compressive Strength
- 20” x 30” (Upper Levels)
- 30” x 30” (Lower Levels)
- 22 per Floor
- #7 - #10 Bars

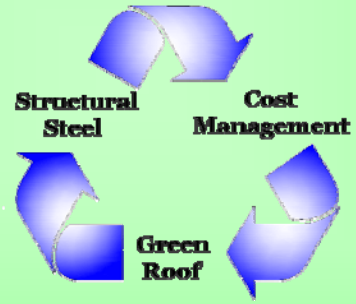


Presentation Outline

- ✓ Project Description
- ✓ Existing Structural System
- o ***Proposal***
- o Structural Redesign
- o Green Roof Study
- o Construction Breadth
- o Recommendation

Proposal

- Precast Hollow-Core Slab and Composite Steel Girder System with Concentrically Braced Steel Frames
- Incorporate Green Roof and Construction Study to Enhance Design



Goals

- Maintain Architectural Exterior/Interior Design
- Meet Needs of Owner and Architect
- Increase Daily Production
- Steel vs. Concrete Frame System

Design Criteria

Codes

- International Building Code 2006
  - ASCE 7 - 05
  - ACI 318 - 05
  - AISC LRFD 3rd Edition
  - PCI Handbook 6rd Edition

Floor System

- Depth Limit of 14”
- Live/360
- Total/240
- Plank Orientation

Lateral System

- Simple Connections
- Connection Geometry
- Common Member Sizes
- H/400

Foundation

Reinforced Concrete Caissons (Reduce Existing)

Presentation Outline

- ✓ Project Description
- ✓ Existing Structural System
- ✓ Proposal
- o ***Structural Redesign***
- o Green Roof Study
- o Construction Breadth
- o Recommendation

Floor System

Span Deck® Hollow-Core Slabs

8” x 96” with 2” Topping

½ Ø, 7-wire, 270KSI

5,000 PSI

29’-6” (Typical Span)

