

James D. Rotunno
Structural Option

The Butler Health System's – New Inpatient Tower Addition

AE Senior Thesis
April 13th, 2010
The Pennsylvania State University

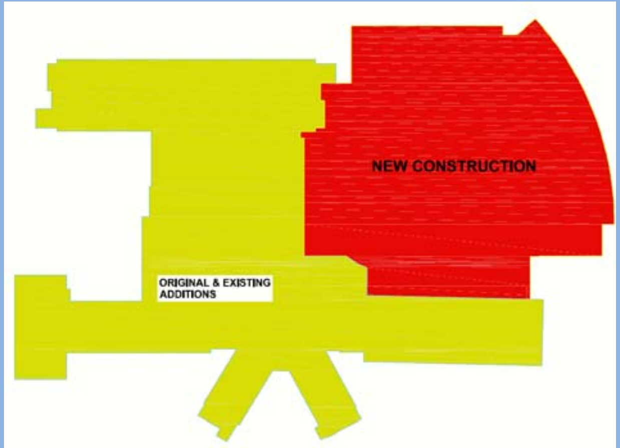
Presentation Outline:

- **Existing Building**
  - **Structural Systems**
  - **Design Codes & Standards**
  - **Lateral Analysis**
- **Thesis Proposal & Goals**
- **Redesigned Gravity System** (Depth Study)
  - **System Description & Use**
  - **Perceived Advantages & Disadvantages**
  - **Member shapes, sizes, capacities & detailing**
  - **Recheck Lateral System**
- **Connecting the Members** (MAE)
- **Additional Considerations** (Breadths)
  - **Acoustical for conflicting spaces**
  - **Architectural vs. acoustical**
  - **Vibration of hospital floor systems**
  - **Cost Comparisons**
- **Overall System Conclusions**
  - **Revisit proposed system advantages & disadvantages**
  - **Design limitations**
- **Acknowledgments**

Presentation Outline:

- **Existing Building**
  - **Building Statistics**
  - **Structural Systems**
  - **Design Codes & Standards**
  - **Lateral Analysis**
- **Thesis Proposal & Goals**
- **Redesigned Gravity System** (Depth Study)
  - **System Description & Use**
  - **Perceived Advantages & Disadvantages**
  - **Member shapes, sizes, capacities & detailing**
  - **Recheck Lateral System**
- **Connecting the Members** (MAE)
  - **Design loads & Connections**
- **Additional Considerations** (Breadths)
  - **Acoustical conflicting spaces**
  - **Architectural vs. acoustical**
  - **Vibration of hospital floor systems**
  - **Cost Comparisons**
- **Overall System Conclusions**
  - **Revisit proposed system advantages & disadvantages**
  - **Design limitations**
- **Acknowledgments**

Building for the Future: A New Era Begins



Presentation Outline:

- Existing Building
  - **Building Statistics**
  - Structural Systems
  - Design Codes & Standards
  - Lateral Analysis
- Thesis Proposal & Goals
- Redesigned Gravity System (Depth Study)
  - System Description & Use
  - Perceived Advantages & Disadvantages
  - Member shapes, sizes, capacities & detailing
  - Recheck Lateral System
- Connecting the Members (MAE)
  - Design loads & Connections
- Additional Considerations (Breadths)
  - Acoustical conflicting spaces
  - Architectural vs. acoustical
  - Vibration of hospital floor systems
  - Cost Comparisons
- Overall System Conclusions
  - Revisit proposed system advantages & disadvantages
  - Design limitations
- Acknowledgments

Building for the Future: A New Era Begins

Project Team:

Owner: Butler Healthcare Providers
Owners Representative: Ritter Const. Management Inc.
Construction Manager: Turner Construction
Architect: Design Group
Design Architect: Hammel, Green, Abrahamson HGA

Size: 206,000 Square Feet
Height: 134'-3" from lowest level
Levels: 6 Above Grade & 2 Below Grade
Construction Dates: September 2008 – Summer 2010
Function: Primarily Surgery & Recovery
Cost: $93M (GMP)

Presentation Outline:

- Existing Building
  - Building Statistics
  - Structural Systems
  - Design Codes & Standards
  - Lateral Analysis
- Thesis Proposal & Goals
- Redesigned Gravity System (Depth Study)
  - System Description & Use
  - Perceived Advantages & Disadvantages
  - Member shapes, sizes, capacities & detailing
  - Recheck Lateral System
- Connecting the Members (MAE)
  - Design loads & Connections
- Additional Considerations (Breadths)
  - Acoustical conflicting spaces
  - Architectural vs. acoustical
  - Vibration of hospital floor systems
  - Cost Comparisons
- Overall System Conclusions
  - Revisit proposed system advantages & disadvantages
  - Design limitations
- Acknowledgments

Building for the Future: A New Era Begins

Existing Structural Systems:

- Steel Wide Flange Members for Columns & Beams
- HSS Members for Various Braced Frame Configurations
- Floor Systems are Composed of Composite Deck & Composite Beams

Drilled piers 30"-78" Ø; down to 79' deep

Presentation Outline:

Design Standards & Codes:

2006 IBC

2000 NFPA 101

2006 Guidelines for Design & Construction of Health Care Facilities

1998 Pennsylvania Department of Health Rules and Regulations for Hospitals

ASCE 7-05: for wind, seismic, snow and gravity loads

ACI 318-08: for concrete construction

AISC Thirteenth Edition: for steel members

ASHRAE Handbook: HVAC Applications & Fundamentals 2003

PCI 2003 for vibration

ATC 1999 for vibration (ADAPT technical note TN209 3/21/09 for reference)

Design Load Summary:

