Westinghouse Electric Company Nuclear Power Engineering Headquarters Campus

1000 Cranberry Woods Drive, Cranberry Township, PA

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Construction Management
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Presentation Outline

I. Project Overview

II. Analysis 1: Energy and Environment

III. Analysis 2: Concrete Slabs

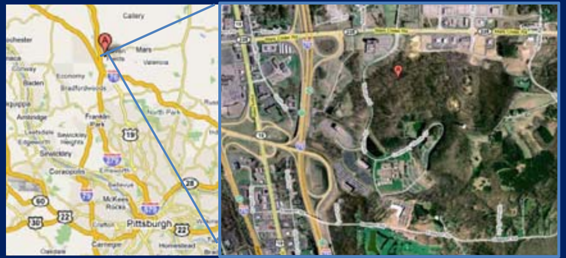
IV. Analysis 3: BIM Implementation

V. Conclusions/Recommendations

VI. Acknowledgements

Presentation Outline

Location: Cranberry Township, PA
Occupant: Westinghouse Electric Company
Building Type: Office
Size: 844,595 square feet
Construction Dates: February 2008 – May 2010
Overall Project Cost: $240,000,000
Delivery Method: Design-Bid-Build



Presentation Outline

PROJECT TEAM:

Owner: Wells Reit II
Tenant: Westinghouse Electric Company
GC/CM: Turner Construction Company
Architect: IKM Incorporated
Engineer: LLI Engineering

PROJECT OVERVIEW

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Architecture

- Consists of 3 Buildings
- Primarily office space for over 4,000 engineers

Structural

- Steel framed with concrete slab-on-deck floors

Building Enclosure

- Aluminum curtain wall
- Insulated wall panels
- Brick
- Polished concrete

Presentation Outline

BACKGROUND

- As energy company Westinghouse has opportunity to raise the standard
- Leased property → Wells Reit would benefit from reduced lifecycle cost

OBJECTIVE

- Identify finishes which could be replaced with "greener" products
- Reduce the energy usage of the Westinghouse campus

ANALYSIS 1: Energy and Environment

Presentation Outline

CURRENT WINDOWS

- 1” insulated tempered glass
- Large percentage of building envelope
- Potential for energy savings by implementing higher efficiency windows

	Tinted Double Pane
U-value	0.57
Shading Coefficient (SC)	0.72
Solar Heat Gain Factor (SHGF)	0.62

Orientation	Window Square Footage	Wall Square Footage	% of Wall
North	14367	25902	55%
South	6717	18327	37%
East	6717	18327	37%
West	12547	25902	48%
Northwest	5299	8140	65%
Southeast	5896	7599	78%
Total	51542	104196	49%

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PPG SOLARBAN 80 WINDOWS

- Excellent thermal properties
- Manufactured locally: United Plate Glass, Butler, PA

Insulating Vision Unit Performance 1-inch (25mm) units with 1/2-inch (13mm) airspace and two 1/4-inch (6mm) lites; interior lite clear

Glass Type	Transmittance			Reflectance		U-Value (Imperial)		European U-Value	Shading Coefficient	Solar Heat Gain Coefficient	Light to Solar Gain (LSG)
	Ultra-violet %	Visible %	Total Solar Energy %	Visible Light %	Total Solar Energy %	Winter Night-time	Summer Day-time				
SOLARBAN® 80 Solar Control Low-E Glass											
SOLARBAN 80 (2) Clear + Clear	13	48	20	33	38	0.29	0.27	1.52	0.28	0.24	1.98
SOLARBAN 80 (2) Clear + OPTIBLUE	10	34	15	32	38	0.29	0.27	1.52	0.27	0.23	1.48
SOLARBAN 80 (2) OPTIBLUE + Clear	9	34	15	19	28	0.29	0.27	1.52	0.23	0.20	1.70
SOLARBAN 80 (2) OPTIBLUE + OPTIBLUE	7	25	11	19	28	0.29	0.27	1.52	0.23	0.20	1.23

	Solarban 80 (2)	Tinted Double Pane
U-value	0.29	0.57
Shading Coefficient (SC)	0.28	0.72
Solar Heat Gain Factor (SHGF)	0.24	0.62

