CityFlats Hotel

Holland, Michigan

Hunter Woron | Structural

Spring 2012 | Professor Parfitt

I. Project Background
II. Scope of Work
III. Structural Depth Study
    i. Gravity System
    ii. Lateral Force Resisting System
    iii. Recommendation & Conclusion
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CITYFLATSHOTEL

Hunter Woron - Structural

CityFlatsHotel - Holland, MI

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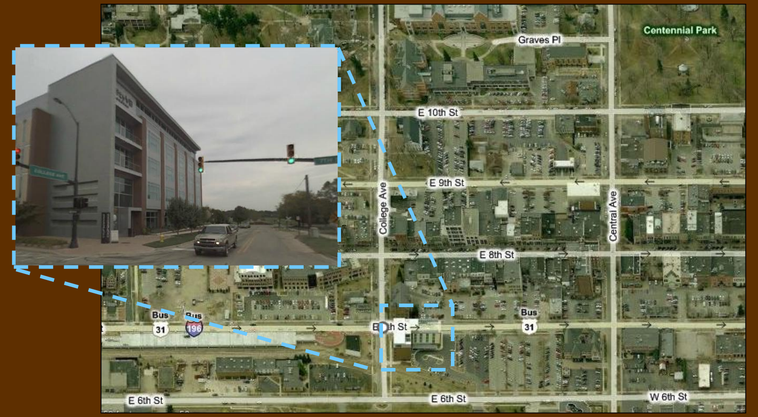
Location: Downtown Holland Michigan
Intersection of 7th Street and College Ave

Function: Eco-Boutique Hotel with 56 Guestrooms
Restaurant, Fitness Center, Cinema Room,
Bar & Lounge

Building Statistics: 65,000 Square Feet
5 Stories Above Grade
Overall Height of 67'-2"



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Owner:	Charter House Innovations
Contract:	Design-Build Delivery Method
Architect / Engineer:	GMB Architecture + Engineering
Construction Manager:	GDK Construction
Cost:	$7.2 Million
Schedule:	February 2007 to February 2008

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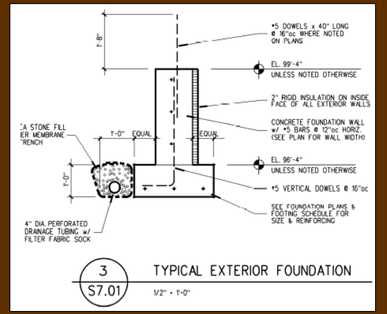

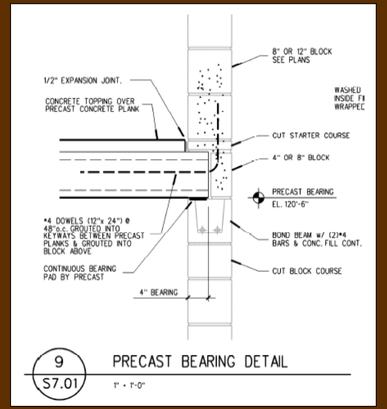

Existing Structural System

Foundation:	4” Concrete Slab
Gravity System:	CMU Load Bearing Walls
	8” Precast Hollow Core Planking w/ 2” Concrete Topping
	Steel Members Where Required
Lateral System:	Reinforced Concrete Masonry Shear Walls
	Typically 8” or 12” Thick CMU

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Project Statement:

Existing Structural System is the Most Efficient and Economical

Design a Viable Alternative System

Project Solution:

Girder-Slab Composite Steel and Precast System

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Scope of Work

Project Goals

Structural Depth:
- Reduce Overall Building Weight
- Optimize Gravity and Lateral Systems
- Verify Impact on Foundation

Architectural / Façade Breadth:
- Research Various Façade Options
- Address Thermal and Sound Effects

Construction Management Breadth:
- Impact on Overall Schedule and Cost

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Structural Depth Study

Gravity System:

Composite Steel and Precast System

Lightweight

Offers Quick Construction

Increases Overall Building Height

Requires Fireproofing

Design Loads

Live Loads (LL)			
Area	**GMB Design Loads (PSF)**	**ASCE 7-05 Load (PSF)**	**Design Load (PSF)**
Private Guest Rooms	40	40	40
Public Spaces	100	100	100
Corridors	100	40 (Private Corridor) / 100 (Public Corridor)	40 (Private Corridor) / 100 (Public Corridor)
Lobbies	100	100	100
Stairs	100	100	10
Storage/Mechanical	125	125 (Light)	125
Theater (Fixed)	60	60	60
Restaurant/Bar	100	100	100
Patio (Exterior)	100	100	100
Dead Loads (DL)			
Material	**GMB Design Loads (PSF)**	**ASCE 7-05 Load (PSF)**	**Design Load (PSF)**
8" Precast w/ Topping	Unknown	Section 3.1	81
Steel	Unknown		Varies
Partitions	Unknown		10
MEP	Unknown		10
Finishes/Miscellaneous	Unknown		5
Roof	Unknown		20
Snow Load (SL)			
Area	**GMB Design Loads (PSF)**	**ASCE 7-05 (PSF)**	**Design Load (PSF)**
Flat Roof	35	35	35

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Structural Depth Study

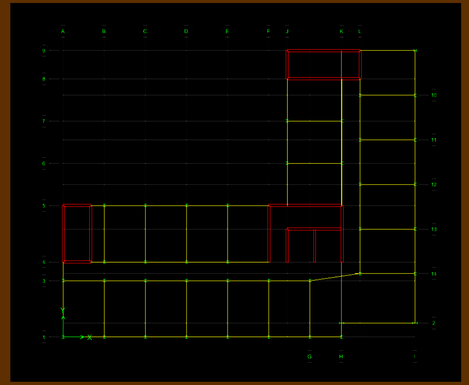
Framing Plan:

Typical Bay Size - 18’ x 24’
Beam Size: W18x40
Columns Aligned with Partition Walls
Increased Floor-to-Ceiling Height

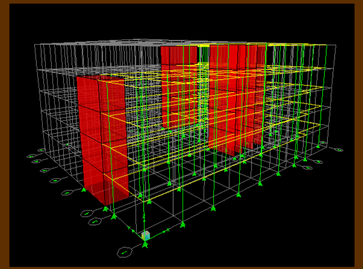
Controlling Load Combination:

$1.2D + 1.6L + 0.5L_r$

Deflection Criteria:
Live Load: L/360
Total Load: L/240



Typical Floor Plan Layout



Framing Plan

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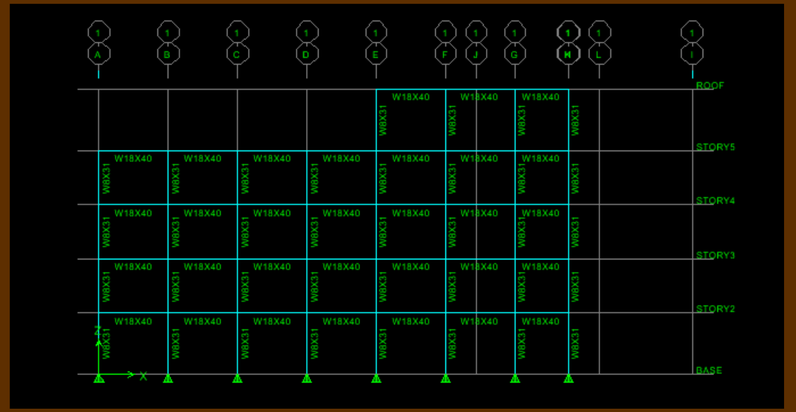
Column Design:

Comply with LRFD methods and AISC Steel Manual

Optimal Members Designed by ETABS

Resist Gravity Loads Only

Typical Size - W8x31



Typical Section of Structural Components

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Pre-Cast Plank Design:

Live Load: 40 PSF

Dead Load: 15 PSF

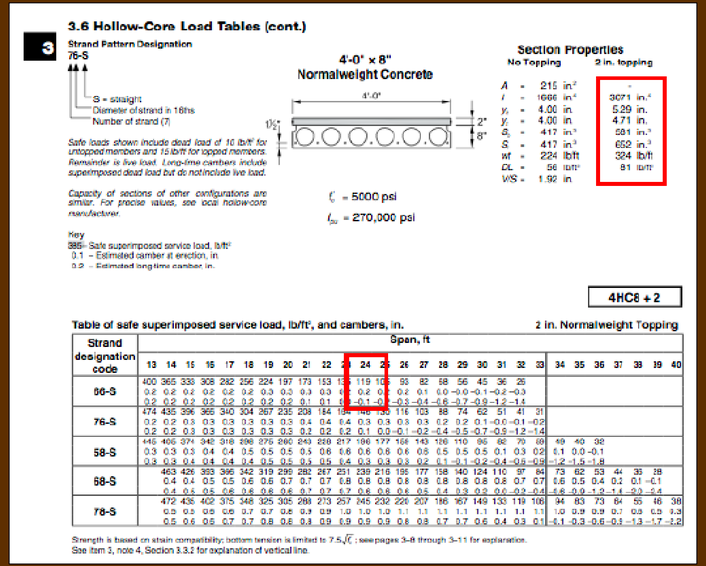
Superimposed Dead: 25 PSF

PCI Design Handbook Results:

66-S Strands

6 Strands @ 6/16” Diameter

Self Weight of 81 PSF



3 **3.6 Hollow-Core Load Tables (cont.)**

Strand Pattern Designation 76-S

S = straight
Diameter of strand in 16ths
Number of strand (7)

4'-0" x 8" Normalweight Concrete

Section Properties

		No Topping	2 in. topping
A	=	215 in.²	–
I	=	1666 in.⁴	3071 in.⁴
y_b	=	4.00 in.	5.29 in.
y_t	=	4.00 in.	4.71 in.
S_b	=	417 in.³	581 in.³
S_t	=	417 in.³	652 in.³
wt	=	224 lb/ft	324 lb/ft
DL	=	56 lb/ft²	81 lb/ft²
WS	=	1.92 in.	

Safe loads shown include dead load of 16 lb/ft² for untopped members and 15 lb/ft² for topped members. Remainder is live load. Long-time cambers include superimposed dead load but do not include live load.

Capacity of sections of other configurations are similar. For precise values, see local hollow-core manufacturer.

f'_c = 5000 psi

f_{ps} = 270,000 psi

Key
385– Safe superimposed service load, lb/ft²
0.1 – Estimated camber at erection, in.
0.2 – Estimated long-time camber, in.

4HC8 + 2

Table of safe superimposed service load, lb/ft², and cambers, in. — 2 in. Normalweight Topping

Strand designation code	Span, ft																												
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
66-S	400	365	338	308	282	256	224	197	173	153	135	119	105	93	82	68	56	45	36	26								
	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.0	−0.0	−0.1	−0.2	−0.3								
	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	−0.1	−0.2	−0.3	−0.4	−0.6	−0.7	−0.9	−1.2	−1.4							
76-S	474	435	396	365	340	304	267	235	208	184	164	146	130	116	103	88	74	62	51	41	31							
	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	−0.0	−0.1	−0.2							
	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.0	−0.1	−0.2	−0.4	−0.5	−0.7	−0.9	−1.2	−1.4							
58-S	445	406	374	342	316	286	275	260	243	228	217	196	177	158	143	126	110	96	82	70	59	49	40	32				
	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.1	0.3	0.2	0.1	0.0	−0.1				
	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.1	−0.1	−0.2	−0.4	−0.6	−0.9	−1.2	−1.5	−1.8			
68-S		463	426	393	366	342	319	296	282	267	251	239	216	195	177	158	140	124	110	97	84	73	62	53	44	36	28	
		0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.2	0.1	−0.1	
		0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.0	−0.2	−0.4	−0.6	−0.9	−1.2	−1.4	−0.3	−0.4
78-S		472	438	402	375	348	325	305	288	273	257	245	232	220	207	195	167	149	133	119	106	94	83	73	64	55	46	38
		0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	0.9	0.9	0.7	0.3	0.0	0.3
		0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.4	0.3	0.1	−0.1	−0.3	−0.6	−0.8	−1.3	−1.7	−1.2

