Library In Metropolitan Washington, D.C.

Penn State Architectural Engineering Senior Capstone Project

Lowell Stine | Construction | Rob Leicht

Outline

Picture Provided by Multivista

Project Introduction

Outline

Building Name: Library in Metropolitan Washington, D.C.

Location: Metropolitan Washington, D.C. (Undisclosed)

Occupant: County Library & Non-profit Art Group

Function Types: A-3 (Assembly)
B (Business)
M (Mercantile)

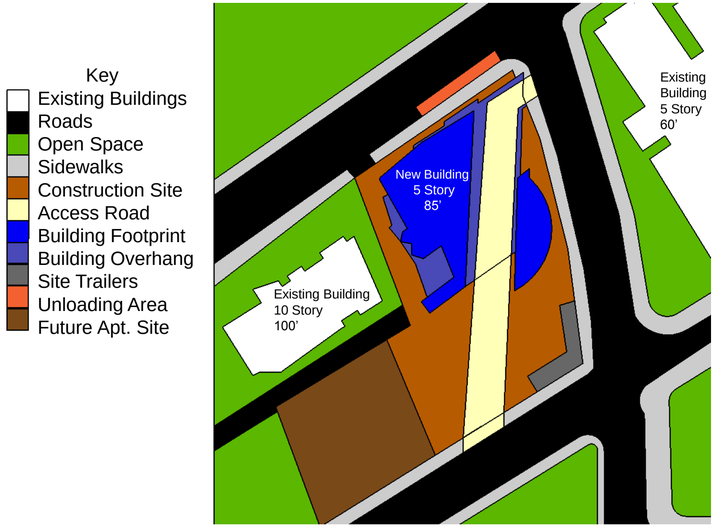
Gross Area: 90,000 ft^2

Number of Stories: Five Plus Basement

Project Delivery: Design-Bid-Build

Construction Dates: January 2013 – October 2014

Project Cost: $69.5 Million



Project Team

Owner:
Undisclosed County

Construction Manager:
MBP

Civil Engineer:
ADTEK

Architect:
The Lukmire Partnership

Mechanical & Plumbing Engineer:
Mendoza, Ribas, Farinas & Associates

Landscape Architect:
Parker Rodriguez

Contractor:
Costello Construction

Electrical Engineer:
Mendoza, Ribas, Farinas & Associates

Interior Design:
The Studio of Sandra Ragan

Structural Engineer:
Columbia Engineering

IT/Security:
Wright Engineering

Lighting Consultant:
MCLA

Project Introduction

Outline

Systems

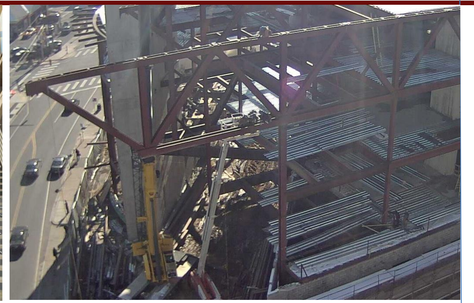
Architectural:
- 50’ Cantilever of 3rd thru 5th Floors
- Exposed Structure in Library Space

Structure:
- Concrete Caissons
- Structural Steel
- Composite Slabs

Building Enclosure:
- 53% Curtain Wall – UV Protection
- Terra Cotta Panels
- Architectural CMU’s

Mechanical:
- IPEC (Integrated Packages Equipment Center)
- Hydronic In-Slab Heating

Picture Courtesy of The Lukmire Partnership, Inc.



Picture Provided by Multivista

Picture Provided by http://www.systecon.com

Analysis Overview

Outline

Measurable Success

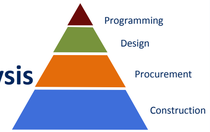
1) Minimize costs and schedule delays from change orders and rework

2) Minimize wasted material and labor costs and limit schedule delays

3) Shorten structural erection durations

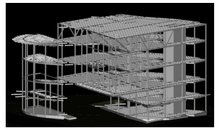
4) Cost effectiveness and fewer constructability challenges

Early Involvement in Design Research Analysis

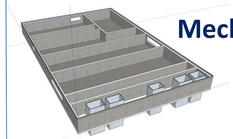


Caisson Rebar Cage Fabrication Analysis

Structural Sequencing Analysis



Structural Breadth



Mechanical Penthouse vs. IPEC Analysis

Acoustical Breadth

Design

↓

Foundation

↓

Structure

↓

Building Systems

Outline

Early Involvement in Design Research Analysis

Early Involvement in Design Research Analysis

Outline

Goal

Considerations / Requirements
Specifics of this Project
Typical Problem Areas

Early Involvement in Design Research Analysis

Outline

Goal

Considerations / Requirements
Specifics of this Project
Typical Problem Areas

Industry Member Interviews

Scopes
Benefits
Owner Buy-in
Future

Similar Topics		
#	Criteria	Consistency
1	Owner Buy-in	5 of 5
2	Cost Considerations	5 of 5
3	Scope Included	5 of 5
4	Relationship Outcomes	4 of 5
5	Quality & Project Flow	4 of 5
6	Schedule Considerations	4 of 5
7	Contract Considerations	3 of 5
8	Owner Involvement	3 of 5
9	Future of Early Involvement	3 of 5

Early Involvement in Design Research Analysis

Outline

Goal

Considerations / Requirements
Specifics of this Project
Typical Problem Areas

Industry Member Interviews

Scopes
Benefits
Owner Buy-in
Future

Mind Maps

Show Topics
Trace Patterns

Similar Topics		
#	Criteria	Consistency
1	Owner Buy-in	5 of 5
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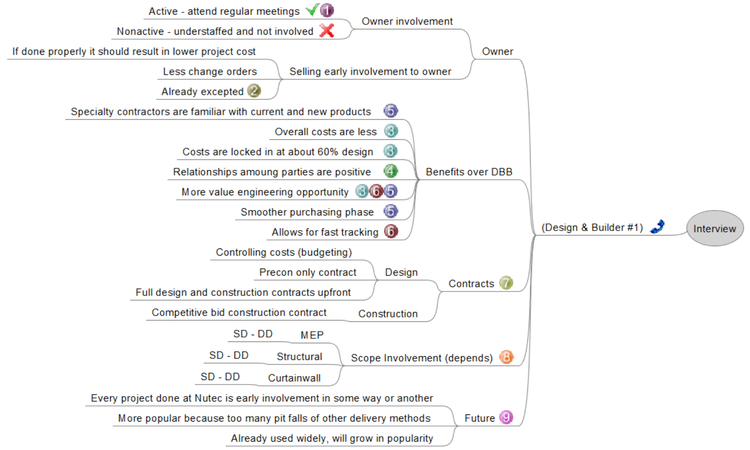
Mind Maps



Early Involvement in Design Research Analysis

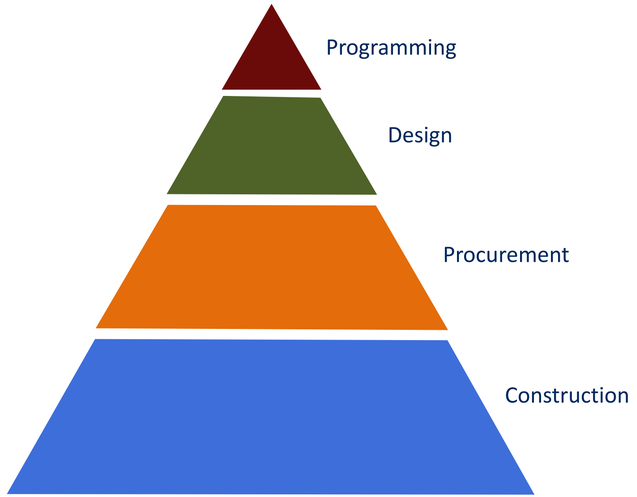
Outline

Overall Conclusions

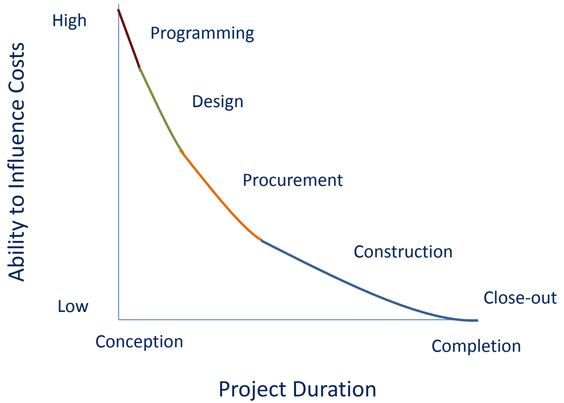
Smooth Transition Between Phases

Early Cost Influence

Process Flow



Influence of Cost Curve



Early Involvement in Design Research Analysis

Outline

Results

Earlier Involvement is Beneficial

Less Change Orders

Cost Savings

Funding Issues

Scope Selection (Project Specific)