Topping

3,000 PSI

Grout

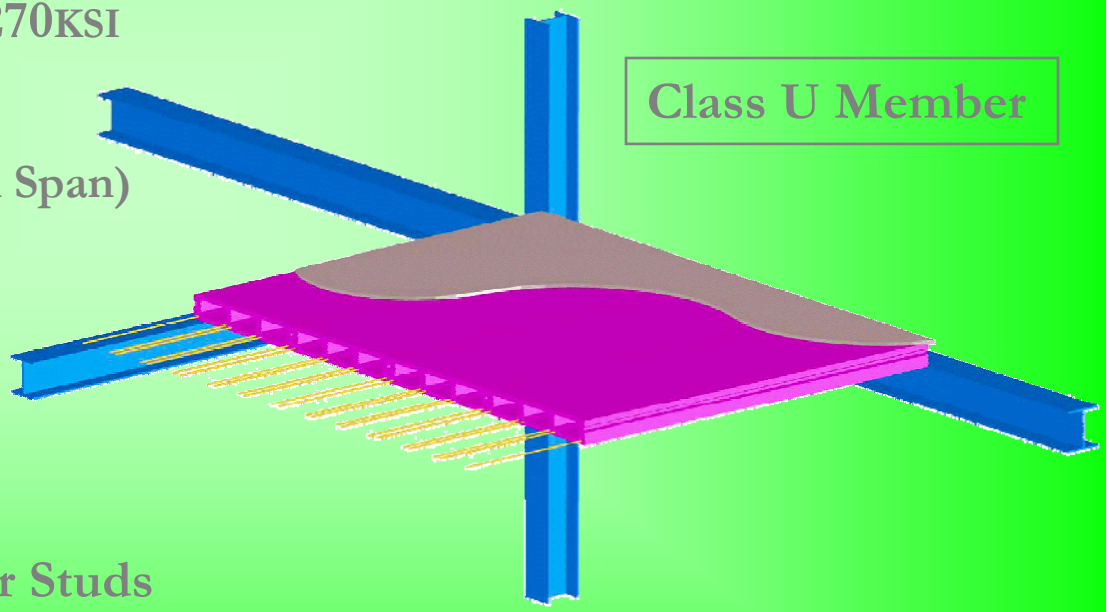
4,000 PSI

Connections

4” ½ Ø Shear Studs

Field Weld to Plate

Simple Shear for Girders

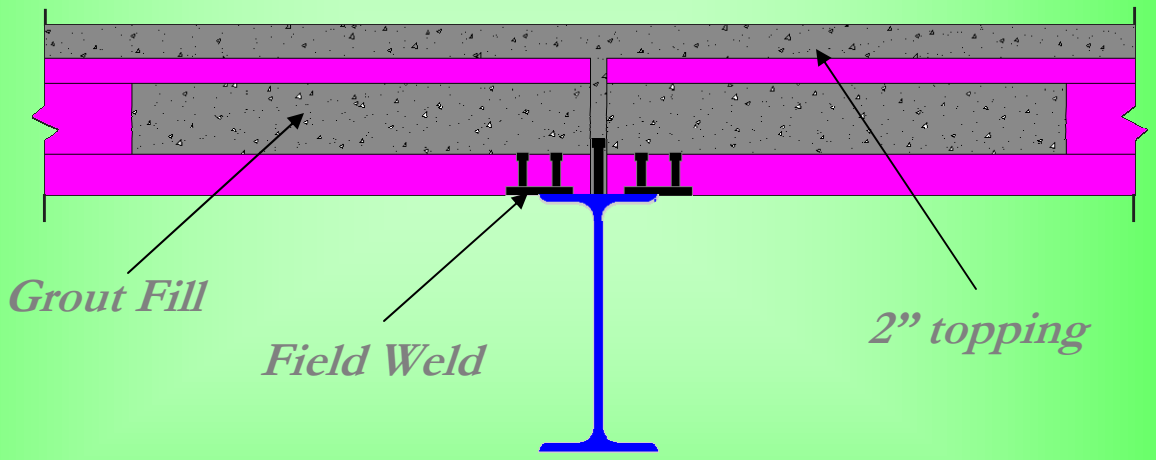


Class U Member

Composite System

Rigid Diaphragm

Horizontal Forces → 2" Topping/Studs → Lateral Elements

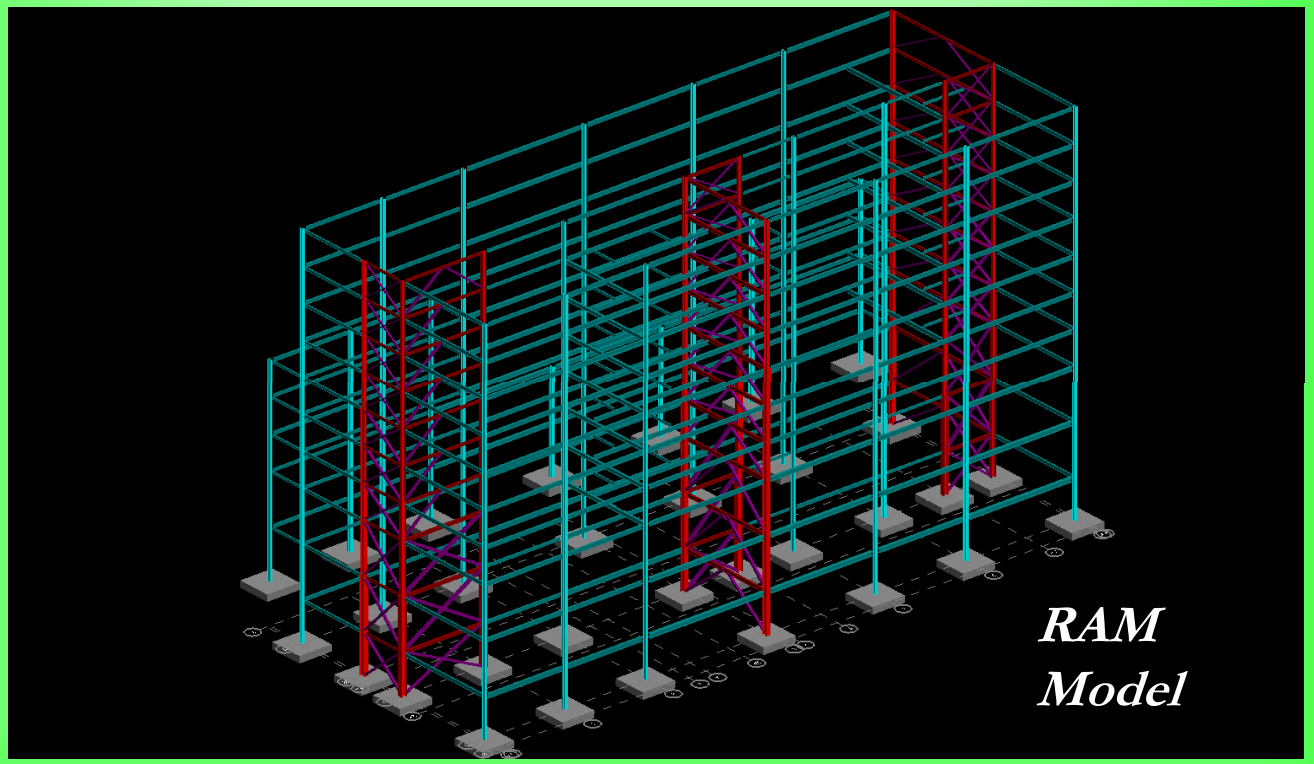


W14 x 26 (non-composite) → W10 x 12 (composite)

