

Mansfield University Dormitories

Mansfield, Pennsylvania



Michael Mahoney
Construction Option
Senior Thesis Presentation 2013
The Pennsylvania State University

Michael Mahoney
Construction Management

Mansfield University Dormitory Project

Presentation Outline

- I. Project Overview
- II. Modular Preconstruction
- III. Modular Setting Precision
- IV. Flooring System Analysis
- V. Panelized Façade Design
- VI. Acknowledgements



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Project Overview

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Project Team

Owner:
Mansfield University

Architect:
WTW Architects

Construction Manager:
Wohlsen Construction

Cost: \$39 Million

Function: Student Residence Buildings

Size:
Building C: 79,500 SF
Building D: 135,400 SF

Room Type: Suite Style Room Including Bathroom

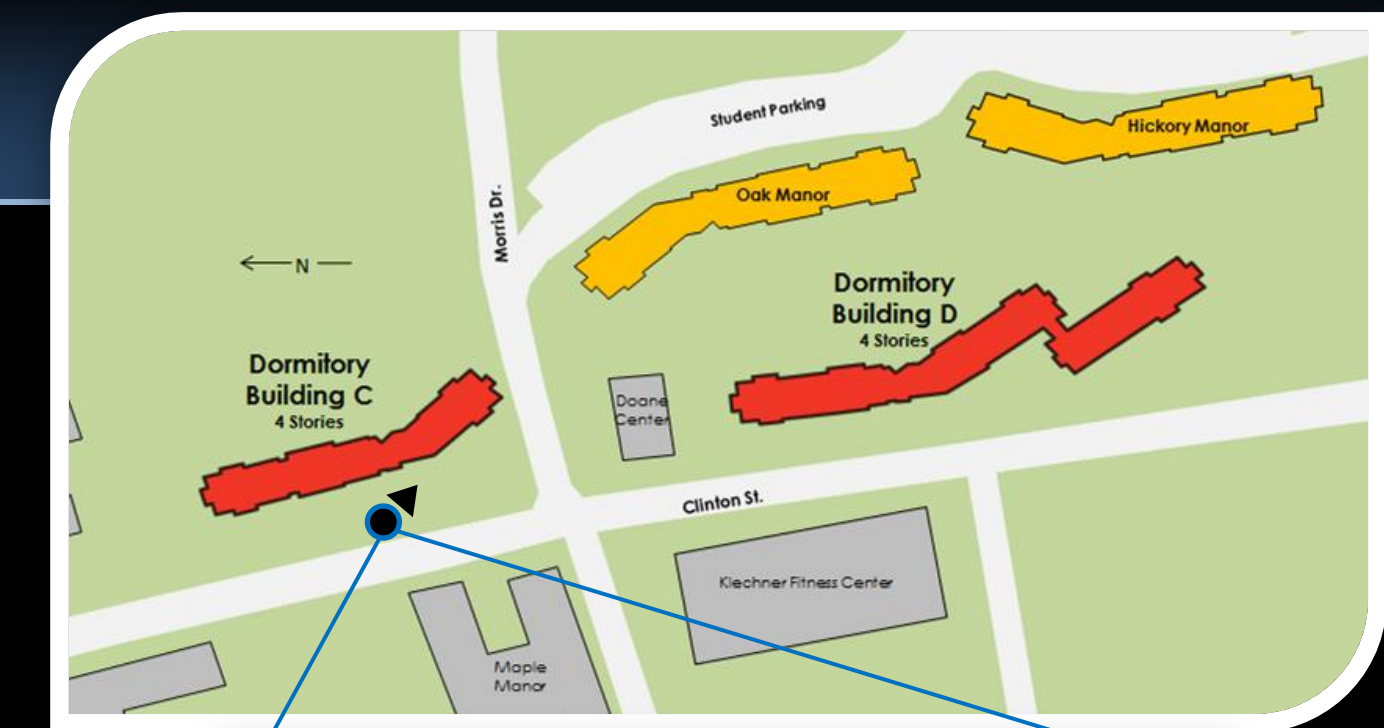
Capacity: 700 Students

Facilities: Kitchen, Snack Shack and Health Center

Height: 4 Stories

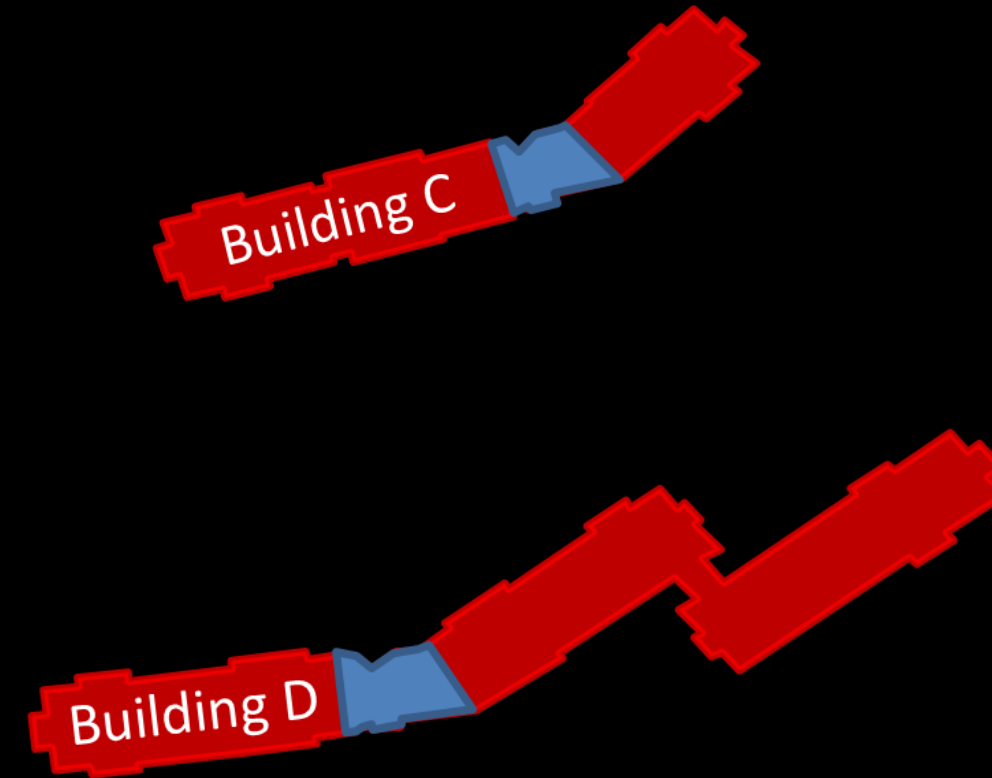
Schedule: August 2012 – October 2013

Delivery Method: CM @ Risk with GMP



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PROBLEM

- Added Time Needed During Preconstruction for Modularization

GOAL

- Evaluate the Value of Time Saved in the Field vs. Time Spent During Precon
- Evaluate if BIM Would Increase Productivity in Modular Unit Construction



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TOTAL PROJECT

300 units

BUILDING C

27 Units per Floor

108 Units Total

Building C			
Type	Total	Ppl/Rm	Residents
B	48	2	96
C	64	2	128
E	4	4	16
G	4	2	8
H	1	2	2
I	2	3	6
			256

