FDA CDRH Laboratory

Timothy Mueller

Senior Thesis, Spring 2006

Structural Option

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Project Background
General Architecture
Existing Structure
Depth Study
- Gravity Analysis
- Lateral Analysis
- Additional Considerations

Breadth Study
- Construction Management
- Architectural Analysis

Summary and Conclusions
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PROJECT BACKGROUND

Navy Ordnance Site

U.S. General Services Administration

U.S. Food and Drug Administration

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PROJECT BACKGROUND

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PROJECT BACKGROUND

Delivery Method: Design-Bid-Build

Major Building Code: IBC 2000

Cost: $63 Million

Start Date: March 22, 2005

Finish Date: November 1, 2006

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GENERAL ARCHITECTURE

Size:

- 139,805 Sq Ft

Height:

- 86' above grade
- Central core w/ 5th floor penthouse
- Four story main structure
- One floor below grade

Façade:

- Many decorative aluminum & sheet metal panels
- Ribbon windows
- Full glazing curtain walls
- Horizontal sunshields

High Bay Laboratory:

- Located on West Side
- Decorative curved metal roof

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EXISTING STRUCTURE

Roof:

Typical concrete on metal deck w/ steel frame of:

- W14X122
- W10X73

Superstructure:

Typically one-way cast-in-place concrete w/ monolithic poured:

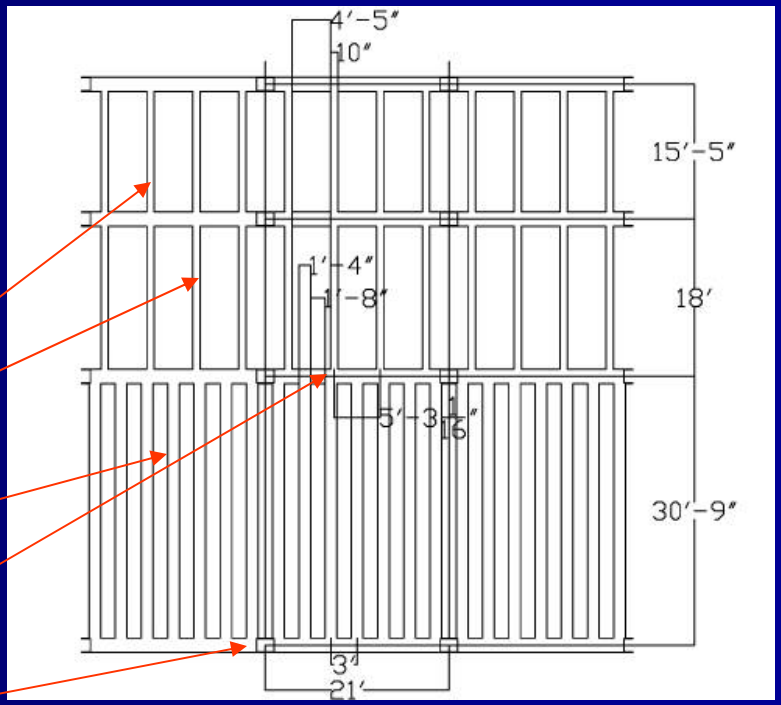
- 4.5" slab
- 10"X16" joist
- 16"X16" joist
- 20"X20.5" beams
- 18"X24" columns

Unique protection:

- 20"X30" progressive collapse beams

Foundation:

- 3' deep step footing
- 10'X10'spread footing below columns



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DEPTH STUDY

Considerations:

Concrete Pros:

- High Vibration Stability
- Integrated Fireproofing
- Small Floor Sandwich

Concrete Cons:

- Labor Intensive
- Large Total Mass
- Steel Roof System

Proposed Solution:

- Construct the FDA CDRH Laboratory with Steel

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DEPTH STUDY

Loading:

Dead load: **73psf**

USF2X deck and Concrete: 48psf
Superimposed: 25psf

Snow load (Washington D.C.): **30psf**

Live Load: **125psf**

Light Manufacturing (Most Laboratory Spaces): 125psf
Light Storage (Supplementary Laboratory Spaces): 125psf

