The Maryland Public Health Laboratories

Baltimore, MD

Penn State Architectural Engineering Capstone Project

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Outline

Building Overview

Building: The Maryland Public Health Laboratories

Building Location: Lot-4 on the Science + Technology Park at Johns Hopkins University, Baltimore, MD.

Building Size: 234,046 Gross S.F.

Number of Stories: 6 Stories + 2 Story Mechanical Penthouse

Occupancy/Function Type: Offices & Medical Research Laboratories

Project Cost: $111,400,000

Dates of Construction: December 19, 2011- April 19, 2014

Project Delivery Method: Design Build

Contract Type: Lump Sun CMc

Project Participants

Developer: Forest City-New East Baltimore Partnership

Owner: Maryland Economic Development Corporation

Occupants: The Maryland Department of Health & Mental Hygiene

Building Designer: HDR, Inc.

Project Management: Jacobs Engineering

General Contractor: Turner Construction Co.

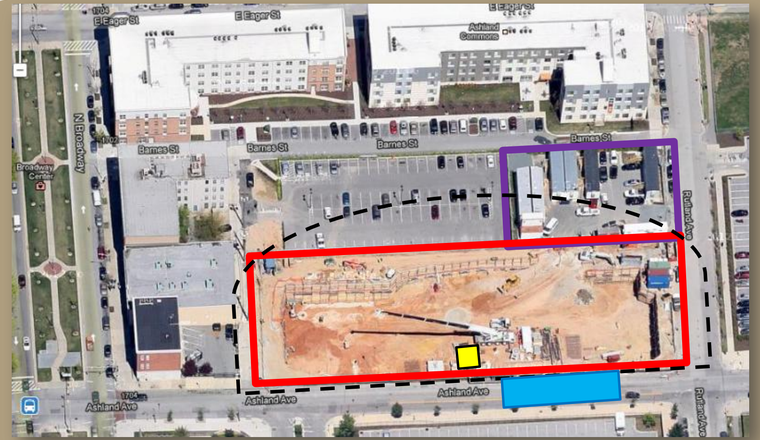
JACOBS™ Turner HDR

Outline

Building Location

1710 Ashland Avenue, Baltimore, Maryland, United States

Construction Site Plan



Analysis #1: Precast Concrete Structural System

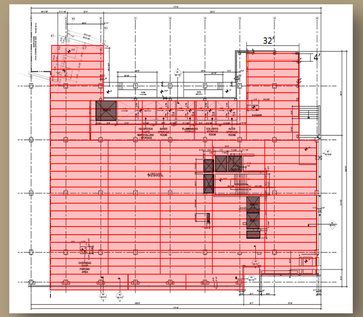
Outline

Precast Concrete System Overview

- **8” Hollowcore Plank Slab System with 2” topping**
  - 2 hour fire rating - IBC 2009 & NFPA Standard No. 1
- **Precast Concrete Structural Beams**
  - Original steel reinforcement layout. (1-1/2”)
- **Precast Concrete Columns**
  - Original steel reinforcement layout (Depends on concrete column)

Structural System Breakdown

- Building Slab sectioned into plank dimensions 4’x32’ & 4’x36’
  - Cutting the slab necessary to meet irregular building perimeter.
- Beams produced to match the beam schedule provided.
  - Long beams were divided into parts
- Columns produced combining multiple columns within column schedule
  - 54’ in height max. (necessary for delivery and erection)
  - Splicing occurs at slab connections.



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Sequencing

PRECAST STRUCTURAL SYSTEM PRODUCTION DURATION

Structural Member	Quantity	Production Rate	Production Duration
Hollow Core Planks	665	3/days	222 days
Beams/Columns	1833	50/day	36.75 days

- Beams/columns and hollow core planks produced simultaneously.
- Total Production Duration: 222 days
- 75% of production complete before installation. (Begin June 25, 2011)

Construction

- Columns erected by column lines from west to east and from north to south.
- Beam erection
    - Connect to beams by grouting them to hunches.
- Hollow core plank installation
    - Place shoring during lifts.