** Depth Gain of 4"*

Lateral System

Six - Ordinary Concentrically Braced Frames



The HUB on Chestnut

PHILADELPHIA, PA

Wind

Analytical Procedure
Exposure B
Non-Hurricane
Flexible Structure

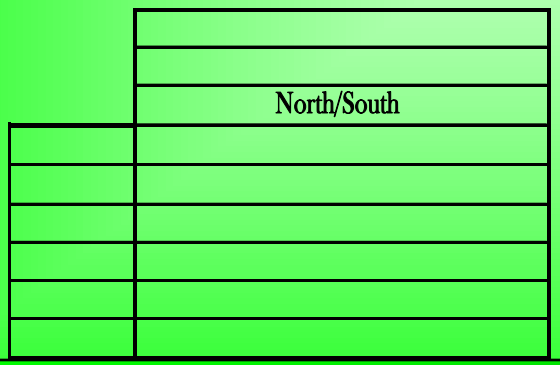
Seismic

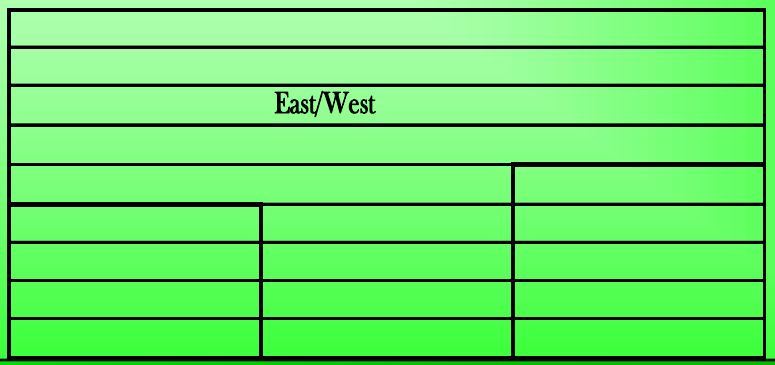
Equivalent Lateral Force
Site Classification D
Seismic Design Category B
1/T = 0.965 < 1.00 Hz

Case 1 → V = 258 K
East/West

Base Shear → V = 350 K
Both Directions

System Controlled by Seismic Loading





Frames

Six Braced Frames

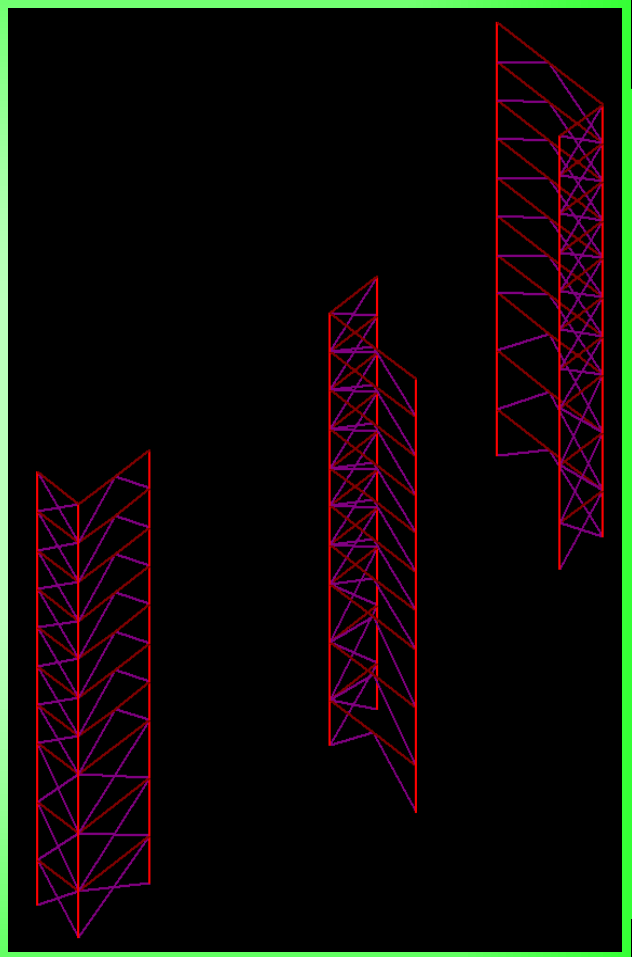
(3) North/South
(3) East/West
Chevron (Inverted-V)
X Diagonals

Members Sizes

HSS 4x4x½ (Upper Levels)
HSS 6x6x½
HSS 8x8x½ (Lower Levels)

