Emory Psychology Building
Atlanta, GA

Chris Renshaw
Construction Management
Senior Thesis Presentation 2009
The Pennsylvania State University

Presentation Outline

- **Project Overview**
  - **Building statistics, use, project team**
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Building Statistics

- Size
  - 119,000 SF; 5 stories+mechanical penthouse
- Cost
  - $35,029,000 (GMP)
- Schedule
  - October 2007 - March 2009
- Structure
  - Concrete, steel penthouse framing
- Façade
  - Limestone dimension stone, stucco, glazed curtain wall

LEED NC
silver certified

Presentation Outline

- **Project Overview**
  - **Building statistics, use, project team**
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

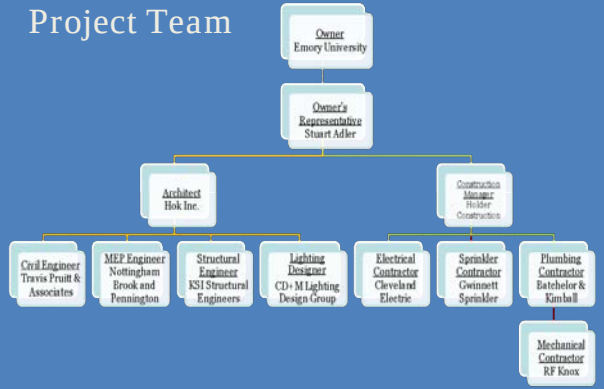
Use

- Labs, Classrooms, Offices of Psychology Department
  - Currently spread throughout campus in six buildings

Presentation Outline

- **Project Overview**
  - **Building statistics, use, project team**
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Project Team



Presentation Outline

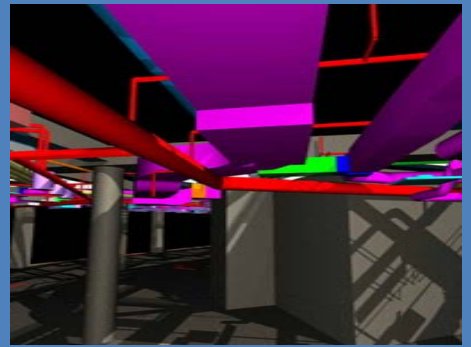
- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

- Used successfully on Psychology Building

- How and why?

BIM Implementation (Depth Study)

- How does this measure up across the industry?

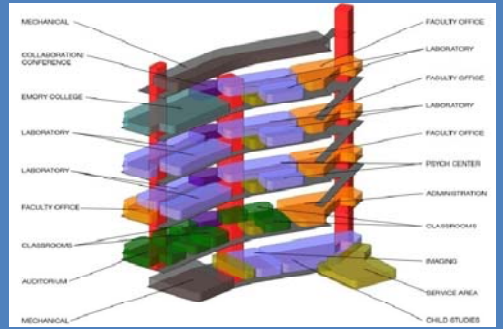


Presentation Outline

- Project Overview
- Building statistics, use, project team
- BIM Implementation
- **Psychology Building**
- **Industry-wide**
- **Conclusions**
- Background of
- Benefits, design considerations, cost
- Structural implications (Structural Breadth)
- Energy savings (Mechanical Breadth)
- Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

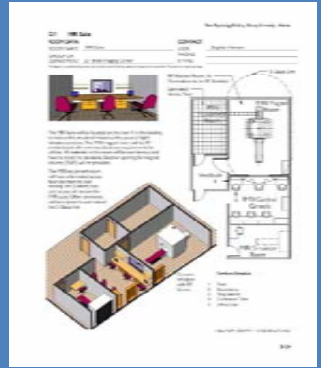
Psychology Building BIM Use

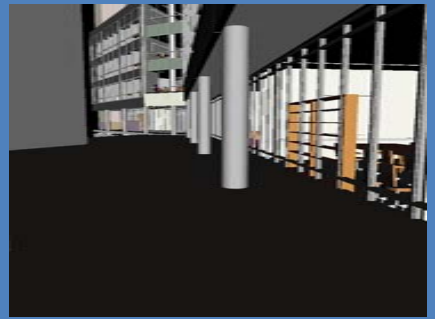
- HOK decided to use BIM
  - Develop spatial relationships
  - Create room data sheets