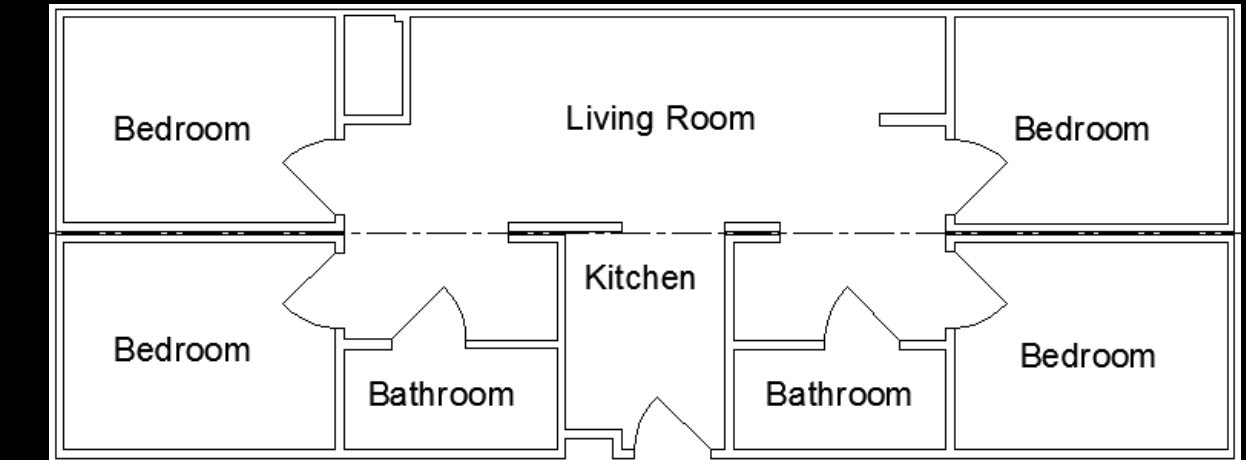
BUILDING D

48 Units per Floor

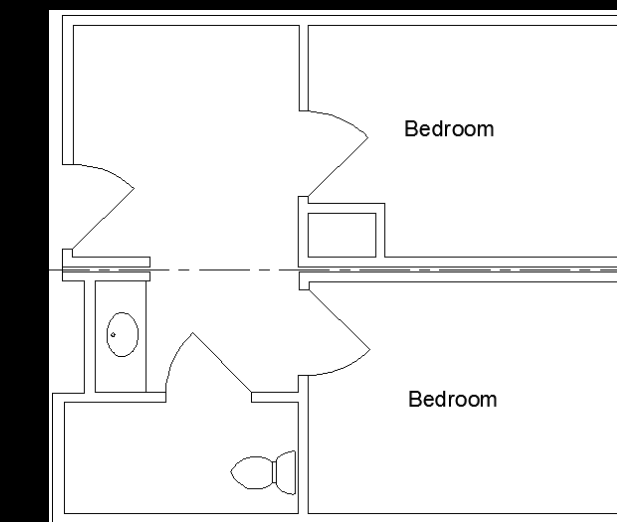
192 Units Total

Building D			
Type	Total	Ppl/Rm	Residents
B	56	2	112
C	122	2	244
D	4	4	16
E	4	4	16
F	9	2	18
G	4	2	8
H	4	3	12
			426

Type E Room



Type C Room



Mansfield University Dormitory Project Modular Preconstruction

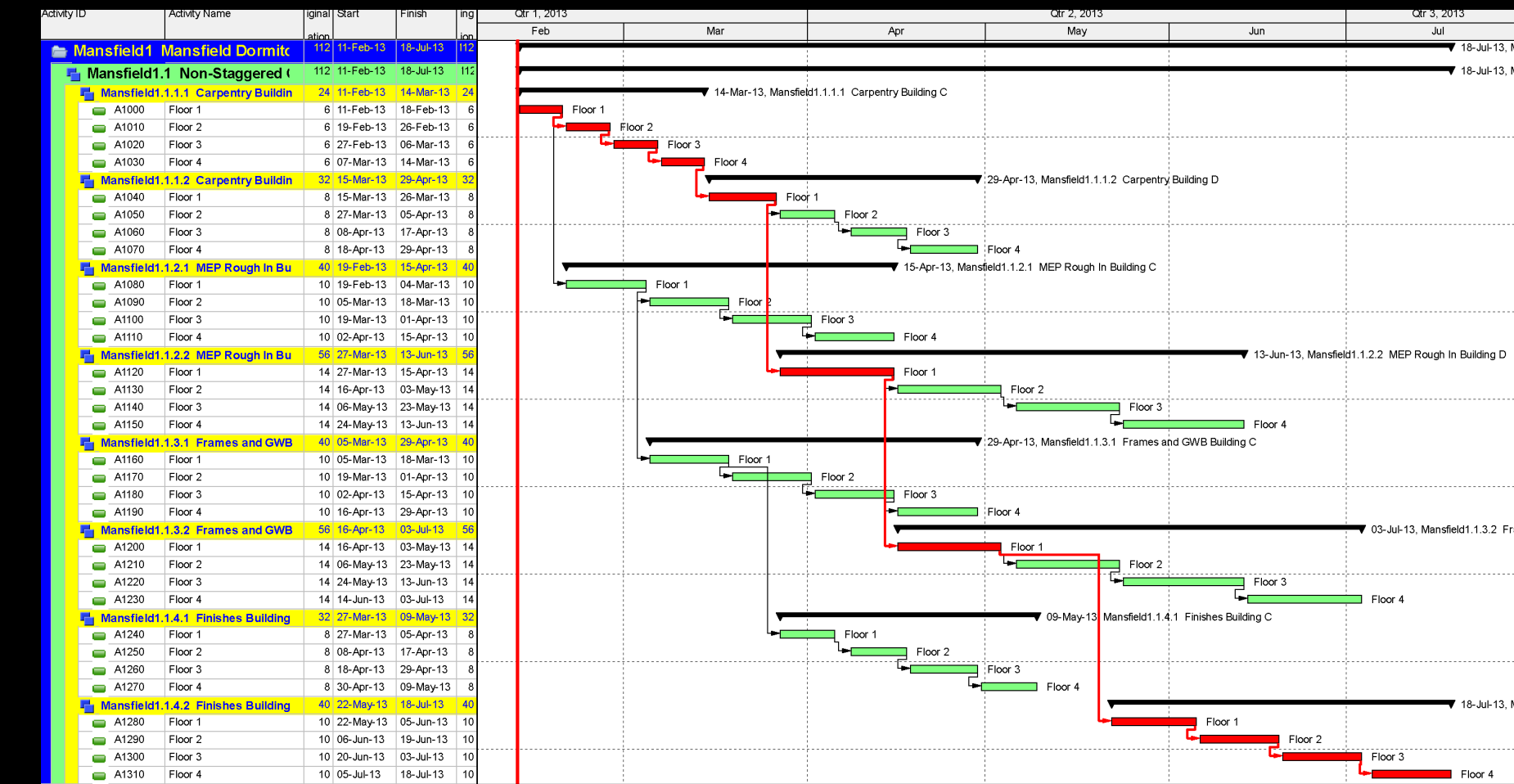
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Stick Built Schedule

- Large Crew Sizes
- Durations Taken from Phase I Dormitory Construction
- Durations Adjusted for Size of Building
- 112 Day Total Duration



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Mansfield University Dormitory Project Modular Preconstruction

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Modular Unit Schedule

- Set 10 Units a Day
- 300 Total Units
- 30 Total Days of Modular Setting

Schedule Comparison

- 112 Days Stick Built vs. 30 Days Modular
- 82 Days Difference
- 16 Weeks Difference



February 12, 2013 1:00 PM

- 5 Units Set

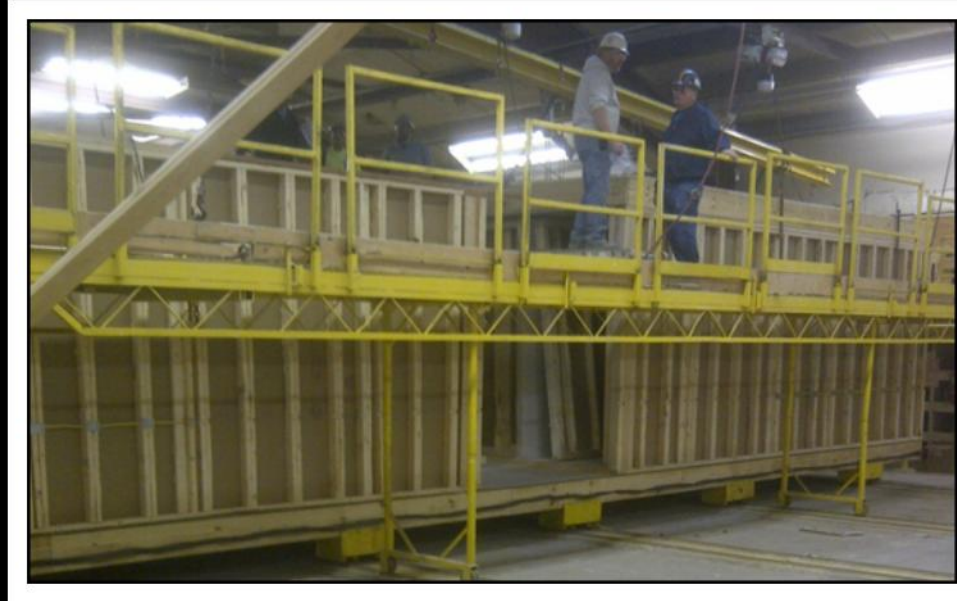
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- 15 Units Set