Gravity Loads					
Description/location	DL/ LL	ASCE 7-05/ IBC 1607.9 values	HGA's values	Reduction available/used	**Design value**
Concrete floors	DL	90-115pcf	115pcf	NO/NO	**115pcf**
MEP/partitions/finishes	SDL	20-25psf	44psf	NO/NO	**35psf**
1st floor mechanical	LL		125psf	YES/NO	**125psf**
2nd floor/ lobby	LL	100psf	100psf	YES/NO	**100psf**
Hospital floors	LL	40-80psf	80psf	YES/YES	**80psf**
Stairs & exits	LL	100psf	100psf	NO/NO	**100psf**
5th floor roof	LL		115psf	NO/NO	**115psf**
Mech. Penthouse floor	LL		125psf	NO/NO	**125psf**
Elevator Machine room floor	LL		125psf	YES/NO	
Roof top equipment areas	LL		125psf (or actual equipment wt.)	NO/NO	**125psf**
Balconies	LL	100psf	100psf	YES/YES	**100psf**
Snow	LL	24-30psf	24-30psf	NO/NO	**24-30psf**

Presentation Outline:

- ➢Existing Building
  - ➢Building Statistics
  - ➢Structural Systems
  - ➢Design Codes & Standards
  - ➢**Lateral Analysis**
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢Member shapes, sizes, capacities & detailing
  - ➢Recheck Lateral System
- ➢Connecting the Members (MAE)
  - ➢Design loads & Connections
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

Building for the Future: A New Era Begins

Wind Load Data for Calculations

North-South direction			ASCE section
Basic wind speed	V	90mph	6.5.4 (Figure 6-1)
Mean roof height	h	122ft	
Wind directionality factor	K_d	0.85	6.5.4 (Table 6-4)
Importance Factor	I	1.15	6.5.5 (Table 6-1)
Exposure category		C	6.5.6.3
Velocity pressure coefficient	K_z	varies	6.5.6 (Table 6-3)
Topographic factor	K_{zt}	varies	6.5.7 (Figure 6-4)
Gust effect factor	G	0.857	6.5.8
Enclosure Classification		Enclosed	6.5.9
Internal pressure coefficient	GC_{pi}	±0.18	6.5.11.1 (Table 6-3)
External pressure coefficients windward side	C_p	0.8	6.5.11.2 (Figure 6-6)
External pressure coefficients leeward side	C_p	-0.5	(Figure 6-6)
Velocity pressure @ height Z	q_z	varies	6.5.10
Velocity pressure @ mean roof height	q_h	30.41/ft²	6.5.10
Design wind load	F	determine	

North - South Base & Story Shears with Overturning Moment

Level	Height ft	Pressure lbs/ft ^{2}	Force(F) kips	Shear (V) kips	Moment (M) Kips*ft
		Windward + leeward			
0- Ground	0	0	0	557.55	4086.84
1	14'-8"	24.60	15.69	557.55	4086.84
2	29'-4"	26.61	72.10	541.86	3971.83
3	44'-0"	27.33	98.45	469.76	3443.34
5	58'-8"	27.61	100.27	371.31	2721.70
6	73'-4"	27.63	93.73	271.04	1986.72
7	88'-0"	27.43	86.37	177.31	1299.68
8-Roof	102'-8"	26.91	62.53	90.94	666.59
9- P.H. 1	122'-0"	26.34	23.96	28.41	274.58
10- P.H. 2	135'- 0"	25.90	4.45	4.45	28.93
			Base Shear =	557.55	
			Overturning Moment =		22567.05

Presentation Outline:

- ➢Existing Building
  - ➢Building Statistics
  - ➢Structural Systems
  - ➢Design Codes & Standards
  - ➢**Lateral Analysis**
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢Member shapes, sizes, capacities & detailing
  - ➢Recheck Lateral System
- ➢Connecting the Members (MAE)
  - ➢Design loads & Connections
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

Building for the Future: A New Era Begins

Deflection criteria as per 2006 International Building Code:

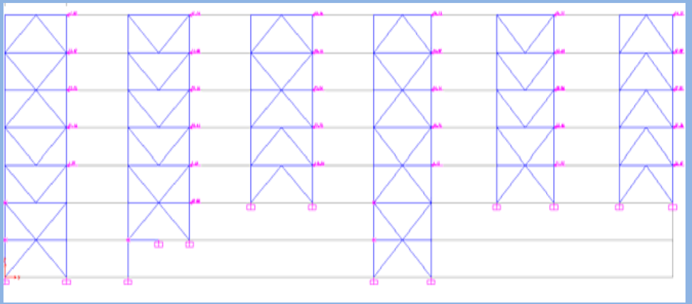
Allowable building drift: $\Delta_{wind} = H/400$

Allowable story drift: $\Delta_{seismic} = 0.10h_{sx}$ (Table 12.12-1 ASCE 7-05)

Equation used to calculate story drift Δ_s: $K=P/\Delta_p$ $\Delta_p=P/K$

Wind Drift Comparison of Frame #2										
Level	Story Height (ft)	Story Drift (in)	Allowable Story Drift $\Delta_{wind} = H/400$ (in)			Total Drift (in)	Allowable Total Drift $\Delta_{wind} = H/400$ (in)			
3	14.67	0.0782	<	0.44	Acceptable	0.0782	<	1.32	Acceptable	
5	14.67	0.0837	<	0.44	Acceptable	0.162	<	1.76	Acceptable	
6	14.67	0.0782	<	0.44	Acceptable	0.240	<	2.2	Acceptable	
7	14.67	0.0856	<	0.44	Acceptable	0.326	<	2.64	Acceptable	
8/roof	14.67	0.0620	<	0.44	Acceptable	0.388	<	3.08	Acceptable	

Concentric Braced Frame Configurations



Presentation Outline:

- Existing Building
- **Thesis Proposal** & Goals
- Redesigned Gravity System (Depth Study)
  - System Description & Use
  - Perceived Advantages & Disadvantages
  - Member shapes, sizes, capacities & detailing
  - Recheck Lateral System
- Connecting the Members (MAE)
  - Design loads & Connections
- Additional Considerations (Breadths)
  - Acoustical conflicting spaces
  - Architectural vs. acoustical
  - Vibration of hospital floor systems
  - Cost Comparisons
- Overall System Conclusions
  - Revisit proposed system advantages & disadvantages
  - Design limitations
- Acknowledgments

- Replace the existing gravity system with a modified version of the Girder-slab D-beam System
- Check lateral system compatibility & loading
- Check connections for feasibility
- Acoustical considerations of conflicting spaces
- Vibration considerations
- Structural System cost analysis estimate

Presentation Outline:

- ➢Existing Building
- ➢**Thesis Proposal & Goals**
- ➢Redesigned Gravity System (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢Member shapes, sizes, capacities & detailing
  - ➢Recheck Lateral System
- ➢Connecting the Members (MAE)
  - ➢Design loads & Connections
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

➢Reinforce structural classes by studying a relatively new structural system concept and modifying the idea to expand its current use.

