

PHOENIXVILLE AREA MIDDLE SCHOOL



PHOENIXVILLE, PENNSYLVANIA

PENN STATE AE SENIOR CAPSTONE
PROJECT

Richard Schimpf

Construction Option

Advisor: Dr. Robert Leicht

PHOENIXVILLE AREA MIDDLE SCHOOL



PHOENIXVILLE, PENNSYLVANIA



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Project Background

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Project Size: 188,500 sq. ft

3 Stories

Building Cost: Roughly \$ 38 Million

Total Project Cost: \$56 Million

Construction: May 2010 to June 2012



Original Site



Site Under Construction



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Project Background

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Owner: Phoenixville Area Middle School

Architect: Gilbert Architects
Str. Eng: Baker, Ingram & Associated

Agency CM Reynolds Construction Management

General Trades

Mechanical

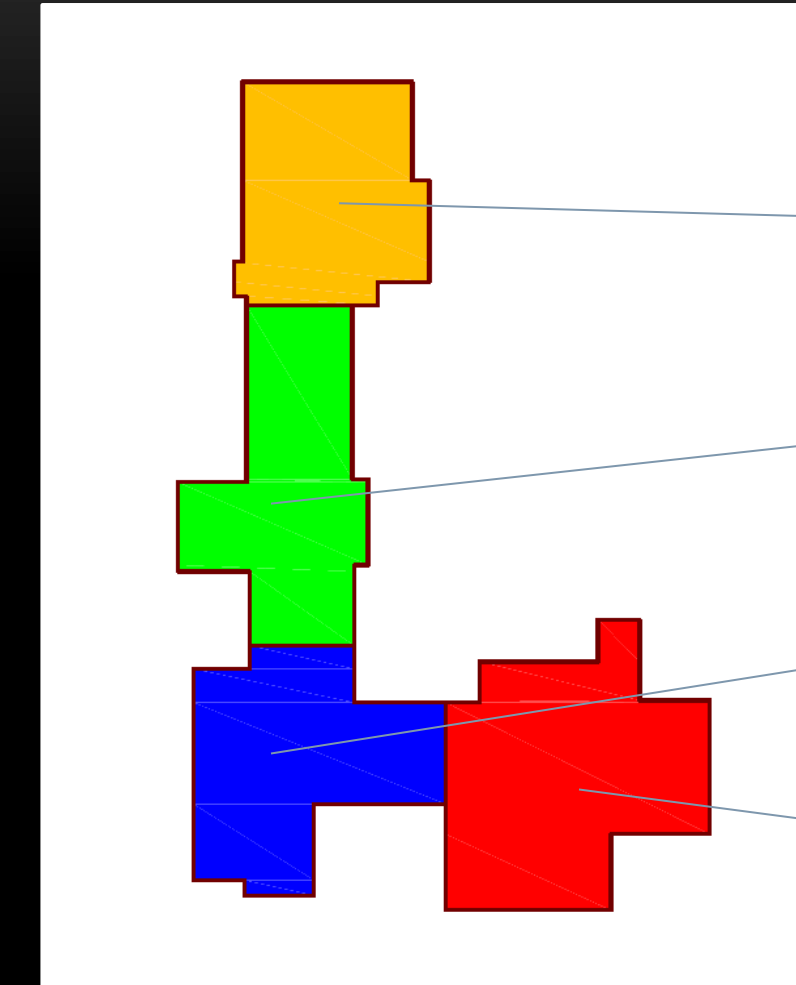
Roofing

Electrical

Fire Protection

Food Services

Plumbing



Area D: Auditorium and Music Rooms

Area C: Classrooms and Library

Area B: Classrooms and Cafeteria

Area A: Gymnasium and Locker Rooms



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Project Background

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Building Systems

Structural System

- Steel Structure
- Metal Decking with Concrete Slab
- Cast-in-Place Concrete Floor Slabs

Mechanical System

- Water Source Heat Pumps
- Cooling Towers and Condensing Boilers

Façade Details

- Split and Ground Face CMU's
- CMU and Metal Stud Backing
- Limestone Trim
- Glazing





PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Research Background

Multiple Prime historically regarded as producing lowest cost of construction

Limitations in contracting have come under criticism in past two decades

Only four states currently have this type of legislation in effect

Growing project complexity has placed greater responsibility on management

Pennsylvania Separations Act of 1913

All publicly funded work over \$25,000 must be contracted separately to four prime contractors