The controlling combination in both N/S and E/W direction is

1.2D +1.0E + 0.5L + 0.2S

for all floors except the first floor which was controlled in both directions by

1.2D + 1.6W + 0.5L + 0.5S

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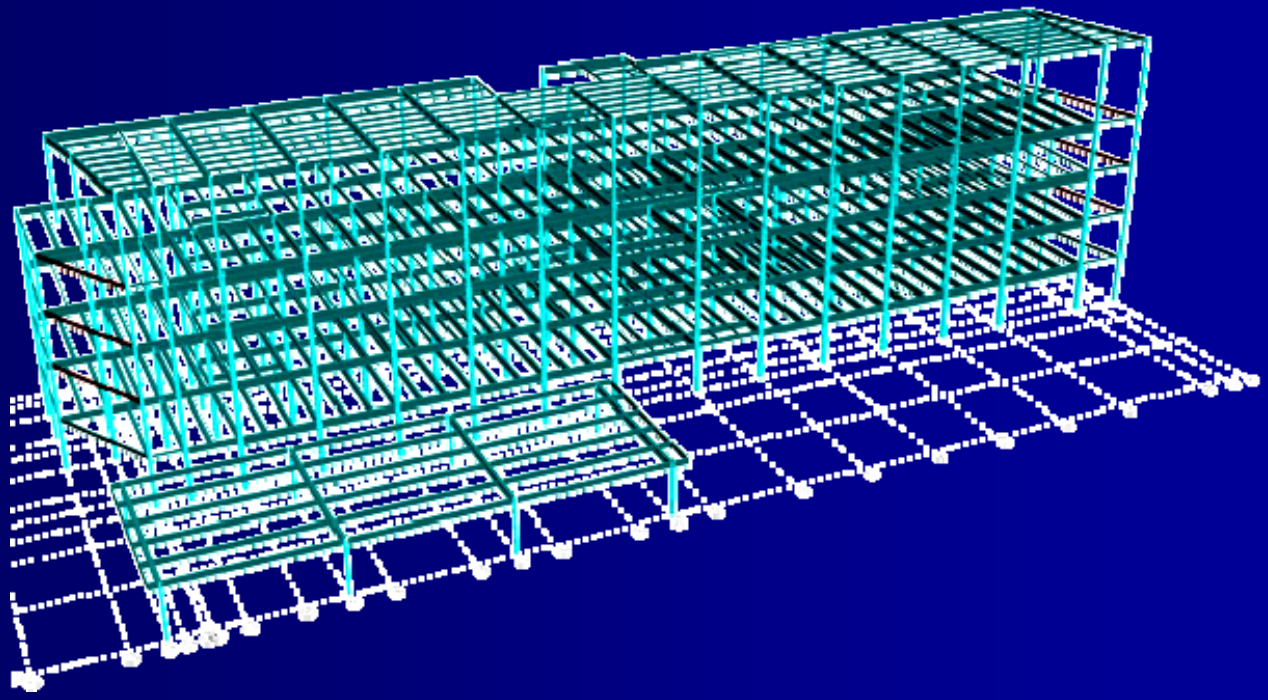
DEPTH STUDY • GRAVITY ANALYSIS



Deflection Criteria:

Live: l/360, Total: l/240, & Vibration Criteria

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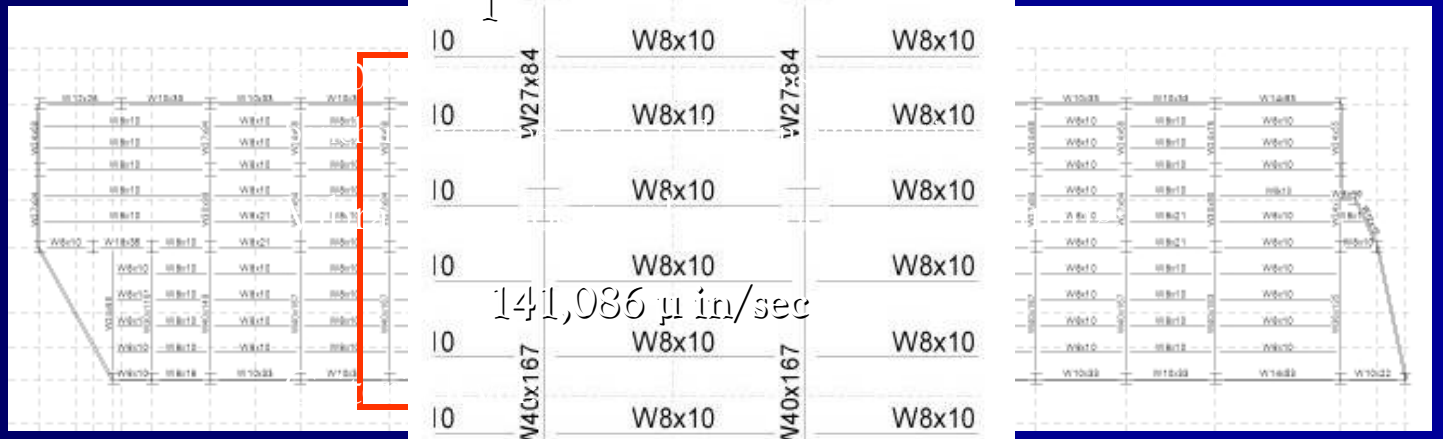
DEPTH STUDY • GRAVITY ANALYSIS