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Modular Unit Schedule

- Set 10 Units a Day
- 300 Total Units
- 30 Total Days of Modular Setting

Schedule Comparison

- 112 Days Stick Built vs. 30 Days Modular
- 82 Days Difference
- 16 Weeks Difference

General Condition Costs Saved

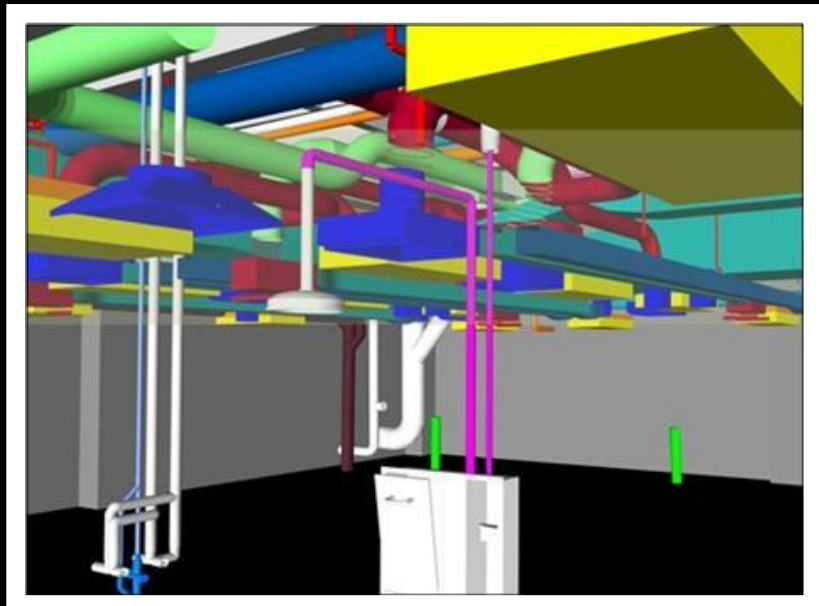
- 16 Weeks Saved
- Costs \$170,000 per a Month
- Total Savings of \$680,000

Preconstruction Costs

- 16 Weeks of Preconstruction

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BIM Uses in Modular Preconstruction

- Design Phase Uses of BIM
 - Design Reviews
 - 3D Coordination
 - Phase Planning
- Advantages of BIM
 - Field Productivity
 - Easier to Interpret
 - Starting Point for Field BIM

Design	
	Design Authoring
X	Design Reviews
X	3D Coordination
	Engineering Analysis
	Sustainability Evaluation
	Code Validation
X	Phase Planning
	Cost Estimation
	Existing Conditions Modeling

Modular Unit Construction and BIM

- Highly Repetitive Work
 - 280 of 300 Rooms are Type B or C
- Trades Are Working for the Same Company
 - Increased Cooperation
- Factory Atmosphere
 - Design Engineers Locally Located

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CONCLUSION

- Preconstruction Took 16 Weeks
- Modular Setting Saved 16 Weeks
- BIM is not Ideal for Modular Construction



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PROBLEM

- Precision of Modular Setting Technique

GOAL

- Find More Precise Way to Sent Units



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Step 1: Delivery of Modular Unit

Step 2: Attach Rigging

Step 3: Crane Lifts Unit into Place

Step 4: Crew Members in Lifts Guide Unit into Final Placement

Step 5: Fasten Units and Detach Rigging



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Mansfield University Dormitory Project
Modular Setting Analysis

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Possible Errors in Setting Process

- Men on Lifts Adjusting Units into Place
- Plumb and Level

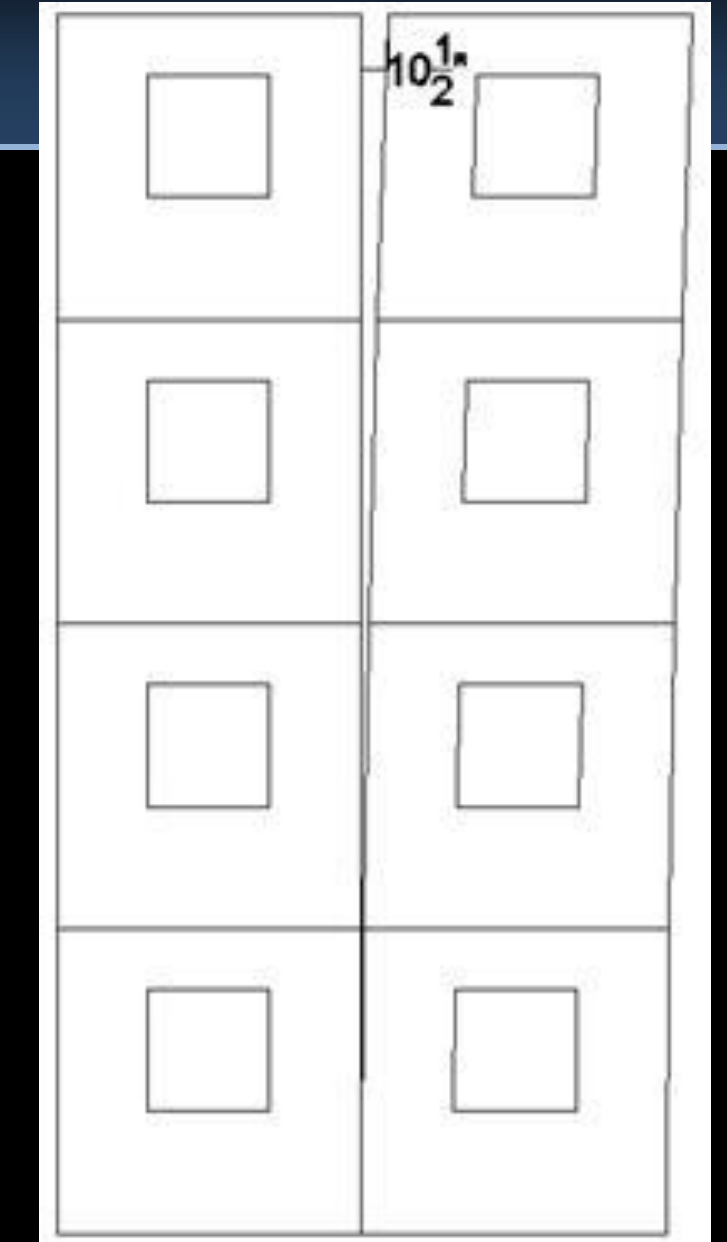
Large Gaps

- Create More Finish Work for Field Subcontractors
 - Slower Schedule
- Create Possible Structural Issues

Example:

0.5 Degrees Off for 4 Floors

Gap at the Top Would be 10.5 Inches



Mansfield University Dormitory Project

Modular Setting Analysis

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Possible Solution

- GPS Machine Control for Dozers
- System Would Check Unit Location with 3D Model



