School of Engineering And Applied Sciences Building

Jonathan Kirk
Structural Option

Miami University
Oxford, OH

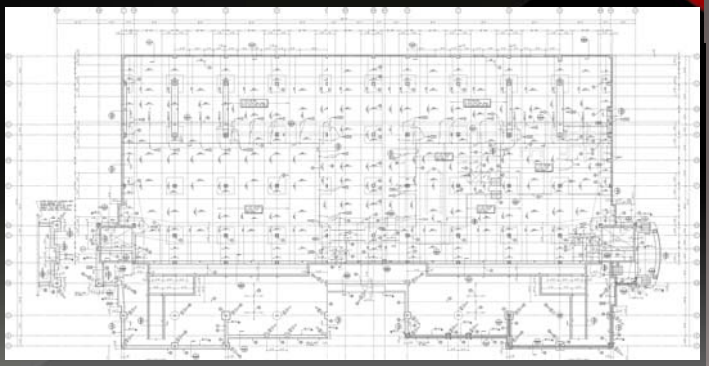
Building Background

- Connected to existing Benton Hall via skywalk
- Size: 103,154 SF above grade on 4 levels
  82,661 SF below grade parking on 3 levels
- Cost: $23,651,159
- Constructed: Oct. 2004 – Jan. 2007
- Delivery Method: Design-Bid-Build
- General Contractor: Monarch Construction
- Architect: Burt Hill Kosar Rittleman Associates
- Structural Engineer: THP Limited

Presentation Outline

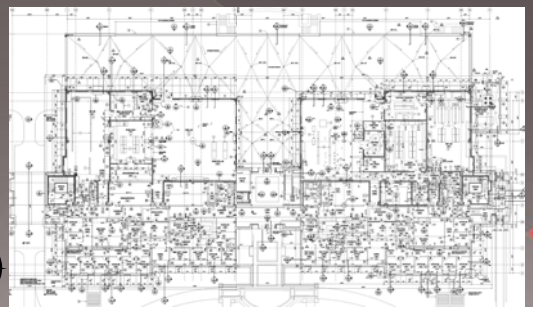
- Introduction
  - *Building Background*
  - Project Goals
- Structural Depth
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Ground Floor Framing Plan



Existing Conditions

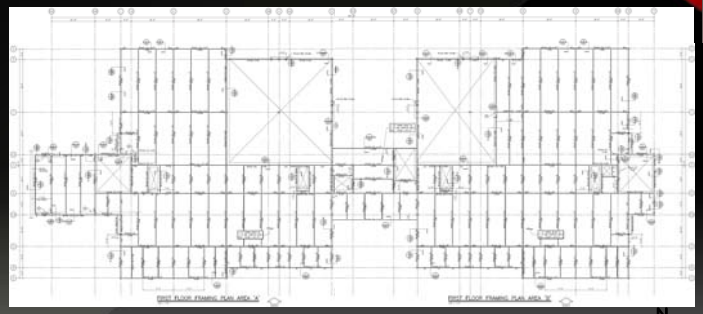
- Substructure
  - Ground Floor and Garage
    - 2-way C.I.P. slab with drop panels



Presentation Outline

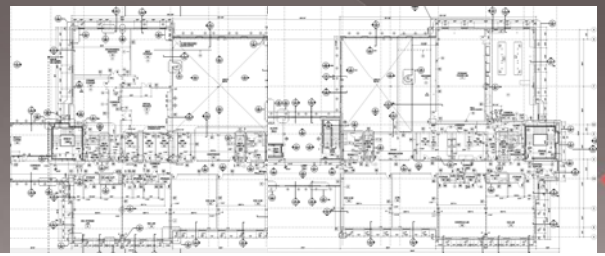
- Introduction
- Structural Depth
  - *Existing Conditions*
  - Proposed Redesign
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

First Floor Framing Plan



Existing Conditions

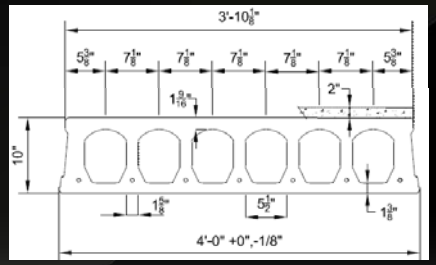
- Superstructure
  - 1st, 2nd, Mechanical, and Roof Levels
    - 3½" Composite slab on 3" composite deck on steel frame structure



Presentation Outline

- Introduction
- Structural Depth
  - *Existing Conditions*
  - Proposed Redesign
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Hollowcore Floor Planks



10" Hollowcore Plank with 2" Concrete Topping

ECHO by Nitterhouse Concrete Products, Inc.

