The Office Building

Washington, D.C.

Lynn Appel

Construction Management

Penn State AE Senior Capstone Project

Presentation Overview

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Presentation Outline:

I. Project Overview
II. Integrated Project Delivery
  I. Critical Industry Issue
III. PV Panels on the Green Roof
IV. Coordination of the Chilled Water Plant
  I. Acoustics Breadth
V. Conclusions
VI. Acknowledgements
VII. Q & A

Project Overview

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Presentation Outline:

Location: 200 C Street SW, Washington, D.C. 20024

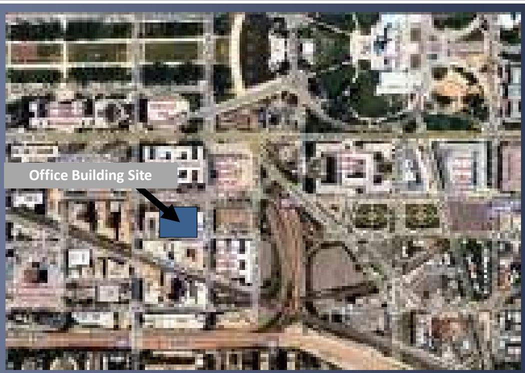
Type of Building: Government Office Space

Size: 550,000 ft^2

Number of Stories: Below Grade – 2, Above Grade – 6 + PH

Dates of Construction: March 2010 – August 2012

Project Delivery Method: Design – Bid - Build



Building Systems

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Presentation Outline:

- **Structure**
  - Existing 8" concrete slabs will remain with the addition of concrete on metal deck around perimeter
  - New Steel Moment frame beams and columns around the perimeter
- **Building Enclosure**
  - New glass entry pavilion, new curtain wall, bay windows on the north and south elevations
  - Existing roof will be removed and replaced with a Green Roof

- **Sustainability Features**
  - LEED Gold Rating
  - Green Roof
  - Maximum use of natural light
  - Storm water retention for landscape irrigation
  - Energy saving LEDs
  - Smart building controls technology
  - Charging stations in the lower parking level for electric vehicles

Integrated Project Delivery

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- **Background**
  - Construction industry is one of the most inefficient industries in America
  - 30% waste in the U.S. construction industry
  - 2004 study targets lack of interoperability as costing the industry $15.8 billion annually
  - The construction industry is the only non-farm industry to decrease in productivity since 1964

- **Research Goals**
  - Investigate the benefits and possible outcomes of using an IPD method compared to a traditional DBB
  - Show how an IPD method would benefit the Office Building

Drawbacks of Design-Bid-Build

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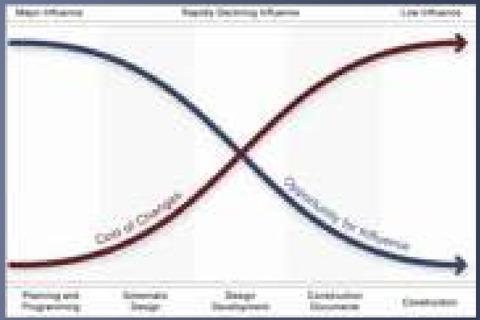
- Very inefficient delivery method
- Does not take advantage of collaboration between the owner, architect and construction manager
- Construction management personnel are not brought onto the project until the bid process
- Everyone is making decisions based on what is best for them and not what is best for the project as a whole



IPD - Contracting

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- Typical construction contracts do not fit into an IPD because of the required collaboration
- Owner, Architect and Contractor are under one contract
- Shared risk/reward
  - The focus of the team is finding a solution rather than assigning blame for a problem
  - Eliminates "defensive documentation"

IPD - Communication

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Presentation Outline:

- Communication is the foundation of IPD
- Share and apply common goals
- Co-location of the project team – Edith Green-Wendell Wyatt Federal Building modernization
  - Dramatic reduction in design phase durations
  - Early bid packages
  - Design and cost estimating are concurrent
  - Reduced RFIs and Change Orders

Edith Green-Wendell Wyatt Federal Building modernization - iRoom

IPD - Schedule

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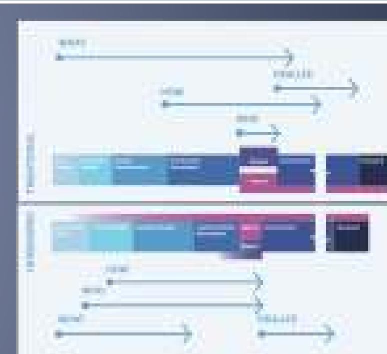
- Increased team involvement and collaboration in the early phases of design
- Shorter amount of time to establish the goals of the project
- Subcontractors provide valuable information
- Project is defined and coordinated at a much higher level prior to construction start



IPD for the Office Building

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- A more collaborative project delivery method would be very beneficial for the Office Building
- The Office Building is a federal building so a “true” IPD may not be possible
- Project managers at GSA do not have the authority to enter into multi-party agreements
- The Association of General Contractors (AGC) considers this to be a Level 2 IPD or IPD-ish method

Level 2 IPD or IPD-ish Method:

- Do not need to use a multi-party contract
- Co-location of team members
- Design team involvement in performance and risk sharing
- Construction team incentivized by productivity

Owner involvement is key!