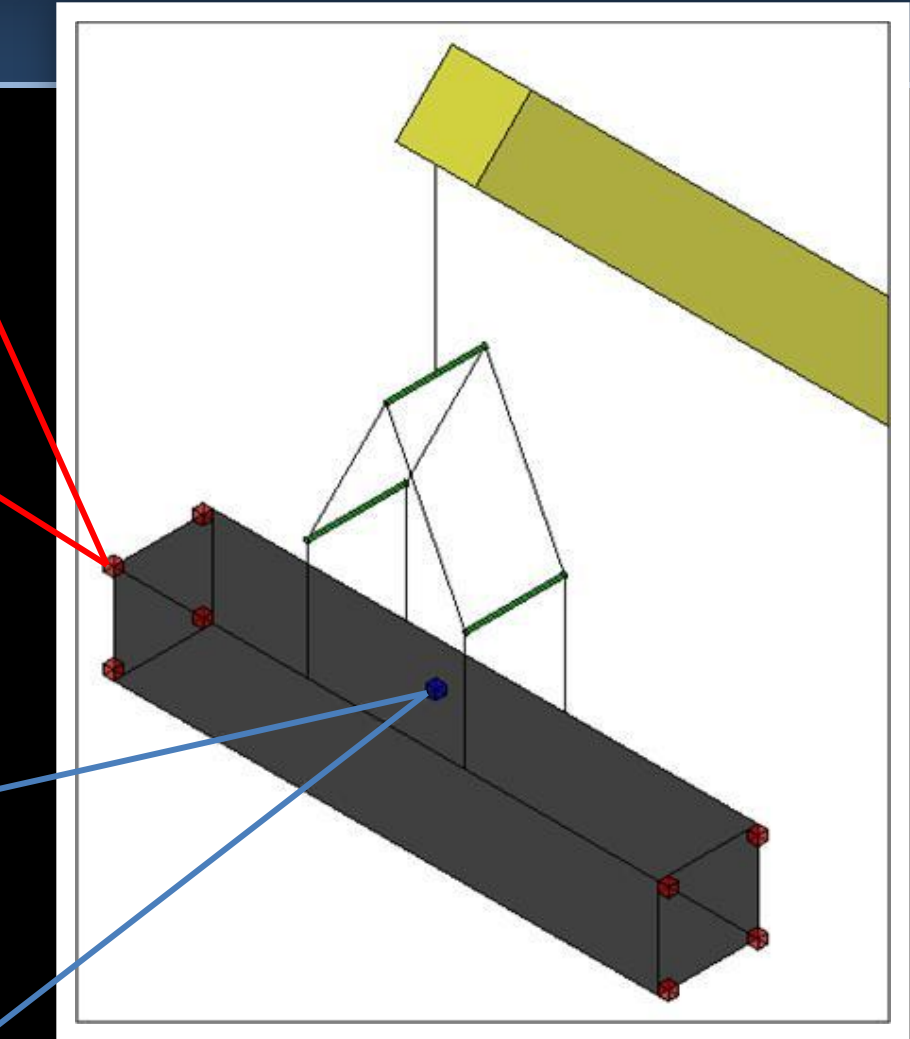
Sensor



Operator Interface



GPS Transmitter



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Modular Subcontractor's Precision Check

- Factory Dimension Check
- Setting Order
- Crew On Lifts Check



10	13	15	16
6	9	12	14
3	5	8	11
1	2	4	7

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CONCLUSION

- GPS Machine Control System is Costly
- Modular Subcontractor's Checks in Factory Saved a lot of Work in the Field
- GPS system is not Recommended



Mansfield University Dormitory Project Flooring System Analysis

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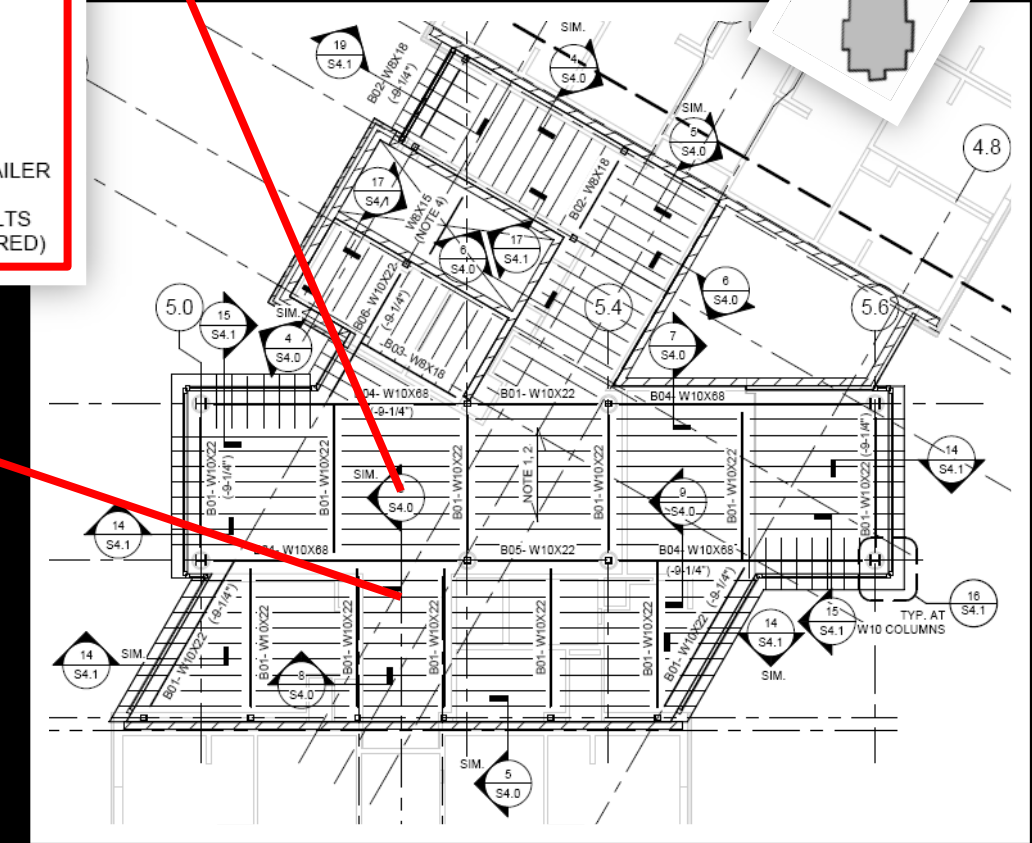
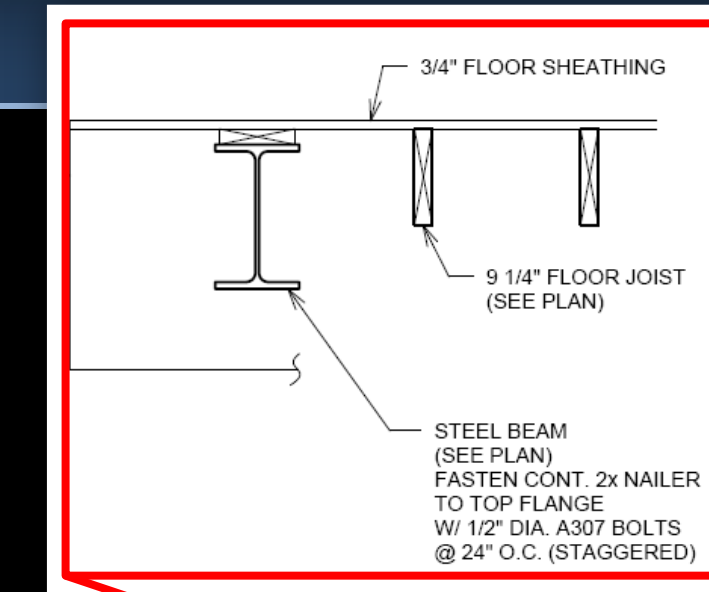


