Oklahoma University Children's Medical Office Building

Oklahoma City, Oklahoma

AE Senior Thesis Final Report

April 14, 2014

Jonathan Ebersole

Structural Option

Dr. Hanagan

- **Introduction**
  - **Building Statistics**
  - Project Team
  - Existing Structure
- Proposal
- Structural Depth
- Architectural Breadth
- Construction Breadth
- Conclusion

Building Statistics

- Location: 1200 North Children's Avenue, Oklahoma City, Oklahoma
- Occupancy: Office
- Size: 320,000 gsf
- Height: 12 stories for a total of 172 ft.
- Construction Dates: February 2007- Spring 2009
- Building Cost: $59,760,000
- Delivery Method: Design-Bid-Build

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Project Team

- Owner: University Hospitals Trust
- Construction Manager: Flintco, Inc.
- Project Architect: Miles Associates
- Structural Engineer: Zahl-Ford Inc.
- MEP Engineer: ZRHD, P.C.
- Civil Engineer: Smith, Roberts, Baldischwiler, Inc.

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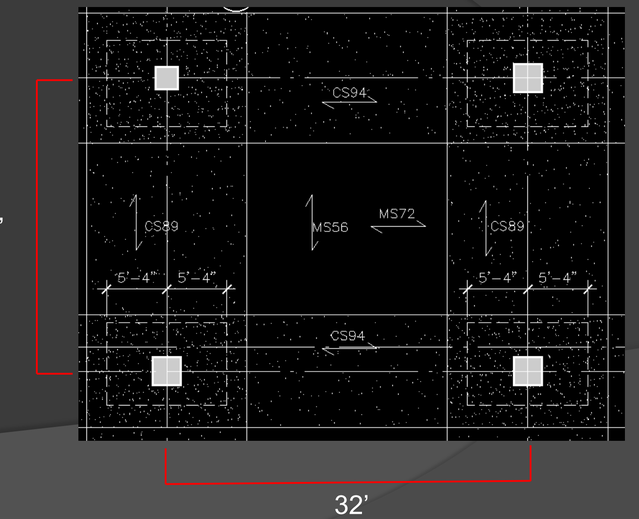
Existing Building Structure

Gravity

- Reinforced, cast-in-place concrete
- Foundations
  - Drilled piers, spread footings, and grade beams
- Two way flat slab system with drop panels
  - 10” slab with 4” drop panels
- Exterior Beams

Typical Bay



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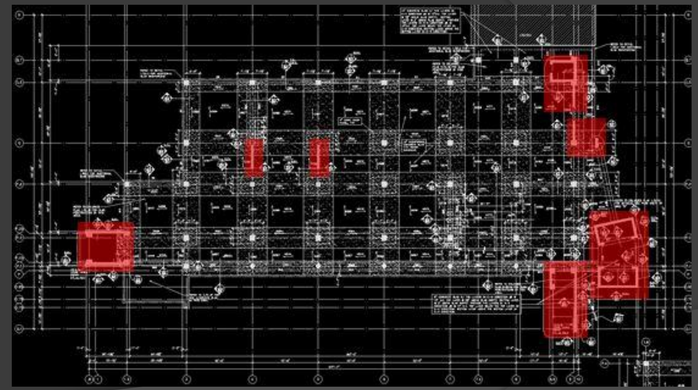
Existing Building Structure

Lateral

- Reinforced cast-in-place concrete shear walls
  - Located in stairwells, elevator shafts, and center of floor plan
  - Typically 12” thick
- Moment frames located along the floor plan perimeter

Lateral Layout



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- Introduction
- **Proposal**
  - **Problem Statement**
  - Depth Introduction
  - Breadth Introduction
- Structural Depth
- Architectural Breadth
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Problem Statement

- Reduce overall building costs
- Reduce the schedule duration
- Develop an economical steel system
- Maintain a low impact on the building architecture

http://www.metalconstructionnews.com/articles/columns/high-flying-inspiration.aspx

- Introduction
- Proposal
- **Structural Depth**
  - **Design Loads**
  - RAM Model
  - Composite Steel Redesign
  - Steel Joist Redesign
  - Lateral System Redesign
  - Drift Comparison
- Architectural Breadth
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Design Loads

Gravity Loads

Floors	
Live Load	80 psf
Superimposed Dead Load	15 psf
Flooring	2 psf
Roof	
Roof Live Load	20 psf
Snow Load	10 psf
Green Roof Dead Load	30 psf
Superimposed Dead Load	15 psf
Additional Loads	
Helicopter Pad Dead Load	8.33 kips
Ambulance Bay Live Load	60 psf