Scope Inclusion Areas

Scopes	Program	Conceptual	Schematic Design	Design Development	Construction Documents	Construction
Contractor	Start-up	Scope Selection & Sign Contract	Sub Selection & Design Input	Sub Selection & Design Input	Design Input & Long Lead Items	Management
MEP	-	Planning, Questions & Sign Contract	Consult w/ Subs	Design Input	Design Input & Long Lead Items	Procurement
Structural	-	-	-	Consult w/ Subs, Design Input & Sign Contract	Design Input & Long Lead Items	Procurement
Curtain Wall	-	-	Consult w/ Subs & Sign Contract	Design Input	Design Input & Long Lead Items	Procurement

Rating Scale

	Owner	CM	Contractor	Design Team
Funding	X	-	-	-
Resources Available	✓	✓	✓	✓
Experience	✓	✓	X	✓

Outline

Caisson Rebar Cage Fabrication Analysis

Caisson Rebar Cage Fabrication Analysis

Outline

Goal

Determine Appropriate Fabrication Method
Cost Savings
Scheduled Reduction

Picture Provided by Multivista

Caisson Rebar Cage Fabrication Analysis

Outline

Goal

Determine Appropriate Fabrication Method
Cost Savings
Scheduled Reduction

Background

9 Caisson Types (48 Total)
Prefab to Planned Length
Planned Lengths Incorrect
15 Day Delay

Caisson Types						
Type	Vertical Rebar #	Qty. of Vertical Rebar	Tie #	# of Ties per LF	Weight of Vertical Rebar (lb/LF)	Weight of Ties (lb/LF)
1a	9	8	4	1	27	6
1b	9	6	4	1	20	6
2a	11	8	4	1	43	9
2b	11	12	4	1	64	11
2c	11	16	4	1	85	13
2d	11	24	4	1	128	15
2e	11	28	5	1	149	21
2f	11	16	4	2	85	27
2g	11	28	5	2	149	41

Picture Provided by Multivista

Caisson Rebar Cage Fabrication Analysis

Outline

Goal

Determine Appropriate Fabrication Method
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Scheduled Reduction

Background

9 Caisson Types (48 Total)
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15 Day Delay

Fabrication Methods

100% Planned
Planed + 10%
80% of Planned
10’ Sections
15’ Sections

Caisson Types						
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Picture Provided by Multivista

Caisson Rebar Cage Fabrication Analysis

Outline

Results

30’ Max Cage Length

Picture Provided by www.rebarsuply.net

Caisson Rebar Cage Fabrication Analysis

Outline

Results

30’ Max Cage Length

Truck Crane Installation

Concrete Pump Placement

Picture Provided by www.rebarsuply.net

Picture Provided by Multivista

Caisson Rebar Cage Fabrication Analysis

Outline

Results

30’ Max Cage Length

Truck Crane Installation

Concrete Pump Placement

High Splice Costs

Cut-off Higher Productivity

Picture Provided by http://news.thomasnet.com/

Picture Provided by www.rebarsuply.net

Picture Provided by Multivista

Caisson Rebar Cage Fabrication Analysis

Outline

Results

30’ Max Cage Length

Truck Crane Installation

Concrete Pump Placement

High Splice Costs

Cut-off Higher Productivity

Use 100% Prefabricated Method

Accept Unknowns

Prefabrication Option Comparison

Caisson Types	Base Line	Over 10% Prefab Estimation	Prefab 80% of Estimation	10’ Length Sections	15’ Length Sections
1a	$ 1,207.13	$ 2,018.26	$ 580.70	$ 2,545.31	$ 1, 040.01
1b	$ 1,756.59	$ 2,059.49	$ 993.63	$ 579.61	$ 285.71
2a	$ 2,313.82	$ 2,827.37	$ 1,856.53	$ 3,661.62	$ 1,512.15
2b	$ 1,845.69	$ 2,300.02	$ 937.03	$ 2,177.57	$ 260.10
2c	$ -	$ -	$ -	$ 2,022.40	$ 1,011.20
2d	$ 1,516.80	$ -	$ 1,516.80	$ 3,033.60	$ 1,516.80
2e	$ 12,484.19	$12,139.79	$ 13,377.24	$ 33,762.24	$ 15,289.27
2f	$ -	$ 243.22	$ 3,024.00	$ 3,725.88	$ -
2g	$ 1,827.72	$ 2,183.29	$ 1,116.59	$ -	$ 808.19
Grand Totals	**$ 22,951.94**	**$ 32,329.00**	**$ 23,402.52**	**$ 51,508.23**	**$ 21,723.43**

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Outline

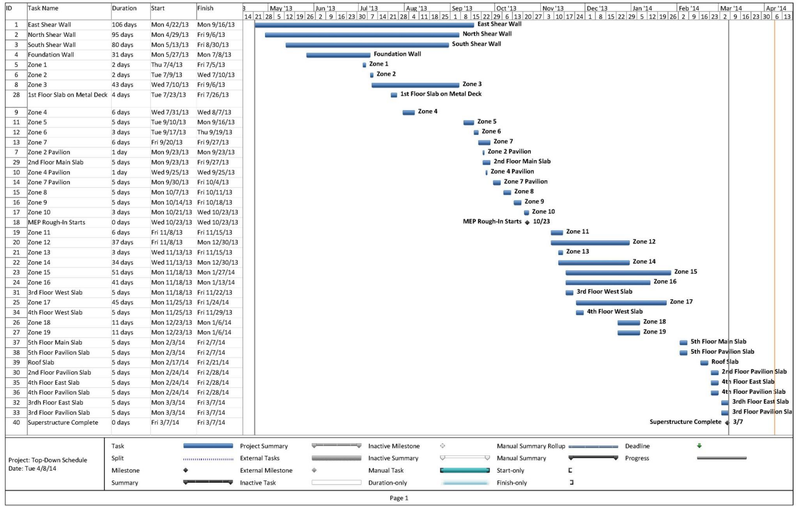
Structural Sequencing Analysis

Structural Sequencing Analysis

Outline

Goal

Reevaluate Structural Sequence
Save Erection Costs
Shorten Erection Schedule



Structural Sequencing Analysis

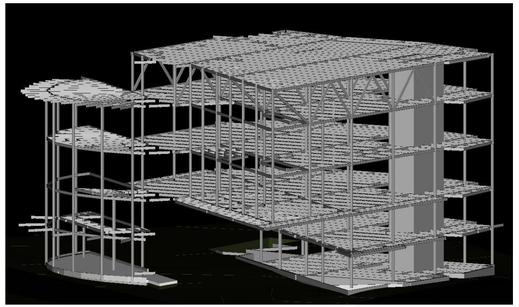
Outline

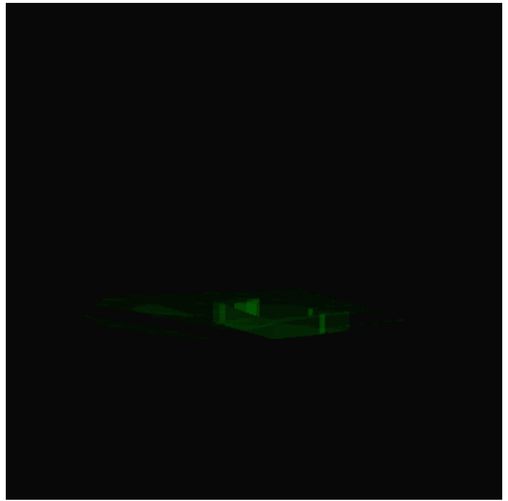
Goal

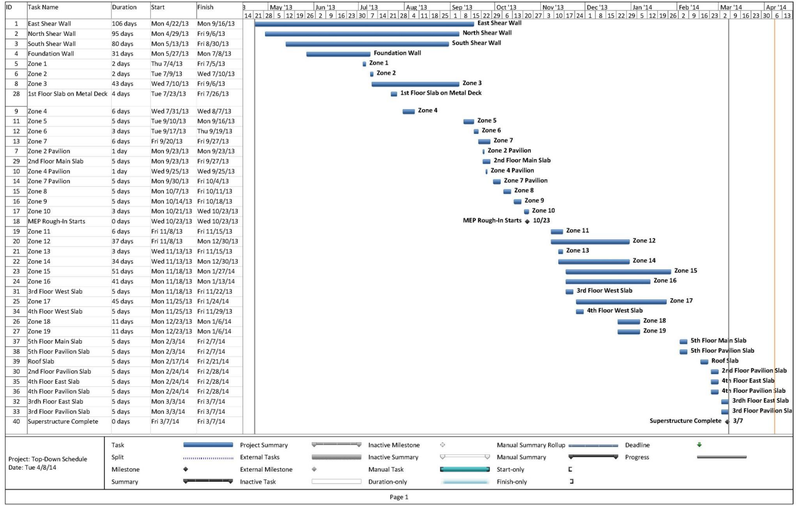
Reevaluate Structural Sequence
Save Erection Costs
Shorten Erection Schedule