Psychology Building BIM Use

- Benefits of architect using BIM
  - Pushed design decisions earlier
  - Early information stays with the model
  - Made occupants aware of what they were getting
  - Allowed renderings from any angle
  - Sustainable Design

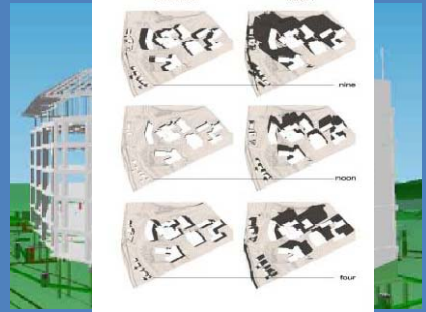




Psychology Building BIM Use

- Integrated Project Delivery
- Holder brought on during schematic design
  - Aid with constructability
  - Create structural model early
  - 4D scheduling/phase planning
  - Estimating

Structura



4D Scheduling

Psychology Building BIM Use

- Integrated Project Delivery
- Holder brought on during schematic design
  - Aid with constructability
  - Create structural model early
  - 4D scheduling/phase planning
  - Estimating

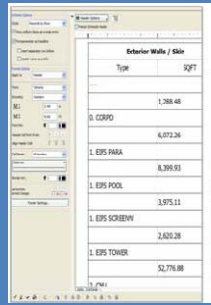
Structural Model

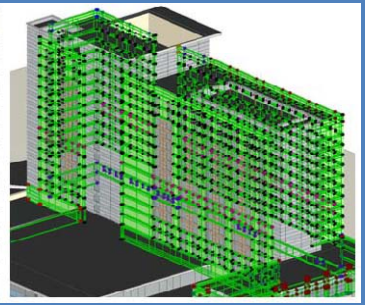
4D Scheduling

Psychology Building BIM Use

- Integrated Project Delivery
- Holder brought on during schematic design
  - Aid with constructability
  - Create structural model early
  - 4D scheduling/phase planning
  - Estimating

Estimating

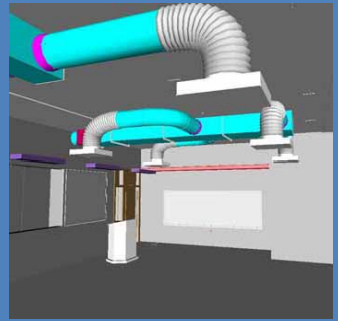




Psychology Building BIM Use

- Integrated Project Delivery
- Subcontractors brought on during design development
  - Required to purchase Navisworks
  - Created models of their disciplines
  - Accepted training from Holder if necessary
  - Coordinated weekly

HVAC Model



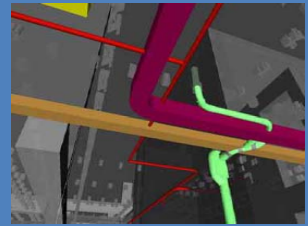
Presentation Outline

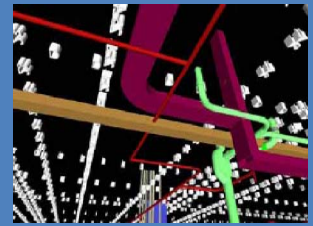
- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Psychology Building BIM Use

- Construction phase
  - Weekly Coordination meetings continued
  - Clashes fixed as needed
- Post-Construction
  - HOK and Holder will provide as-built models

Collision Detection/Resolution





Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Problem - Still skewed perceptions of BIM
  - Modeling without information
  - Beyond MEP clash detection
- Goal
  - Determine how the model is being used in addition to clash detection
  - Determine what would allow more usage of BIM

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- 4 construction managers
- Known to be successful users of BIM
  - What has made them so successful?
  - What characteristics do they share?
  - How do they analyze a building for BIM use?
  - What are they doing with BIM that others aren't?