➢What are the defining limits and parameters keeping this system from expanding its use?

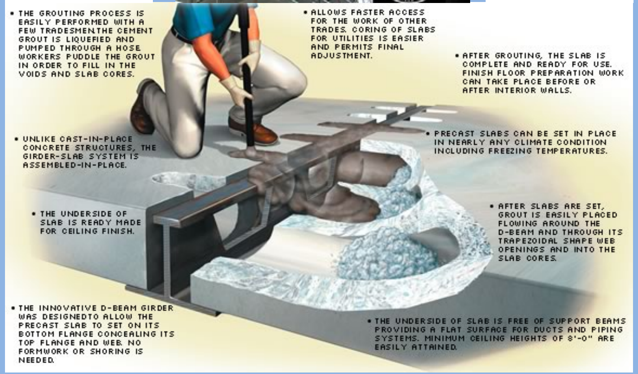
➢Can the use of the proposed system be expanded to this type of structure or others?

Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢**Redesigned Gravity System** (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢Member shapes, sizes, capacities & detailing
  - ➢Recheck Lateral System
- ➢**Connecting the Members** (MAE)
  - ➢Design loads & Connections
- ➢**Additional Considerations** (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

GIRDER SLAB
COMPOSITE STEEL AND PRECAST SYSTEM

GIRDER-SLAB TECHNOLOGIES, LLC



HOTELS
STUDENT HOUSING
CONDOS & APARTMENTS
TALL BUILDINGS

Project: Marriott Courtyard

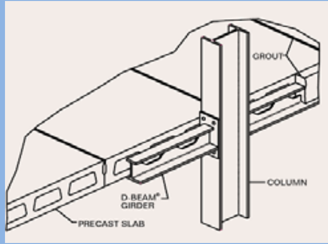
Project: Lawrenceville Graduate Apartments at Princeton University

Presentation Outline:

- Existing Building
- Thesis Proposal & Goals
- **Redesigned Gravity System** (Depth Study)
  - System Description & Use
  - Perceived Advantages & Disadvantages
  - Member shapes, sizes, capacities & detailing
  - Recheck Lateral System
- **Connecting the Members** (MAE)
  - Design loads & Connections
- **Additional Considerations** (Breadths)
  - Acoustical conflicting spaces
  - Architectural vs. acoustical
  - Vibration of hospital floor systems
  - Cost Comparisons
- **Overall System Conclusions**
  - Revisit proposed system advantages & disadvantages
  - Design limitations
- **Acknowledgments**

Disadvantages:

❖Large lead times with this type of system
❖Girders and columns would need fireproofing
❖Much more efficient and cost effective at shorter spans
❖Column spacing may have to be reduced, increasing footing requirements
❖Floor penetrations must be well coordinated with the slab designer/manufacture



Advantages:

❖Easy & fast to install
❖The lateral system can still be utilized
❖No formwork required and concrete slabs are already at usable capacity when they arrive
❖No intermediate beams in interior of bays needed
❖Can be installed in any type of weather
❖Other trades can start work underneath almost immediately
❖Additional unobstructed ceiling space for MEP's.
❖Meets or exceeds floor fireproofing requirements
❖Reduce noise transmission from floor to floor through baffled cavities
❖No increase in floor to floor heights
❖Reduces overall weight of the structure

Presentation Outline:

- Existing Building
- Thesis Proposal & Goals
- **Redesigned Gravity System** (Depth Study)
  - System Description & Use
  - Perceived Advantages & Disadvantages
  - **Member shapes, sizes, capacities & detailing**
  - Recheck Lateral System
- **Connecting the Members** (MAE)
  - Design loads & Connections
- **Additional Considerations** (Breadths)
  - Acoustical conflicting spaces
  - Architectural vs. acoustical
  - Vibration of hospital floor systems
  - Cost Comparisons
- **Overall System Conclusions**
  - Revisit proposed system advantages & disadvantages
  - Design limitations
- Acknowledgments

Required Moments vs. Spans

Span (ft)	M_u @ 80psf LL & Constant DL (k*ft)	M_u @ 125psf LL & Constant DL (k*ft)
14	207	260
27	770	967
28	828	1040
29	888	1115
30	950	1193
31	1014	1274
32	1080	1358

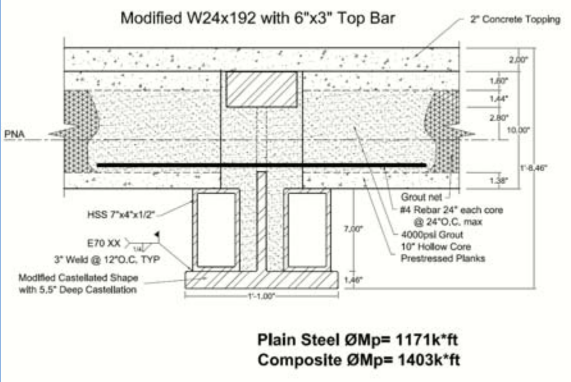
Shear & Moment Capacity per Shape

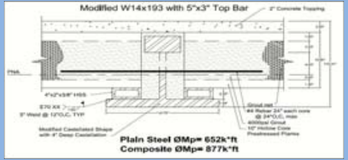
Modified Girder Shape Size (Modified)	Shear Capacity @ Least Section (kips)	Total Depth Inc. 2" Concrete Topping (in)	Non-composite Plastic Moment Capacity (ΦM_p) (k*ft)	Composite Plastic Moment Capacity (ΦM_{pc}) (k*ft)
W_m27x217	359.8	22.50	1328	1674
W_m24x192	314.0	20.46	1171	1403
W_m18x211	345.0	18.91	985	1287
W_m14x193	233.6	15.44	652	877
W_m10x68	70.1	12	286	Uncalculated