Background Information

Current Erection
Complex Erection Sequence
5 Week Delay



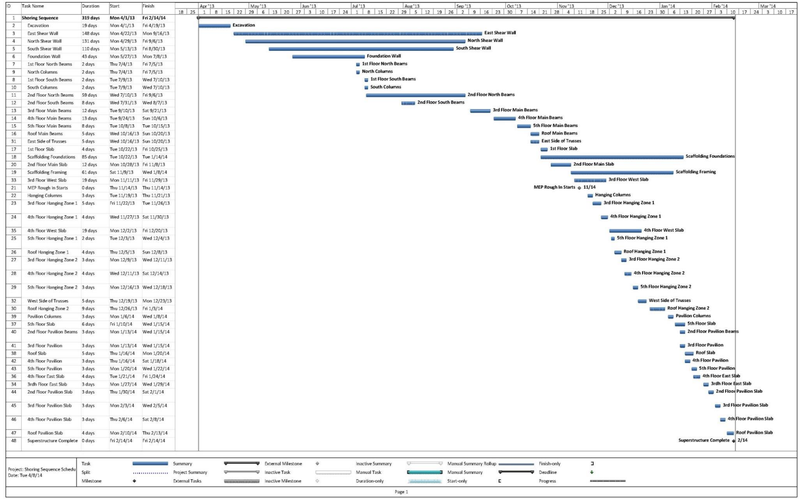




Outline

Shoring Sequence

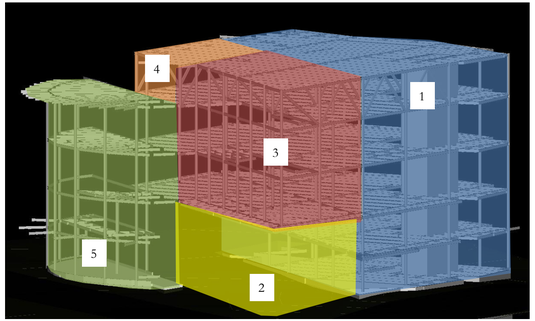
Linear

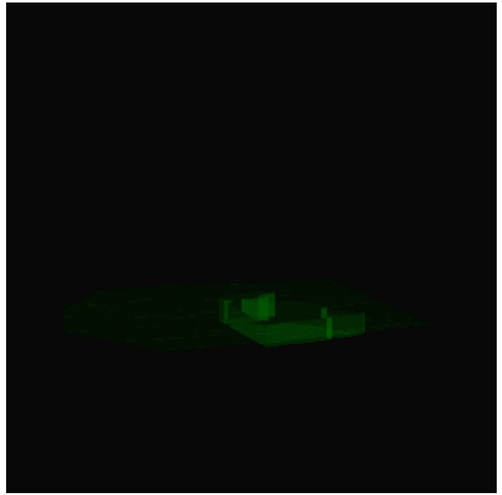


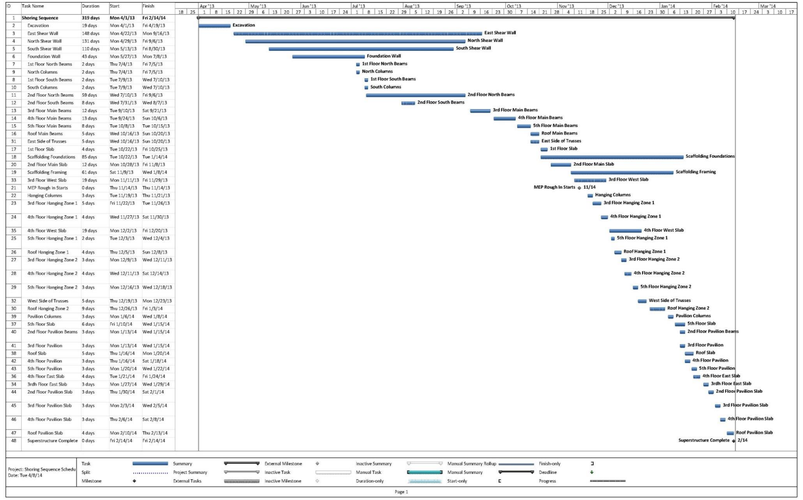
Outline

Shoring Sequence

Linear
4-D Comparisons
Slabs After Shoring
Hanger Resizing?







Outline

Complexity of Erection

Complex structure
Inconsistent erection sequence

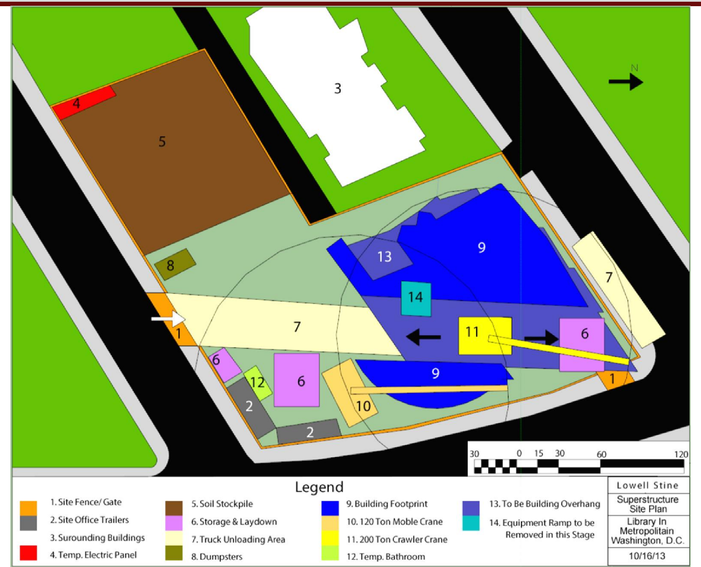
Outline

Complexity of Erection

Complex structure
Inconsistent erection sequence

Site

Very urban site
Shoring will occupy large area
Tight delivery scheduling



Structural Sequencing Analysis

Outline

Complexity of Erection

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Very urban site
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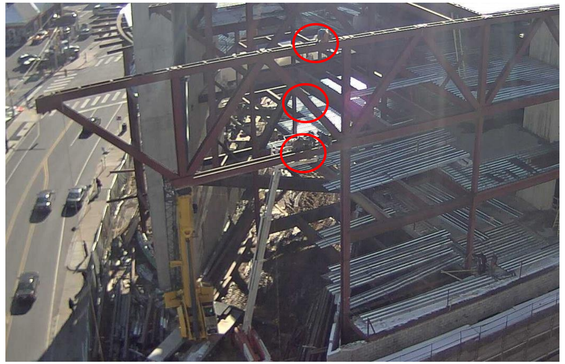
Tight delivery scheduling

Safety

High priority
Dangerous welding locations
OSHA compliance



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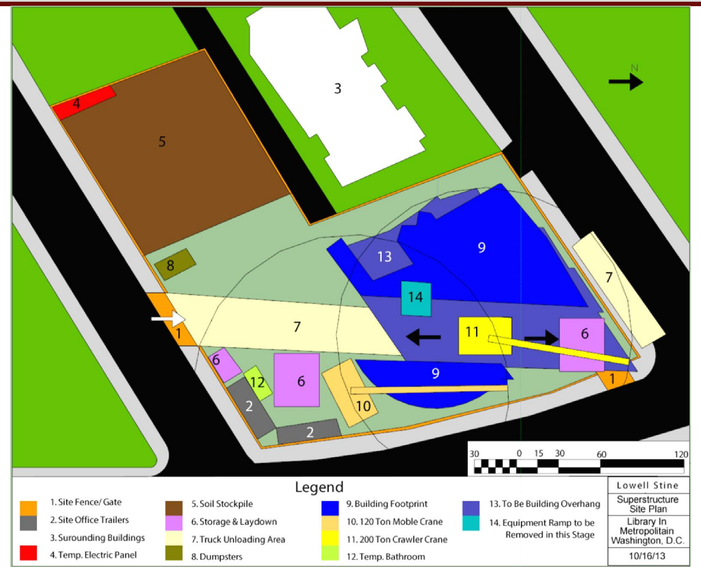

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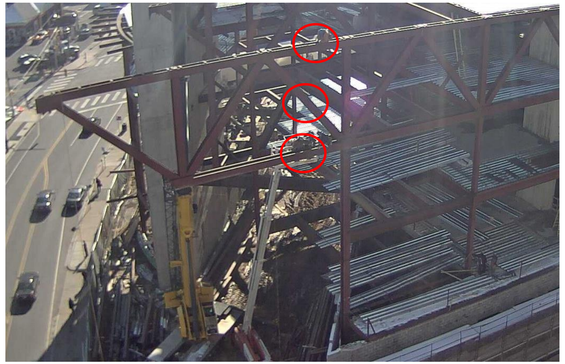
OSHA compliance

Trade Integration

Delay of MEP rough-in start-up

MEP Rough-in Start Dates		
Description	Top-Down Option	Shoring Option
MEP Rough-in Start	10/23/13	11/14/13