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Interviews pertained to 19 categories
- Consensus on 8 Categories
  - Early assessment of project (RFP Review)
  - Project Players and MEP coordination are focus
  - MEP clash detection is the primary use

- Architects rarely design in 3D or provide a model
- Subcontractors are expected to create the model for their discipline
- Subcontractors eventually realize benefits after learning curve
- RFI decrease and increased response time are one of the largest benefits
- Estimation is not fully trusted and is backed up

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Other categories vary
  - Owner's reactions
  - IPD view
  - Stages of new technology implementation

Owner's Reactions

- Most are apprehensive and lack awareness of what BIM is and is capable of
- Like the idea but don't know how to ask for what they want from the model
- Unrealistic expectations

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Other categories vary
  - Owner's reactions vary
  - IPD view
  - Stages of new technology implementation

IPD View

- Helps but not crucial
- Is a huge benefit, one of the larger benefits of BIM as a whole

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

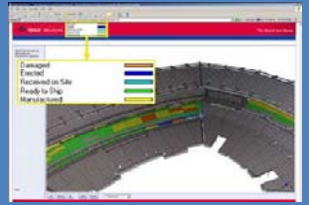
Construction Manager BIM Study

- Beyond clash detection…
  - Estimating
  - 4/5D modeling for scheduling
  - Material tracking
  - Facilities management model development

Material Tracking

VELA SYSTEMS

- Radio frequency identification tags
- Large volume of material
- Tells location on building, delivery status, installation status, etc.



Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Beyond clash detection…
  - Estimating
  - 4/5D modeling for scheduling
  - Material tracking
  - Facilities management model development

Facilities Management

- Provides an as-built model with information linked to it
  - Warranties
  - Owner's manuals
  - Insurance information
  - Preventative maintenance information

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- **BIM Implementation**
  - **Psychology Building**
  - **Industry-wide**
  - **Conclusions**
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- Questions

Construction Manager BIM Study

- Conclusions
  - Owner's need to be informed
  - Find a way to quantify schedule and cost savings
  - IPD is most effective now while there is a learning curve for the software
  - Several uses of BIM are being applied, CMs must keep an open mind and look for ways to expand BIM use

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study

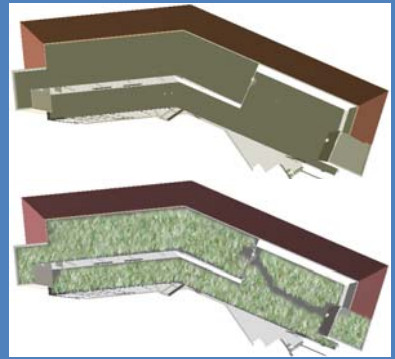
- Problem
  - A green roof may have been added to the flat roof to achieve higher energy efficiency and a better return on investment.
- Goal
  - Determine if a green roof would be more beneficial than the currently designed white roof.

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study

- Benefits
  - Energy conservation
  - Longer service life
  - Heat island mitigation
  - Additional LEED credits
  - Less storm water input
  - Aesthetic improvement
- Negatives
  - High initial cost
  - Impact on structure
  - Other roofs can achieve similar LEED credits

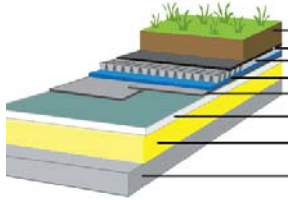


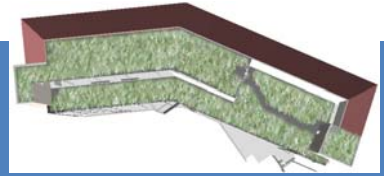
Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study

- Green Roof design
  - 14,600 SF flat roof area available
  - Extensive system (4” growing media)
  - Waterproofing system by NationsRoof
  - Flood irrigation system
  - Plants mostly sedum and delosperma





Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study

- Cost
  - Original roof: $382,000.00 ($26.16/SF)
  - Green roof: $391,629.03 ($26.82/SF)
  - Additional: $9,629.03 ($0.66/SF)