Strength is based on strain compatibility; bottom tension is limited to $7.5\sqrt{f'_c}$; see pages 3–8 through 3–11 for explanation.
See item 3, note 4, Section 3.3.2 for explanation of vertical line.

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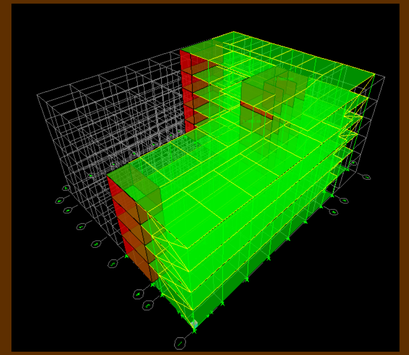
Lateral Force Resisting System:



Assumptions and Considerations:

Modeled Lateral Members Only

Columns Pinned at Base

Beams and Braces Pinned

Floor Diaphragms Modeled as Rigid Elements

Accidental and Inherent Torsion was Considered

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Wind / Seismic Effects:

Design Wind and Seismic Load Cases Were Used

$1.2D + 1.6\,W_Y + 1.0L + 0.5L_r$

$0.9D + 1.0E_X$

Seismic Comparison		
	Existing Building Design	**New Building Design**
Building Weight	**10258 kips**	**7913 kips**
Base Shear	**463.7 kips**	**200 kips**
Total Moment	**15745 ft-k**	**7983 ft-k**

Wind / Seismic Drifts:

Controlling Wind Drift					
Level	Height Above Ground, h (ft)	Allowable Drift Δallowable = h/400	Total Drift (X-Direction)	Total Drift (Y-Direction)	Adequate
Roof	74.92	2.25	1.11	1.53	Yes
Level 5	58.00	1.74	0.84	1.13	Yes
Level 4	44.00	1.32	0.60	0.81	Yes
Level 3	30.00	0.90	0.38	0.51	Yes
Level 2	16.00	0.48	0.19	0.29	Yes
Level 1	0.00	0.00	0.00	0.00	Yes

Drift Criteria:

Wind - H/400

Seismic - $0.02H_{SX}$

Controlling Seismic Drift					
Level	Height of Story, h (ft)	Allowable Story Drift Δallowable = 0.02hsx	Total Drift (X-Direction)	Total Drift (Y-Direction)	Adequate
Roof	16.92	0.34	0.0085	0.026	Yes
Level 5	14.00	0.28	0.0056	0.017	Yes
Level 4	14.00	0.28	0.0056	0.014	Yes
Level 3	14.00	0.28	0.0056	0.010	Yes
Level 2	14.00	0.28	0.0042	0.008	Yes
Level 1	16.00	0.32	0.0011	0.002	Yes

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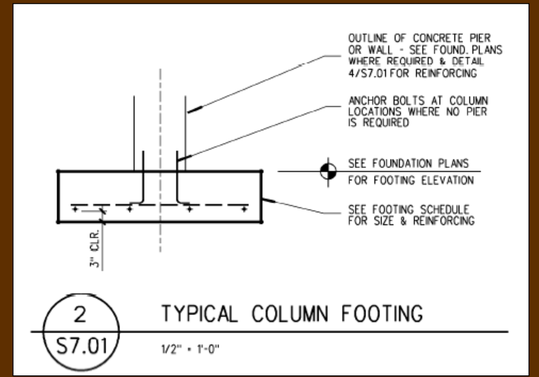
Impact of Lateral Loads:

Overturning Moments						
Floor	Height Above Ground Z (ft)	Story Height (ft)	N/S Wind Forces		E/W Seismic Forces	
			Lateral Force Fx (k)	Total Moment Mx (ft-k)	Lateral Force Fx (k)	Total Moment mx (ft-k)
Top of Roof	77.17	2.25	4.0	0.0	-	-
Roof	74.92	16.92	34.3	77.2	17.4	1173.9
Fifth	58.00	14.00	54.4	997.7	74.9	3818.1
Fourth	44.00	14.00	47.5	1662.8	55.1	2037.5
Third	30.00	14.00	45.7	2302.5	35.5	815.8
Second	16.00	14.00	43.1	2906.0	17.2	137.9
First	0.00	16.00	20.8	3196.9	0.0	0.0
		Total=	249.8	11143.1	200.0	7983.2

Overturning NOT a Concern - Gravity Loads Much Larger

Impact on Foundation:



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Structural Conclusion:

Steel Structure Sufficiently Designed for Strength and Serviceability Requirements

Reduced the Overall Building Weight

Reduced Base Shear and Overturning Moment

Increase Floor-to-Ceiling Height

Increase Overall Building Height

Avoided Major Architectural Changes / Impacts

Structural Recommendation:

Viable Option as an Alternative Structural System

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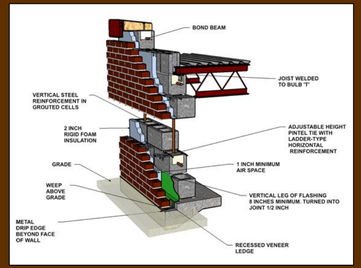
Goals:

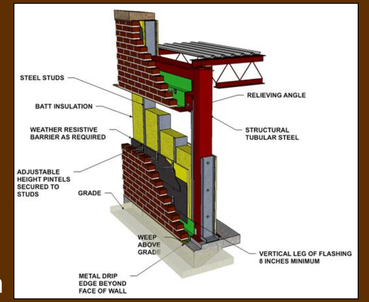
To Analyze the Thermal Effects of Alternative Facades

Compare Construction Cost and Scheduling Impacts

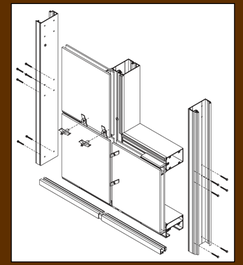
Determine Additional Consequences of Replacing the Existing Structure



www.masonrysystems.com



www.kawneer.com



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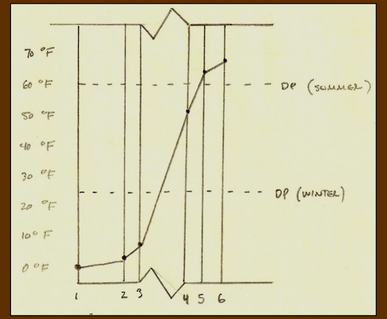
Thermal Gradients:

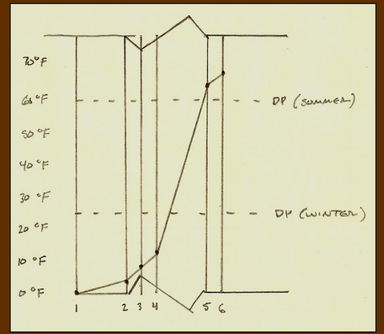
Existing CMU/Masonry System		
Between Material	ΣRo-x (°F-ft2-h/BTU)	Temperature (°F)
0 - 1	0.17	0
1 - 2	0.81	3.4
2 - 3	1.79	7.6
3 - 4	12.06	51.3
4 - 5	15.26	64.9
5 - I	15.82	67.3
Total	16.46	70.0
U-Value = 0.0608 (BTU/°F-ft2-h)		