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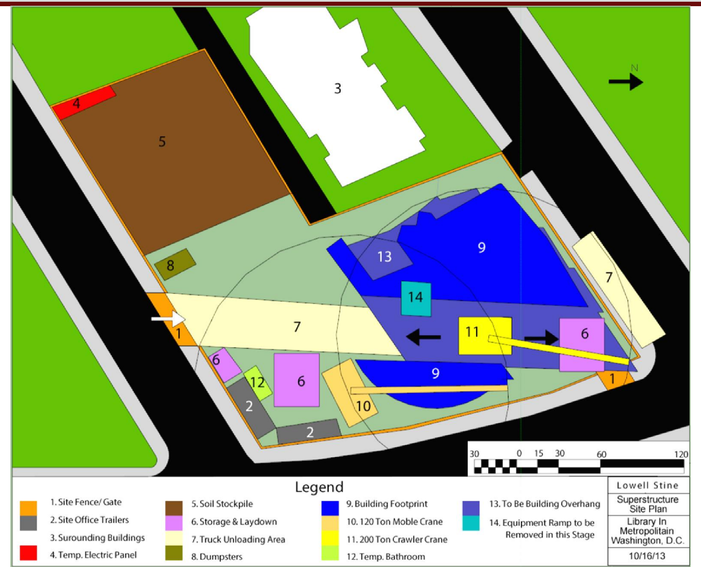

Structural Breadth - Shoring Design

Outline

Required Shoring Load

Dead Loads
Live Loads
P_u= 291 psf

$$L = L_0 \times \begin{cases} 0.4 \\ 0.25 + \dfrac{15}{\sqrt{K_{LL} A_T}} \end{cases}$$

$$P_u = 1.2D + 1.6L$$

Structural Breadth - Shoring Design

Outline

Required Shoring Load

Dead Loads
Live Loads
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Picking Shoring System

Mabey's Mass Series
Shoring Towers

Picture Provided by Mabey Inc.

mabey
rent the right way

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Picking Shoring System

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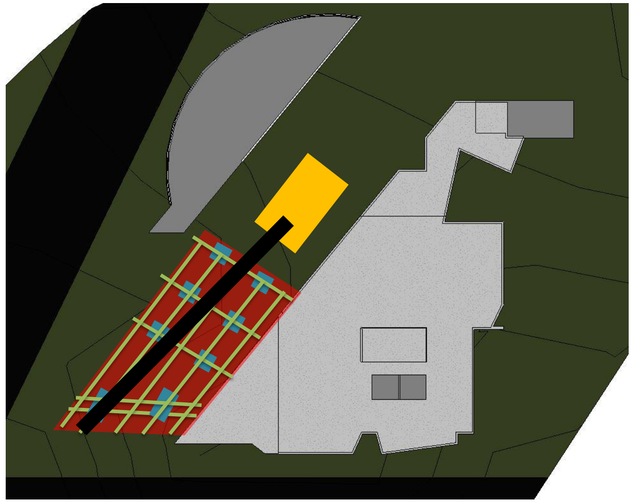
Finalize Shoring Design

Mass 25 - 100 kips
Space at 20'x18'
(16) 5'x5' & (2) 5'x10'



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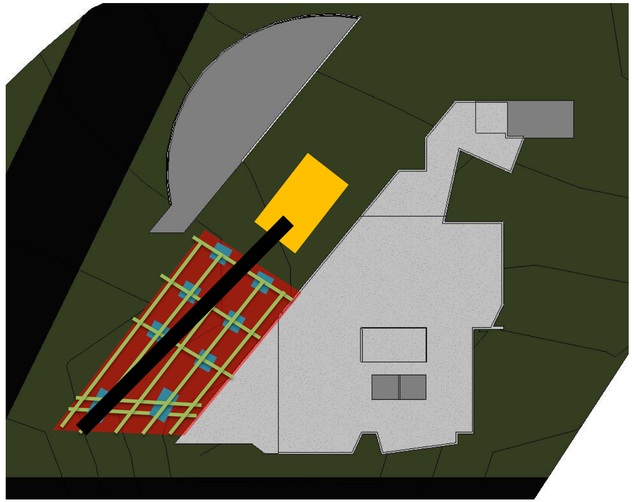
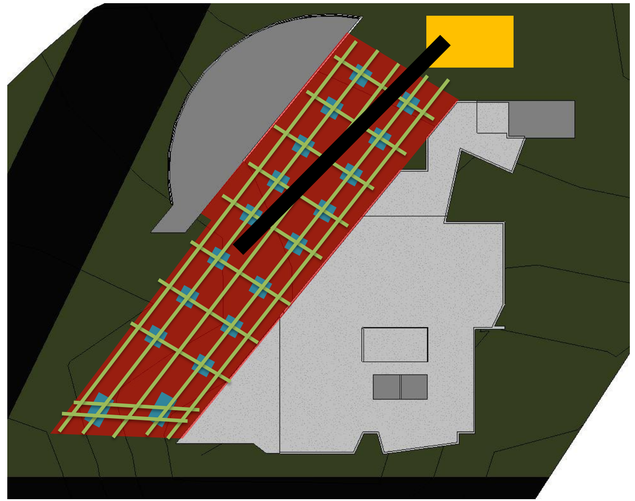




Structural Sequencing Analysis

Outline

Results

3 Week Schedule Savings (with shoring install)

$30,000 Savings

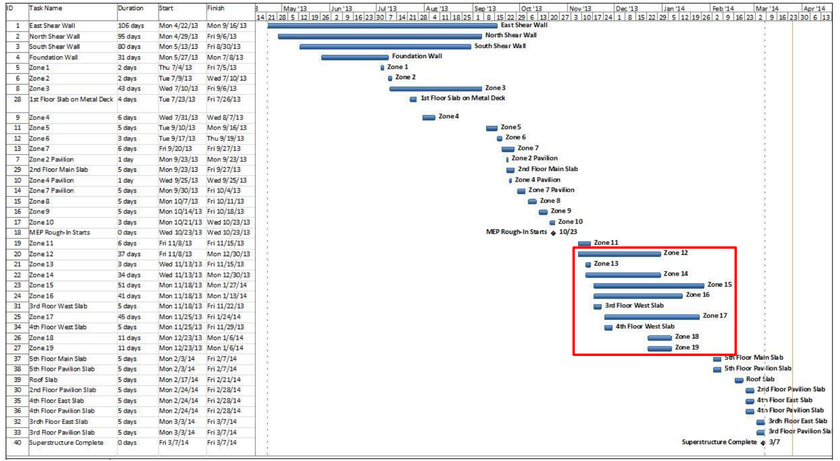
Better Productivity (Specific Zones)

Recommend the Shoring Sequence

IPEC vs. Mechanical Penthouse

Criteria & Categories	Top-Down	Shoring
Constructability	x	✓
Schedule	x	✓
Cost	✓	✓
Site	✓	x
Safety	x	✓
Other Trades	x	✓

Zone Delays



Structure Duration Comparisons

Description	Planned	Top-Down Option	Shoring Option
Steel Erection Start	6/25/13	7/4/13	7/4/13
Structure Complete Milestone	1/1/14	3/7/14	2/13/14
Total Duration (weeks)	28	33	30

Shoring Cost Break Down

Description	Per Tower	Total
Minimum First 4 Weeks	$1357	$24,430
Every Week After for 4 Weeks	$828	$14,900
Tax (6%)	$131	$2,360
Total	$2,316	$41,690

Cost Comparisons

Description	Per Tower
General Condition Savings	$72,000
Shoring Costs	$41,690
Total Estimated Costs Savings	**$30,000**

Outline

Mechanical Penthouse vs. IPEC Analysis

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Outline

Goals

IPEC & Penthouse Differences
How to Chose Which to Use
Gain Knowledge of Each

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IPEC & Penthouse Differences
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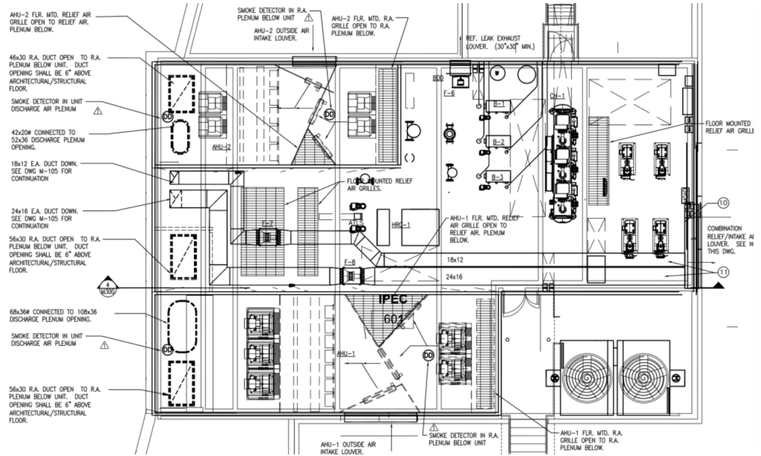
Gain Knowledge of Each