Design A Vibrat lking slowly:

5" slab over

Criteri ric.



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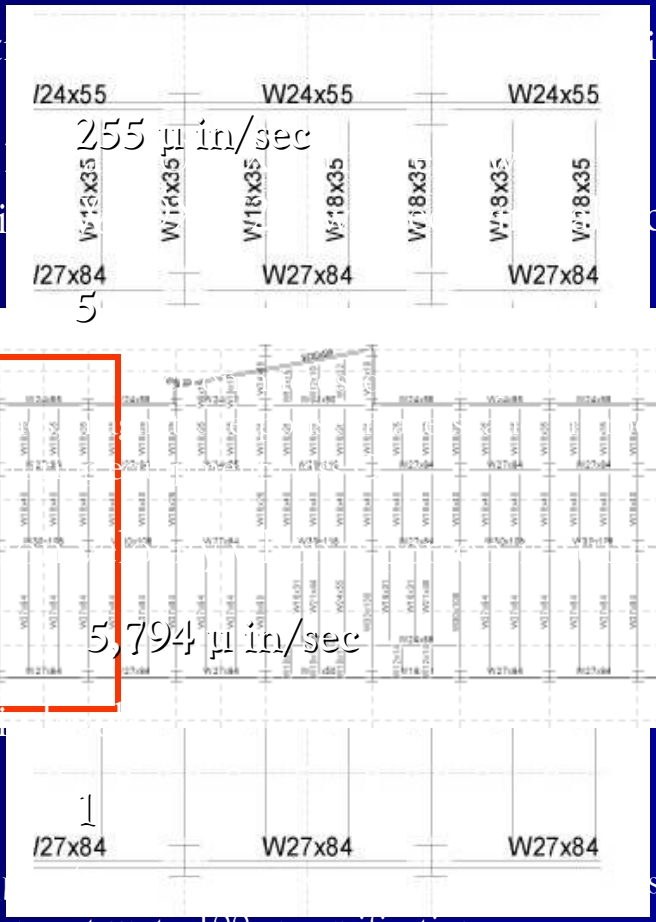
DEPTH STUDY • GRAVITY ANALYSIS

Design B Vibrat ing slowly:

5" slab over

Criteri c.



≤ 8,000 s, surgery, and bench microscopes at up to 100x magnification

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DEPTH STUDY • LATERAL ANALYSIS

Deflection Criteria:

h/400

Seismic Deflection Criteria:

0.02h/floor

No damage to building systems (h/180)

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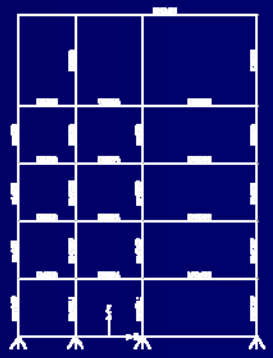
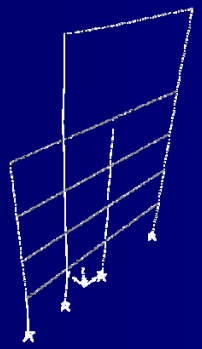
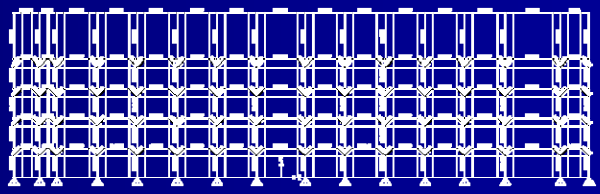
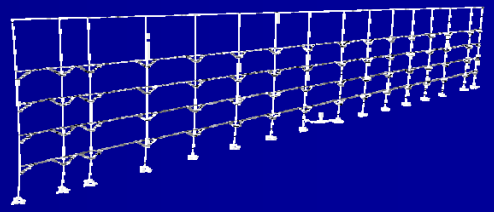
DEPTH STUDY • LATERAL ANALYSIS