PHYSICAL PROPERTIES
Composite Section

A_c = 327 in.^{2}	Precast S_{bc} = 824 in.^{3}
I_c = 5102 in.^{4}	Topping S_{tc} = 1242 in.^{3}
Y_{bc} = 6.19 in.	Precast S_{tc} = 1340 in.^{3}
Y_{tc} = 3.81 in.	Wt_c = 272 PLF
	Wt_c = 68.00 PSF

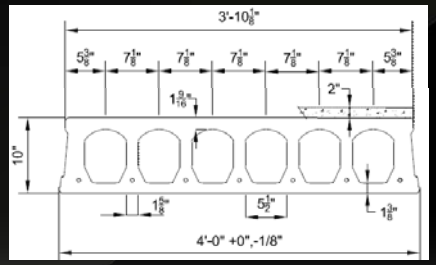
Proposed Redesign

- Goals and Design Constraints
  - Accelerated construction schedule
  - Decrease or maintain cost
  - Do not change architecture
  - Maintain floor-to-ceiling and total heights
- Method
  - Prefabricated structure
    - Precast concrete hollowcore floor planks
    - Supported on similar steel frame

Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Hollowcore Floor Planks



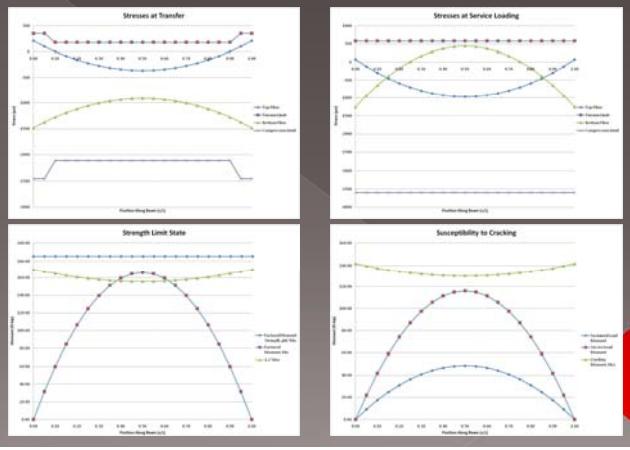
10" Hollowcore Plank with 2" Concrete Topping

ECHO by Nitterhouse Concrete Products, Inc.

PHYSICAL PROPERTIES
Composite Section

A_c = 327 in.^{2}	Precast S_{bc} = 824 in.^{3}
I_c = 5102 in.^{4}	Topping S_{tc} = 1242 in.^{3}
Y_{bc} = 6.19 in.	Precast S_{tc} = 1340 in.^{3}
Y_{tc} = 3.81 in.	Wt.= 272 PLF
	Wt.= 68.00 PSF

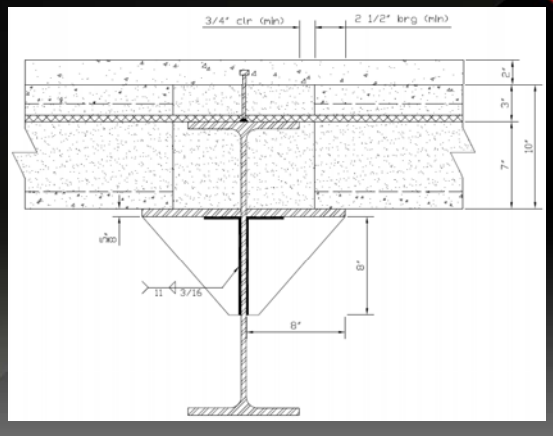
Hollowcore Floor Planks



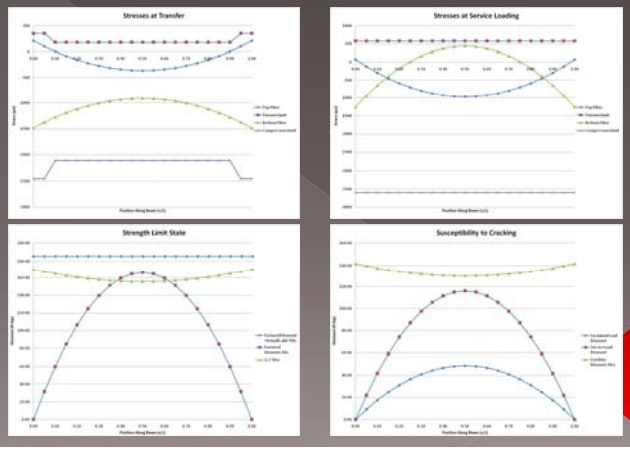
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Support System



Hollowcore Floor Planks



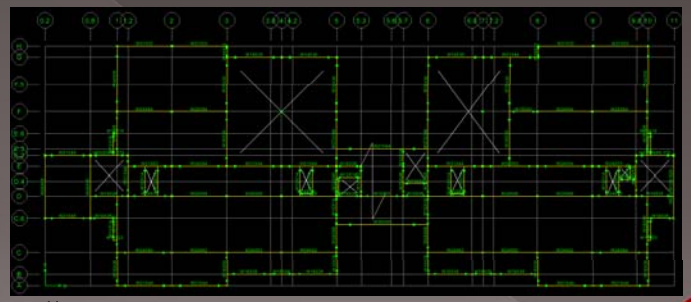
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Seismic Loads