Cost Breakdown

Component	Cost/Unit	Unit	Qty.	Cost
Plants	$ 7.60	SF	14600	$ 110,960.00
Media	$ 1.74	SF	14600	$ 25,404.00
EPDM	$ 2.88	SF	14600	$ 42,048.00
Insulation	$ 3.45	SF	14600	$ 50,370.00
Prime Board	$ 1.87	SF	14600	$ 27,302.00
Adhesive	$ 0.68	SF	43800	$ 29,784.00
Asphalt Layer	$ 1.03	SF	14600	$ 15,038.00
Pavers	$ 3.69	SF	2607	$ 9,619.83
Edging	$ 12.80	LF	1614	$ 20,659.20
Drainage Layer	$ 4.14	SF	14600	$ 60,444.00
			Total	**$ 391,629.03**
			SF Cost	**$ 26.82**

Presentation Outline

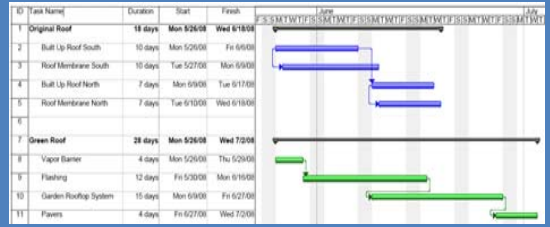
- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study

- The green roof will take longer to install
  - Original roof: Approx. 3.5 weeks
  - Green roof: Approx. 5.5 weeks
- The building will not be dried in for another 5.5 weeks after the green roof is installed

Original roof finish date:	6/18/08
Green roof finish date:	7/2/08
Building enclosure:	8/8/08

Schedule Impact



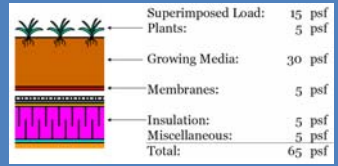
Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural impact
- Penthouse Steel

	Dead Load	Live Load	Factored Load
Green Roof	65 psf	20 psf	112.4 psf
Original Roof	42 psf	20 psf	82.4 psf
% Increase	54.8%	0%	**36.4%**



Beam Redesign:

Member	Max Shear (kips)	Max Moment (ft.-kips)
W14x22	94.8	125
x1.364	**129.3**	**170.5**
W16x31	**131**	**203**

Girder Redesign:

Member	Max Shear (kips)	Max Moment (ft.-kips)
W18x40	169	294
x1.364	**230.5**	**401**
W18x65	**248**	**499**

Column Redesign:

Member	Max Axial (kips)
W8x24	76
x1.364	**103.7**
W8x35	**115**

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural steel cost increase:

	Member	LF	Cost/LF	Cost
Original	W14x22	797	$ 40.40	$ 32,198.80
Redesign	W16x31	797	$ 55.64	$ 44,345.08
			Difference=	**$ 12,146.28**
Original	W18x40	268	$ 71.62	$ 19,194.16
Redesign	W16x31	268	$ 113.00	$ 30,284.00
			Difference=	**$ 11,089.84**
Original	W8x24	494	$ 47.10	$ 23,267.40
Redesign	W8x35	494	$ 65.60	$ 32,406.40
			Difference=	**$ 9,139.00**
			Additional Cost	**$32,375.12**

Beam Redesign:

Member	Max Shear (kips)	Max Moment (ft.-kips)
W14x22	94.8	125
x1.364	**129.3**	**170.5**
W16x31	**131**	**203**

Girder Redesign:

Member	Max Shear (kips)	Max Moment (ft.-kips)
W18x40	169	294
x1.364	**230.5**	**401**
W18x65	**248**	**499**

Column Redesign:

Member	Max Axial (kips)
W8x24	76
x1.364	**103.7**
W8x35	**115**

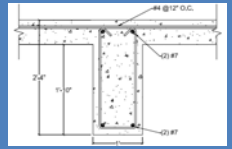
Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

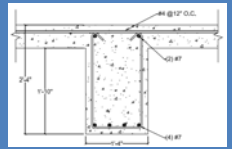
Green Roof Study (Structural Breadth)

- Structural impact
- Concrete
  - Additional loads will cause an increase in structure
  - Beam concrete increased by 33%
  - Reinforcement doubled
  - Post-tensioning assumed to increase in similar manner

Original Beam Design



Beam Redesign



Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural impact
- Concrete
  - Formwork, concrete quantity and reinforcing will be affected
  - Concrete columns will also be affected