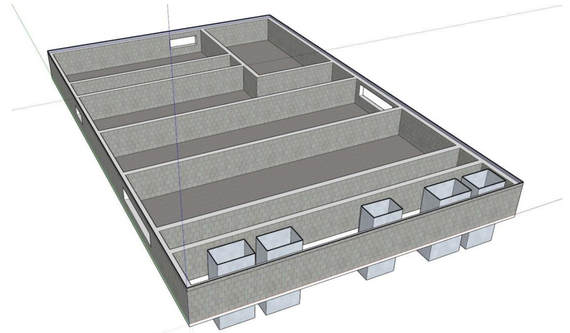
IPEC

Prefabricated Equipment Module
4’ CMU Base Wall
One Supplier



Provided by MBP (Construction Documents Courtesy of MBP)

Integrated Packaged Equipment Center (IPEC)



Mechanical Penthouse vs. IPEC Analysis

Outline

Goals

IPEC & Penthouse Differences
How to Chose Which to Use
Gain Knowledge of Each

IPEC

Prefabricated Equipment Module
4’ CMU Base Wall
One Supplier

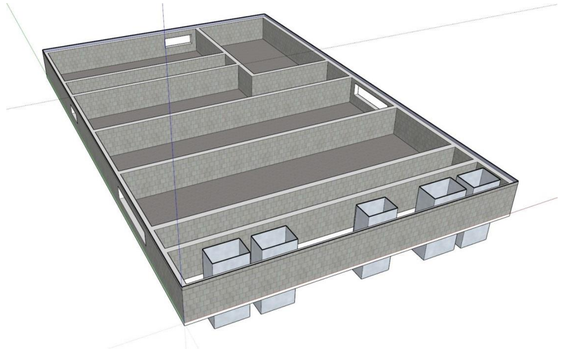
Mechanical Penthouse

Site Constructed
On Concrete Structural Roof
Multiple Different Suppliers

Mechanical Penthouse

Picture Provided by http://www.jetsongreen.com/

Integrated Packaged Equipment Center (IPEC)



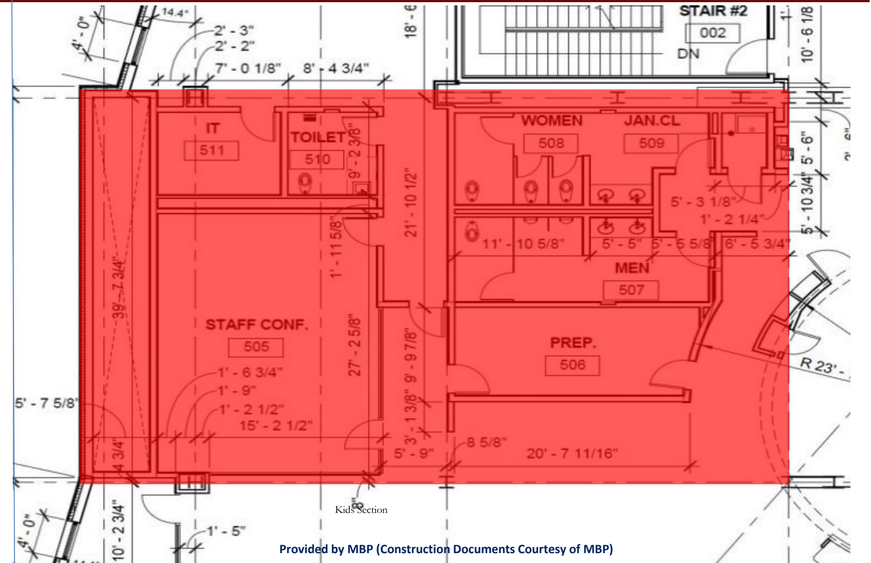
Outline

Acoustical Impacts of IPEC and Penthouse

Library Spaces
Outdoor Environment

Differences

Similar Acoustical Properties
Over Estimates



Provided by MBP (Construction Documents Courtesy of MBP)

Acoustical Breadth

Outline

Acoustical Impacts of IPEC and Penthouse

Library Spaces
Outdoor Environment

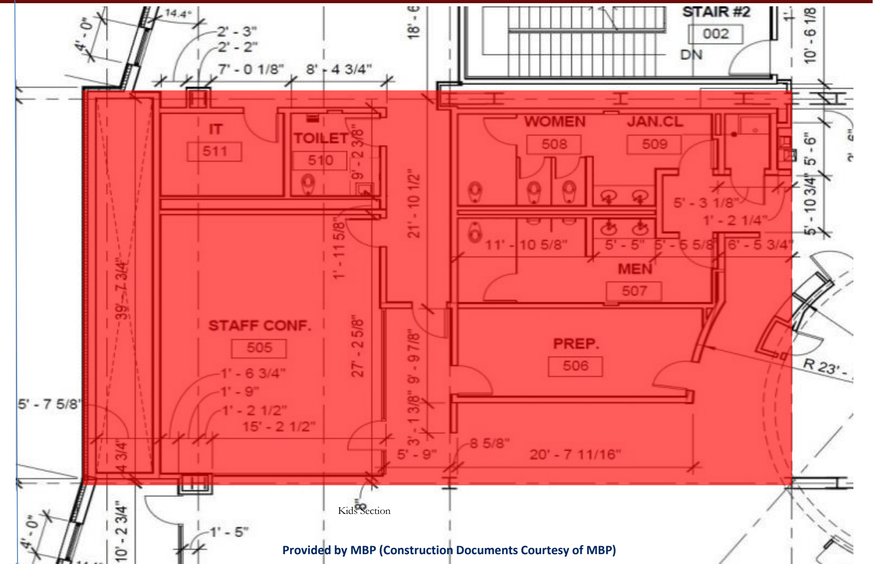
Differences

Similar Acoustical Properties
Over Estimates

Recommendations

IPEC Would Be More Desirable

Noise Levels		
	Limit	Actual
Conference Room	35 dB	37 dB
Property Line	55 dB	57 dB



Provided by MBP (Construction Documents Courtesy of MBP)

Mechanical Penthouse Vs. IPEC Analysis

Outline

Results

1 Week On Site vs. 10.5 Weeks On Site

Potential $1 Million Savings

Flexible Design

Penthouse

Design-Build Package

IPEC vs. Mechanical Penthouse Schedule		
System	Lead Time	Site Install Time
IPEC	1 Long Lead Item (Months)	1 Week
Penthouse	Multiple Shorter Lead Times (Weeks)	10.5 Weeks

IPEC vs. Mechanical Penthouse Costs			
System	Equipment	Enclosure/ Structure	Total
IPEC	$5,800,000	$50,000	$5,850,000
Penthouse	$4,880,000	$100,000	$4,880,000

IPEC vs. Mechanical Penthouse		
Criteria & Categories	IPEC	Penthouse
Acoustical	✓	✓
Maintenance	x	✓
Flexibility in Design	x	✓
Responsibility	✓	✓
Constructability	✓	✓
Costs	x	✓
Schedule	✓	x

Conclusions

Outline

Design (Early Involvement)

↓

Foundation (100% Prefabrication Cage Length)

↓

Structure (Shoring Sequence)

↓

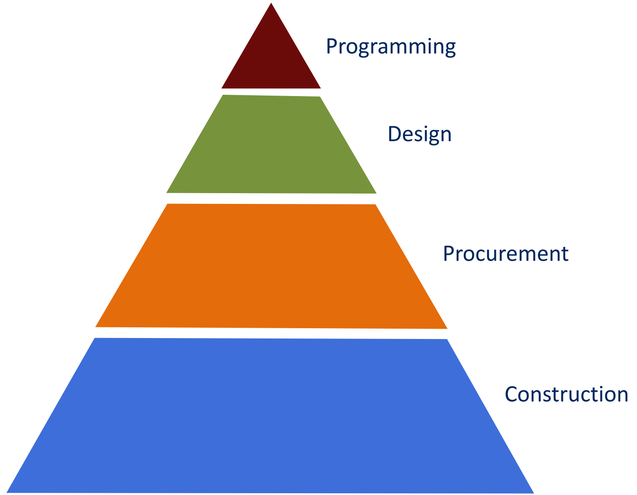
Building Systems (Mechanical Penthouse)

Early Involvement
Undetermined Cost Savings
Undetermined Schedule Savings

100% Prefabrication Cage Length
$0.00 Savings
Account for Caissons in Schedule

Shoring Sequence
$30,000 Savings
3 Week Schedule Savings

Mechanical Penthouse
Possible $1 Million Savings
Additional 9.5 Week Mechanical Schedule



Outline

Academic

Michelle Vigeant
Moses Ling
Dr. Robert Leicht
Kevin Parfitt
Ray Sowers

Special Thanks

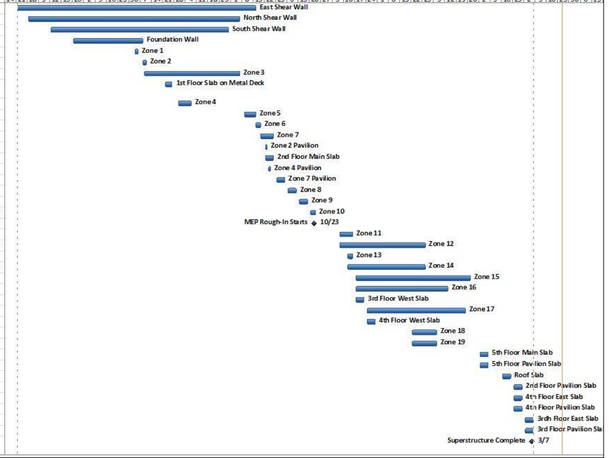
Library's Owner
PACE Industry Members
Matt Strevig
Friends and Family

Questions?