Seismic Design Summary			
Design Parameter	Symbol	Value	ASCE 7-05 Reference
Occupancy category		III	Table 1.1
Site classification		C	Table 20.3-1
Seismic Design Category	SDC	B	Tables 11.6-1 & 2
Seismic importance factor	I	1.25	Table 11.5-1
Short period spectral response	S_s	0.171g	Section 11.4.1
Acceleration-based Site coefficient	F_a	1.2	Table 11.4-1
Maximum short period spectral response	S_{MS}	0.137	Equation 11.4-3
Spectral Response at 1 sec	S_1	0.073g	Section 11.4.1
Velocity-based site coefficient	F_v	1.7	Table 11.4-2
Maximum spectral response at 1 sec	S_{M1}	0.083g	Equation 11.4-4
Response modification factor	R	3.0	Table 12.2-1
Deflection amplification factor	C_d	3.0	Table 12.2-1
N-S building period	T	1.161 s	Calculated on ETABS
N-S Maximum building period	T_{max}	0.708 s	Section 12.8.2
E-W building period	T	1.855 s	Calculated on ETABS
E-W Maximum building period	T_{max}	1.214 s	Section 12.8.2
Long-period transition period	T_L	12 s	Figure 22-15
N-S Seismic design coefficient	C_S	0.0487	Section 12.8.1.1
E-W Seismic design coefficient	C_S	0.0284	Section 12.8.1.1
Height above ground level	h_n	57.33 ft	
Ground level base shear N-S loading	V	484.8 k	
Overturning moment N-S loading	M	19,728 ft-k	
Ground level base shear E-W loading	V	282.8 k	
Overturning moment E-W loading	M	12,068 ft-k	

Steel Framing



First Floor Framing Plan

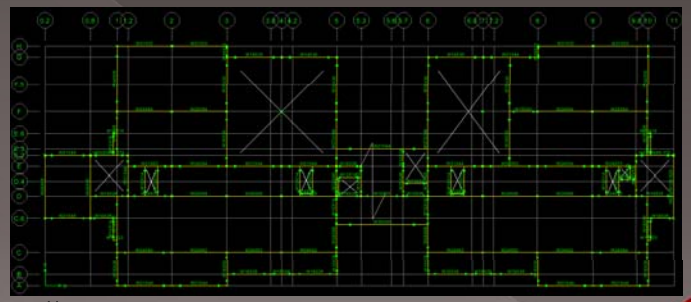
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Wind Loads

Wind Design Summary			
Design Parameter	Symbol	Value	ASCE 7-05 Reference
Occupancy category		III	Table 1.1
Wind design method		Method 2	
Wind importance factor	I	1.15	Table 6-1
Exposure category		B	Section 6.5.6.3
Enclosure classification		Enclosed	
Wind directionallity factor	k_d	0.85	Section 6.5.4.4 & Table 6-4
Topographical factor	k_z	1.00	Table 6.5.7.2
Basic wind speed	V	90 mph	Figure 6-1
Approximate building period	T_a	0.438 s	Equation 12.8-7
Gust effect factor	G	0.85	Section 6.5.8
North-South length		356.25 ft	
East-West length lower 2 levels		134.0 ft	
East-West length top 2 levels		86.0 ft	
Height above grade	h_n	61.33 ft	
Ground level base shear N-S Wind	V	348 k	
Overturning moment N-S Wind	M	13,516 ft-k	
Ground level base shear E-W Wind	V	71 k	
Overturning moment E-W Wind	M	1175 ft-k	

Steel Framing



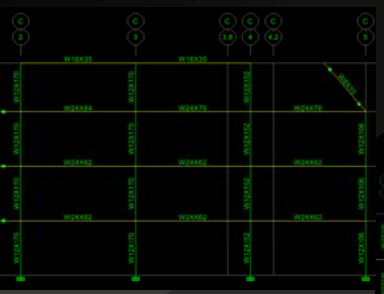
N

First Floor Framing Plan

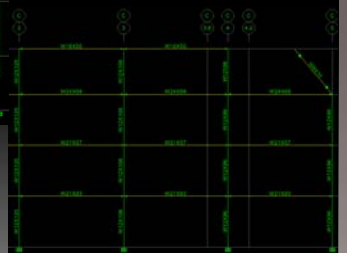
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Lateral Resisting System

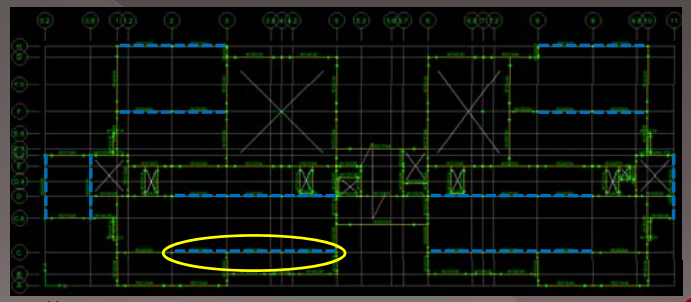


Resized Frame C



Original Frame C

Steel Framing



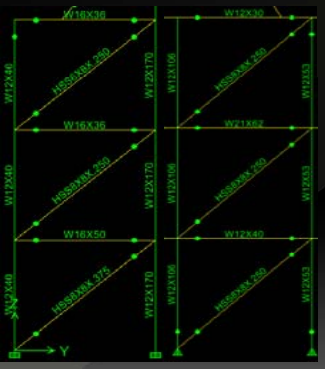
First Floor Framing Plan

Moment Frame

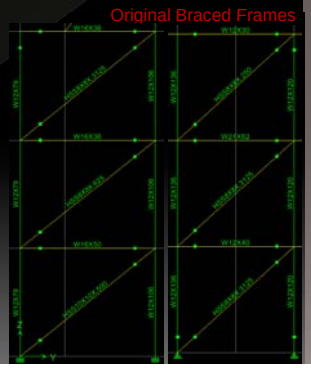
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Lateral Resisting System