PROBLEM

- Nonconventional Flooring System

GOAL

- Evaluate a More Common System



Mansfield University Dormitory Project Flooring System Analysis

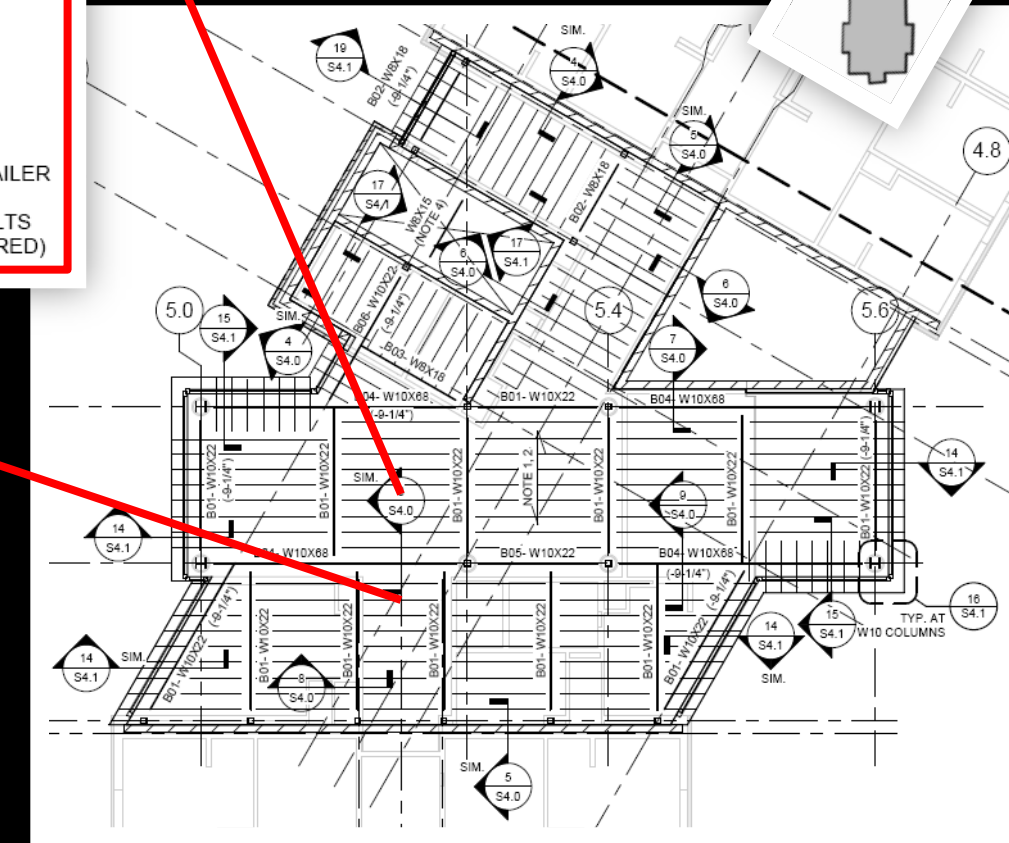
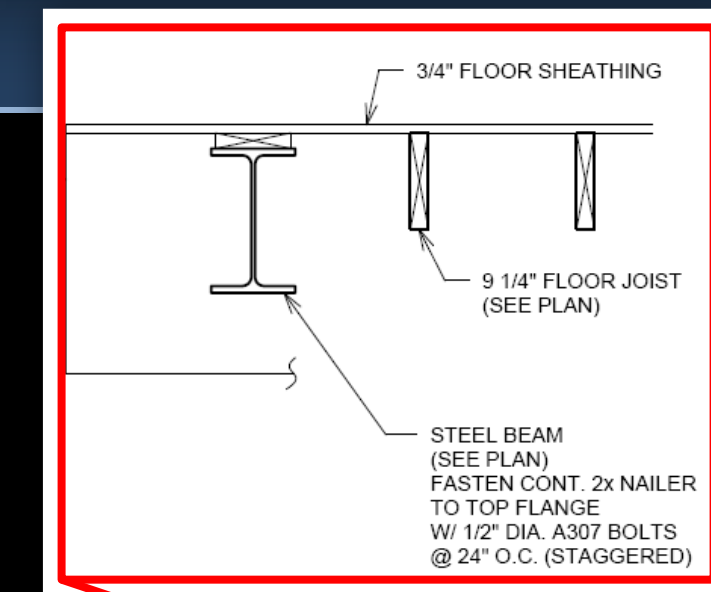
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Current Flooring System

- 2x10 Wood Floor Joists
- Plywood Sheathing
- W10 Structural Steel Beams and Girders
- Steel Tube and W10 Steel Columns
- CMU Walls Around Stairwell and Elevator
- CMI Walls Separating Core from Modular Sections



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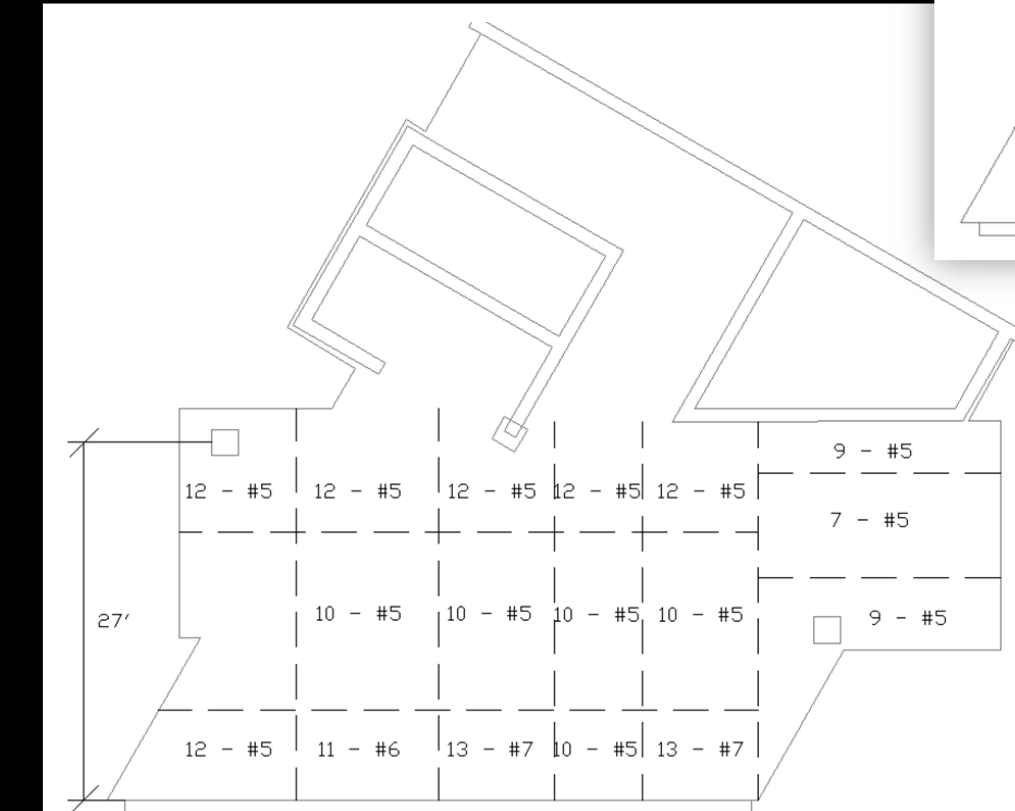
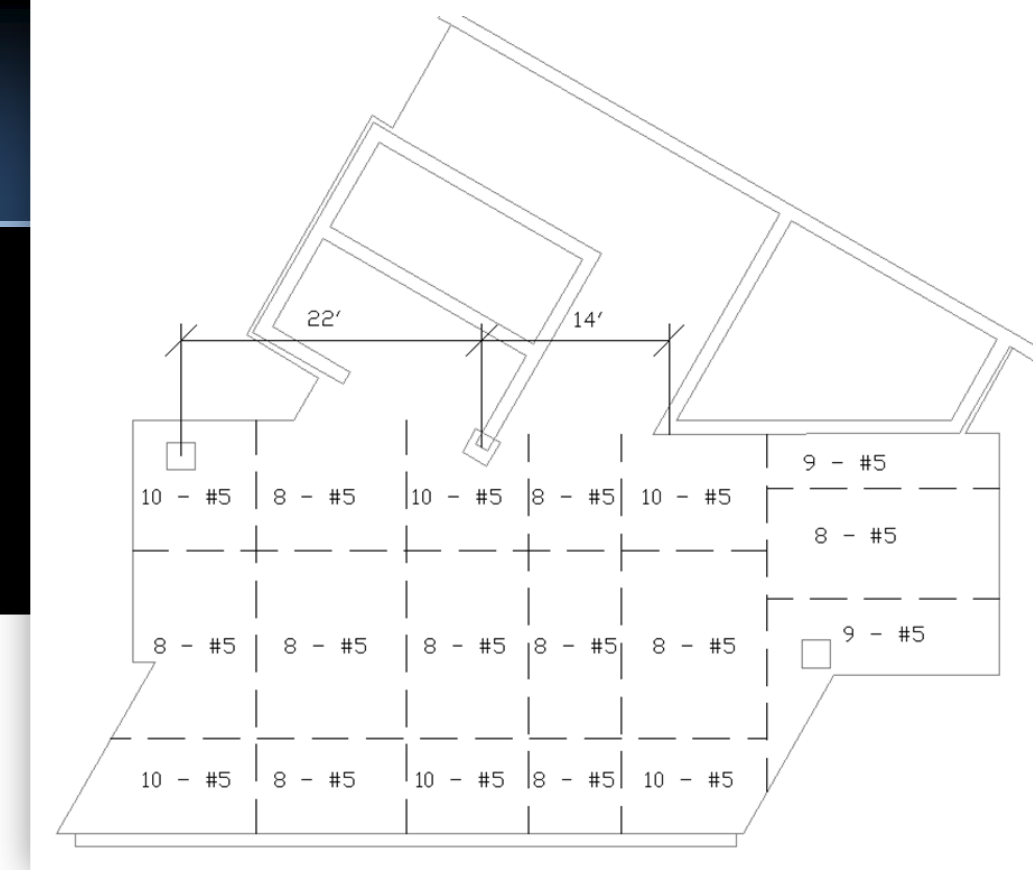
Proposed Flooring System