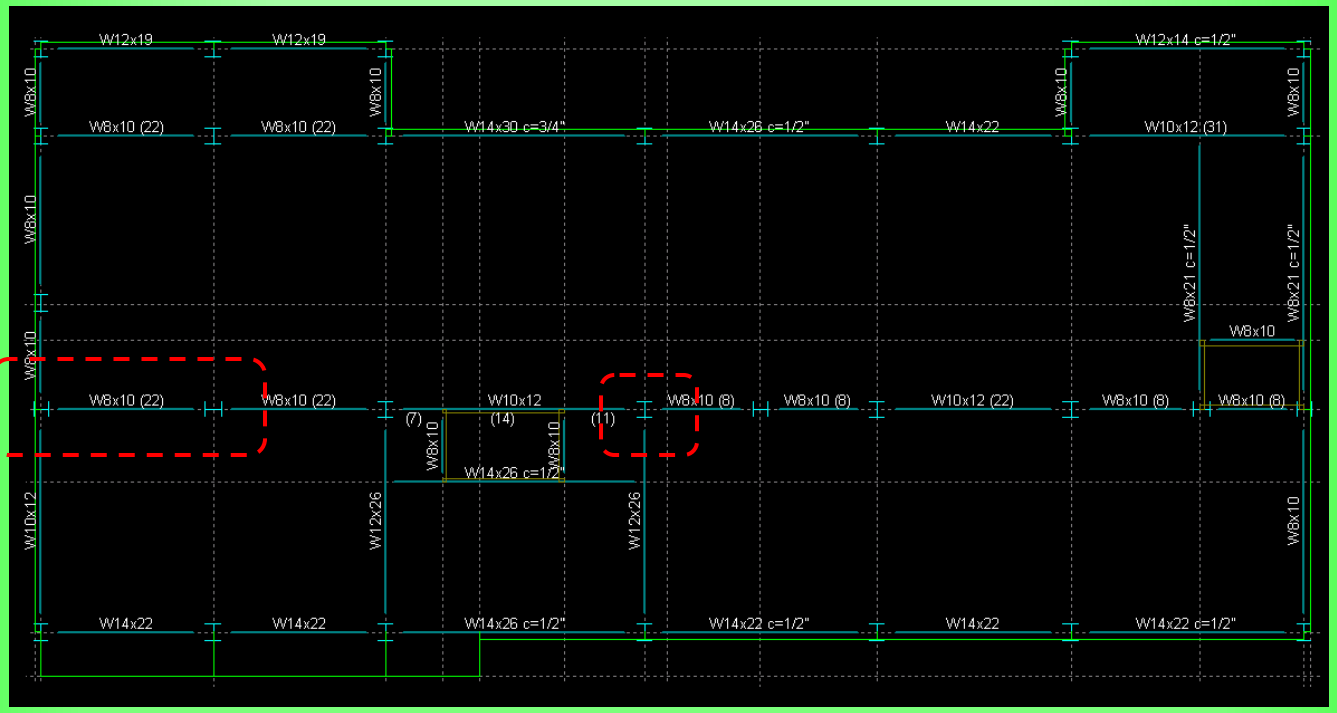
Design Selection

Stiffness of Frames
Tension Forces
Aesthetics in Retail Area

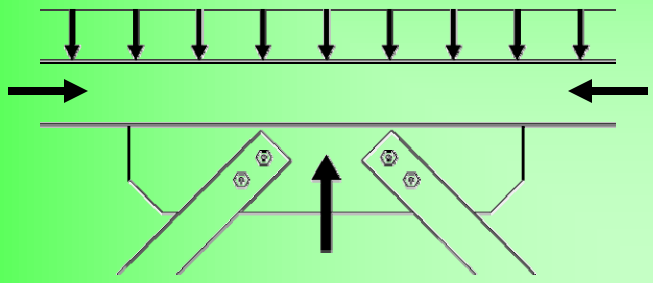


Combined Loading

Axial Compression and Flexure Members



Beam



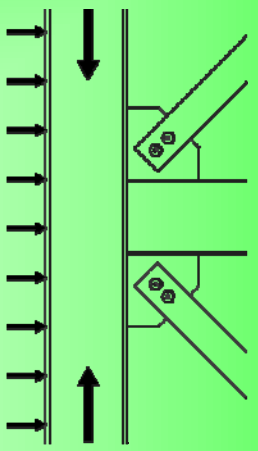
Gravity Analysis

W8 x 10 (22)