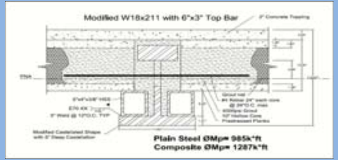
Presentation Outline:

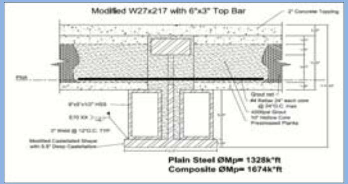
- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢**Member shapes, sizes, capacities & detailing**
  - ➢Recheck Lateral System
- ➢Connecting the Members (MAE)
  - ➢Design loads & Connections
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

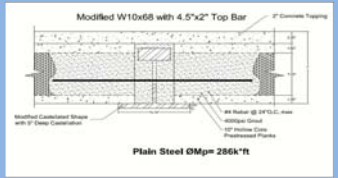
Modified D-Beam Girder Shapes









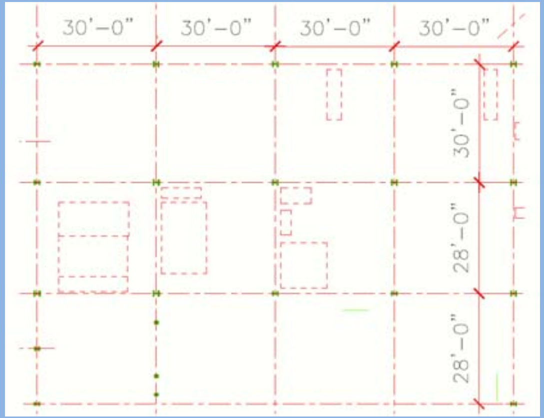


Other Designed Shapes

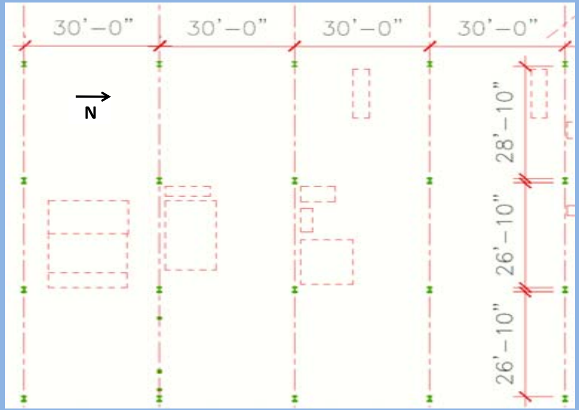
Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢**Redesigned Gravity System** (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢**Member shapes, sizes, capacities & detailing**
  - ➢Recheck Lateral System
- ➢**Connecting the Members** (MAE)
  - ➢Design loads & Connections
- ➢**Additional Considerations** (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢**Overall System Conclusions**
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

As Designed Floor System



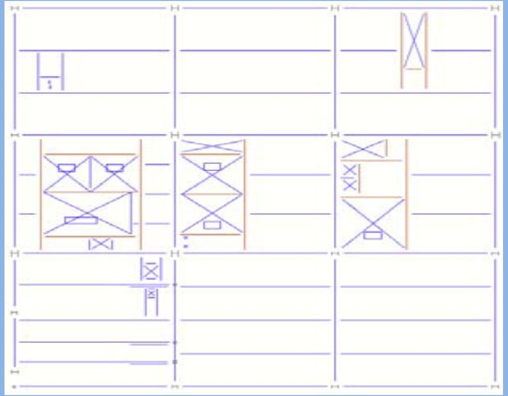
Proposed Floor System



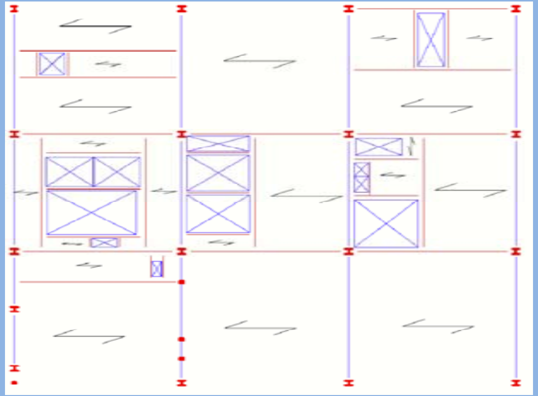
Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢**Redesigned Gravity System** (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢**Member shapes, sizes, capacities & detailing**
  - ➢Recheck Lateral System
- ➢**Connecting the Members** (MAE)
  - ➢Design loads & Connections
- ➢**Additional Considerations** (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

As Designed Floor System



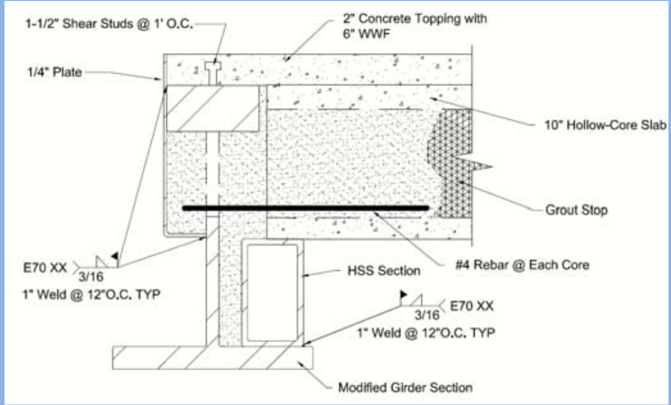
Proposed Floor System



Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢**Redesigned Gravity System** (Depth Study)
  - ➢System Description & Use
  - ➢Perceived Advantages & Disadvantages
  - ➢**Member shapes, sizes, capacities & detailing**
  - ➢Recheck Lateral System
- ➢**Connecting the Members** (MAE)
  - ➢Design loads & Connections
- ➢**Additional Considerations** (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