Schedule Impact

PRECAST STRUCTURAL SYSTEM ERECTION DURATION

Structural Member	# of Members	Erection Rate	Erection Duration
Beams/Columns	665	30 min./member	41.6 days
Hollow Core Planks	1833	10 min./member	38.2 days
TOTAL DURATION			79.8 ~ 80 days

- Structural Members grouted and connected between picks.
- Hoist block remains the same, do not need to account for additional time.

Original Baseline Schedule: 97 work days

Potential Schedule Savings: 17 days (3.4 weeks)

Outline

Cost of System

- Cost for the Precast System were estimated by Nitterhouse Concrete Products pricings and RSMeans Assemblies Cost Data.
- **Vendors Pricing:**
    - Hollow core planks - $8.00/ S.F.
    - Columns - $140/ L.F.
    - Beams - $155/ L.F.

PRECAST SYSTEM COST ESTIMATES	
Vendor Cost Estimate	$5,425,087
RSMeans Estimate	$7,793,203
Adjusted Estimate	$6,300,000

*Adjusted estimate accounts for lack of specifications in RSMeans and lack of materials in lump sum vendor price. Also takes into account crane sizing upgrade.

Cost Analysis

TOTAL SYSTEM COSTS (based on source)	
Original Design – Cast in Place	
Jacobs Cost Estimate	$7,168,807
Turner Pay Application	$6,835,598
Proposed Design – Precast Concrete	
Precast System Cost	$6,300,000

Cost Savings: $535,598

Outline

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III. Analysis #1: Precast Concrete Structural System

  I. Structural Breadth Analysis – Punching Shear and Slab Strength

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Structural Analysis

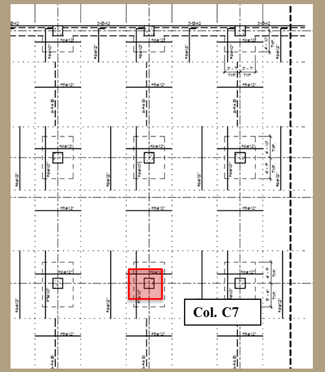
Interior Column Punching Shear

- Precast System eliminates drop panels at columns.
- Stronger concrete used in precast system (6000 psi)

Calculated Shear Load at Column: 984 psf

Calculated Shear Strength: 1416 psf

$V_c \geq V_u$, therefor adequate design



Hollow Core Slab Strength

- Criteria for allowable superimposed load and plank span (feet).
- HDR, Inc. calculated live load of typical floor = 125 psf

SAFE SUPERIMPOSED SERVICE LOADS — IBC 2006 & ACI 318-05 (1.2 D + 1.6 L)

Strand Pattern		SPAN (FEET)																	
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
4 - 1/2"ø	LOAD (PSF)	280	248	214	185	159	138	118	102	87	74	62	52	42						
6 - 1/2"ø	LOAD (PSF)	366	341	318	299	271	239	211	187	165	146	129	114	101	88	77	67	58	50	42
7 - 1/2"ø	LOAD (PSF)	367	342	320	300	282	265	243	221	202	181	161	144	128	114	101	90	79	70	61

- Increased Schedule because of reduced span.
  - Additional approximated 6 days added to erection.
- No Additional Costs because cost based on square footage.

Analysis #2: Virtual Mock-ups for Building Façade System

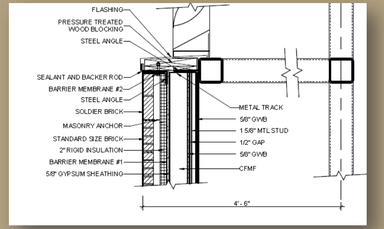
Outline

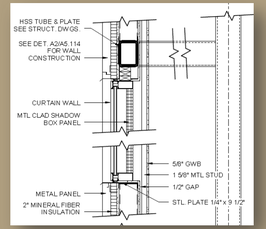
Virtual Mock-Up Overview

- Create Virtual Mock-ups for building envelop.
- Detail connections to superstructure and to other façade systems.
- Façade systems includes:
  - Curtain wall
  - Metal Panels
  - Brick Veneer
  - Shop Window

Quality & Safety Improvements

- Quality significantly increases when performing the tasks.
- Subcontractors can easily understand the work to be performed and how to effectively complete the work.
- Better understanding how to complete the task effectively reduces risks and potential safety hazards.





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Schedule Impact

- ***Time to create mock-ups:*** 2-3 weeks
  - The time creating the mock-ups should occur around Dec. 8, 2011.