Lateral Analysis

W8 x 21

Column



Gravity Analysis

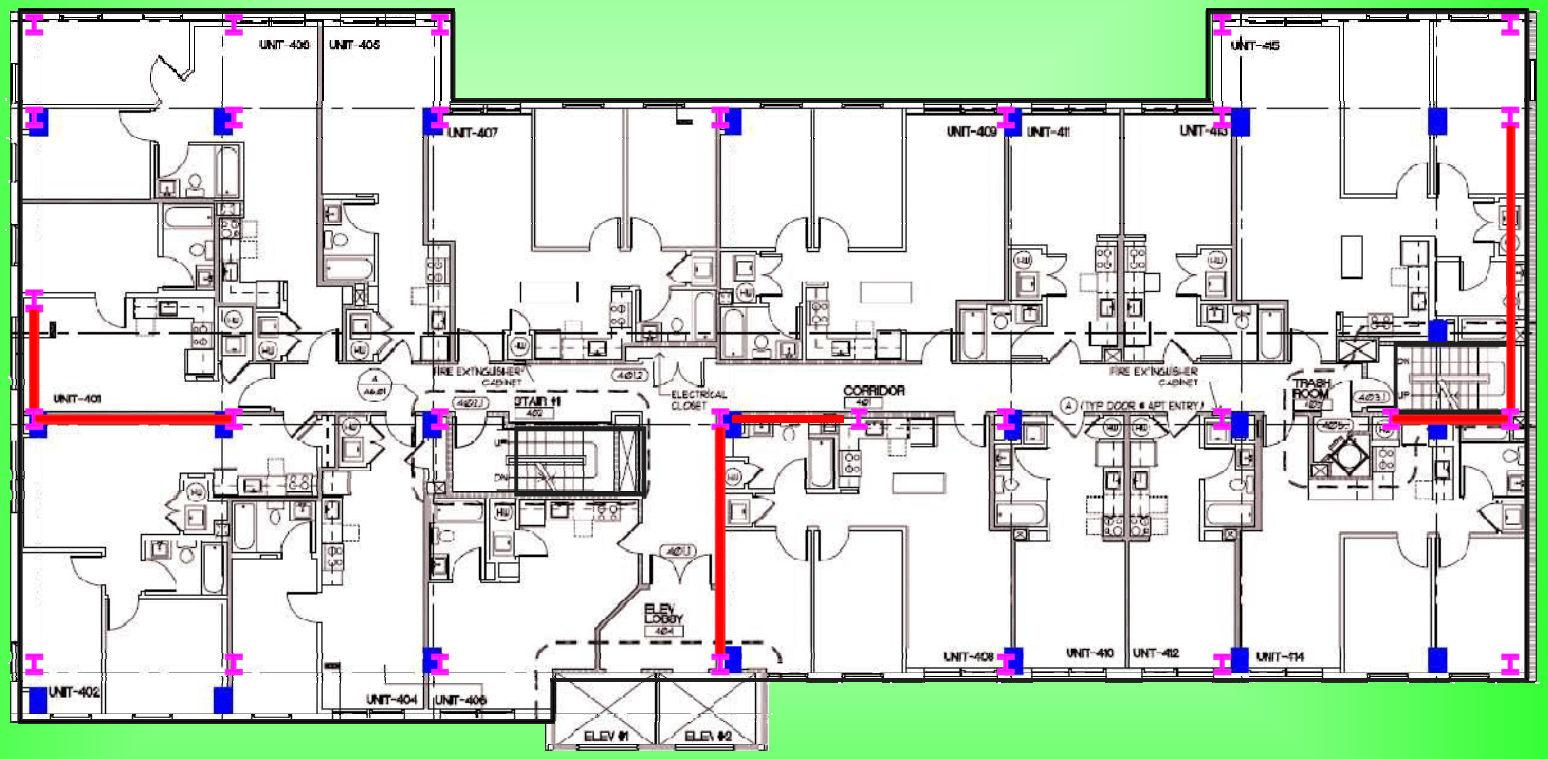
W12 x 45

Lateral Analysis

W12 x 106

The HUB on Chestnut

PHILADELPHIA, PA

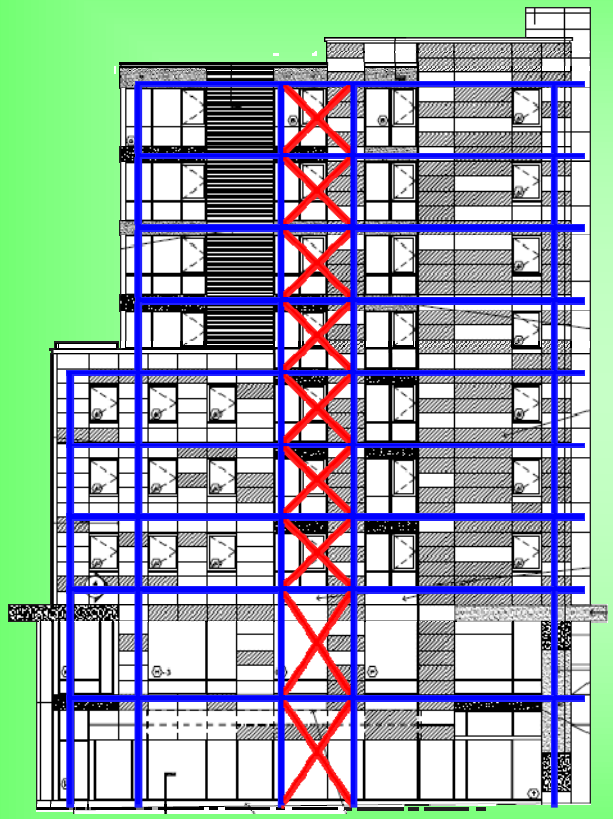


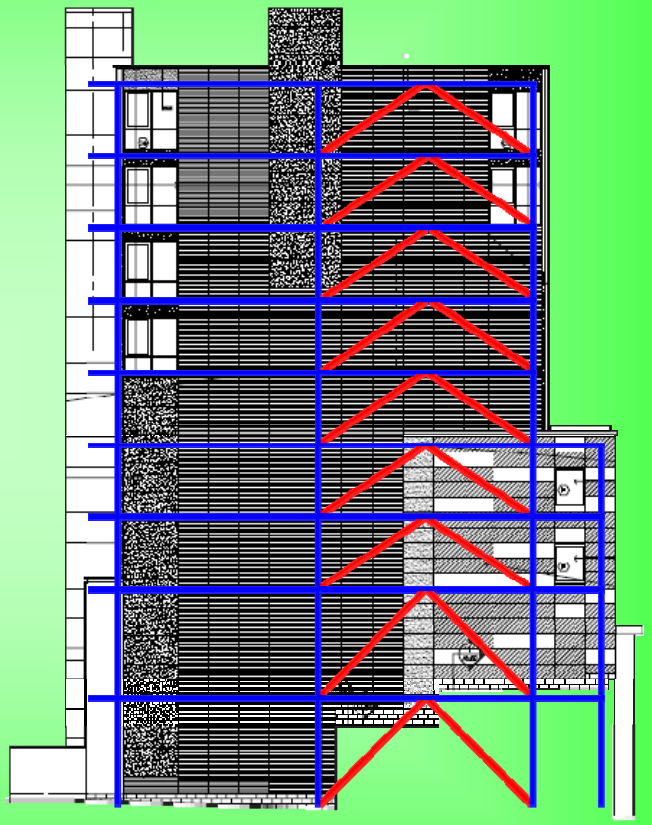
Andrew Simone

Structural

The HUB on Chestnut

PHILADELPHIA, PA





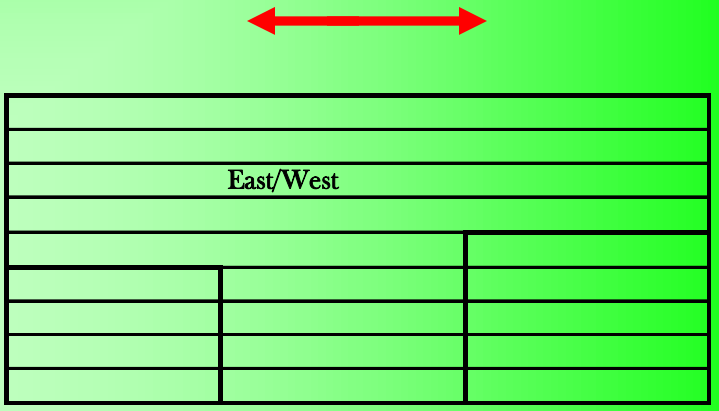
Andrew Simone

Structural

Serviceability

North/South *ASCE 7-05 [12.12.1]*

Level	Story Height Below (ft)	Displace (in)	Δ (in)	Δa (in)	Δ ≤ Δa=0.015hsx
Roof	10	4.597	0.577	2.4	✓