IPD - Conclusions

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Conclusions

-IPD is an innovative solution to solving the problems that are associated with a DBB delivery method
-Federal or public projects can still pursue a more collaborative delivery approach without entering into multi-party contracts
-Owner involvement is crucial!

Recommendations

- If the Office Building had been delivered in a more collaborative fashion, it is believed that the owner would end up with a higher quality building

Photovoltaic Array System

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Problem Identification:

-Project is pursuing a LEED Gold certification
-As a public funded project, the Office Building should be doing everything possible to achieve this

Research Goals:

-Determine the feasibility of implementing photovoltaic panels onto the green roof

PV Panels and Green Roofs

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- PV Arrays and Green Roof technologies complement each other
- Green roofs can improve photovoltaic efficiency by reducing the ambient temperature
- Shading provided by the solar panels benefit green roof vegetation, which often suffers during hot, dry months
- Solar panels also protect the green roof from damage from gusting winds

http://solarseeds.blogspot.com/2010/05/solar-pv-power-on-green-roofs.html

System Design

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Presentation Outline:

Diagram of Panel Spacing

Orientation:

-Large, flat roof with a central atrium
-The west side of the is the most logical location for the photovoltaic panels

Solar Shading:

-No shading of panels throughout the day
-Panels do not cast shadows on each other

PV Array System

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Actual System Size:

- 40.0 kW
- 99 PV panels
- Fixed at 39.2° tilt

System Production:

- 49,282 kWh per year
- 4,100 kWh average per month
- 140 kWh average per day

PV Watts Energy Production Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.59	3544	283.52
2	4.28	3719	297.52
3	4.80	4492	359.36
4	5.34	4644	371.52
5	5.32	4534	362.72
6	5.66	4676	374.08
7	5.46	4556	364.48
8	5.38	4569	365.52
9	5.07	4258	340.64
10	4.72	4227	338.16
11	3.56	3206	256.48
12	3.03	2854	228.32
Year	4.68	49282	3942.56
PV Watts Factor = Annual AC Energy/System DC Rating = 1232			

PV Watts Calculator – www.pvwatts.org

Feasibility Analysis

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System Cost:

•Teris Pantazes of Seven Seas Energy in Annapolis, MD recently completed a similar project – quoted $5.75/Watt

Rebates/Incentives:

•Business Energy Investment Tax Credit (BEIT) – 30% gross installation cost

•D.C. Renewable Incentive Program (DC-REIP)

- $3.00/W DC for the first 3 kW installed
- $2.00/W DC for the following 7 kW installed
- $1.00/W DC for the next 10 kW installed
- Incentives capped at a maximum of $33,000 per site per year

Initial Investment			
Item	Quantity	Cost/Unit	Total Cost
PV Panels	40,000 W	$5.75/W	$ 230,000.00
Inverters	6	$ 3,000.00	$ 18,000.00
Incentive Savings	BEIT: $90,000		($69,000)
	DC-REIP: $33,000		($33,000)
Total Cost			$ 146,000.00

Feasibility Analysis

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Presentation Outline:

Yearly Savings:

- Using the data provided by the PV Watts Calculator, it was determined that the 40 kW system would essentially save $3,942.56 on electricity annually

Payback Period:

- Considering the initial investment of $146,000 and the fact that the array produces approximately $4,000 of electricity per year in savings:

Payback Period = ($146,000)/($4,000/year) = **36 years**

PV Watts Energy Production Results		
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PV Array System

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Presentation Outline:

Conclusions:

- A 40 kW solar array would occupy approximately 3600 sf of the roof and provide 49,282 kWh of energy annually
- Initial Investment = $146,000
- Approximately $4,000 worth of electricity produced annually
- Payback Period = 36 years

Recommendations:

- It is recommended that the PV array system not be installed at the Office Building
- The benefits do not outweigh the initial investment
- The system does not produce enough electricity to make the installation worthwhile

Coordination of the Chilled Water Plant

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Problem Identification

- The interior of the Office Building was completely demolished with the exception of an existing Chilled Water plant located in the sub-basement
- Chilled Water plant must remain in operation 24/7
- Chilled Water plant supplies chilled water to an adjacent office building