Detail Around Openings



Presentation Outline:

- ➢ Existing Building
- ➢ Thesis Proposal & Goals
- ➢ Redesigned Gravity System (Depth Study)
  - ➢ System Description & Use
  - ➢ Perceived Advantages & Disadvantages
  - ➢ Member shapes, sizes, capacities & detailing
  - ➢ **Recheck Lateral System**
- ➢ Connecting the Members (MAE)
  - ➢ Design loads & Connections
- ➢ Additional Considerations (Breadths)
  - ➢ Acoustical conflicting spaces
  - ➢ Architectural vs. acoustical
  - ➢ Vibration of hospital floor systems
  - ➢ Cost Comparisons
- ➢ Overall System Conclusions
  - ➢ Revisit proposed system advantages & disadvantages
  - ➢ Design limitations
- ➢ Acknowledgments

Total Dead Load for Seismic Calculation

				W_T Load type							
Floor Level	square footage	wall	Plank & Topping	Superimposed MEP/Partitions	Columns	Beams	equipment	roof	exterior walls	Floor weight	**Fx**
		square footage	psf		kips	lb/ft²	psf	psf	psf/wall	Totals	
			93.0	35.0		10.0	1.0	93.0	28.6	w_t	**kips**
Ground	8240										
Level 1	20405	170	1897.67	714.18	70.07	204.05	20.41	0	4.86	2906.4	**29.06**
Level 2	45545	458	4235.69	1594.08	60.70	455.45	45.55	0	13.10	6391.5	**63.91**
Level 3	42165	458	3921.35	1475.78	82.79	421.65	42.17	0	13.10	5943.7	**59.44**
Level 5	31525	458	2931.83	1103.38	50.20	315.25	31.53	0	13.10	4432.2	**44.32**
Level 6	27720	678	2577.96	970.20	47.40	277.20	27.72	0	19.39	3900.5	**39.00**
Level 7	27760	678	2581.68	971.60	35.83	277.60	27.76	0	19.39	3894.5	**38.94**
Level 8 (roof)	45545							4235.69		4235.7	**42.36**
TOTALS	**248905**	**2900**	**18146.16**	**6829.2**	**346.99**	**1951.2**	**195.12**	**4235.7**	**82.94**		

W_T = 31787.3 kips

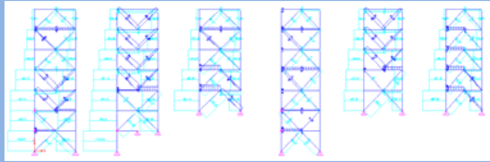
Base Shear = 317.04 kips

Presentation Outline:

- ➢**Existing Building**
- ➢**Thesis Proposal & Goals**
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
  - ➢**Design loads & Connections**
- ➢**Additional Considerations** (Breadths)
  - ➢**Acoustical conflicting spaces**
  - ➢**Architectural vs. acoustical**
  - ➢**Vibration of hospital floor systems**
  - ➢**Cost Comparisons**
- ➢**Overall System Conclusions**
  - ➢**Revisit proposed system advantages & disadvantages**
  - ➢**Design limitations**
- ➢**Acknowledgments**

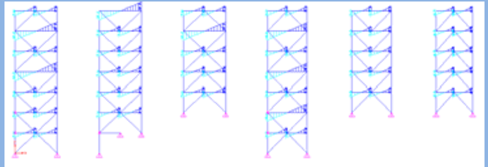
Full gravity and calculated lateral loads for connection designs

Axial Loads generated



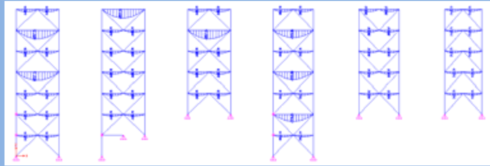
Compressive   Tensile

Shears generated



Positive   Negative

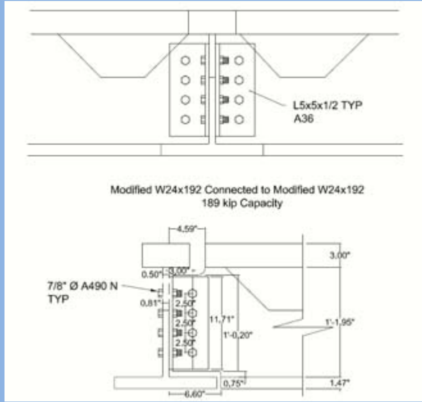
Moments generated



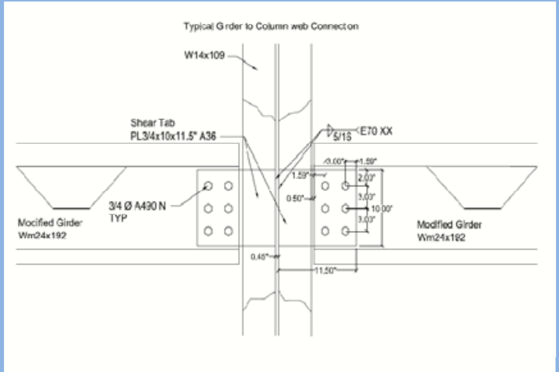
Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
  - ➢**Design loads & Connections**
- ➢**Additional Considerations** (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

Double Angle
Modified Girder to Modified Girder



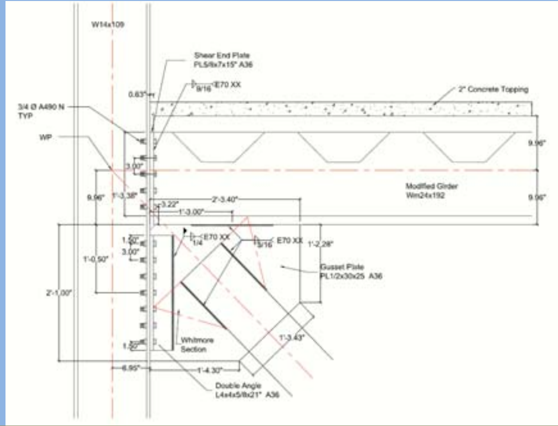
Extended Shear Tab
Modified Girder to Column Web