Lateral Load Base Shears

Wind Loads	
Wind N-S	430 kips
Wind E-W	942 kips
Seismic	
Seismic N-S	447 kips
Seismic E-W	447 kips

- Wind E-W controls

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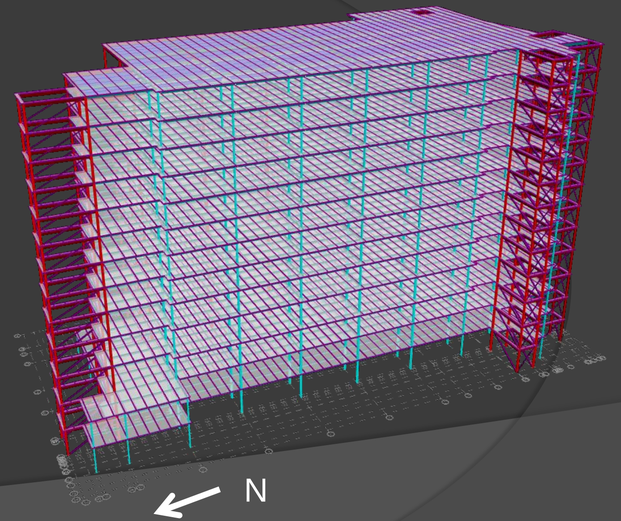
RAM Model

Model Assumptions

- Columns are considered as pinned connections at the base
- Wind Loads are to be applied at the center of pressure
- Each floor diaphragm is considered rigid



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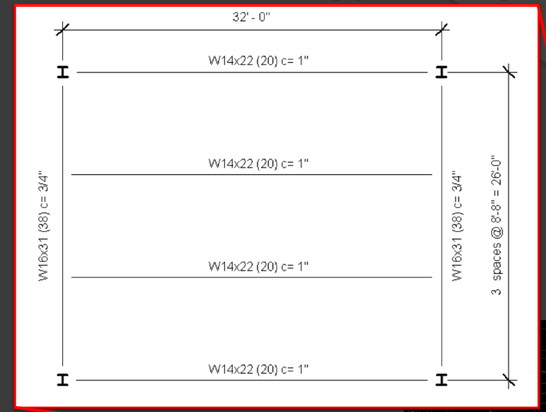
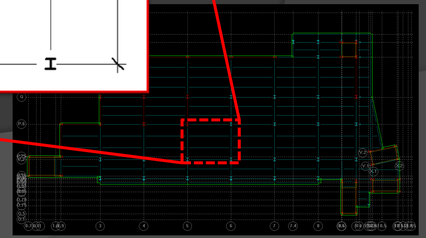
Composite Steel Floor Redesign

- Typical Bay
  - 1.5 VLR 22 gauge composite deck
    - 3 ¼” lightweight topping
    - Unshored, 3 span construction
  - Beams
    - W14x22 with 20 studs and a 1” camber
  - Girders
    - W16x31 with 38 studs and a ¾” chamber
  - Beams, girders, and columns are to be fireproofed for a two hour fire rating

Typical Bay





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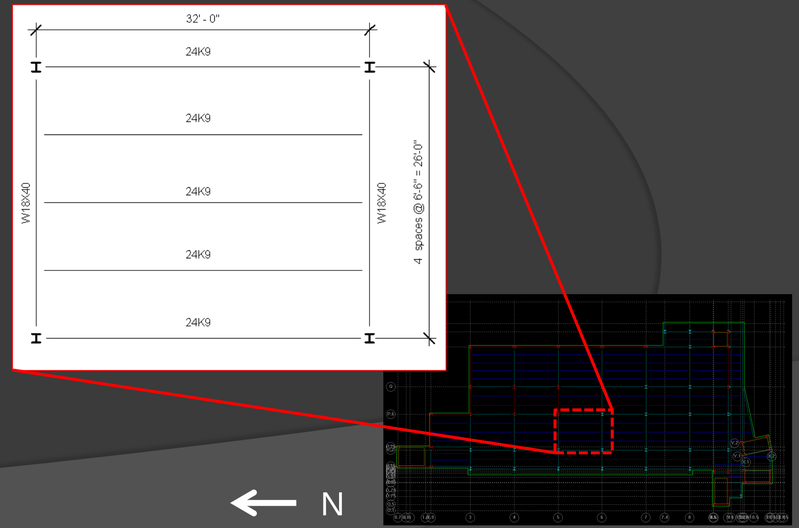
Steel Joist Roof Redesign