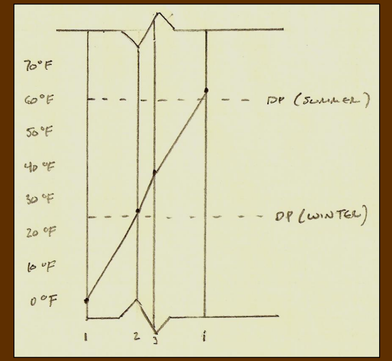
1.Brick 2. Cavity 3. Insulation

4. CMU Block 5. Gyp Wall Board

Brick Vaneer Ssytem		
Between Material	ΣRo-x (°F-ft2-h/BTU)	Temperature (°F)
0 - 1	0.17	0
1 - 2	0.81	3.4
2 - 3	1.79	7.6
3 - 4	3.11	13.2
4 - 5	15.30	64.9
5 - I	15.86	67.3
Total	16.50	70.0
U-Value = 0.0606 (BTU/°F-ft2-h)		



Curtain Wall System		
Between Material	ΣRo-x (°F-ft2-h/BTU)	Temperature (°F)
0 - 1	0.17	0
1 - 2	2.27	26.5
2 - 3	3.25	38.0
3 - I	5.35	62.5
Total	5.99	70.0
U-Value = 0.167 (BTU/°F-ft2-h)		



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Cost and Time Comparison:

Façade Comparisions							
Façade of Exisiting System							
Wall System	S.F.	Crew Size	Material Cost / SF	Labor Cost / SF	Total Cost	Daily Output (SF)	Construction Time (Days)
CMU/Brick System	8041	3 Bricklayers, 3 Bricklayer Helpers	$7.65	$14.90	$181,325	130	62
Façade Systems for Redesigned System							
Wall System	S.F.	Crew Size	Material Cost / SF	Labor Cost / SF	Total Cost	Daily Output	Construction Time
Brick Vaneer System / Metal Stud Backup	9183	3 Bricklayers, 2 Bricklayer Helpers	$6.60	$11.60	$167,131	220	42
Curtain Wall System	9183	2 Glazers, 2 Structural Steel Workers	$24.50	$8.85	$306,253	205	45

Additional Concerns:

Acoustics:

- Noise Limitations Important in Hotel
- Sound Absorbing Panels
- Hanging Ceilings
- Various Floor Coverings
- Multiple Layers of Gypsum Wall Board

Construction Management Breadth

I. Project Background
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VII. Acknowledgments

Construction Schedule Impact:

Existing Structural System:

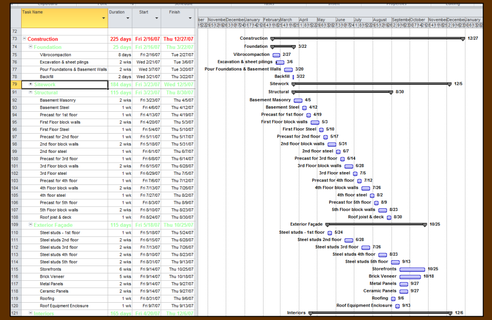
Start Date: March 23, 2007

End Date: August 23, 2007

Redesigned Structural System:

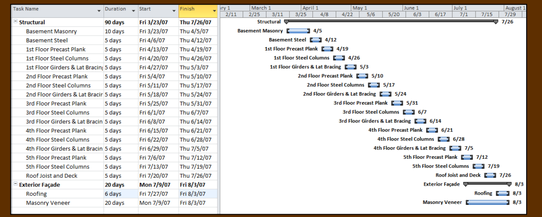
Start Date: March 23, 2007

End Date: July 26, 2007



Existing Schedule

Redesigned Schedule



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Overall Cost Impact:

Overall Cost Comparison			
Component	Existing System	Redesigned System	Additional Cos
CMU Walls	$701,125	$160,975	-$540,150
Steel Bracing	$0	$206,250	$206,250
Steel Framing	$130,134	$524,358	$394,224
Total	$831,259	$891,583	$60,324