Presentation Outline:

- ➢**Existing Building**
- ➢**Thesis Proposal & Goals**
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
  - ➢**Design loads & Connections**
- ➢**Additional Considerations** (Breadths)
  - ➢**Acoustical conflicting spaces**
  - ➢**Architectural vs. acoustical**
  - ➢**Vibration of hospital floor systems**
  - ➢**Cost Comparisons**
- ➢**Overall System Conclusions**
  - ➢**Revisit proposed system advantages & disadvantages**
  - ➢**Design limitations**
- ➢**Acknowledgments**

Column to Modified Girder to HSS Brace



Presentation Outline:

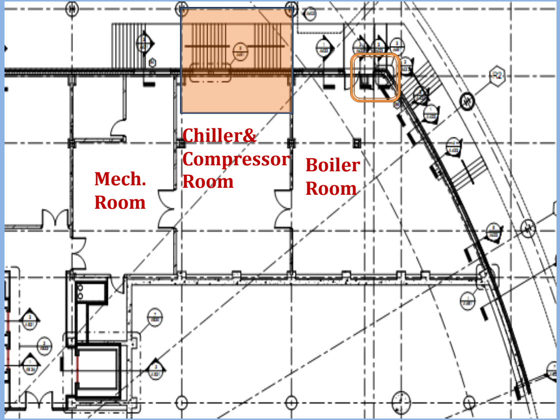
- ➢**Existing Building**
- ➢**Thesis Proposal & Goals**
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
- ➢**Additional Considerations** (Breadths)
  - ➢**Acoustical conflicting spaces**
  - ➢**Architectural vs. acoustical**
  - ➢**Vibration of hospital floor systems**
  - ➢**Cost Comparisons**
- ➢**Overall System Conclusions**
  - ➢**Revisit proposed system advantages & disadvantages**
  - ➢**Design limitations**
- ➢**Acknowledgments**

BHS Butler Health System

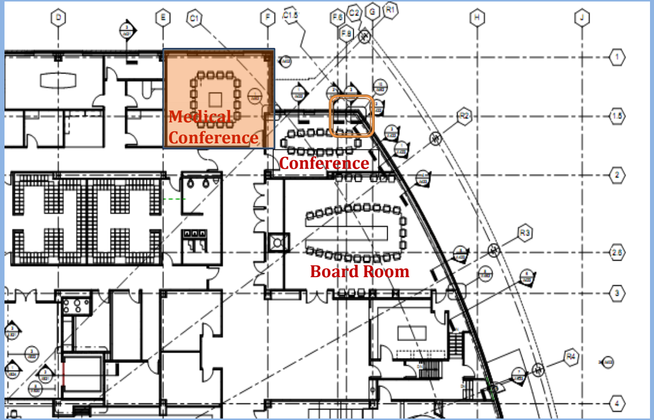
Building for the Future: A New Era Begins

Conflicting Spaces

Level 1



Level 2



Presentation Outline:

- ➢**Existing Building**
- ➢**Thesis Proposal & Goals**
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
- ➢**Additional Considerations** (Breadths)
  - ➢**Acoustical conflicting spaces**
  - ➢**Architectural vs. acoustical**
  - ➢**Vibration of hospital floor systems**
  - ➢**Cost Comparisons**
- ➢**Overall System Conclusions**
  - ➢**Revisit proposed system advantages & disadvantages**
  - ➢**Design limitations**
- ➢**Acknowledgments**

Receiver Room Sound Correction As Designed

Hz	63	125	250	500	1000	2000	4000	8000
Max. dB Build up	80 +9	75 +9	92 +9	88 +9	90 +9	87 +9	79 +9	67 +9
total A weighting	89 -25	84 -15	101 -8	97 -3	99 +0	96 +1	88 +1	76 +1
A weighted adjusted	64	69	93	94	99	97	89	75
TOTAL (dBA)	64	70	93	95	100	102	102	**102**

Floor Systems Effectiveness Comparison

As Designed	Proposed
25≥105-51=54	25≥105-57=48
25<54 NOT ACCEPTABLE	25<48 NOT ACCEPTABLE

Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢**Acoustical conflicting spaces**
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

Receiver Room Sound Correction As Designed

Hz	63	125	250	500	1000	2000	4000	8000
Max. dB	80	75	92	88	90	87	79	67
Build up	+9	+9	+9	+9	+9	+9	+9	+9
total	89	84	101	97	99	96	88	76
A weighting	-25	-15	-8	-3	+0	+1	+1	+1
A weighted adjusted	64	69	93	94	99	97	89	75
TOTAL (dBA)	64	70	93	95	100	102	102	102

Floor Systems Effectiveness Comparison

As Designed	Proposed
25≥105-51=54	25≥105-57=48
25<54 NOT ACCEPTABLE	25<48 NOT ACCEPTABLE

Receiver Room Sound Correction with Acoustical Barrier

Hz	63	125	250	500	1000	2000	4000	8000
Max. dB	80	75	92	88	90	87	79	67
Build up	+6	+6	+6	+6	+6	+6	+6	+6
total	86	81	98	94	96	93	85	73
(+A)	+1	+0	-1	-2	-3	-4	-5	-5
(+B)	-9	-9	-9	-9	-9	-9	-9	-9
total	78	72	88	83	84	80	71	59
Art composite TL	-	-10	-12	-16	-21	-26	-32	-
total	-	62	76	67	63	58	39	-
A weighting	-25	-15	-8	-3	+0	+1	+1	+1
A weighted adjusted	-	47	68	64	63	59	40	-
TOTAL (dBA)	-	47	68	69	70	70	70	70