9	10	4.02	0.594	2.4	✓
8	10	3.426	0.600	2.4	✓
7	10	2.826	0.563	2.4	✓
6	10	2.263	0.537	2.4	✓
5	10	1.726	0.490	2.4	✓
4	10	1.236	0.429	2.4	✓
3	15	0.807	0.494	3.6	✓
2	15	0.313	0.313	3.6	✓
1	0	0	0	0	



Initial Displacement

H/400 → 3.00”

Final Displacement

H/265 → 4.59”

**Acceptable by Seismic Drift Limit*

[Strength Design Governs]

Presentation Outline

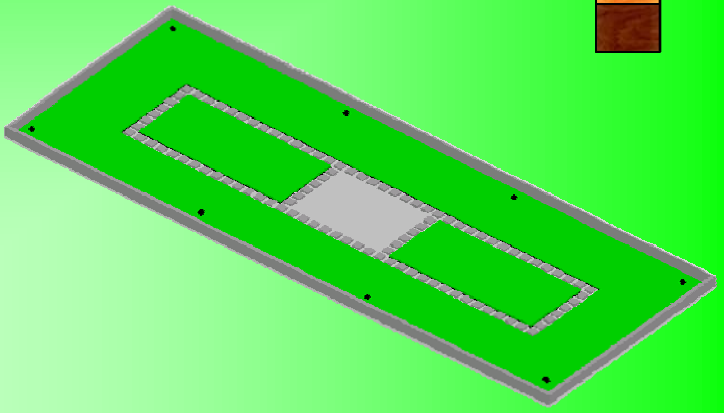
- ✓ Project Description
- ✓ Existing Structural System
- ✓ Proposal
- ✓ Structural Redesign
  - o ***Green Roof Study***
  - o Construction Breadth
  - o Recommendation