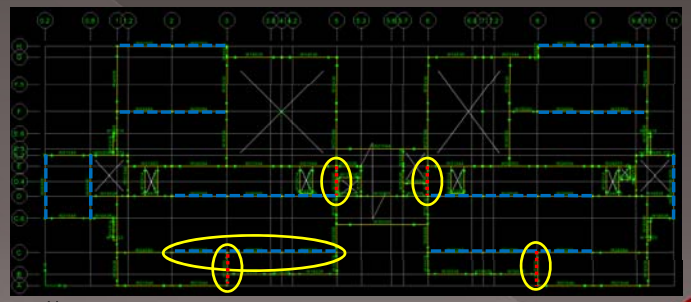


Resized Braced Frames



Original Braced Frames

Steel Framing



First Floor Framing Plan

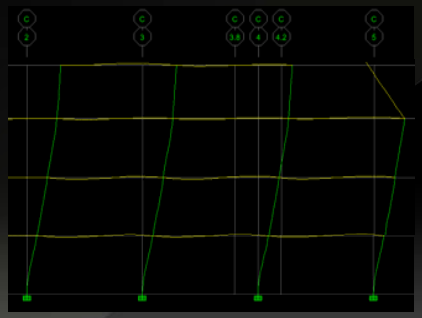
Moment Frame

Braced Frame

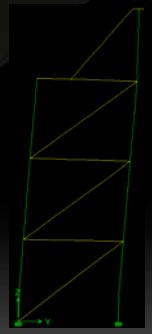
Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Lateral Displacement



Moment Frame C Deflection Under Seismic Loading



Braced Frame 3 Deflection Under Seismic Loading

Story Drifts

Seismic Story Drift

Story	Height (ft)	Deflection Amplification Factor, C_d	ETABS Displ. in E-W direction (in)	Amplified Story Drift in E-W direction (in)	ETABS Displ. in N-S direction (in)	Amplified Story Drift in N-S direction (in)	Allowable Drift = $0.01Sh_{sx}$ (in)
Roof	57.33	3.0	1.212	0.017	1.007	0.031	2.40
Mech.	44.00	3.0	1.205	0.835	0.994	0.737	2.64
2nd	29.33	3.0	0.857	0.998	0.687	0.929	2.64
1st	14.67	3.0	0.441	1.058	0.300	0.720	2.64

Wind Story Drift

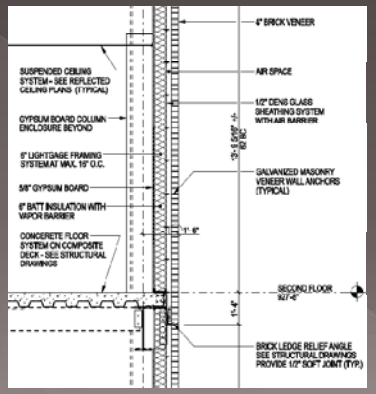
Story	Height (ft)	ETABS Displ. in E-W direction (in)	Story Drift in E-W direction (in)	ETABS Displ. in N-S direction (in)	Story Drift in N-S direction (in)	Allowable Drift = H/400 (in)
Roof	57.33	0.235	0.000	0.717	0.013	0.40
Mech.	44.00	0.235	0.052	0.704	0.217	0.44
2nd	29.33	0.183	0.078	0.487	0.263	0.44
1st	14.67	0.105	0.105	0.224	0.224	0.44

Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Existing Walls

Existing Walls



Typical Wall Section

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
  - *Existing Conditions*
  - Proposed Redesign
- Construction Management Breadth
- Conclusions

Proposed Redesign

- Goals
  - Accelerated construction schedule
  - Decrease or maintain cost
  - Minimize architectural effects
  - Retain thermal properties
- Method
  - Prefabricated wall panels
    - Precast concrete insulated sandwich panels

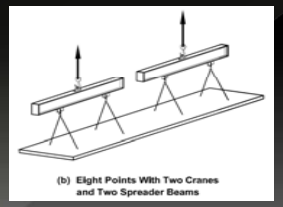
Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
  - Existing Conditions
  - *Proposed Redesign*
- Construction Management Breadth
- Conclusions

Proposed Wall Panels



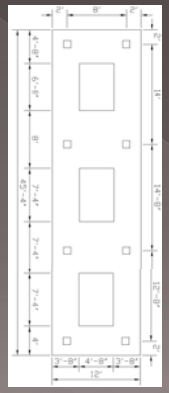
Thin Brick provides look of traditional brick veneer