Additional Concrete Costs

	Increase	Unit	$/Unit	Cost
Concrete	98.8	CY	$ 132.15	$ 13,056.42
Formwork	1540	SF	$ 5.96	$ 9,178.40
Rebar	5.006	Ton	$ 2,170.00	$ 10,863.02
PT Tendons	5347.86	$	N/A	$ 5,347.86
				$ 38,445.70

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural impact
- Concrete
  - Formwork, concrete quantity and reinforcing will be affected
  - Concrete columns will also be affected

Concrete Column Costs

- Columns increase by 13.95%
- Column cost increase will be the same

Columns	Load Increase
5th Floor	0.3600
4th Floor	0.1800
3rd Floor	0.0900
2nd Floor	0.0450
1st Floor	0.0225
Total	0.6975
Total / 5	**0.1395**

0.1395*($197,509.81) = **$27,552.62**

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural impact

Additional Structural Cost	
Penthouse Steel	$ 32,375.12
5th Floor Roof	$ 38,445.70
Columns	$ 27,552.62
Total	**$ 98,373.44**

Concrete Column Costs

- Columns increase by 13.95%
- Column cost increase will be the same

Columns	Load Increase
5th Floor	0.3600
4th Floor	0.1800
3rd Floor	0.0900
2nd Floor	0.0450
1st Floor	0.0225
Total	0.6975
Total / 5	**0.1395**

0.1395*($197,509.81) = **$27,552.62**

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Structural impact

Additional Structural Cost	
Penthouse Steel	$ 32,375.12
5th Floor Roof	$ 38,445.70
Columns	$ 27,552.62
Total	**$ 98,373.44**

Schedule Impact

- Formwork and reinforcing will take longer
  - Extra 2 days for each penthouse slab section
  - Total extra 4 days
- Columns do not increase enough to cause delay
- Slabs will still be poured in one day
- Green roof installation will start and end 4 days later
- Will finish 1 month before building dry in

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Study (Structural Breadth)

- Total cost of adding green roof:
- Initial cost: $391,629.03
- Structural additions: $ 98,373.44

- **Total: $490,002.47**

($33.56/SF)

Additional Green Roof Costs

- Original Roof Cost: $382,000.00
- Green Roof Cost: $490,002.47

- **Additional Cost: $108,002.47**

(+$7.40/SF)

How can adding $108k to the roof cost be justified?

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Energy Savings (Mechanical Breadth)

- Will the energy savings be enough to pay back the initial cost?
  - Green roof will only help the Psychology Building roof stay cool in the summer
  - Annual air conditioning load reduction:

kWH (load)	kWH (electricity)	$/kWh	Energy Savings
1301.34	1445.93	0.0917	$ 132.59

Why isn't there a larger reduction?

- Current roof is a white roof
  - Proven to keep roof temperature cooler than a typical modified bituminous membrane roof
- The current roof is very well insulated
  - Will not be as effective as the green roof but will still perform well
  - Performs well in the winter

Presentation Outline

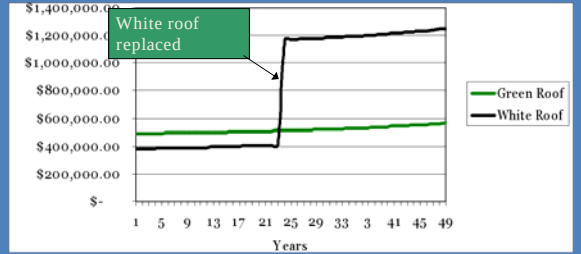
- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Life Cycle Cost Analysis

- Determine the cost of the original white roof and the proposed green roof after 50 years

Cost	Green Roof	White Roof
Initial	$ 490,002.47	$ 382,000.00
Annual Energy	$ 174.56	$ 307.15
Annual Maintenance	$ 336.00	$ 415.00
Re-roofing Time	50 years	25 years
Annual Energy Inflation	5%	5%
Annual Inflation	2.89%	2.89%