Design A









Typical Column:

W14

Moment Frames:

3

Moment Frame Second Redesign		
Story	Allowable Drift (in.)	Story Drift (in.)
1	0.4830	0.4688
2	0.4830	0.2619
3	0.4830	0.2230
4	0.4830	0.1829
Penthouse	0.7599	0.3941
Full Building	3.1749	1.5307

Braced Frame First Redesign		
Story	Allowable Drift (in.)	Story Drift (in.)
1	0.4830	0.3367
2	0.4830	0.2280
3	0.4830	0.1947
4	0.4830	0.1748
Penthouse	0.7599	0.2740
Full Building	3.1749	1.1416

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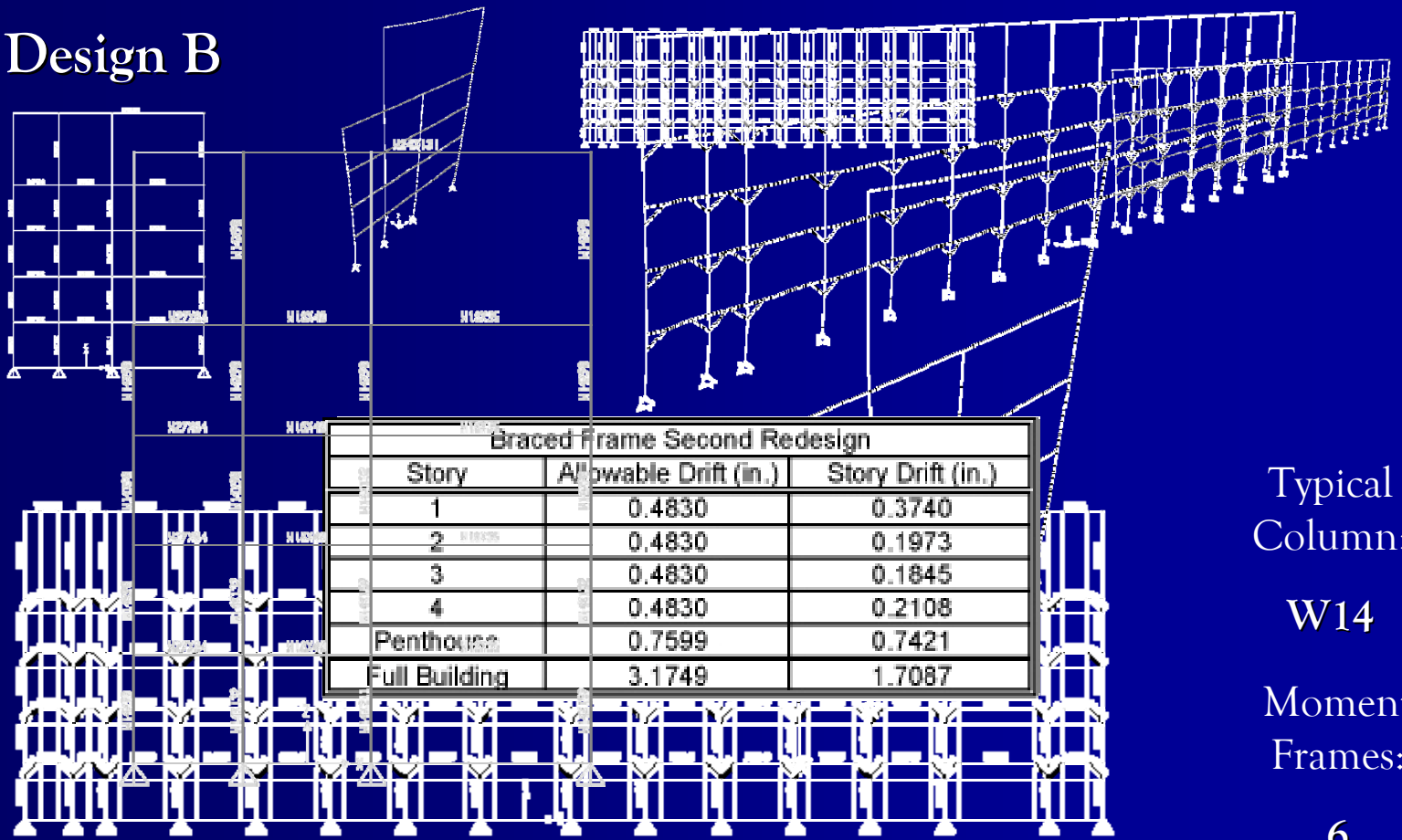
DEPTH • STUDY