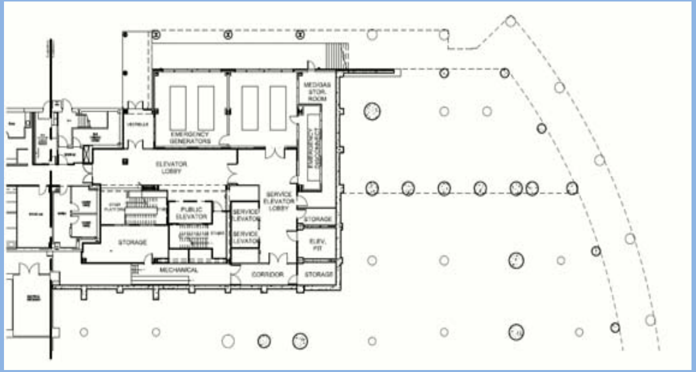
Floor Systems Effectiveness Comparison with Sound Barrier

As Designed	Proposed
25≥73-51=22	25≥73-57=16
25>22 ACCEPTABLE	25>16 ACCEPTABLE

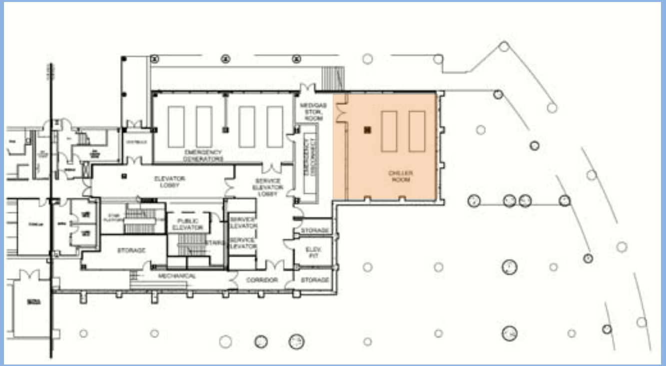
Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢**Architectural vs. acoustical**
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

As Designed Ground Level



Proposed Ground Level



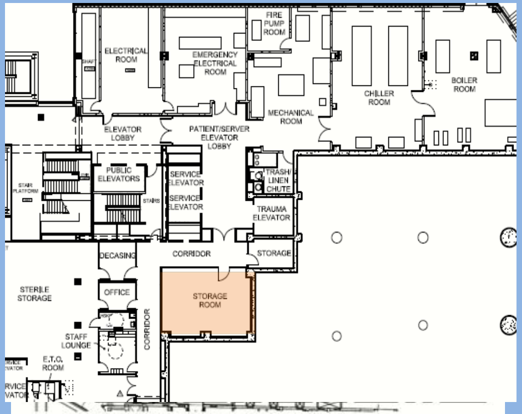
Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢**Architectural vs. acoustical**
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

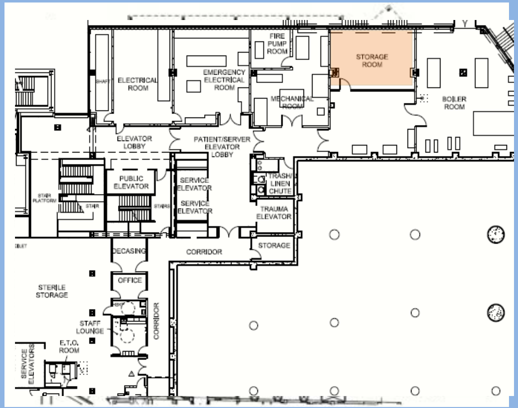
BHS BUTLER HEALTH SYSTEM

Building for the Future: A New Era Begins

As Designed Level 1



Proposed Level 1



Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

BHS Butler Health System

Building for the Future: A New Era Begins

Acoustical Treatment VS. Architectural Redesign

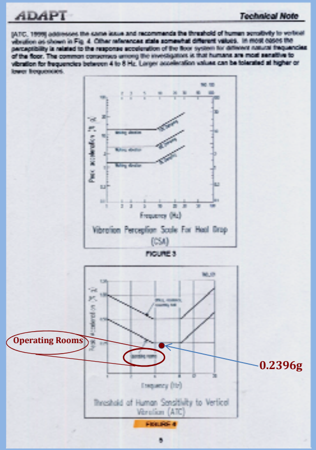
Acoustical Considerations	Estimated Cost ($)	Redesign Considerations	Estimated Cost ($)
Sound Barrier	7,500.00	Excavation of 8400ft^3	1440.00
Adhesive	450.00	Additional 60′ of Foundation Walls (Ground)	25,645.00
Labor	15,840.00	Additional 44′ of 8" Reinforced CMU Wall	4818.00
		Additional Slab On Grade	9800.00
		Less 5 Columns @15′	-6263.00
		Additional 2 sets of double doors	6000.00
		Additional 30′ of interior wall for storage area	1200.00
		Less 54′ of Foundation Wall (1st)	-23,528.00
		Mechanical Considerations (pipes, ducts, sprinkler)	3500.00
TOTAL	**23,790.00**	TOTAL	**22,612.00**

Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢**Vibration of hospital floor systems**
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments

BHS Butler Health System

Building for the Future: A New Era Begins



Floor Excitation Analysis

Sources: PCI & ADAPT

Assumptions:

Po= weight of an individual = 150lb

β= 0.05 (TN209)

Calculated Values:

W= weight of the floor section = 107.5k

f_n =fundamental natural frequency = 5.2Hz

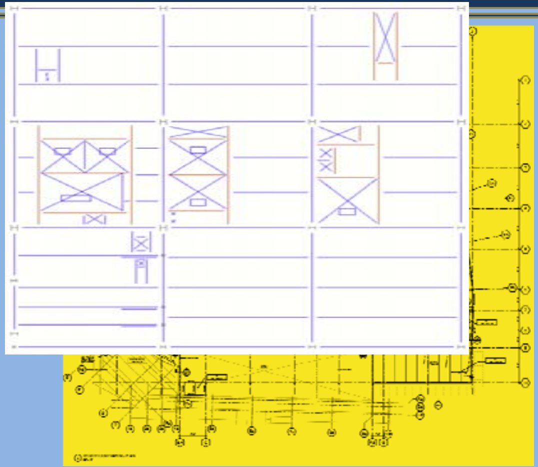
$$a = [P_o e^{(-0.35 * f_n)} / \beta W] g \leq 0.25\% g$$

a = 0.2396g OK

Table 4.22: Construction Management Cost Comparison Based on section of Level 3
Total square feet = 22,080

Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
  - ➢Acoustical conflicting spaces
  - ➢Architectural vs. acoustical
  - ➢Vibration of hospital floor systems
  - ➢Cost Comparisons
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
- ➢Acknowledgments



Cost Comparison of Structural Systems

As Designed	Estimated Cost ($)	Proposed	Estimated Cost ($)
		Licensing Fee	206,000
Columns (42 @ 69kips) Labor to install	3500	Columns (42 @ 82.8kips) Labor to install	3500
Fabrication	411,337	Fabrication	1,319,640
Girders (37 @ 45.7kips) Labor to install	3500	Girders (37 @ 203.3kips) Labor to install	3500
Beams (121 @ 102.7kips) Labor to install	10,500	Beams (40 @ 116.2kips) Labor to install	3500
Connections (336)	252,000	Connections (142)	106,500
Shear studs & decking (2177) & (22,080ft^2)	135,667	Shear studs (175)	347
Concrete forming & placement 3pours @ 7360ft^2 ea.	155,142	Hollow-core slab & install	234,048
		Opening & grouting HCS	44,160
		2" Concrete topping	34,707
Fireproofing (200 full members)(Total feet=4649)	19,850	Fireproofing (119 members) (Total feet=2150)	5850
TOTAL	991,400	TOTAL	1,755,800
		DIFFERENCE	764,400

Presentation Outline:

- Existing Building
- Thesis Proposal & Goals
- **Redesigned Gravity System** (Depth Study)
- **Connecting the Members** (MAE)
- **Additional Considerations** (Breadths)
- Overall System Conclusions
  - **Revisit proposed system advantages & disadvantages**
  - Design limitations
  - Final Summary & Conclusions
- Acknowledgments

Disadvantages:

- Large lead times with this type of system
- Girders and columns would need fireproofing
- Much more efficient and cost effective at shorter spans
- Column spacing may have to be reduced, increasing footing requirements
- Floor penetrations must be well coordinated with the slab designer/manufacture

Advantages:

- **Easy & fast to install**
- The lateral system can still be utilized
- No formwork required and concrete slabs are already at usable capacity when they arrive
- **No intermediate beams in interior of bays needed**
- **Can be installed in any type of weather**
- **Other trades can start work underneath almost immediately**
- Additional unobstructed ceiling space for MEP's.
- Meets or exceeds floor fireproofing requirements
- Reduce noise transmission from floor to floor through baffled cavities
- No increase in floor to floor heights
- **Reduces overall weight of the structure**

Presentation Outline:

- ➢**Existing Building**
- ➢**Thesis Proposal & Goals**
- ➢**Redesigned Gravity System** (Depth Study)
- ➢**Connecting the Members** (MAE)
- ➢**Additional Considerations** (Breadths)
- ➢**Overall System Conclusions**
  - ➢**Revisit proposed system advantages & disadvantages**
  - ➢**Design limitations**
  - ➢**Final Summary & Conclusions**
- ➢**Acknowledgments**

Limiting Factors

Large Opening Sizes

Dimension Between Top Bar & Bottom Flange

Hollow-core Plank Span

Presentation Outline:

- ➢Existing Building
- ➢Thesis Proposal & Goals
- ➢Redesigned Gravity System (Depth Study)
- ➢Connecting the Members (MAE)
- ➢Additional Considerations (Breadths)
- ➢Overall System Conclusions
  - ➢Revisit proposed system advantages & disadvantages
  - ➢Design limitations
  - ➢**Final Summary & Conclusions**
- ➢Acknowledgments

BHS Butler Health System

Building for the Future: A New Era Begins

Use of Proposed System in a Hospital Building

- ➢Large openings required
- ➢Increased structural costs
- ➢Extra space in ceiling cavity desired (not reduced)
- ➢System inflexibility

Theoretically possible; NOT PROBABLE

Use of Proposed System in Other Structure Types

- ➢Can reduce floor to floor depths by 1' - 1.5'
  - ➢Without reducing open unobstructed ceiling cavity space
  - ➢ Reduces costs associated with façade, elevators, stairs, MEP runs, column lengths and sizes, bracing length and sizes, interior partition wall heights, fireproofing, Heating & cooling costs.
- ➢Better acoustical and vibration aspects

POSSIBLE & PROBABLE

Presentation Outline:

- Existing Building
- Thesis Proposal & Goals
- **Redesigned Gravity System** (Depth Study)
- **Connecting the Members** (MAE)
- **Additional Considerations** (Breadths)
- Overall System Conclusions
- **Acknowledgements**

Butler Health System: Owner

Turner Construction: Construction Manager
Kurt Johnson – Project Manager
William Beck – Project Superintendent
Megan Wortman – Field Engineer

HGA: Design Architect, Structural, Mechanical, Electrical Engineer
Johanna H. Harris P.E. – Associate Vice President
Jonathan Wacker

Girder-Slab: Daniel G. Fisher Sr. – Managing Partner
Peter Naccarato P.E. – Engineer

Pennsylvania State University: Department of Architectural Engineering
Dr. Ali Memari, Ph.D., P.E., – Thesis Advisor
Louis F. Geschwindner Jr., Ph.D., P.E.
Professor Emeritus
AISC Vice President, Special Projects
M. Kevin Parfitt, P.E. – Thesis Faculty Director
Faculty & Staff

Family & Friends

Presentation Outline:

Questions / Comments


30.12.2009 16:05


30.12.2009 16:13


CAT