Cost Estimate of Existing System

Shearwalls	Amount	Unit	Material Cost/Unit	Labor Cost /Unit	Equipment Cost/Unit	Total Cost/Unit	Total Cost w/O&P	Total Cost
8" CMU, reinforced	59500	SF	2.15	2.71	-	4.86	6.85	$407,575
12" CMU, reinforced	28500	SF	3.11	4.16	-	7.27	10.30	$293,550
Steel	**Amount**	**Unit**	**Material Cost/Unit**	**Labor Cost /Unit**	**Equipment Cost/Unit**	**Total Cost/Unit**	**Total Cost w/O&P**	**Total Cost**
Columns	1400	LF	41.50	2.78	2.86	47.14	54.00	$75,600
Baseplates	140	SF	21.00	-	-	21.00	23.00	$3,220
Beams	1945	LF	12.30	2.09	2.15	16.54	19.90	$38,706
Fireproofing	10420	SF	0.45	0.38	0.08	0.91	1.21	$12,608
						Total Cost of Existing Syste		$831,259

Cost Estimate of Redesigned System

Shearwalls	Amount	Unit	Material Cost/Unit	Labor Cost /Unit	Equipment Cost/Unit	Total Cost/Unit	Total Cost w/O&P	Total Cost
12" CMU, reinforced	23500	SF	2.15	2.71	-	4.86	6.85	$160,975
Steel	**Amount**	**Unit**	**Material Cost/Unit**	**Labor Cost /Unit**	**Equipment Cost/Unit**	**Total Cost/Unit**	**Total Cost w/O&P**	**Total Cost**
Columns	6300	LF	41.50	2.78	2.86	47.14	54.00	$340,200
Baseplates	520	SF	21.00	-	-	21.00	23.00	$11,960
Beams	6750	LF	12.30	2.09	2.15	16.54	19.90	$134,325
Braces	2500	LF	31.00	28.50	-	59.50	82.5	$206,250
Fireproofing	31300	SF	0.45	0.38	0.08	0.91	1.21	$37,873
						Total Cost of Redesigned Syste		$891,583

Summary of Conclusions

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Structural Conclusion:

- Steel Structure Sufficiently Designed for Strength and Serviceability Requirements
- Reduced the Overall Building Weight
- Reduced Base Shear and Overturning Moment
- Increase Floor-to-Ceiling Height
  - Increase Overall Building Height
- Avoided Major Architectural Changes / Impacts

Architectural / Façade Conclusions:

- Brick Veneer System Most Efficient
- Additional Acoustical Elements Required

Construction Management Conclusions

- Reduced Schedule Period
- Minimal Increase of Up Front Cost

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- Kara Slater

GMB Architecture + Engineering

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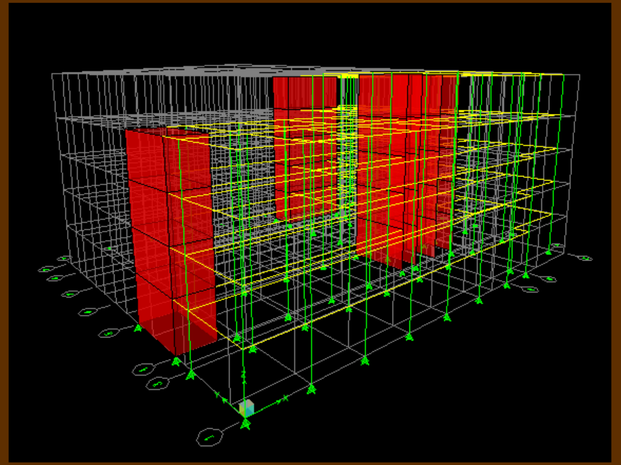
- Professor Kevin Parfitt
- Professor Robert Holland
- The Entire AE Faculty and Staff

All my friends, family, and classmates for their unconditional support and encouragement.

Questions and Comments



Hunter Woron - Structural

CityFlatsHotel - Holland, MI

Spring 2012 - Professor Parfitt