- 10 Inch Thick Concrete 2 Way Reinforced Slab
- Flat Plate Design
- 12 Inch Concrete Walls
- 2ft x 2ft Concrete Columns

Structural Breadth Analysis

- Meets Maximum Moment Requirement
- 2 Way Slab Reinforcing Design

Horizontal Rebar



Vertical Rebar

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Flooring System Analysis

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Concrete System	Total Cost
Concrete Columns	\$ 28,000.00
Additional Reinforcing	\$ 1,000.00
Concrete Flat Plate	\$ 131,000.00
Concrete Walls	\$ 230,000.00
Additional Reinforcing	\$ 12,000.00
	\$ 402,000.00

Estimated Cost Difference of \$82,000

Steel and Wood System	Total Cost
Steel Columns W10	\$ 25,000.00
Steel Columns HSS	\$ 75,000.00
Fireproofing W10	\$ 7,000.00
Fireproofing HSS	\$ 25,000.00
W10 Beams and Girders	\$ 163,000.00
Wood Floor Joists	\$ 28,000.00
3/4" Plywood Sheathing	\$ 9,000.00
Insulation	\$ 5,000.00
CMU Walls	\$ 147,000.00
	\$ 484,000.00

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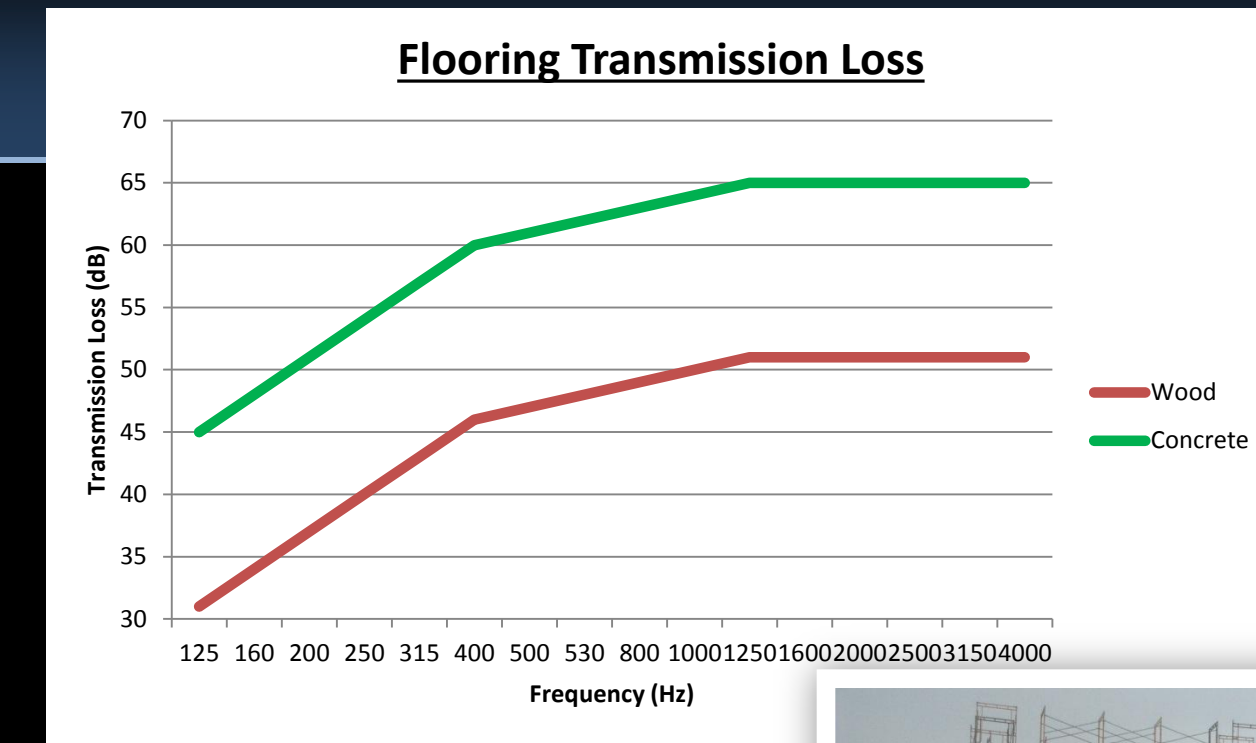
CONCLUSION

Advantages of Concrete System

- Cost
- Better Sound Transmission Class

Disadvantages of Concrete System

- Concrete Subcontractors in North Central Pennsylvania
- Harsh Winters



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Panelized Façade Design

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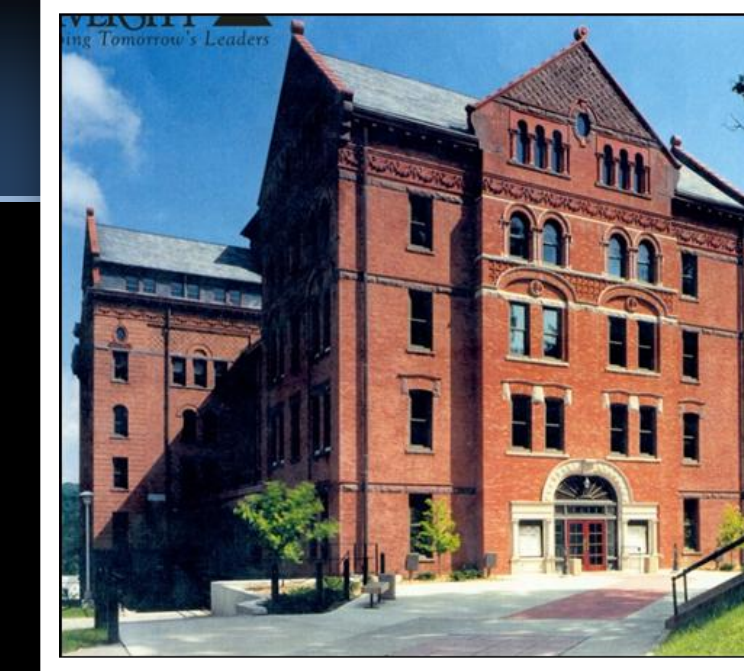