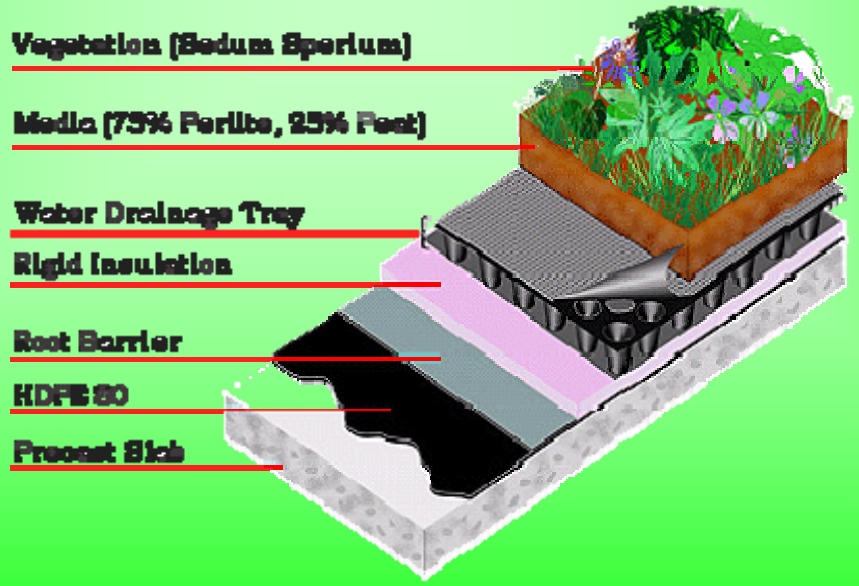
The HUB on Chestnut

PHILADELPHIA, PA

Design Goals

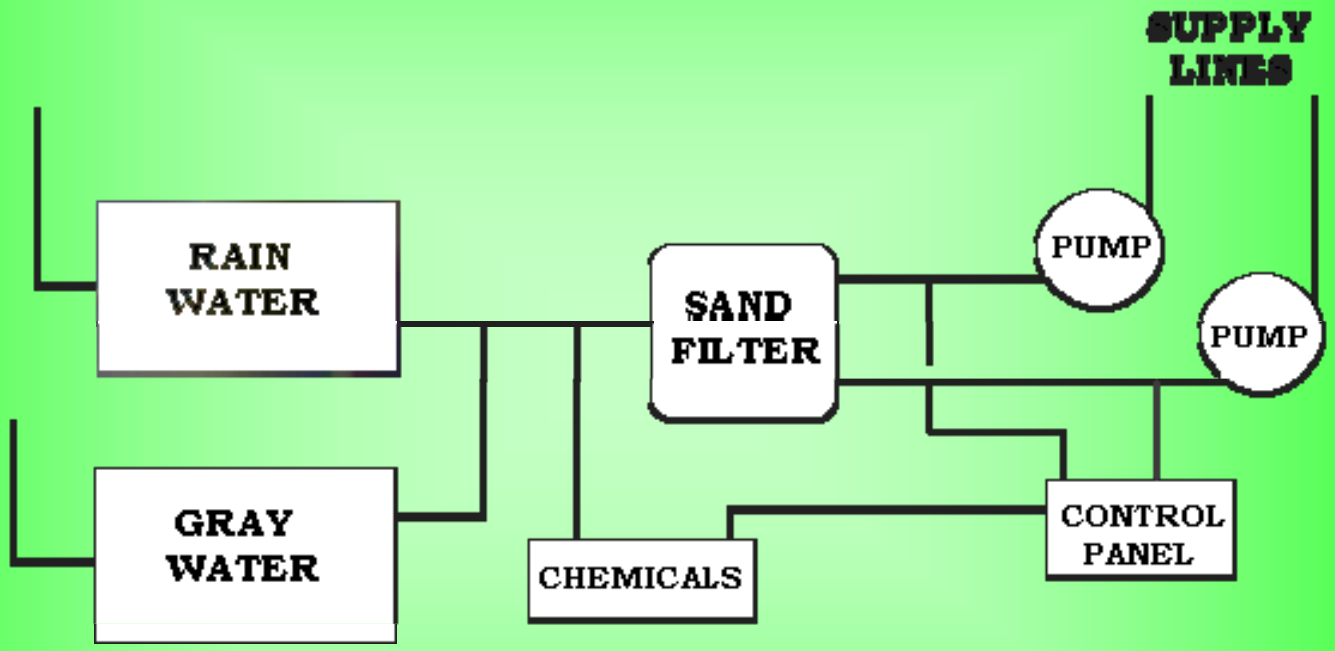
- Reduce and Slow Storm Water Run-Off
- Provide Additional Water Supply
- Reduce Utility Costs 70%
- Provide Habitat for Urban Wildlife