Picture Provided by Multivista

Current Structural Schedule

ID	Task Name	Duration	Start	Finish
1	East Shear Wall	106 days	Mon 4/22/13	Mon 9/16/13
2	North Shear Wall	95 days	Mon 4/29/13	Fri 9/6/13
3	South Shear Wall	80 days	Mon 5/13/13	Fri 8/30/13
4	Foundation Wall	31 days	Mon 5/27/13	Mon 7/8/13
5	Zone 1	2 days	Thu 7/4/13	Fri 7/5/13
6	Zone 2	2 days	Tue 7/9/13	Wed 7/10/13
8	Zone 3	43 days	Wed 7/10/13	Fri 9/6/13
28	1st Floor Slab on Metal Deck	4 days	Tue 7/23/13	Fri 7/26/13
9	Zone 4	6 days	Wed 7/31/13	Wed 8/7/13
11	Zone 5	5 days	Tue 9/10/13	Mon 9/16/13
12	Zone 6	3 days	Tue 9/17/13	Thu 9/19/13
13	Zone 7	6 days	Fri 9/20/13	Fri 9/27/13
7	Zone 2 Pavilion	1 day	Mon 9/23/13	Mon 9/23/13
29	2nd Floor Main Slab	5 days	Mon 9/23/13	Fri 9/27/13
10	Zone 4 Pavilion	1 day	Wed 9/25/13	Wed 9/25/13
14	Zone 7 Pavilion	5 days	Mon 9/30/13	Fri 10/4/13
15	Zone 8	5 days	Mon 10/7/13	Fri 10/11/13
16	Zone 9	5 days	Mon 10/14/13	Fri 10/18/13
17	Zone 10	3 days	Mon 10/21/13	Wed 10/23/13
18	MEP Rough-In Starts	0 days	Wed 10/23/13	Wed 10/23/13
19	Zone 11	6 days	Fri 11/8/13	Fri 11/15/13
20	Zone 12	37 days	Fri 11/8/13	Mon 12/30/13
21	Zone 13	3 days	Wed 11/13/13	Fri 11/15/13
22	Zone 14	34 days	Wed 11/13/13	Mon 12/30/13
23	Zone 15	51 days	Mon 11/18/13	Mon 1/27/14
24	Zone 16	41 days	Mon 11/18/13	Mon 1/13/14
31	3rd Floor West Slab	5 days	Mon 11/18/13	Fri 11/22/13
25	Zone 17	45 days	Mon 11/25/13	Fri 1/24/14
34	4th Floor West Slab	5 days	Mon 11/25/13	Fri 11/29/13
26	Zone 18	11 days	Mon 12/23/13	Mon 1/6/14
27	Zone 19	11 days	Mon 12/23/13	Mon 1/6/14
37	5th Floor Main Slab	5 days	Mon 2/3/14	Fri 2/7/14
38	5th Floor Pavilion Slab	5 days	Mon 2/3/14	Fri 2/7/14
39	Roof Slab	5 days	Mon 2/17/14	Fri 2/21/14
30	2nd Floor Pavilion Slab	5 days	Mon 2/24/14	Fri 2/28/14
35	4th Floor East Slab	5 days	Mon 2/24/14	Fri 2/28/14
36	4th Floor Pavilion Slab	5 days	Mon 2/24/14	Fri 2/28/14
32	3rdh Floor East Slab	5 days	Mon 3/3/14	Fri 3/7/14
33	3rd Floor Pavilion Slab	5 days	Mon 3/3/14	Fri 3/7/14
40	Superstructure Complete	0 days	Fri 3/7/14	Fri 3/7/14

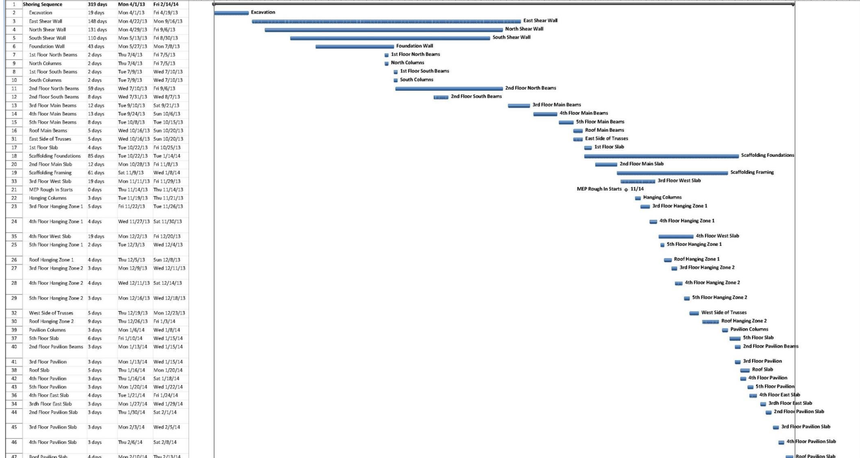


General Conditions Costs

Description	Quantity	Unit	Per/Unit	Total
Site Signage (Fence Cloth)	4,588	SF	$36.04	$165,351.52
Perimater Fencing	1,185	LF	$6.32	$7,489.20
Office Trailers (2)	22	Month	$361.00	$15,884.00
Air Conditioning	22	Month	$48.76	$1,072.72
125 Ton Crane	20	Month	$16,000.00	$320,000.00
200 Ton (Crane Steel)			N/A	
1-1/2 CY Excavator	33	Month	$8,700.00	$287,100.00
Backhoe 1-1/4 CY	22	Month	$3,013.00	$66,286.00
500 BTU Heater	15	Month	$425.00	$6,375.00
Portable Toilet	22	Month	$191.78	$4,219.16
Permits	$3,589,000.00	%	0.50%	$17,945.00
Field Office Bills	22	Month	$377.00	$8,294.00
Main Office Expense	$3,589,000.00	%	3.90%	$139,971.00
Builders Risk Insurance	$3,589,000.00	%	0.42%	$15,000.00
Performance Bond	$3,589,000.00	%	2.79%	$100,000.00
Liability Insurance	$3,589,000.00	%	2.79%	$100,000.00
Multivista (Construction Documentations/ Webcam)	23	Month	$1,700.00	$39,100.00
Project Executive	22	Week	$2,475.00	$54,450.00
LEED Submittal Fees	22	Month	$727.27	$16,000.00
CM Fees	$3,589,000.00	%	3.00%	$107,670.00
Field Engineer	88	Week	$1,325.00	$116,600.00
Project Manager	88	Week	$2,150.00	$189,200.00
Superintendent	88	Week	$2,000.00	$176,000.00
General Purpose Laborer	88	Week	$1,425.00	$125,400.00
Schedule Maintainance	$3,589,000.00	%	0.03%	$1,076.70
Temp. 600 Amp Elec.	1	EA	$3,621.00	$3,621.00
Temp. 75kVA Transformer	1	EA	$3,993.00	$3,993.00
Office Trailer Hook-Up	2	EA	$374.00	$748.00
After Job Clean-up	$3,589,000.00	%	0.30%	$10,767.00
Waste Removal Dumpster	88	Week	$340.91	$30,000.00
Site Water	22	Month	$70.00	$1,540.00
Commissioning	$3,589,000.00	%	0.25%	$8,972.50
Total				**$2,140,125.80**
Project Planned Duration (Weeks)				**88**
Total General Condition Costs per Week				**$24,319.61**