PROBLEM

- Traditional Masonry Construction

GOAL

- Find a Cost Effective Panelized Façade System



North Hall Library



Straughn Hall



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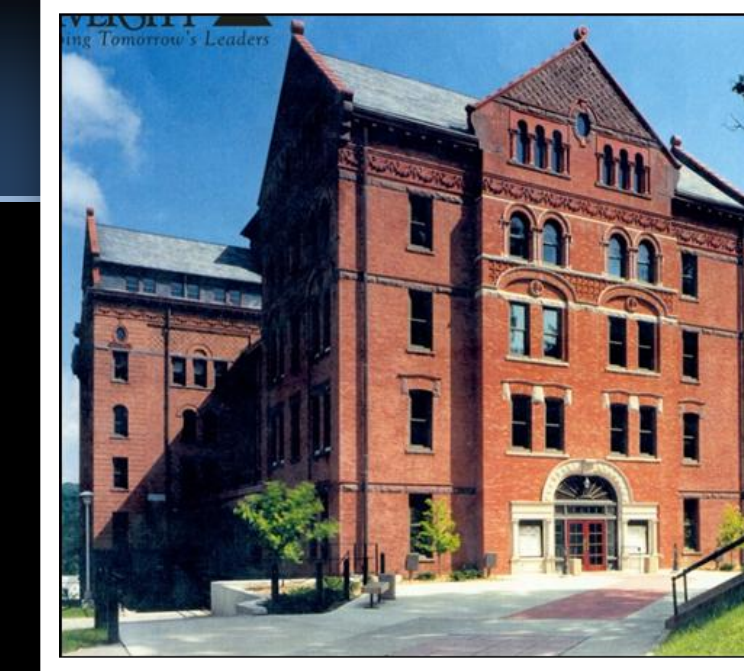


Façade

- Ground and First Floor Cast Stone Masonry
- Floors 2-4 Brick Masonry

Owner's Expectations

- Same Façade as Other Buildings on Campus
- Beginning of Project Value Engineering



North Hall Library



Straughn Hall



Panelized Façade Design

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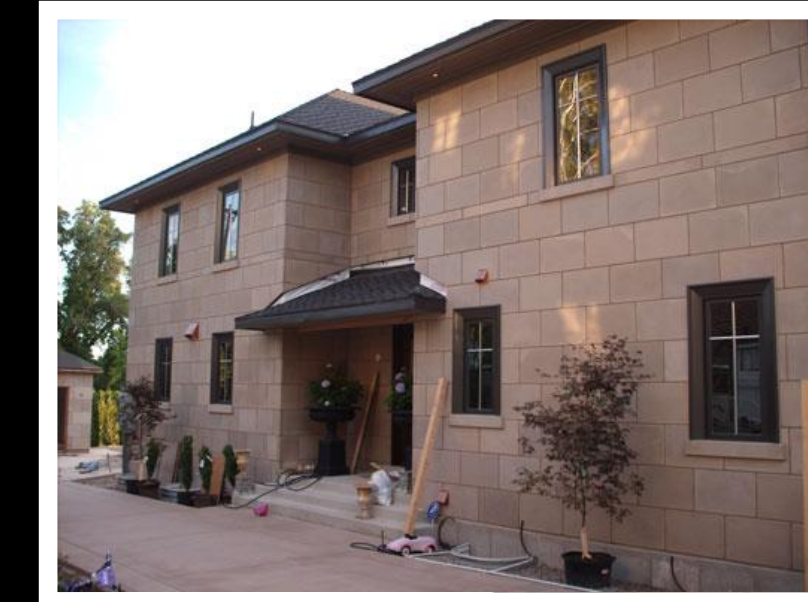
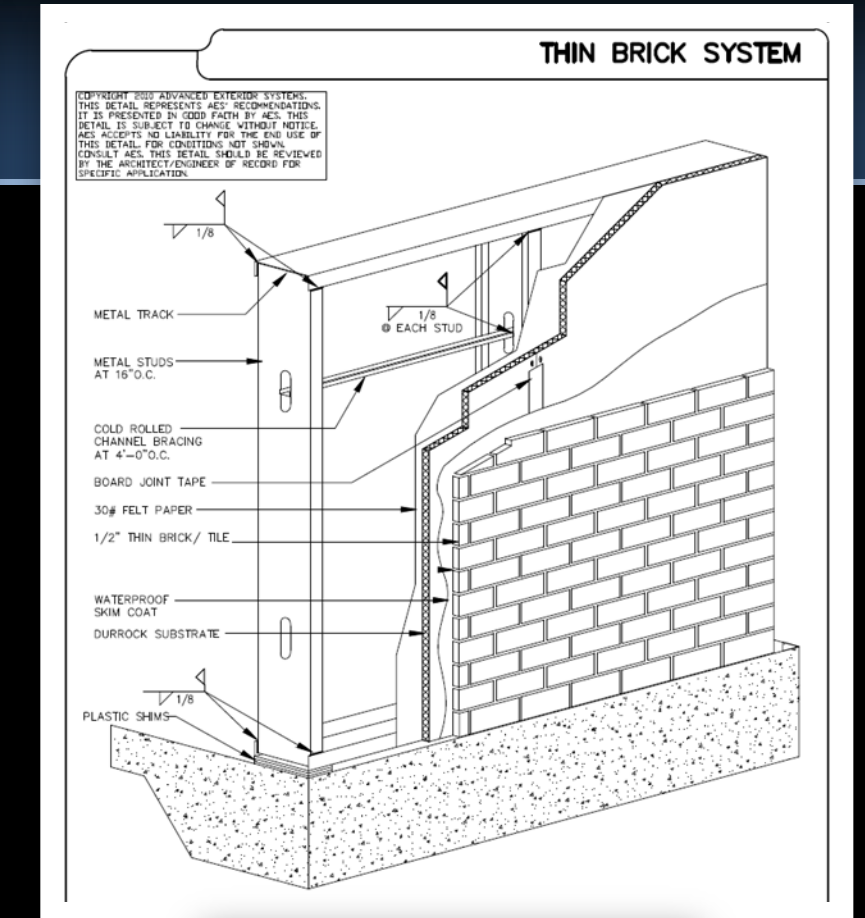
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Potential Panelized Façade Systems

- Thin Brick Panels
 - \$43 per SF
- Precast Concrete Panels
 - \$42 per SF
- Erect About 900 SF per an 8 Hour Day



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Panelized Façade Design

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Brick

\$926,000 Difference

Cast Stone

\$194,000 Difference

Total

\$1.1 Million Difference

Masonry Façade Cost Estimate

	Brick			Stone		
	SF	Cost/SF	Cost	SF	Cost/SF	Cost
Building C	13,098.00	\$ 17.96	\$ 235,240.08	16,510.00	\$ 35.75	\$ 590,232.50
Building D	23,625.00	\$ 17.96	\$ 424,305.00	13,650.00	\$ 35.75	\$ 487,987.50
			\$ 659,545.08			\$ 1,078,220.00

Panelized Façade Cost Estimate

	Thin Brick			Precast Concrete		
	SF	Cost/SF	Cost	SF	Cost/SF	Cost
Building C	13,098.00	\$ 43.18	\$ 565,571.64	16,510.00	\$ 42.18	\$ 696,391.80
Building D	23,625.00	\$ 43.18	\$ 1,020,127.50	13,650.00	\$ 42.18	\$ 575,757.00
			\$ 1,585,699.14			\$ 1,272,148.80