- **Time Savings:** 2-4 days
  - Based on Greenfield Hospital Case Study. (2.5 weeks)
  - 35% of building schedule

Cost Analysis

- **Cost to create mock-ups**: $3,000 - $9,840
  - $3,000 - $4,000 provided by Mortenson Construction
  - $3,280 – $9,840 based on $82 an hour working on models.

- **Associated Cost Savings:** approx. $94,710
  - Reduction of system change orders by 50%
  - Efficiency savings of 0.3%. (based off 17% of project)

- **PROJECT COST SAVINGS:** $84,870 - $91,710

Analysis #3: Implementation of Alternate Dewatering System

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    II. System Sizing
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System Selection

- Geotechnical Report Indicates clay and sandy soils.
- Groundwater table apparent at 18’ depth from surface.
- Confined project boundaries.
- Existing Utilities
- Deep Wells
    - Useful for depth greater 15’.
    - Used in confined areas
    - Adequate effectiveness with low permeable soils

System Sizing

Size depends on these major aspect:

- Site Excavation Dimensions (308’x 96’)
- Groundwater Table Depth (approx. 18’)
- Impervious Layer Depth (approx. 70’)

Flow Rate Calculations and System Sizes

Total Necessary Flow – 0.1793 m^3/s

Number of Wells – 7 deep wells

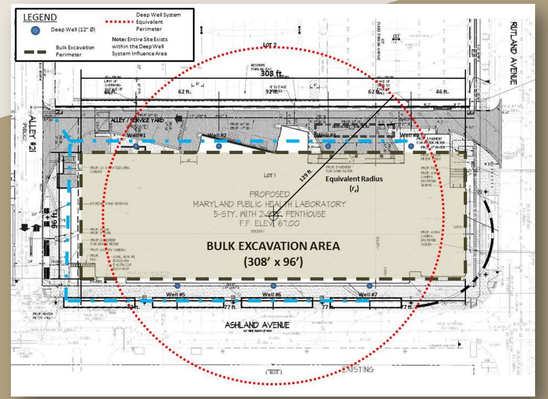
Well Casings/Screens Sizing – 12” diameter

Pump Size- 6”

Outline

System Mapping

Use Forchheimer's equation to place single spot wells and achieve adequate necessary . $Q = \frac{\pi k(H^2 - {h_w}^2)}{\ln R_0 - \left(\frac{1}{N-1}\right)\ln(x_1 x_2 x_3 \ldots . x_n)}$



Installation & Scheduling Durations

DEEP WELL INSTALLATION DURATION			
Drilling Deep Wells	7 wells	2 well/day	3.5 days
Pump Equipment Installation	7 wells	15 min/ well	1 hr. 45 min.
Discharge Pipe Installation	612 ft.	400 ft./day	1.53 days
TOTAL DEWATERING INSTALLATION DURATION			5.25 days

- Installation occurs as excavation begins, Feb. 27, 2012.
- The system will run until all tasks below ground water table are complete (expected 143 days)
- System demobilization takes 2-3 days.
- Total system duration is 150 days.
- Dewatering system doesn't installation doesn't affect critical path, but will save the lost 2 months due to flooding.

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System Cost

DEEP WELL SYSTEM COST	
Equipment	$52,262
Materials	$3,665
Rental/Operational Rates	$53,700
Dewatering Cost	$8,400
Labor	$247,988
Overhead	$2,400
TOTAL COST	$390,596

Cost Analysis

Total Cost of Deep Well System: $390,596

Cost of Original Dewatering System: $185,000

Total Dewatering Cost with Change Orders: $770,381

Turners Projected Productivity Loss: $1.8 million

Total Cost Savings of System: $1.4 million

Analysis #4: Value Engineering

Stormwater Harvesting System

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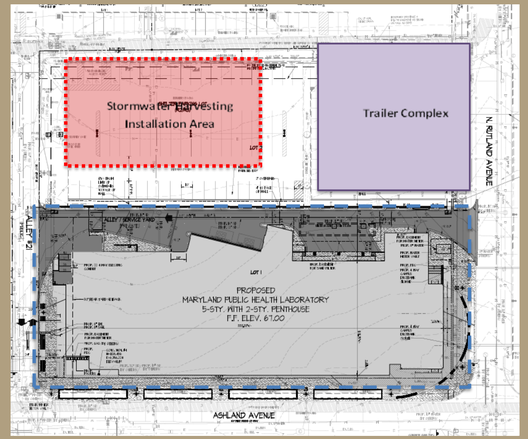
System Overview

- 5 Underground Metal Cisterns that will hold roughly 250,000 gallons of stormwater runoff.
- 8’ diameter cisterns.
- Will store potential grey water, roof run-off water and hardscape run-off water.
- Prefiltration and pump manhole placed within excavated installation area.