Shoring Sequence Schedule

ID	Task Name	Duration	Start	Finish
1	**Shoring Sequence**	**315 days**	**Mon 4/1/13**	**Fri 2/14/14**
2	Excavation	19 days	Mon 4/1/13	Fri 4/26/13
3	East Shear Wall	148 days	Mon 4/22/13	Mon 9/16/13
4	North Shear Wall	131 days	Mon 4/29/13	Fri 9/6/13
5	South Shear Wall	110 days	Mon 5/13/13	Fri 8/30/13
6	Foundation Wall	43 days	Mon 5/27/13	Mon 7/29/13
7	1st Floor North Beams	2 days	Thu 7/4/13	Fri 7/5/13
9	North Columns	2 days	Thu 7/4/13	Fri 7/5/13
8	1st Floor South Beams	2 days	Tue 7/9/13	Wed 7/10/13
10	South Columns	2 days	Tue 7/9/13	Wed 7/10/13
11	2nd Floor North Beams	58 days	Wed 7/10/13	Fri 9/6/13
12	2nd Floor South Beams	8 days	Wed 7/31/13	Wed 8/7/13
13	3rd Floor Main Beams	12 days	Tue 9/10/13	Sat 9/21/13
14	4th Floor Main Beams	13 days	Tue 9/24/13	Sun 10/6/13
15	5th Floor Main Beams	8 days	Tue 10/8/13	Tue 10/15/13
16	Roof Main Beams	5 days	Wed 10/16/13	Sun 10/20/13
31	East Side of Trusses	5 days	Wed 10/16/13	Sun 10/20/13
17	1st Floor Slab	4 days	Tue 10/22/13	Fri 10/25/13
18	Scaffolding Foundations	85 days	Tue 10/22/13	Tue 1/14/14
20	2nd Floor Main Slab	12 days	Mon 10/28/13	Fri 11/8/13
19	Scaffolding Framing	61 days	Sun 11/3/13	Wed 1/8/14
33	3rd Floor West Slab	19 days	Mon 11/11/13	Fri 11/29/13
21	MEP Rough In Starts	0 days	Thu 11/14/13	Thu 11/14/13
22	Hanging Columns	3 days	Tue 11/19/13	Thu 11/21/13
23	3rd Floor Hanging Zone 1	5 days	Fri 11/22/13	Tue 11/26/13
24	4th Floor Hanging Zone 1	4 days	Wed 11/27/13	Sat 11/30/13
35	4th Floor West Slab	19 days	Mon 12/2/13	Fri 12/20/13
25	5th Floor Hanging Zone 1	2 days	Tue 12/3/13	Wed 12/4/13
26	Roof Hanging Zone 1	4 days	Thu 12/5/13	Sun 12/8/13
27	3rd Floor Hanging Zone 2	3 days	Mon 12/9/13	Wed 12/11/13
28	4th Floor Hanging Zone 2	4 days	Wed 12/11/13	Sat 12/14/13
29	5th Floor Hanging Zone 2	3 days	Mon 12/16/13	Wed 12/18/13
32	West Side of Trusses	5 days	Thu 12/19/13	Mon 12/23/13
30	Roof Hanging Zone 2	9 days	Thu 12/26/13	Fri 1/3/14
39	Pavilion Columns	3 days	Mon 1/6/14	Wed 1/8/14
37	5th Floor Slab	6 days	Fri 1/10/14	Wed 1/15/14
40	2nd Floor Pavilion Beams	3 days	Mon 1/13/14	Wed 1/15/14
41	3rd Floor Pavilion	3 days	Mon 1/13/14	Wed 1/15/14
38	Roof Slab	5 days	Thu 1/16/14	Mon 1/20/14
42	4th Floor Pavilion	3 days	Thu 1/16/14	Sat 1/18/14
43	5th Floor Pavilion	3 days	Mon 1/20/14	Wed 1/22/14
36	4th Floor East Slab	4 days	Tue 1/21/14	Fri 1/24/14
34	3rdh Floor East Slab	3 days	Mon 1/27/14	Wed 1/29/14
44	2nd Floor Pavilion Slab	3 days	Thu 2/6/14	Sat 2/1/14
45	3rd Floor Pavilion Slab	3 days	Mon 2/3/14	Wed 2/5/14
46	4th Floor Pavilion Slab	3 days	Thu 2/6/14	Sat 2/8/14
47	Roof Pavilion Slab	4 days	Mon 2/10/14	Thu 2/13/14
48	Superstructure Complete	0 days	Fri 2/14/14	Fri 2/14/14



Dead Load Calculations

Dead Load Calculations				
Description	**Sizes**	**lb/LF**	**Spacing (ft)**	**lb/SF**
Columns	W14x82	82	40x50	2
Trusses	W14x283	283	40	7
	W14x90	90	40	2
	W14x99	99	40	2
End Truss	W14x233	233	50	5
	W14x90	90	50	2
3rd Floor Girder	W36x135	135	40	3
	W24x55	55	40	1
3rd Floor Beams	W27x84	84	10	8
4th Floor Girder	W27x84	84	40	2
4th Floor Beams	W21x50	50	10	5
5th Floor Beams	W27x84	84	10	8
Roof Floor Beams	W21x44	44	5	9
Decking				5
Allowance				8
	Total Dead Load (lb/SF)			**70**

Live Load & Factored Loads

Live Load Calculations			
	Live Load of Construction Surface		50
		# of Floors	4
Live Load Allowance (lb/SF)= L_0			**200**
		K_{LL}	4
	Tributary Area= A_T	20x18	360
		SQRT (K_{LL}*A_T)	37.95
		0.25+{15/ SQRT (K_{LL}*A_T)}	0.65
		Not smaller than 0.4 so use 0.65	
Live Load Reduced (lb/SF)= L			**129**

Total Load Calculations	
Total Load= 1.2D+1.6L (lb/SF)= P_U	**291**
Shoring Tower Estimated Spacing	**20x18**
Total Estimated Load per Shoring Tower (kip)	**105**

Live Load Assumptions

Started with 50 psf

Four floors is 200 psf

In live load reduction total is 129 psf

Factored live load would then be 206 psf
(This would be an acceptable live load on four floors of **only structure**)

Zone 2 Acoustics

Transmission Losses (dB)								
Octave-band Center Frequencies		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	STC Rating
Floor of IPEC		37.0	45.0	54.0	60.0	65.0	47.0	62.0

Absorption Under IPEC Zone 2													
Surface	Area (Sq. ft.)	Absorption Coefficients											
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Concrete	128	0	0	0	0	0	0	1	1	3	3	3	3
Ridged Insulation (3in.)	346	0	1	1	1	1	1	131	207	270	276	270	242
Metal IPEC Bottom	128	0	0	0	0	0	0	19	24	28	50	49	38
Total Absorption (sabins): $a=\sum S\alpha \rightarrow$								151.81	232.96	300.29	328.96	320.77	282.88

Estimated Nosie Level in Zone 2						
Octave-band Center Frequencies	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
TL between IPEC and Under IPEC Zone 2	37	45	54	60	65	47
a_2	152	233	300	329	321	283
Surface Area Between Spaces (sq. ft.)	160					
Noise Reduction of Noise Coming from IPEC	37	47	57	63	68	49
Sound Pressure in IPEC	86	85	84	83	82	80
Sound Pressure in Zone 2 From IPEC Space	49	38	27	20	14	31

Transmission Losses (dB)								
Octave-band Center Frequencies		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	STC Rating
8" reinforced concrete slab		44.0	48.0	55.0	58.0	63.0	67.0	58.0

Absorption of Staff Conference Space													
Surface	Area (Sq. ft.)	Absorption Coefficients											
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Carpet on Foam	409	0	0	1	1	1	1	33	98	233	282	291	299
Gypsum Board, 5/8"	506	1	0	0	0	0	0	279	71	41	20	61	56
Acoustical Ceiling, 3/4"	409	1	1	1	1	1	1	311	381	340	405	405	385
Chairs, Occupied	32	0	0	0	1	1	1	10	13	16	27	28	27
Total Absorption (sabins): a=∑ Sα →								632	562	629	735	784	766

Between Zone1 and Staff Conference Space						
Surface Area Between Spaces (sq. ft.)	325					
Noise Reduction of Noise Coming from Zone 1	42	48	56	60	65	68
Sound Pressure in Zone 1	86	85	84	83	82	80
Sound Pressure in Staff Conference Space from Zone 1	44	37	28	23	17	12

Conference Room Acoustics

Between Zone 2 and Staff Conference Space						
Surface Area Between Spaces (sq. ft.)	120					
Noise Reduction of Noise Coming from Zone 2	47	52	60	64	69	72
Sound Pressure in Zone 2	49	38	27	20	14	31
Sound Pressure in Staff Conference Space from Zone 2	3	-14	-33	-44	-55	-42

Between Zone 3 and Staff Conference Space						
Surface Area Between Spaces (sq. ft.)	293					
Noise Reduction of Noise Coming from Zone 3	43	48	57	60	65	69
Sound Pressure in Zone 3	86	85	84	83	82	80
Sound Pressure in Staff Conference Space from Zone 3	43	37	27	23	17	11

Between Zone 4 and Staff Conference Space						
Surface Area Between Spaces (sq. ft.)	144					
Noise Reduction of Noise Coming from Zone 4	46	52	60	63	68	72
Sound Pressure in Zone 4	86	85	84	83	82	80
Sound Pressure in Staff Conference Space from Zone 4	40	33	24	20	14	8