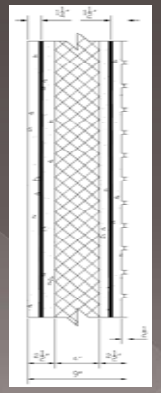
Panel Stripping Configuration

Panel Erection

Typical Sandwich Wall Panel



Typical 12' Wall Panel



Panel Cross Section

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
  - Existing Conditions
  - *Proposed Redesign*
- Construction Management Breadth
- Conclusions

Thermal Resistance

Existing Walls Insulated Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 4" Face Brick	9.1	4.0	2.28	0.44	0.44
C 1.5" Air Gap, c_{gap} = 0.82				0.90	0.90
D 1/2" Dens-Glass Sheathing				1.32	1.32
E 6" Batt Insulation, R19				19.00	19.00
F 5/8" Gyp. Wall Board			1.78	0.56	0.56
G Inside Surface				0.68	0.68
Total				23.15	23.07

Existing Walls Steel Stud Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 4" Face Brick	9.1	4.0	2.28	0.44	0.44
C 1.5" Air Gap, c_{gap} = 0.82				0.90	0.90
D 1/2" Dens-Glass Sheathing				1.32	1.32
E 6" Air Gap, c_{gap} = 0.15				2.11	2.11
F 5/8" Gyp. Wall Board			1.78	0.56	0.56
G Inside Surface				0.68	0.68
Total				6.26	6.18

Existing Walls Window Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 1" Insulated Window			0.35	2.86	2.86
C Inside Surface				0.68	0.68
Total				3.79	3.71

Typical Panel	Area (SF)	$\%A_p$
Gross Area	544.00	
Window Area	99.55	18.30%
Steel Stud Area	20.83	3.83%
Insulated Area	423.62	77.87%

Total R-Value	
Winter	11.35 ft^2-°F-hr/Btu
Summer	11.20 ft^2-°F-hr/Btu

Existing Wall R-Values

Sandwich Walls Panels Insulated Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 1/2" Thin Brick	9.1	0.5	18.20	0.05	0.05
C 2" XPIC	11.1	2.0	5.55	0.18	0.18
D 4" Expanded Polystyrene	0.2	4.0	0.05	20.00	20.00
E 2.5" NWC	11.1	2.5	4.44	0.23	0.23
F Inside Surface				0.68	0.68
Total				21.39	21.31

Sandwich Walls Panels Uninsulated Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 1/2" Thin Brick	9.1	0.5	18.20	0.05	0.05
C 8.5" NWC	11.1	8.5	1.31	0.77	0.77
D Inside Surface				0.68	0.68
Total				1.75	1.67

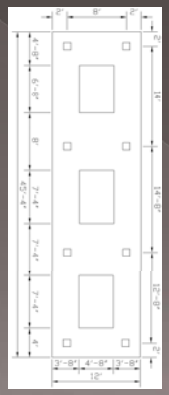
Sandwich Walls Panels Window Path	k	Thickness	U = k/t	R = 1/U Winter	R = 1/U Summer
A Outside Surface				0.25	0.17
B 1" Insulated Window			0.35	2.86	2.86
C Inside Surface				0.68	0.68
Total				3.79	3.71

Typical Panel	Area (SF)	$\%A_p$
Gross Area	544.00	
Window Area	99.55	18.30%
Uninsulated Area	8.00	1.47%
Insulated Area	436.45	80.23%

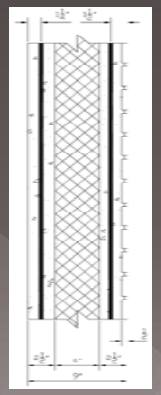
Total R-Value		
Winter	10.61 ft^2-°F-hr/Btu	6.53% less
Summer	10.44 ft^2-°F-hr/Btu	6.79% less

Proposed Wall R-Values

Typical Sandwich Wall Panel



Typical 12' Wall Panel



Panel Cross Section

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
  - Existing Conditions
  - *Proposed Redesign*
- Construction Management Breadth
- Conclusions

Existing Structure Cost

	Equivalent Square Foot Cost					
Old Structure - Composite Floor	Cost/SF	Floor Area (SF)				Total
		1st Floor	2nd Floor	Mech. Floor	Roof	88,298 SF
Concrete, 4000 psi, slab <6", pumped	1.54	25943	20278	19281	0	$100,682
18g. Composite Deck, 3" deep	2.36	25943	20278	19281	0	$154,319
20g. Wide Rib Roof Deck, 1.5" deep	2.08	0	11520	0	11276	$47,416
WWF 6x6 W2.9xW2.9	0.38	25943	20278	19281	0	$24,614
Finish Floor, Monolithic Screed	0.30	25943	20278	19281	0	$19,582
Steel Beams	8.92	25943	31798	19281	11276	$787,200
Steel Columns	4.20	25943	31798	19281	11276	$371,150
Shear Studs, 3/4" diam., 4-7/8" long	0.15	25943	20278	19281		$10,200
Total	$17.16	$445,173	$347,964	$330,855	$0	$1,515,163