The HUB on Chestnut

PHILADELPHIA, PA



The HUB on Chestnut

PHILADELPHIA, PA

Water Usage per Day

$21.14/1000 ft^3 → 3650 gal = 487 f → $10.30

Water Usage per year

$10.30/Day → 365 Days → $3,757.74

Wihtout Rain Supply

$21.14/1000 ft^3 → 1168 gal = 156 f → $3.30

Water Usage per year

$3.30/Day → 365 Days → $1,203.71

Savings $2,554.03 per year

Green Roof		$118,835
5000 Gal tank	$0.50 per gal	$2,500
2500 Gal tank	$0.50 per gal	$1,250
Filtration System		$9,000
		$12,750

** Payoff Filtration System in 5 years*

Presentation Outline

- ✓ Project Description
- ✓ Existing Structural System
- ✓ Proposal
- ✓ Structural Redesign
- ✓ Green Roof Study
- o ***Construction Breadth***
- o Recommendation

The HUB on Chestnut

PHILADELPHIA, PA

Superstructure Cost

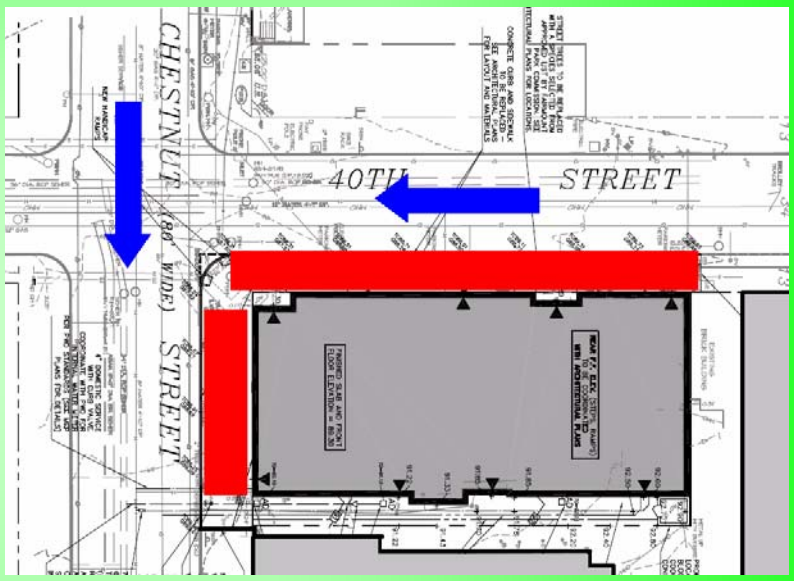
Steel Frame with Hollow-Core Slabs		Flat Plate wih Post-Tensioning	
Precast Slabs	$869,055.39	Flate Plate	$1,263,529.70
Steel Members	$148,586.14	Post-Tensioning	add 2%
Steel Columns	$164,168.20	CIP Columns	$412,695.00
Fire Resistance	$96,239.73		$1,701,495.29
	$1,278,049.46		
Cost per S.F.	$14.10	$18.78	

Difference in Cost	$423,445.83

The HUB on Chestnut
PHILADELPHIA, PA

Design Goals

- Onsite Delivery
- Coordination Among Trades
- Lifting Sequence
- Critical Path Delivery



**** Project Delivery 8 Weeks Ahead***

Presentation Outline

- ✓ Project Description
- ✓ Existing Structural System
- ✓ Proposal
- ✓ Structural Redesign
- ✓ Green Roof Study
- ✓ Construction Breadth
- o ***Recommendation***

Conclusions

- Satisfied Initial Goals
- Strength Design over Serviceability
- Successfully Transformed Superstructure
- Reduced Seismic Base Shear by 5.5%
- Cost Effective Project

Recommendation

- Flat Plate Post-Tensioning for Architecture
- Implement Moment Connections for Dual System
- Coordination of Trades is Critical
- Add Gray Water & Green Roof System

Acknowledgments

- The Department of Architectural Engineering
  - Dr. Memari
  - Faculty and Staff
  - Structural Mentors
- The Department of Agricultural Engineering
- Project Team
  - O'Donnell & Naccarato
  - Domus, Inc.
- 5th Year AE Thesis Peers

The HUB on Chestnut

PHILADELPHIA, PA

THE hub

Andrew Simone

Structural