Estimated Sound Pressure Level in Staff Conference Space						
Octave-band Center Frequencies	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
From Zone 1	44	37	28	23	17	12
From Zone 2	3	-14	-33	-44	-55	-42
From Zone 3	43	37	27	23	17	11
From Zone 4	40	33	24	20	14	8
Add From Zone 1 and 2 Combined	0	0	0	0	0	0
From Zone 1 and 2 Combined	44	37	28	23	17	12
Add From Zones 3 and 4 Combined	2	1	2	2	2	1
From Zones 3 and 4 Combined	45	38	29	25	19	12
Add From Zone (1 and 2) and (3 and 4) Combined	3	3	3	2	2	3
Estimated Sound Level in Staff Conference Space from IPEC	48	41	32	27	21	15
A-Weighting	-15	-8	-3	0	1	1
A-Weighted Noise from IPEC	33	33	29	27	22	16
dB Addition Add	3		2		1	
Result	36		31		23	
dB Addition Add	1				0	
Result	37				23	
dB Addition Add	0					
Sound Level	37 dB					

Equipment

Quantity	Assembly Number	Description	Unit	Material O&P	Installation	Total O&P	Ext. Material O&P	Ext. Installation	Ext. Total
4	D30201061080	Boiler, gas, cast iron, hot water, 1,088 MBH	Ea.	$ 14,914.90	$ 4,706.35	$ 19,621.25	$ 59,659.60	$ 18,825.40	$ 78,485.00
90000	D30301154040	Packaged chiller, water cooled, with fan coil unit, offices, 60,000 SF, 190.00 ton	S.F.	$ 7.76	$ 5.19	$ 12.95	$ 698,400.00	$ 467,100.00	$ 1,165,500.00
40000	D30201081280	Heating systems, CI boiler, gas, terminal unit heaters, 80 MBH, 1,070 SF bldg	S.F.	$ 10.76	$ 7.56	$ 18.32	$ 430,400.00	$ 302,400.00	$ 732,800.00
90000	D30501703680	Split system, air cooled condensing unit, offices, 20,000 SF, 63.32 ton	S.F.	$ 5.46	$ 4.64	$ 10.10	$ 491,400.00	$ 417,600.00	$ 909,000.00
5	D30203301030	Pump, base mounted with motor, end-suction, 4" size, 7-1/2 HP, to 350 GPM	Ea.	$ 15,015.00	$ 4,107.50	$ 19,122.50	$ 75,075.00	$ 20,537.50	$ 95,612.50
2	D30203301020	Pump, base mounted with motor, end-suction, 3" size, 5 HP, to 225 GPM	Ea.	$ 12,812.80	$ 3,426.30	$ 16,239.10	$ 25,625.60	$ 6,852.60	$ 32,478.20
2	D30203301040	Pump, base mounted with motor, end-suction, 5" size, 15 HP, to 1000 GPM	Ea.	$ 20,720.70	$ 6,050.15	$ 26,770.85	$ 41,441.40	$ 12,100.30	$ 53,541.70
11	D30203301010	Pump, base mounted with motor, end-suction, 2-1/2" size, 3 HP, to 150 GPM	Ea.	$ 11,711.70	$ 2,994.10	$ 14,705.80	$ 128,828.70	$ 32,935.10	$ 161,763.80
90000	D30301103400	Packaged chiller, air cooled, with fan coil unit, offices, 6,000 SF, 19.00 ton	S.F.	$ 9.71	$ 5.68	$ 15.39	$ 873,900.00	$ 511,200.00	$ 1,385,100.00
1	D30406101010	Plate heat exchanger, 400 GPM	Ea.	$ 53,553.50	$11,745.60	$ 65,299.10	$ 53,553.50	$ 11,745.60	$ 65,299.10
2	D30402401040	Roof vent. system, power, centrifugal, aluminum, galvanized curb, back draft damper, 2750 CFM	Ea.	$ 3,578.58	$11,446.60	$ 15,025.18	$ 7,157.16	$ 22,893.20	$ 30,050.36
1	D30402401030	Roof vent. system, power, centrifugal, aluminum, galvanized curb, back draft damper, 1500 CFM	Ea.	$ 2,402.40	$ 5,061.10	$ 7,463.50	$ 2,402.40	$ 5,061.10	$ 7,463.50
1.33	D30401161050	AHU, rooftop, cool/heat coils, VAV, filters, 30,000 CFM	Ea.	$173,173.00	$17,149.20	$ 190,322.20	$ 230,320.09	$ 22,808.44	$ 253,128.53
1.1	D30401161030	AHU, rooftop, cool/heat coils, VAV, filters, 15,000 CFM	Ea.	$116,616.50	$12,413.80	$ 129,030.30	$ 128,278.15	$ 13,655.18	$ 141,933.33
						Subtotals	$ 3,246,441.60	$ 1,865,714.42	$ 5,112,156.02
						Location Scale		91%	$4,652,061.96
						GC OH & Profit		5%	$232,603.10
						Grand Total			**$ 4,884,665.08**

Enclosure

Quantity	Assembly Number	Description	Unit	Material O&P	Installation	Total O&P	Ext. Material O&P	Ext. Installation	Ext. Total
		Floor is Same Stuctural Concrete				$ -	$ -	$ -	$ -
3000	B10201206400	Steel Joist Roof	S.F.	$ 5.05	$ 2.96	$ 8.01	$ 15,150.00	$ 8,880.00	$ 24,030.00
3000	B30101206500	Single Ply 60 mils, PVC Membrane Roof Coverings Adhered	S.F.	$ 1.41	$ 0.92	$ 2.33	$ 4,230.00	$ 2,760.00	$ 6,990.00
3750	B2010146	Corrugated 22 Ga Galvanized Steel with Structural Steel Support, Colored	S.F.	$ 4.19	$ 3.60	$ 7.79	$ 15,712.50	$ 13,500.00	$ 29,212.50
3000	D50202360960	Low Bay Lighting Fixtures, 250 watt Metal Halide	S.F.	$ 4.23	$ 5.55	$ 9.78	$ 12,690.00	$ 16,650.00	$ 29,340.00
		Allowance				$ -	$ -	$ -	$ 12,000.00
						Subtotals	$ 47,782.50	$ 41,790.00	$101,572.50
						Location Scale		91%	$92,532.55
						Inflation of 3 Years		3%	$95,308.52
						GC OH & Profit		5%	$4,765.43
						Grand Total			**$100,073.95**

Equipment

Quantity	Assembly Number	Description	Unit	Productivity (units/day)	Crews	Duration (days)
4	D30201061080	Boiler, gas, cast iron, hot water, 1,088 MBH	Ea.	0.3	3	4.4
2	D30301154040	Packaged chiller, water cooled, with fan coil unit, offices, 60,000 SF, 190.00 ton	Ea.	0.1	3	6.7
2	D30501703680	Split system, air cooled condensing unit, offices, 20,000 SF, 63.32 ton	Ea.	0.4	1	5.0
5	D30203301030	Pump, base mounted with motor, end-suction, 4" size, 7-1/2 HP, to 350 GPM	Ea.	5	1	1.0
2	D30203301020	Pump, base mounted with motor, end-suction, 3" size, 5 HP, to 225 GPM	Ea.	7	1	0.3
2	D30203301040	Pump, base mounted with motor, end-suction, 5" size, 15 HP, to 1000 GPM	Ea.	3	1	0.7
11	D30203301010	Pump, base mounted with motor, end-suction, 2-1/2" size, 3 HP, to 150 GPM	Ea.	7	1	1.6
2	D30301103400	Packaged chiller, air cooled, with fan coil unit, offices, 6,000 SF, 19.00 ton	Ea.	0.3	1	6.7
1	D30406101010	Plate heat exchanger, 400 GPM	Ea.	0.8	1	1.3
2	D30402401040	Roof vent. system, power, centrifugal, aluminum, galvanized curb, back draft damper, 2750 CFM	Ea.	2	1	1.0
1	D30402401030	Roof vent. system, power, centrifugal, aluminum, galvanized curb, back draft damper, 1500 CFM	Ea.	2	1	0.5
1.33	D30401161050	AHU, rooftop, cool/heat coils, VAV, filters, 30,000 CFM	Ea.	0.3	1	4.4
1.1	D30401161030	AHU, rooftop, cool/heat coils, VAV, filters, 15,000 CFM	Ea.	0.3	1	3.7
					Total Days	37

Enclosure

Quantity	Assembly Number	Description	Unit	Productivity (units/day)	Crews	Duration (days)
		Floor is Same Structural Concrete				
2400	B10201206400	Steel Joist Roof	L.F.	160	2	7.5
2400	B30101206500	Single Ply 60 mils, PVC Membrane Roof Coverings Adhered	S.F.	250	2	4.8
2400	B2010146	Corrugated 22 Ga.Galvanized Steel with Structural Steel Support, Colored	L.F.	800	1	3
					Total Days	15.3