Proposed Structure Cost

	Equivalent Square Foot Cost					
New Structure - Hollowcore Plank	Cost/SF	Floor Area (SF)				Total
		1st Floor	2nd Floor	Mech. Floor	Roof	88,298 SF
10" Hollowcore	7.67	25943	31798	19281	11276	$677,266
2" Concrete Topping, 3000 psi, slab <6", pumped	0.59	25943	20278	19281	0	$38,400
WWF 6x6 W1.4xW1.4	0.28	25943	20278	19281	0	$18,459
Finish Floor, Monolithic Screed	0.30	25943	20278	19281	0	$19,582
Steel Beams	4.19	25943	31798	19281	11276	$369,707
Steel Columns	4.76	25943	31798	19281	11276	$420,502
Shear Studs, 3/4" diam., 4-3/16" long	0.02	25943	31798	19281	11276	$1,782
5/8" Supporting A36 Steel Plate	1.58	25943	31798	19281	11276	$139,228
1/4" A36 Bracket Plates	0.20	25943	31798	19281	11276	$17,631
3/16" Fillet Welds	0.35	25943	31798	19281	11276	$31,356
Total	$19.64	$509,415	$624,383	$378,600	$221,413	$1,733,813

Additional Cost = $218,650 = 14.4% Increase

If hollowcore is supported by top flange of girder, eliminates approximately $1.83/SF, for a new total cost of $1,572,228, only a $57,065 increase (3.8%)

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
- Construction Management Breadth
  - *Cost Comparison*
  - Schedule Comparison
- Conclusions

Existing Walls Cost

Old Walls - Stud Backup	Cost/SF	Wall Area (SF)				
		1 Story	2 Story	3 Story	Total	
Scaffolding - Complete System rent/mo	0.35	4184	7107	19012	30303	$10,455
Scaffolding - labor erect/dismantle	1.14	4184	7107	19012	30303	$34,546
16g. 6" Stl. Stud Wall, 16" O.C., 16' high	2.26	4184	7107	19012	30303	$68,527
Standard 4" Face Brick Veneer, running bond	8.13	4184	7107	19012	30303	$246,234
6" Fiberglass Batt. Insulation, 15" wide	0.82	4184	7107	19012	30303	$24,922
Wall Ties	0.14	4184	7107	19012	30303	$4,274
Shelf Angles	1.63	4184	7107	19012	30303	$49,364
Acid Brick Wash, Smooth Brick	0.52	4184	7107	19012	30303	$15,746
Joint Backer Rod	0.09	4184	7107	19012	30303	$2,649
Sealant	0.24	4184	7107	19012	30303	$7,343
Flashing, Aluminum	0.36	4184	7107	19012	30303	$11,041
Sheathing, 1/2" Dens Glass	0.90	4184	7107	19012	30303	$27,409
Building Paper, Asphalt Felt, 15 lb.	0.17	4184	7107	19012	30303	$5,011
5/8" Gypsum Wall Board, taped & finished	0.77	4184	7107	19012	30303	$23,461
Total	$17.52	$73,307	$124,539	$333,134		$530,981

Old Walls - CMU Backup	Cost/SF	Wall Area (SF)				
		1 Story	2 Story	3 Story	Total	
Scaffolding - Complete System rent/mo	0.35	0.00	3226	0.00	3226	$1,113
Scaffolding - labor erect/dismantle	1.14	0.00	3226	0.00	3226	$3,678
Concrete Block Backup, Reinfinforced, 8" thick	0.33	0.00	3226	0.00	3226	$1,072
Standard 4" Face Brick Veneer, running bond	8.13	0.00	3226	0.00	3226	$26,214
1" Rigid Insulation, Perlite	0.64	0.00	3226	0.00	3226	$2,059
Wall Ties	0.14	0.00	3226	0.00	3226	$455
Shelf Angles	1.63	0.00	3226	0.00	3226	$5,255
Acid Brick Wash, Smooth Brick	0.52	0.00	3226	0.00	3226	$1,676
Joint Backer Rod	0.09	0.00	3226	0.00	3226	$282
Sealant	0.24	0.00	3226	0.00	3226	$782
Flashing, Aluminum	0.36	0.00	3226	0.00	3226	$1,175
Collar Joint	0.15	0.00	3226	0.00	3226	$488
5/8" Gypsum Wall Board, taped & finished	0.77	0.00	3226	0.00	3226	$2,498
Total	$14.49	$0	$46,747	$0		$46,747
						$577,728

Proposed Wall Panel Cost

New Walls - Sandwich Panels	Cost/SF	Wall Area (SF)				
		1 Story	2 Story	3 Story	Total	
9" Insulated Precast Sandwich Wall Panels with a	30.62	4184	10334	19012	33529	$1,026,669
2.5" - 4" - 2.5" layup with 1/2" thin brick exterior	$30.62					
Total before 30% O&P	$23.55					$789,745

Cost of panel quoted by Nitterhouse Concrete Products, Inc. to be $29.00/SF including overhead and profit, which was approximated to be 30%