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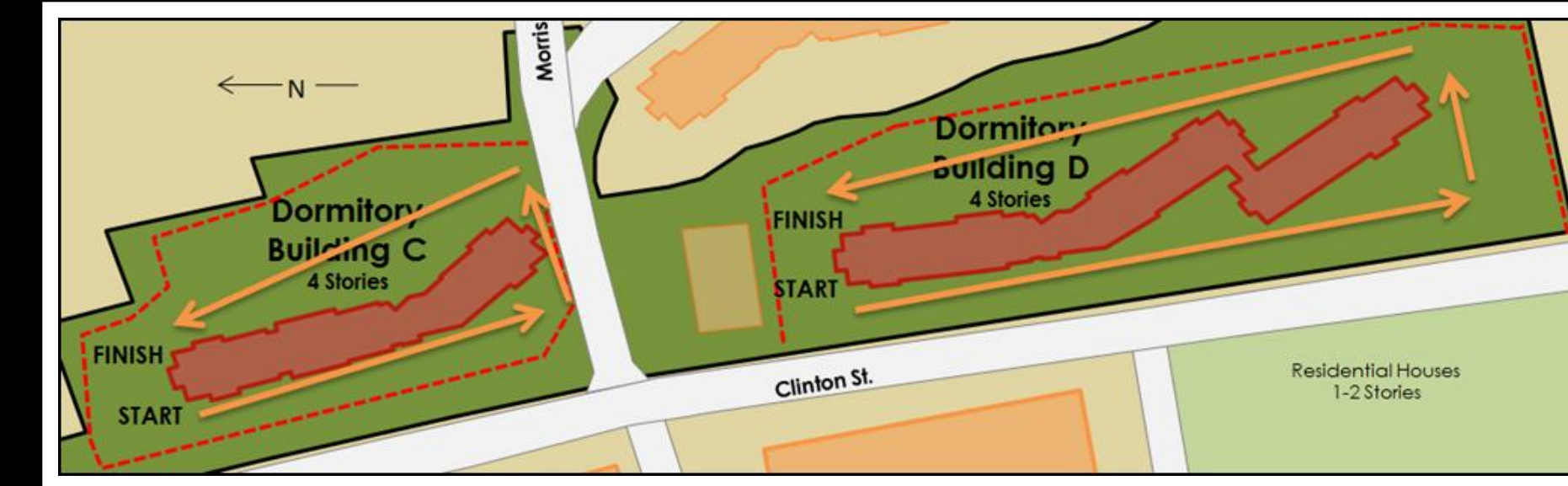


Building C
Masonry: 81 Days
Panelized: 21 Days

Building D
Masonry: 110 Days
Panelized: 31 Days

Masonry: 2 Crews 110 Days to Complete
Panelized: 1 Crew 52 Days to Complete
Difference of 58 Days or Over 11 Weeks

Panelized Façade Installation Sequence



Panelized Façade Design

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CONCLUSION

Positives

- 11 Week Schedule Reduction
- General Condition Cost Savings

Disadvantages

- \$1.1 Million Cost Difference
 - Owner's Expectations Caused Large Difference
 - Panelized EFIS Similar Cost to Masonry Brick



Acknowledgements

Industry Acknowledgements

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Project Team Members

Wohlsen Construction
Mansfield Auxiliary Corporation
WTW Architects
Simplex Industries

AE Faculty

Special Thanks for Support
Advanced Exterior Systems

Friends and Family



Mansfield University Dormitories

Mansfield, Pennsylvania

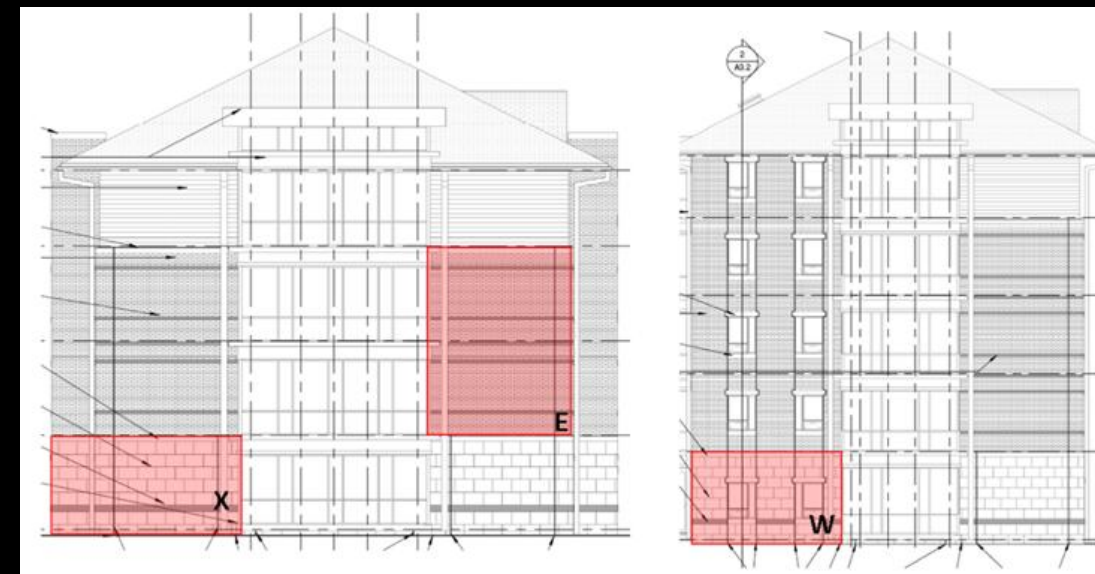


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Appendix

Building C								
Type	Gr	1	2	3	4	Total	Ppl/Rm	Residents
B	0	12	12	12	12	48	2	96
C	0	16	16	16	16	64	2	128
D	0	0	0	0	0	0	4	0
E	0	1	1	1	1	4	4	16
F	0	0	0	0	0	0	2	0
G	0	1	1	1	1	4	2	8
H	1	0	0	0	0	1	2	2
I	2	0	0	0	0	2	3	6
								256

Building D								
Type	Gr	1	2	3	4	Total	Ppl/Rm	Residents
B	0	14	14	14	14	56	2	112
C	6	29	29	29	29	122	2	244
D	0	1	1	1	1	4	4	16
E	0	1	1	1	1	4	4	16
F	1	2	2	2	2	9	2	18
G	0	1	1	1	1	4	2	8
H	0	1	1	1	1	4	3	12
								426



Panel Type	Size (SF)	Total Number	Total Area (SF)
<i>Thin Brick</i>			
A	165	111	18,315
B	148	16	2,368
C	250	40	10,000
D	162	20	3,240
E	280	10	2,800
<i>Precast</i>			
Z	380	24	9,120
Y	270	36	9,720
X	170	16	2,720
W	215	40	8,600

Appendix

	Wood	Concrete
125	31	45
160	34	48
200	37	51
250	40	54
315	43	57
400	46	60
500	47	61
530	48	62
800	49	63
1000	50	64
1250	51	65
1600	51	65
2000	51	65
2500	51	65
3150	51	65
4000	51	65

Concrete Columns				
Cost Data	Amount	Cost	Number	Total Cost
\$ 180.00 vert LF	52 vert LF	\$ 9,360.00 /column	3 columns	\$ 28,080.00
Additional Reinforcing				
\$ 5.20 SF	52 SF	\$ 270.40 /column	3 columns	\$ 811.20
Concrete Flat Plate				
\$ 16.05 SF	8160 SF	\$130,968.00		\$130,968.00
Concrete Walls				
\$ 24.15 SF	9532 SF	\$230,197.80		\$230,197.80
Additional Reinforcing				
\$ 1.25 SF	9534 SF	\$ 11,917.50		\$ 11,917.50
			Total	\$401,974.50

Steel Columns					
Type	Cost Data	Amount	Cost	Number	Total Cost
W10	\$ 120.00 vert LF	52 vert LF	\$ 6,240.00 /column	4 columns	\$ 24,960.00
HSS	\$ 97.00 vert LF	52 vert LF	\$ 5,044.00 /column	15 columns	\$ 75,660.00
Steel Column Fireproofing					
W10	\$ 33.61 vert LF	52 vert LF	\$ 1,747.72 /column	4 columns	\$ 6,990.88
HSS	\$ 31.83 vert LF	52 vert LF	\$ 1,655.16 /column	15 columns	\$ 24,827.40
Structural Steel Floor					
	\$ 19.95 SF	8160 SF	\$162,792.00		\$162,792.00
2x10 Wood Joists					
	\$ 3.47 SF	8160 SF	\$ 28,315.20		\$ 28,315.20
3/4 Plywood Underlayment					
	\$ 1.13 SF	8160 SF	\$ 9,220.80		\$ 9,220.80
6" Batt Insulation					
	\$ 0.59 SF	8160 SF	\$ 4,814.40		\$ 4,814.40
CMU walls					
	\$ 15.40 SF	9531 SF	\$146,777.40		\$146,777.40
				Total	\$484,358.08