Proposed Installation Area



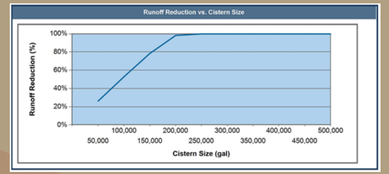
Excavation Dimensions: 160’ x 85’

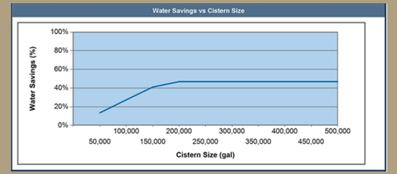
Outline

Cost Savings

	Rainfall		Stormwater		Supply		Demand	Captured
	Total	Targeted	Targeted	Peak	Targeted SW	Total		
Typical Rainfall Year	40	39	1,127,795	33,367	62,359,354	62,386,365	132,811,059	62,378,145
Max Rainfall Year	58	56	1,628,058	62,930	1,628,058	62,922,547	132,811,059	62,922,547
21 Year Total	836	816	23,683,690	567,240	1,309,546,424	1,310,113,682	2,789,032,239	1,309,941,040

	Runoff Retained (Targeted Rainfall)		Water Savings		Total Retained (Targeted, Peak, Secondary)		Savings
Typical Rainfall Year	1,127,795	100%	62,378,144	47%	62,378,145	100%	$455,360
Max Rainfall Year	1,628,058	100%	62,922,546	47%	62,922,547	100%	$459,335
21 Year Total	23,683,690	100%	1,309,941,033	47%	1,309,941,040	100%	$9,562,568





Cost of Installation

STORMWATER HARVESTING SYSTEM INSTALLATION COST	
Demolition	$22,238
Earthwork	$210,416
System Installation Fee	$113,000
Stormwater Harvesting Equipment	$500,725
Site Improvement	$176,500
TOTAL STORMWATER HARVESTING COST	$1,999,379

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Cost Analysis

Potential Cost Savings:

Annual Savings with Typical Rainfall: $455,360
Annual Savings with Max. Rainfall: $459,335
21 Year Total Cost Savings: $9,562,568

Total Cost of Stormwater Harvesting System: approx. $2 million

Pay off Period: 4.5 Years

Sustainability Evaluation

Water Efficiency

Innovative Wastewater Technologies (0 out of 2 points)

1.) Reduce potable water for sewage by 50%. UNATTAINABLE

2.) Treat 50% of wastewater onsite. UNATTAINABLE

Water Use Reduction (2 out of 4 points)

1.) Reduce water consumption to 40%. UNATTAINABLE

Waster Reduction Percentage: 2.23% (Total of 33.23%)

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Analysis #1: Precast Concrete Structural System

COST SAVINGS: $535,598

SCHEDULE SAVINGS: 2 weeks

INCREASED SAFETY

Analysis #2: Virtual Mock-ups for Building Façade Systems

COST SAVINGS: $84,870 - $91,710

SCHEDULE SAVINGS: 2-4 days

INCREASED PRODUCT QUALITY

SAFTEY SAFETY

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Analysis #3: Implementation of Alternate Dewatering System

COST SAVINGS: $1,400,000

SCHEDULE SAVINGS: 2 months

NO MATERIAL AND PROPERTY DAMAGE

Analysis #4 Value Engineering Stormwater Harvesting System

COST OF INSTALLATION: $2,000,000

ANNUAL COST SAVINGS: $455,000

PAY OFF PERIOD: 4.5 years

ADDITIONAL WORK DURATION: 1.5 months

NO LEED POINTS ABLE TO BE ACQUIRED

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QUESTIONS