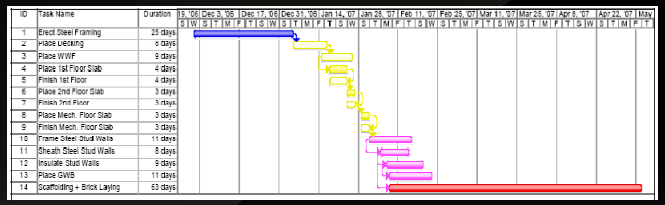
Labor cost calculated by the rate of a steel erection crew (C-11) erecting 12 panels/day

Additional Cost = $212,017 = 36.7% Increase

Presentation Outline

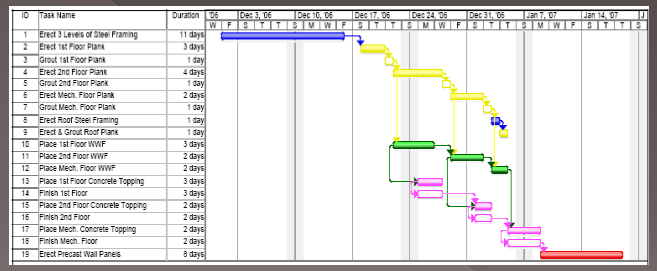
- Introduction
- Structural Depth
- Building Enclosures Breadth
- Construction Management Breadth
  - *Cost Comparison*
  - Schedule Comparison
- Conclusions

Existing Systems Schedule



ID	Task Name	Duration
1	Erect Steel Framing	25 days
2	Place Decking	6 days
3	Place WWF	9 days
4	Place 1st Floor Slab	4 days
5	Finish 1st Floor	4 days
6	Place 2nd Floor Slab	3 days
7	Finish 2nd Floor	3 days
8	Place Mech. Floor Slab	3 days
9	Finish Mech. Floor Slab	3 days
10	Frame Steel Stud Walls	11 days
11	Sheath Steel Stud Walls	8 days
12	Insulate Stud Walls	9 days
13	Place GWB	11 days
14	Scaffolding + Brick Laying	63 days

Proposed Systems Schedule



ID	Task Name	Duration
1	Erect 3 Levels of Steel Framing	11 days
2	Erect 1st Floor Plank	3 days
3	Grout 1st Floor Plank	1 day
4	Erect 2nd Floor Plank	4 days
5	Grout 2nd Floor Plank	1 day
6	Erect Mech. Floor Plank	2 days
7	Grout Mech. Floor Plank	1 day
8	Erect Roof Steel Framing	1 day
9	Erect & Grout Roof Plank	1 day
10	Place 1st Floor WWF	3 days
11	Place 2nd Floor WWF	2 days
12	Place Mech. Floor WWF	2 days
13	Place 1st Floor Concrete Topping	3 days
14	Finish 1st Floor	3 days
15	Place 2nd Floor Concrete Topping	2 days
16	Finish 2nd Floor	2 days
17	Place Mech. Concrete Topping	2 days
18	Finish Mech. Floor	2 days
19	Erect Precast Wall Panels	8 days

Approximately 5 weeks saved from critical path
Subcontractors in the building interior sooner
Increased flexibility from addition of float time

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
- Construction Management Breadth
  - Cost Comparison
  - *Schedule Comparison*
- Conclusions

Further Considerations

- Project circumstances and local practices
- Impact on garage structure and foundations
- Increase structural sandwich to eliminate hollowcore supporting plates
- Fabrication lead times
- Full vibration and acoustical analysis of hollowcore planks
- Transfer beam on northern wall for wall panels
- Change of substructure to precast concrete

Presentation Outline

Further Considerations

- Project circumstances and local practices
- Impact on garage structure and foundations
- Increase structural sandwich to eliminate hollowcore supporting plates
- Fabrication lead times
- Full vibration and acoustical analysis of hollowcore planks
- Transfer beam on northern wall for wall panels
- Change of substructure to precast concrete

Final Recommendations

- All goals met except cost control
- Current structural and wall systems best for the project
  - No time constraints so accelerated schedule not a necessity
  - No direct advantage to justify increased cost

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions
  - Further Considerations
  - *Final Recommendations*
  - Acknowledgements
  - Questions

Acknowledgements

- My parents – Victoria and Edward Kirk
- Miami University of Ohio
- Steve Nearhoof and Alex Wing – Burt Hill
- John Jones, Bart Staley, Mike Thomas, Cliff Miles – Nitterhouse Concrete Products, Inc.
- Dr. Andres Lepage, Dr. John Messner – PSU AE
- Industry professionals
- Fellow students

Final Recommendations

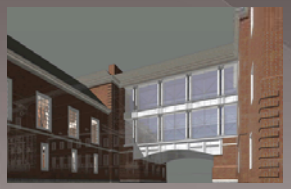
- All goals met except cost control
- Current structural and wall systems best for the project
  - No time constraints so accelerated schedule not a necessity
  - No direct advantage to justify increased cost

Presentation Outline

Acknowledgements

•My parents – Victoria and Edward Kirk
•Miami University of Ohio
•Steve Nearhoof and Alex Wing – Burt Hill
•John Jones, Bart Staley, Mike Thomas, Cliff Miles – Nitterhouse Concrete Products, Inc.
•Dr. Andres Lepage, Dr. John Messner – PSU AE
•Industry professionals
•Fellow students