ANALYSIS 1: Energy and Environment

Presentation Outline

ENERGY ANALYSIS

- U.S. Department of Energy (DOE) 2.2 Building Energy Analysis Simulation Tool
  - Calculates hour-by-hour energy consumption using hourly climate data

Assumptions:

- City = Philadelphia, PA
- Window Sq. Footage = 50,976 sq ft
- Floor area = 270,000 sq ft

ANALYSIS 1: Energy and Environment

Presentation Outline

Results:

Glazing	Electricity	Gas	Total Operating Electric Cost	Total Operating Gas Cost	Total Operating Cost	Total Capital Cooling HVAC Cost	Annual Operating Cost Savings of Low E Coatings vs DT	Initial Capital Cost Savings of Low E Coatings vs DT	Annual CO2 Savings of Low E vs DT	40 Year Building Life CO2 Savings of Low E Coatings vs DT
Double Pane Tinted	4,227,796	80,139	$270,227	$108,093	$378,320	$1,772,085	$	$		
Solarban 60 (2)	3,994,261	67,312	$259,954	$91,054	$351,008	$1,652,488	$27,312	$119,597	193	7,734
Solarban 70XL (2)	3,937,998	64,914	$257,477	$87,809	$345,286	$1,556,917	$33,034	$215,169	236	9,446
Solarban 80 (2)	3,916,355	65,265	$256,524	$88,247	$344,771	$1,551,027	$33,549	$221,059	246	9,824
Solexia Sungate 500 (3)	4,078,747	72,311	$263,670	$97,705	$361,375	$1,718,370	$16,945	$53,715	121	4,858
VE 2-2M (2)	3,960,163	65,311	$259,332	$88,358	$347,690	$1,580,829	$30,630	$191,257	212	8,471

Building One=460,000 square feet	Electricity	Gas	Total Operating Electric Cost	Total Operating Gas Cost	Total Operating Cost	Total Capital Cooling HVAC Cost
Double Pane Tinted	$7,202,912	$136,533	$460,387	$184,158	$644,545	$3,019,108
Solarban 80 (2)	$6,672,309	$111,192	$437,041	$150,347	$587,388	$2,642,490
Savings	**$530,603**	**$25,341**	**$23,346**	**$33,812**	**$57,158**	**$376,617**

- ✓ Total operating cost reduced by 9%
- ✓ Total cooling HVAC cost reduced by 12.5%

ANALYSIS 2: Prefabricated Concrete Slabs

Presentation Outline

BACKGROUND

- Campus constructed on a compressed schedule
  - 22 month → 15 month
- Slabs on critical path of schedule
- Cost of overtime had large impact on overall cost

OBJECTIVE

- Explore the feasibility of precast concrete
  - Cost
  - Schedule
  - Structural Ramifications

Presentation Outline

CURRENT SLAB ON DECK SYSTEM

- 2 ½" lightweight concrete on 22 gauge metal deck

Schedule:

- Poured in the typical workflow pattern
  - Bottom to Top: Center → East → West

Location	Duration	Start Date	End Date
Slab on Deck- Center	35	16-Jul-08	2-Sep-08
Slab on Deck- East	35	13-Aug-08	30-Sep-08
Slab on Deck- West	35	1-Oct-08	18-Nov-08
Total	**90**	**16-Jul-08**	**18-Nov-08**

ANALYSIS 2: Prefabricated Concrete Slabs

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CURRENT SLAB ON DECK SYSTEM

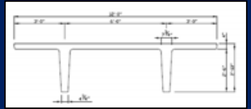
Cost:

- No actual cost data provided
- Estimate calculated using RS Means
- Approximate cost = **$3,400,000**

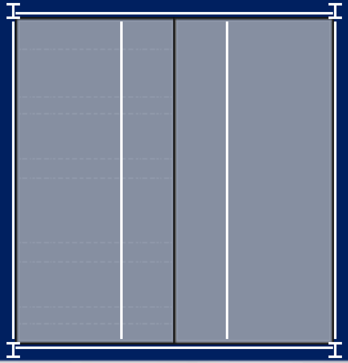
Location	Forming	Placing	WWF	Material	Total
1st Floor	$476,079		$ 36,641	$126,564	$639,284
2nd Floor	$476,079		$ 36,641	$126,564	$639,284
3rd Floor	$476,079		$ 36,641	$126,564	$639,284
4th Floor	$476,079		$ 36,641	$126,564	$639,284
5th Floor	$476,079		$ 36,641	$126,564	$639,284
Total	$2,380,395	$181,192	$ 183,205	$632,820	$3,377,612