LATERAL ANALYSIS

Design B



Braced Frame Second Redesign

Story	Allowable Drift (in.)	Story Drift (in.)
1	0.4830	0.3740
2	0.4830	0.1973
3	0.4830	0.1845
4	0.4830	0.2108
Penthouse	0.7599	0.7421
Full Building	3.1749	1.7087

Typical Column:

W14

Moment Frames:

6

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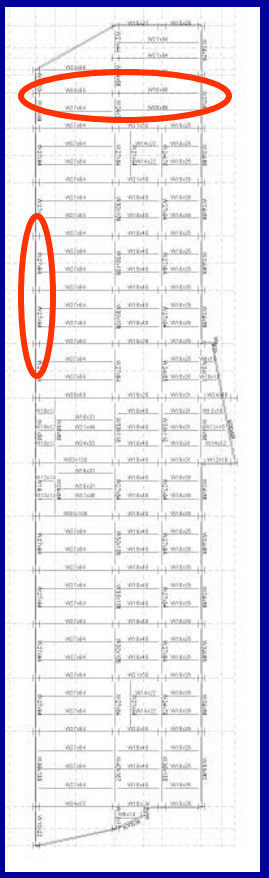
DEPTH STUDY • ADDITIONAL CONSIDERATIONS

Blast Control:

- **Location** - center of the limited access White Oak campus
- One **road access** point - north end of the building
- No interior **below grade parking** garages

- Extra layer of **welded wire mesh** in upper portion of the deck
- **Moment connections**
- **Square columns** - HSS shapes versus W-shape resistance torsion
- **progressive collapse beam**
  support the load of two bay spans without deflection criteria
  W40X230 to **W40X431**

- Overall cost of a blast resistant system as compared to a non-resistive
  5% increase



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DEPTH • STUDY

ADDITIONAL CONSIDERATIONS

Height

Total height increase: **8.25'**

- No height restrictions
- Slight increase in wind loads
- Minimal additional cladding cost

Weight/Foundation

Total mass decrease: **¼ original design** (just under 6 million kips)

- Lower seismic forces
- Foundations reduced to 1/3 original area

Fireproofing

Compatible **spray-on fireproofing**

- Decking: 3/8"
- Beams and girders: 1"
- Columns: 1-3/8"

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DEPTH STUDY

Considerations:

Concrete Pros:

- High Vibration Stability
- Integrated Fireproofing
- Small Floor Sandwich

Concrete Cons:

- Labor Intensive
- Large Total Mass
- Steel Roof System

Proposed Solution:

- Design B Steel Structure

Proposed Solution:

- Fewer members
- Construct the FDA CDRH Laboratory with Steel
- High vibration control
- Blast control
- More moment connections

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BREADTH STUDY

• CONSTRUCTION MANAGEMENT

Cost:

• Current System (concrete)	$4,492,275.00
• Design A (steel spanning N-S)	$6,972,354.00
• Design B (steel spanning E-W)	$1,100,052.00
• Design B with Blast Resistance	$9,364,385.15