- Typical Bay
  - 1.5 B 22 gauge roofing deck
    - Unshored, 3 span construction
  - Joists
    - 24K9 joists
  - Girders
    - W18x40
  - Roof deck, joists, girders, and columns will be fireproofed for a two hour fire rating

Typical Roof Bay



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Lateral System Redesign

- Concentric, diagonal braced frames
  - Located in existing shear wall locations
  - Consists of square HSS steel tubes
- Additional moment frames are needed
  - Located along the eastern wall
  - Moment frames where used to minimize the impact on the architecture

Lateral System Layout

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Concentric Braced Frames

Additional Frames

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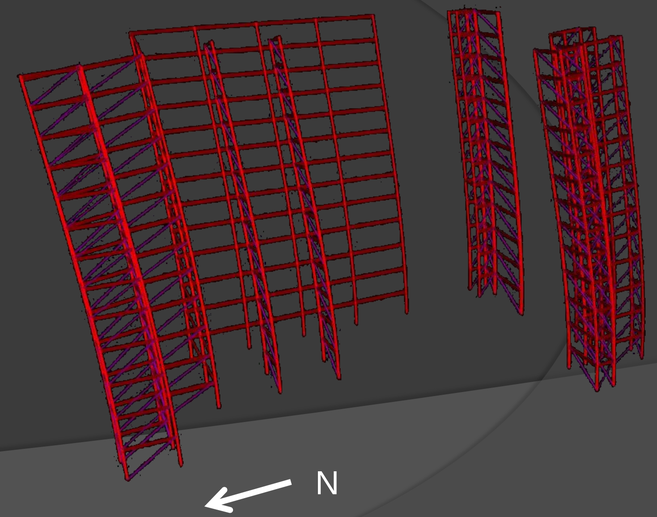
Drift Comparison

- Existing concrete lateral system drift: 4.77 inches
- Proposed steel lateral system drift: 4.75 inches
- IBC 2009 allowable building drift: 4.98 inches

Building Drift Under Controlling Case



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  - **Plant selection**
  - Material Selection
  - Impact on Structural System
  - Green Roof Cost Analysis
- Construction Breadth
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Plant Selection

- Oklahoma City hardiness zone: 7a and 7b
  - Identifies the appropriate plants for a specific environment
- Sedum plants are used
  - Hardy plants that can survive a variety of different environments
  - Can grow in shallow soil depths
  - Ability to resist droughts

Sedum Floriferum
http://macgardens.org/?m=201306

Sedum Oreganum
http://www.greatcity.org/

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Material Selection

- Growing Medium
  - Rooflite Extensive MCL
- Filter Fabric
  - Green Roof Solutions FF35
- Drainage Panel
  - Green Roof Solutions GRS 32

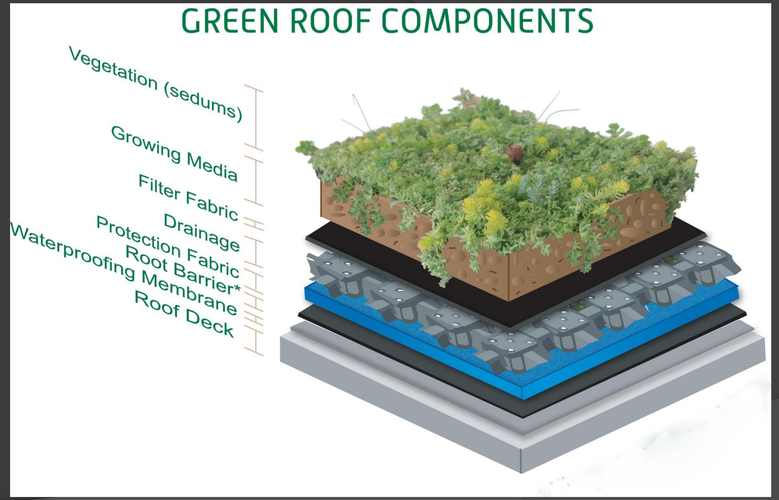

Image obtained from http://www.vegetalid.us/green-roof-systems/green-roof-101/what-is-a-green-roof