ANALYSIS 2: Prefabricated Concrete Slabs

PREFABRICATED CONCRETE SLABS



- Double Tees
  - Larger widths
  - Reduce number by 2/3 over Hollowcore planks
  - Reduce steel
- Placement
  - Typical bay sizes were maintained (24’)
  - 12’ wide double tees selected



ANALYSIS 2: Prefabricated Concrete Slabs

PREFABRICATED CONCRETE SLABS

Schedule Analysis:

- 20-30 minute erection time → 20
- Maintained initial start date → July 16, 2008
- Duration → 32 days
- Estimated completion date → August 28, 2008

✓ 58 days ahead of current schedule (November 18, 2008)

Location	Members	Erection Time (Minutes)	Erection Time (Days)	Start Date	End Date
Slab on Deck- Center	**332**	**6640**	**13.83**	**16-Jul-08**	**4-Aug-08**
1st Floor	84	1680	3.5	16-Jul-08	21-Jul-08
2nd Floor	66	1320	2.75	21-Jul-08	24-Jul-08
3rd Floor	54	1080	2.25	24-Jul-08	28-Jul-08
4th Floor	54	1080	2.25	28-Jul-08	30-Jul-08
5th Floor	54	1080	2.25	30-Jul-08	1-Aug-08
6th Floor	20	400	0.83	4-Aug-08	4-Aug-08
Slab on Deck- East	**212**	**4240**	**8.83**	**5-Aug-08**	**15-Aug-08**
1st Floor	48	960	2	5-Aug-08	6-Aug-08
2nd Floor	36	720	1.5	7-Aug-08	8-Aug-08
3rd Floor	36	720	1.5	8-Aug-08	11-Aug-08
4th Floor	36	720	1.5	12-Aug-08	13-Aug-08
5th Floor	36	720	1.5	13-Aug-08	14-Aug-08
6th Floor	20	400	0.83	15-Aug-08	15-Aug-08
Slab on Deck- West	**212**	**4240**	**8.83**	**18-Aug-08**	**28-Aug-08**
1st Floor	48	960	2	18-Aug-08	19-Aug-08
2nd Floor	36	720	1.5	20-Aug-08	21-Aug-08
3rd Floor	36	720	1.5	21-Aug-08	22-Aug-08
4th Floor	36	720	1.5	25-Aug-08	26-Aug-08
5th Floor	36	720	1.5	26-Aug-08	27-Aug-08
6th Floor	20	400	0.83	28-Aug-08	28-Aug-08
Total	**756**	**15120**	**32**	**16-Jul-08**	**28-Aug-08**

Presentation Outline

PREFABRICATED CONCRETE SLABS

Cost Analysis:

- Material and shipping costs from Nitterhouse
- Erection costs from RS Means
- Removal of steel cost data taken from previous estimate
- Cost after steel savings → $1,723,017

✓ Savings of $1,654,5895 off current system ($3,377,612)

Precast Cost Summary

Location	Number of Slabs	Square Footage	Material Cost ($7.50/sf)	Shipping Cost ($9/mile)	Erection Costs* ($360 ea.)
1st Floor	180	74000	$ 555,000	$ 283,500	$ 64,800
2nd Floor	138	74000	$ 555,000	$ 217,350	$ 49,680
3rd Floor	126	74000	$ 555,000	$ 198,450	$ 45,360
4th Floor	126	74000	$ 555,000	$ 198,450	$ 45,360
5th Floor	126	74000	$ 555,000	$ 198,450	$ 45,360
6th Floor	60	37000	$ 277,500	$ 94,500	$ 21,600
Total	**756**	**407000**	**$ 3,052,500**	**$ 1,190,700**	**$ 272,160**