Questions & Answers



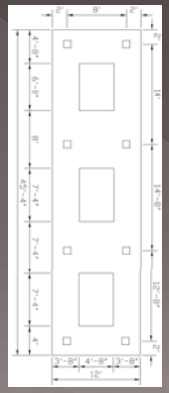
Presentation Outline

Wall Panel Connections

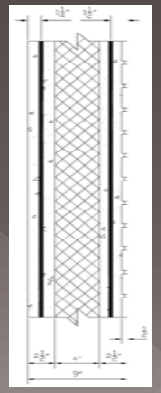
PSA Slotted Insert by JVI

4-Way Adjustment Connection at Column

Typical Sandwich Wall Panel



Typical 12' Wall Panel



Panel Cross Section

Presentation Outline

- Introduction
- Structural Depth
- Building Enclosures Breadth
  - Existing Conditions
  - *Proposed Redesign*
- Construction Management Breadth
- Conclusions

Gravity Loads

Dead Loads

Item	Weight
10" Hollowcore Plank	68 psf
2" Concrete Topping (Normal Weight)	25 psf
Steel Framing	5 psf
Ceiling and Mechanical Allowance	
Typical Floor	15 psf
Mechanical Floor	25 psf
Roof	10 psf
Garage	10 psf
Partition Allowance	10 psf
Roof Materials	
4" Rigid Insulation	6 psf
Metal Deck	2 psf
Roof Membrane	1 psf
1/2" Gypsum Board	2 psf

Live Loads

Area	Design Live Load
Typical Floor	100 psf
Labs at Ground Level	125 psf
Mechnical Equipment Rooms	150 psf
Plaza	100 psf
Roof	25 psf
Parking Decks	50 psf

Proposed Redesign

- Goals and Design Constraints
  - Accelerated construction schedule
  - Decrease or maintain cost
  - Do not change architecture
  - Maintain floor-to-ceiling and total heights
- Method
  - Prefabricated structure
    - Precast concrete hollowcore floor planks
    - Supported on similar steel frame

Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions

Seismic Loads

Lateral Seismic Force Distribution Through the Levels (East-West Moment Frames)

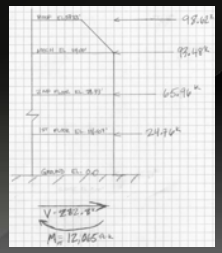
Level	Story Height h_x	Story Weight w	Exponent k	$\sum w_i h_i^k$	C_{vx}	Story Force f_x	Shear V_x	Moment M_x
Roof	57.33 ft	1422 k	1.6775	1266186	0.3487	98.62 k	98.6 k	5654 ft-k
Mech.	44.00 ft	2501 k	1.6775	1200153	0.3305	93.48 k	192.1 k	4113 ft-k
2nd	29.33 ft	2927 k	1.6775	846770	0.2332	65.96 k	258.1 k	1934 ft-k
1st	14.67 ft	3512 k	1.6775	317621	0.0875	24.76 k	282.8 k	363 ft-k
Sum		W = 9962 k		3630927		V = 282.8 k		M = 12065 ft-k

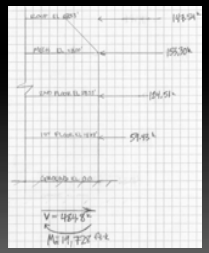
E-W Moment Frame Distribution

Lateral Seismic Force Distribution Through the Levels (North-South Braced Frames)

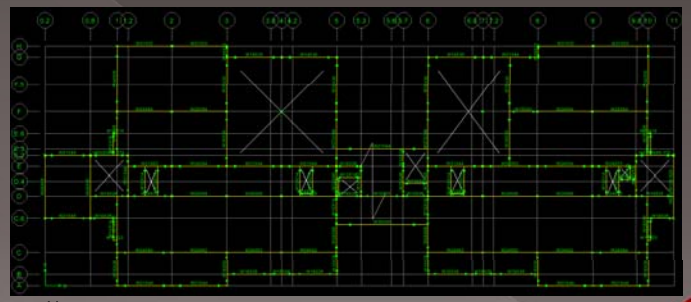
Level	Story Height h_x	Story Weight w	Exponent k	$\sum w_i h_i^k$	C_{vx}	Story Force f_x	Shear V_x	Moment M_x
Roof	57.33 ft	1422 k	1.3304	310635	0.3043	147.54 k	147.5 k	8459 ft-k
Mech.	44.00 ft	2501 k	1.3304	327757	0.3162	153.30 k	300.8 k	6745 ft-k
2nd	29.33 ft	2927 k	1.3304	262141	0.2568	124.51 k	425.4 k	3652 ft-k
1st	14.67 ft	3512 k	1.3304	125133	0.1226	59.43 k	484.8 k	872 ft-k
Sum		W = 9962 k		1026666		V = 484.8 k		M = 19728 ft-k

N-S Braced Frame Distribution





Steel Framing



First Floor Framing Plan

Presentation Outline

- Introduction
- Structural Depth
  - Existing Conditions
  - *Proposed Redesign*
- Building Enclosures Breadth
- Construction Management Breadth
- Conclusions