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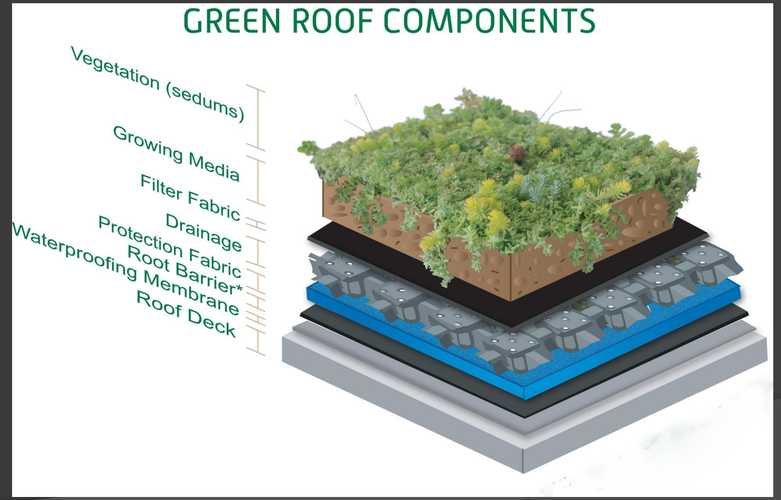
Material Selection

- Root Barrier
  - Green Roof Solutions RB20
- Waterproof Membrane
  - Kemper System Kempero 2K-PUR
- Rigid Insulation
  - DOW Building Solutions Highload 60 Insulation
- Vapor Barrier
  - Roof Aqua Guard BREA



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Impact on the Structural System

- Initial dead load estimation for the green roof was 30 psf.
- The total dead load for the green roof is 22 psf
- The estimated dead load is conservative compared to the actual dead load

Material	Weight
Vegetation	2 psf
Growing Media	17 psf
Filter Fabric	0.024 psf
Drainage Panel (Including Water)	2 psf
Root Barrier	0.05 psf
Water Proof Membrane	0.05 psf
Total	22 psf

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Green Roof Cost Analysis

- Green roofs have a higher initial costs compared to a standard built up roof
- Using RS Means Cost Construction Data, the total additional cost for the green roof is $412,000.00

Green Roof							
	Unit	Quantity	Waste Factor	Unit Price	Labor	Equipment	Total
Vegetation	S.F.	22705.50	1.00	2.50	0.33	0.00	64256.57
Growing Medium	S.F.	22705.50	1.00	0.25	0.53	0.41	27019.55
Filter Fabric	S.F.	22705.50	1.00	0.26	3.88	0.51	105580.58
Drainage Panel	S.F.	22705.50	1.00	2.70	0.67	0.00	76517.54
Root Barrier	S.F.	22705.50	1.00	0.70	0.77	0.00	33377.09
Water Proof Membrane	S.F.	22705.50	1.00	0.26	3.88	0.51	105580.58
						Total:	$412,331.88

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  - Schedule Comparison
- Conclusion

Cost Comparison

- Detailed cost analysis using RS Means for each system
- Original concrete design estimate: $9,055,000.00
- Proposed steel design estimate: $5,125,000.00
- Cost is significantly reduced

Concrete Cost Summary	
Cost of Concrete	$2,025,000.00
Cost of Formwork	$5,380,000.00
Cost of Reinforcement	$1,650,000.00
Total	$9,055,000.00

Steel Cost Summary	
Steel Beams	$2,230,000.00
Steel Columns	$1,170,000.00
Steel Braces	$250,000.00
Steel Decking	$756,000.00
Concrete Topping	$365,000.00
Welded Wire Fabric	$120,000.00
Steel Joists	$29,000.00
Fireproofing	$142,000.00
Shear Connectors	$63,000.00
Total	$5,125,000.00

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Schedule Comparison

- Schedule determined from RS Means
- Original Concrete System
  - Assumed three crews to decrease schedule times
  - 710 days to complete
- Proposed Steel System
  - Assumed one crew erecting the steel
  - 189 days to complete

http://www.projsolco.com/portfolio/healthcare-imaging-solutions

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Design Conclusion

Goals

- Reduce overall building costs
- Reduce the schedule duration
- Develop an economical steel system
- Maintain a low impact on the building architecture

Results

- Redesign was more cost effective
- The schedule time was reduced
- Composite steel with unshored construction
- Steel provides an open floor plan
- Lateral system has little impact of exterior facade

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Acknowledgements

- University Hospitals Trust
- Miles Associates
- Zahl-Ford Inc.
- Department of Architectural Engineering
- Friends and Family

MILES | ASSOCIATES
ARCHITECTURE + PLANNING + INTERIORS

zfi engineering
Structural Solutions that Work

PENNSTATE
1855
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Questions?