Steel Cost Summary

Location	Beams Omitted	Length of Beams	Beam Cost Savings
1st Floor	180	6660	$ 639,160
2nd Floor	138	5712	$ 548,181
3rd Floor	126	4960	$ 476,011
4th Floor	126	4960	$ 476,011
5th Floor	126	4960	$ 476,011
6th Floor	60	1844	$ 176,969
Total	**756**	**29096**	**$2,792,343**

Total Precast Cost	$4,515,360
Steel Savings	$2,792,343
Adjusted Total	**$1,723,017**

ANALYSIS 2: Prefabricated Concrete Slabs

Presentation Outline

STRUCTURAL RAMIFICATIONS (STRUCTURAL BREADTH ANALYSIS)

- Bay size and layout would remain the same
- Ceiling height would be reduced
- Calculations
- Redesign of steel members according to Table 3-10 of the AISC Steel Manual

✓ Increase steel joist size to W21x101 (from W24x80)

Calculations:

- Tributary Area: At= 864 sq ft
- Live Load Reduction: L=61 psf
- Dead Load: D=108 psf
- Factored Load: Wu= 227 psf = 8.2 klf
- Maximum Shear: Vu= 98 kips ≈ 100 kips
- Maximum Moment: Mu=590 kip – ft ≈ 600 kip – ft
- Unbraced length= 24’

Presentation Outline

BACKGROUND

- Large push from industry towards Building Information Modeling (BIM)
- Can provide value by:
  - Identifying potential clashes
  - Enhancing coordination
  - Better communicate ideas

OBJECTIVE

- Determine where BIM could have been effective
- Explore views of Turner staff
- Analyze potential of clash detection

ANALYSIS 3: BIM Implementation

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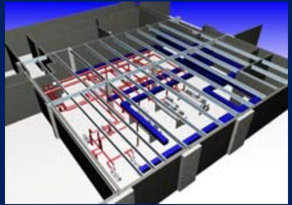
3D and 4D Modeling

- Autodesk Revit 2010
- Autodesk Navisworks 2010
- Chose to explore the benefits of clash detection
- Basement mechanical space was modeled
  - Ductwork
  - Piping
  - Steel
  - Equipment



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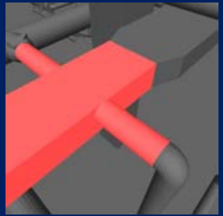
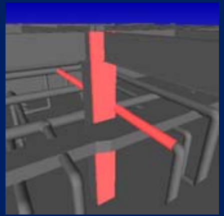
Clash Detection

- Tests were run against:
  - Plumbing vs Mechanical → 10 clashes
  - Plumbing vs Structural → 2 clashes
  - Structural vs Mechanical → 0 clashes
- If found in the field result in RFIs, change orders, and/or delays





Presentation Outline

COST AND SCHEDULE ANALYSIS

- Difficult to quantify
  - Problems never actually faced
- Slightly higher upfront cost
  - Even this is reducing with BIM becoming a standard

- Minor conflict found between piping and ceiling heights
  - No money to cover coordination issues in budget
  - Bulkheads installed to cover piping

CONCLUSIONS/RECOMMENDATIONS

Presentation Outline

Analysis 1: Energy and the Environment

- Current finishes within building meet LEED requirements
  - Low levels of VOC and regionally manufactured
- Opportunity to save money by implementing high efficiency windows
  - Total operating costs could be reduced up to 9%
- Load on mechanical equipment would be reduced

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Analysis 2: Prefabricated Concrete Slabs

- Prefabricated Concrete slabs could have saved time and money
  - 58 days ahead of schedule
  - $1.7 million less
- Negative impacts on structural system
  - Heavier steel
  - Reduced ceiling height
- Difficult to determine the lead time necessary to complete the project

CONCLUSIONS/RECOMMENDATIONS

Presentation Outline

ANALYSIS 3: BIM IMPLEMENTATION

- Staff did not feel BIM could have been successfully employed due to incomplete drawings
  - Would not have been an issue if designed with BIM
- Clashes found in mechanical room
  - Value of these findings is unknown
- Clashes found in field which carried an additional cost

Presentation Outline

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QUESTIONS?