Research Goals

•Determine how BIM could have been used more effectively to help with the coordination of the Chilled Water Plant

Coordination of the Chilled Water Plant

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Background Information:

- There are 4 chillers located in the sub-basement
  - Two out of the four chillers were only replaced five years ago so they were to remain in the sub-basement and not be demolished
  - They were intended to keep running throughout the construction process so the adjacent building would continue to receive chilled water
- There are 6 cooling towers located on the roof
  - At first, it was determined that only two of the six cooling towers were needed for the two chillers to continue to run properly
  - Before demolition, it was discovered that all six cooling towers were running at full power to keep the two chillers running
  - The cooling towers were in such bad shape that it was necessary for all six to be running
- The general contractor had to issue a change order to the owner

Coordination of the Chilled Water Plant

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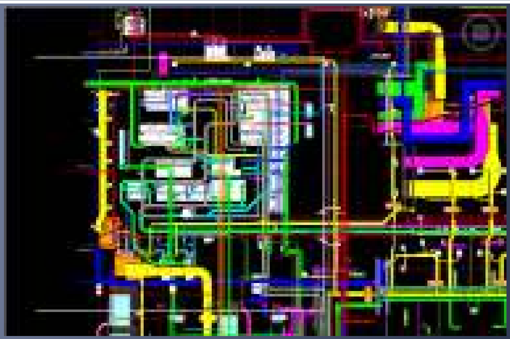
BIM could have been used more efficiently to:

Perform a constructability review of the demolition and replacement of the chillers and cooling towers.

- There are 2 options that need to be thought through
  1. Keeping the two existing chillers running
  2. Performing a complete demolition of the chillers and cooling towers



Screenshot of current BIM model

Acoustic Concerns

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GOAL: Reduce the airborne sound pressure around the temporary chillers

- The temporary chillers were placed on the north side of the building, right across the street from another building
- Currently, the temporary chillers have no sound treatment
- A sound barrier must be constructed around the temporary chillers and then the attenuation must be calculated

Attenuation Equation:

$$A = 10*\log(H^2/R) + 10*\log f - 17$$

A = Attenuation
H = Height above the acoustical line of sight
R = distance between the source and the barrier
f = frequency

Acoustic Concerns

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Airborne Sound Pressure, dB (L1)

	Octave Band Center Frequency, Hz								
Percent Load	31.5	63	125	250	500	1000	2000	4000	8000
100	71	72	74	74	74	74	75	83	76
75	73	72	77	78	75	74	78	83	72
50	75	74	78	78	78	77	80	82	72
25	76	76	79	79	79	78	81	82	74

Sound Attenuation/Noise Reduction, dB (A)

	Octave Band Center Frequency, Hz								
Percent Load	31.5	63	125	250	500	1000	2000	4000	8000
100	13.2	16.2	19.2	22.2	25.2	28.2	31.2	34.3	37.3
75	13.2	16.2	19.2	22.2	25.2	28.2	31.2	34.3	37.3
50	13.2	16.2	19.2	22.2	25.2	28.2	31.2	34.3	37.3
25	13.2	16.2	19.2	22.2	25.2	28.2	31.2	34.3	37.3

Airborne Sound Pressure, dB (L2)

	Octave Band Center Frequency, Hz								
Percent Load	31.5	63	125	250	500	1000	2000	4000	8000
100	57.8	55.8	54.8	51.8	48.8	45.8	43.8	48.7	38.7
75	59.8	55.8	57.8	55.8	49.8	45.8	46.8	48.7	34.7
50	61.8	57.8	58.8	55.8	52.8	48.8	48.8	47.7	34.7
25	62.8	59.8	59.8	56.8	53.8	49.8	49.8	47.7	36.7

For example, when the temporary chillers are performing at 100% load at 250 Hz:

- L1 = 74 dB (without sound treatment)
- A = 22.2 dB (attenuation with sound treatment)
- L2 = L1 – A = 74 dB – 22.2 dB = 51.8 dB

For this particular case, the sound barrier was able to reduce the airborne sound pressure by 22.2 dB.

Conclusions

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Analysis #1: Integrated Project Delivery

•If the Office Building had been delivered in a more collaborative fashion, it is believed that the owner would end up with a higher quality building

Analysis #2: PV Panels on the Green Roof

- It is recommended that the PV array system not be installed at the Office Building
- The system does not produce enough electricity to make the installation worthwhile

Analysis #3: Coordination of the Chilled Water Plant

•BIM could have helped the project team weigh their options from the beginning so a change order could have been avoided
•Sound treatment of the temporary chillers would provide a more comfortable working environment

Acknowledgments

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Questions?

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