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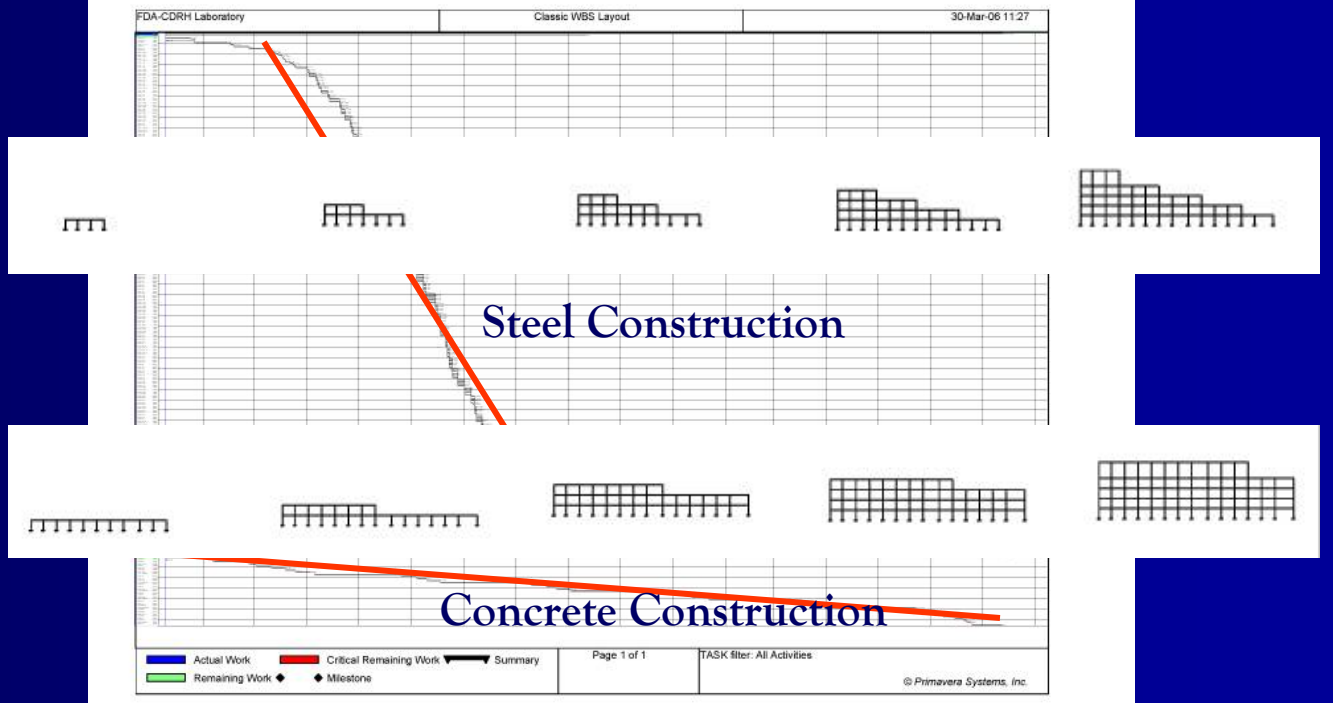
BREADTH STUDY • CONSTRUCTION MANAGEMENT



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BREADTH STUDY • CONSTRUCTION MANAGEMENT

Considerations:

Concrete Pros:

- High Vibration Stability
- Integrated Fireproofing
- Small Floor Sandwich

Concrete Cons:

- Labor Intensive
- Large Total Mass
- Steel Roof System

Proposed Solution:

Proposed Solution:

- Design B Steel Structure
- Design B Steel Structure
  - Fewer members
  - Fewer members
  - Increased vibration control
  - High Vibration control
  - More moment connections
  - Blast control
  - Cost savings
  - More moment connections
  - Time savings

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BREADTH STUDY • ARCHITECTURAL ANALYSIS