Cumulative Costs Per Year



Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

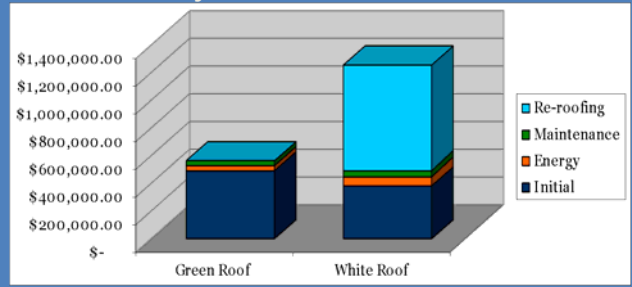
Life Cycle Cost Analysis

- Results
  - It will take 25 years for the green roof to pay off
  - After 50 years the green roof will have saved:

  - White roof 50 year cost: $1,248,485.26
  - Green roof 50 year cost: $ 563,236.94

$685,248.32

Total 50 year costs



Presentation Outline

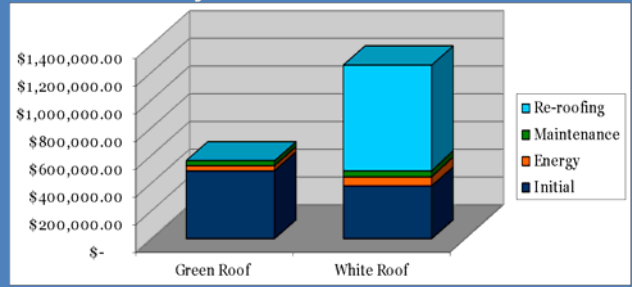
- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Life Cycle Cost Analysis

- Results
  - Over the 50 year period, the green roof will save an average of:

$13,704.97 / year

Total 50 year costs



Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Conclusions

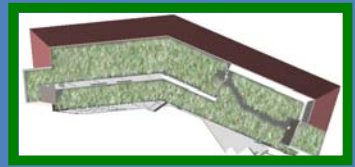
- The initial cost will be $108,002.47 (28.3%) higher
- Over time the green roof will save money, but savings won't be realized for 25 years
- The majority of the payoff will come from the extended life of the roof, otherwise ROI is not practical
- LEED impact will be minimal if any for this building

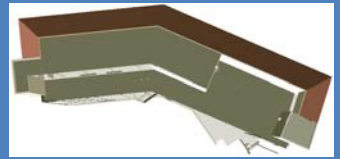
Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- **Green Roof**
  - **Benefits, design considerations, cost**
  - **Structural implications (Structural Breadth)**
  - **Energy savings (Mechanical Breadth)**
  - **Life-cycle cost analysis**
- Conclusion, Recommendations
- Questions

Green Roof Recommendation

- Add the green roof
- The initial cost is higher but it will be returned
- The owner expects to have the building for longer than the 50 year period examined and will have the opportunity to realize the cost benefits





Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- **Conclusion, Recommendations**
- Questions

Overall Conclusions

- BIM was used effectively on the Psychology Building, but there are always more possibilities to be explored
- The more construction managers keep an open mind, the more uses they will find for BIM and make their lives easier
- The green roof will cost more initially, but the owner will realize the long term savings since they plan on having the building for many years

Presentation Outline

- Project Overview
  - Building statistics, use, project team
- BIM Implementation
  - Psychology Building
  - Industry-wide
  - Conclusions
- Green Roof
  - Benefits, design considerations, cost
  - Structural implications (Structural Breadth)
  - Energy savings (Mechanical Breadth)
  - Life-cycle cost analysis
- Conclusion, Recommendations
- **Questions**

Questions?

Acknowledgements

Emory University:	Stuart Adler	Balfour Beatty:	Mark Konchar Jesse Whalen
Holder Construction:	Brad Hutto Paul Hedgepath Josh Thompson	Barton Malow:	Corinne Ambler
		Penn State OPP:	John Bechtel George Hoover
Turner Construction:	Pat Bolger Graham Dewar Keith Mondock	NationsRoof:	Joe Carbine
Emory Knoll Farms:	Ed Snodgrass	Saul Nurseries:	Diana Armitrano
Penn State University:	Dr. Robert Berghage Dr. David Riley Dr. Linda Hanagan Professor Robert Holland Professor Kevin Parfitt Dr. John Messner	All other AE faculty, classmates, friends, family, and especially my parents, Karen and Steve Renshaw...Thanks!	