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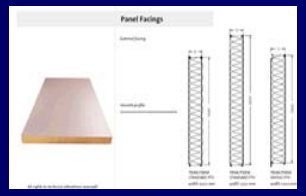
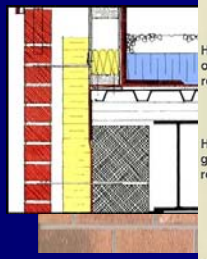
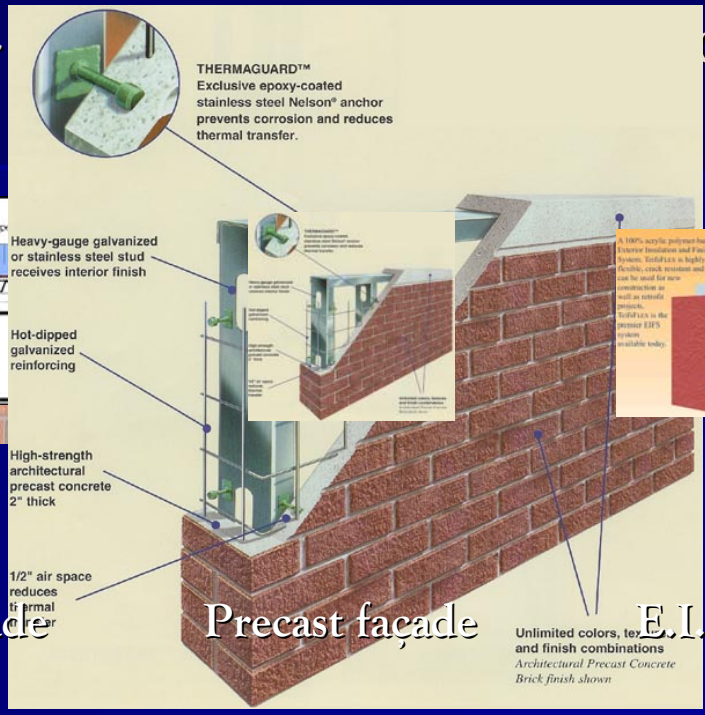
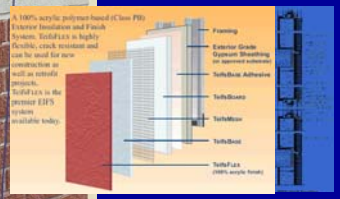
BREADTH STUDY • ARCHITECTURAL ANALYSIS









Steel façade

Brick façade

Precast façade

E.I.F.S. façade

W27X84 to W30X90
W21X50 to W24X76
W18X40 to W21X48

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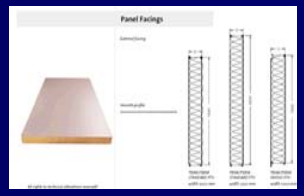
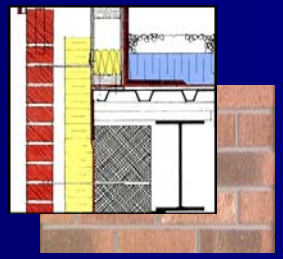
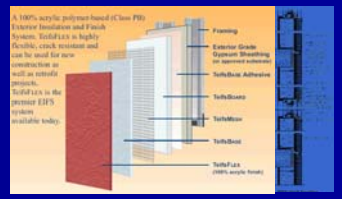
BREADTH STUDY • ARCHITECTURAL ANALYSIS







Steel façade	Brick façade	Precast façade	E.I.F.S. façade
$1,086,093.35	$1,592,609.37	$1,457,993.45	$1,036,786.72

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BREADTH STUDY

ARCHITECTURAL • ANALYSIS

Considerations:

Concrete Pros:

- High Vibration Stability
- Integrated Fireproofing
- Small Floor Sandwich

Concrete Cons:

- Labor Intensive
- Large Total Mass
- Steel Roof System

Proposed Solution:

Proposed Solution:

- Design B Steel Structure
  - Fewer members
  - Increased vibration control
  - More moment connections
  - Cost savings
  - Time savings
- Precast Facade
  - Fast installation
  - Time savings
  - Traditional image
  - Additional blast resistance

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SUMMARY AND CONCLUSIONS

Current Building (concrete structure & steel façade)	$5,578,368.35
Proposed Building (steel structure & steel façade)	$4,647,925.50
Proposed Building (steel structure & precast façade)	$5,136,827.60

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SUMMARY AND CONCLUSIONS

Current Building $5,578,368.35
(concrete structure & steel façade)

Time Savings

Greater Than Satisfactory Vibration Control

Proposed Building $930,440.85
(steel structure & steel façade)

Equivalent Fireproofing

Proposed Building $441,540.75
(steel structure & precast façade)

Campus Unifying Façade

Smaller Foundation

Increased Blast Protection

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The AE Faculty and Staff, Penn State University, for providing me with a truly unique and extraordinary college experience and the ability to present my thesis.

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My Friends, who without their help, support, and ear, I would never have been able to survive this past year.

and

My Family, who not only provided me with a sounding board this past year, but a sound foundation to build my future from.

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Questions?