Generally,

1. Mechanical
2. Plumbing
3. Electrical
4. General Trades



PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Mandate Waiver Program

In effect from 2000 – 2010

Approved application allowed exemption from separations of contract

Lawsuit in 2003, 2004 in Commonwealth Court blocked new applications until Supreme Court ruling in 2007

Result: Only 128 applications submitted, 80 approved

Application Process

School board makes the decision to apply

Had to prove benefit to project

Costs savings of 128 applicants ranged from \$4,000 to \$28.3 million



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Separations Act Analysis

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Supporters of Mandate Waiver

School districts

Large general contractors

Opponents of Mandate Waiver

Subcontractors

Small general contractors

Small construction managers



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Separations Act Analysis

Reynolds Bid Cost Comparison

Construction Type	Multiple Prime Bid	Single GC Bid	\$ Increase for Single Prime
Renovation / Addition	182.72%	193.43%	\$74,658.00
Renovation / Addition	126.94%	138.18%	\$1,112,600.00
New Construction	101.12%	101.49%	\$66,560.00
New Construction	125.45%	130.35%	\$813,300.00
Renovation	105.06%	123.28%	\$5,085,600.00

Single vs. Multiple Prime Bids

Reflects bids for various types of projects

Separated by construction type:

Construction Type	Multiple Prime Bid	Single GC Bid	% Increase for Single Prime
Renovation / Addition	138.24%	151.63%	110.69%
New Construction	113.29%	115.92%	102.13%

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Separations Act Analysis

Final Construction Cost Comparison

	Delivery Method	Construction Type	Bid Price	Final Cost	% Increase
1	Single Prime	New Elementary	\$12,787,250.00	\$14,626,868.00	114.39%
	Multiple Prime	New Elementary	\$12,749,130.00	\$13,970,994.00	109.58%
2	Single Prime	New Elementary	\$11,013,909.00	\$11,226,517.00	101.93%
	Multiple Prime	New Elementary	\$12,208,976.00	\$14,291,400.00	117.06%
3	Single Prime	New High School	\$71,068,610.00	\$74,573,052.00	104.93%
	Multiple Prime	New High School	\$39,558,845.00	\$38,554,328.00	97.46%
4	Single Prime	Addition / Renovation	\$7,452,739.00	\$7,331,307.00	98.37%
	Multiple Prime	Addition / Renovation	\$6,874,130.00	\$7,375,596.00	107.29%
5	Single Prime	Addition / Renovation	\$9,060,312.00	\$10,858,755.00	119.85%
	Multiple Prime	Addition / Renovation	\$9,808,989.00	\$9,778,714.00	99.69%
6	Single Prime	Addition / Renovation	\$32,046,370.00	\$33,123,185.00	103.36%
	Multiple Prime	Addition / Renovation	\$12,385,406.00	\$12,964,481.00	104.68%
7	Single Prime	Addition / Renovation	\$21,345,610.00	\$21,227,168.00	99.45%
	Multiple Prime	Addition / Renovation	\$8,721,953.00	\$8,558,181.00	98.12%

Final Project Cost Comparison

Primary Comparison Points:

- Bid Year
- Building Type
- Type of Construction

Secondary Comparison Points:

- Region of State
- Enrollment
- Expenditures
- Structural Costs
- Architectural Area
- Square Foot Cost

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Separations Act Analysis

Final Construction Cost Comparison

Total Results for New Construction			
Delivery Method	Total Bid Price	Total Final Cost	Percentage Increase
Single Prime	\$94,869,769.00	\$100,426,437.00	105.86%
Multiple Prime	\$64,516,951.00	\$66,816,722.00	103.56%

Total Results for Addition / Renovation			
Delivery Method	Total Bid Price	Total Final Cost	Percentage Increase
Single Prime	\$69,905,031.00	\$72,540,415.00	103.77%
Multiple Prime	\$37,790,478.00	\$38,676,972.00	102.35%

Final Project Cost Comparison

The final costs of projects are closer than the bid costs by contractors

Potential Reasons:

Better management means a lower average of problems

Renovation work which requires added coordination specifically benefits from single prime

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Separations Act Analysis

Conclusion

Reinstate Mandate Waiver program

Use new data collection for further analysis

Require separate bids for single and multiple prime

PRESENTATION OUTLINE:

I. Project Background

II. Separations Act Analysis

III. Geothermal Heat Pump

IV. BIM in Preconstruction

V. Precast Façade

VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Geothermal Heat Pump System

Problem Background

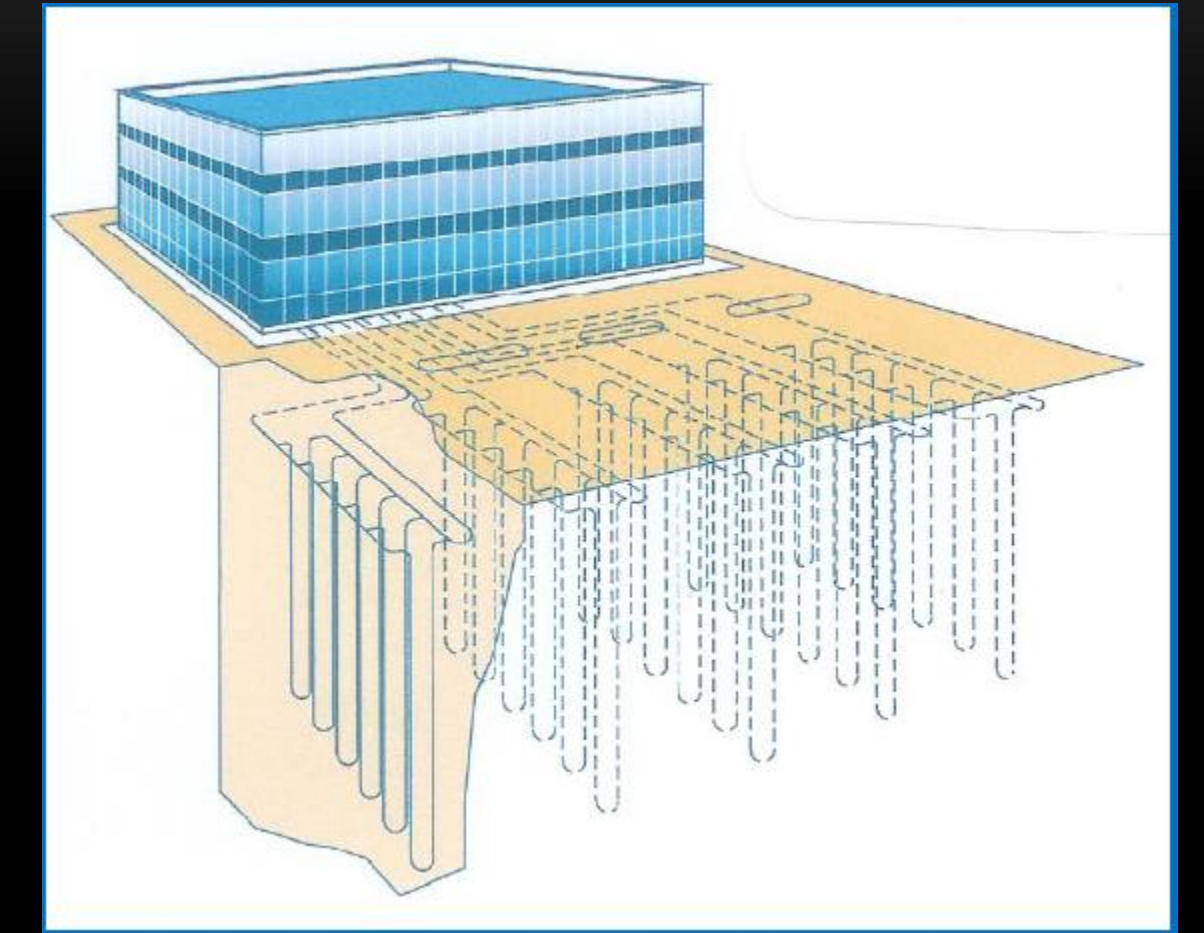
Energy efficient building important to school district

Water source heat pump system chosen

Geothermal system could be a better long term approach

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion





PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Geothermal Heat Pump System

System Design

Loading based on loads of the currently design water source heat pumps

Vertical loops chosen over horizontal

Water used as refrigerant

Used Ground Loop Design Commercial Version 2012 software by GLD

Design Features

Total Length (ft): 53963.1

Boreholes Number: 120

Borehole Depth: 449.7

Borehole Spacing: 20'

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

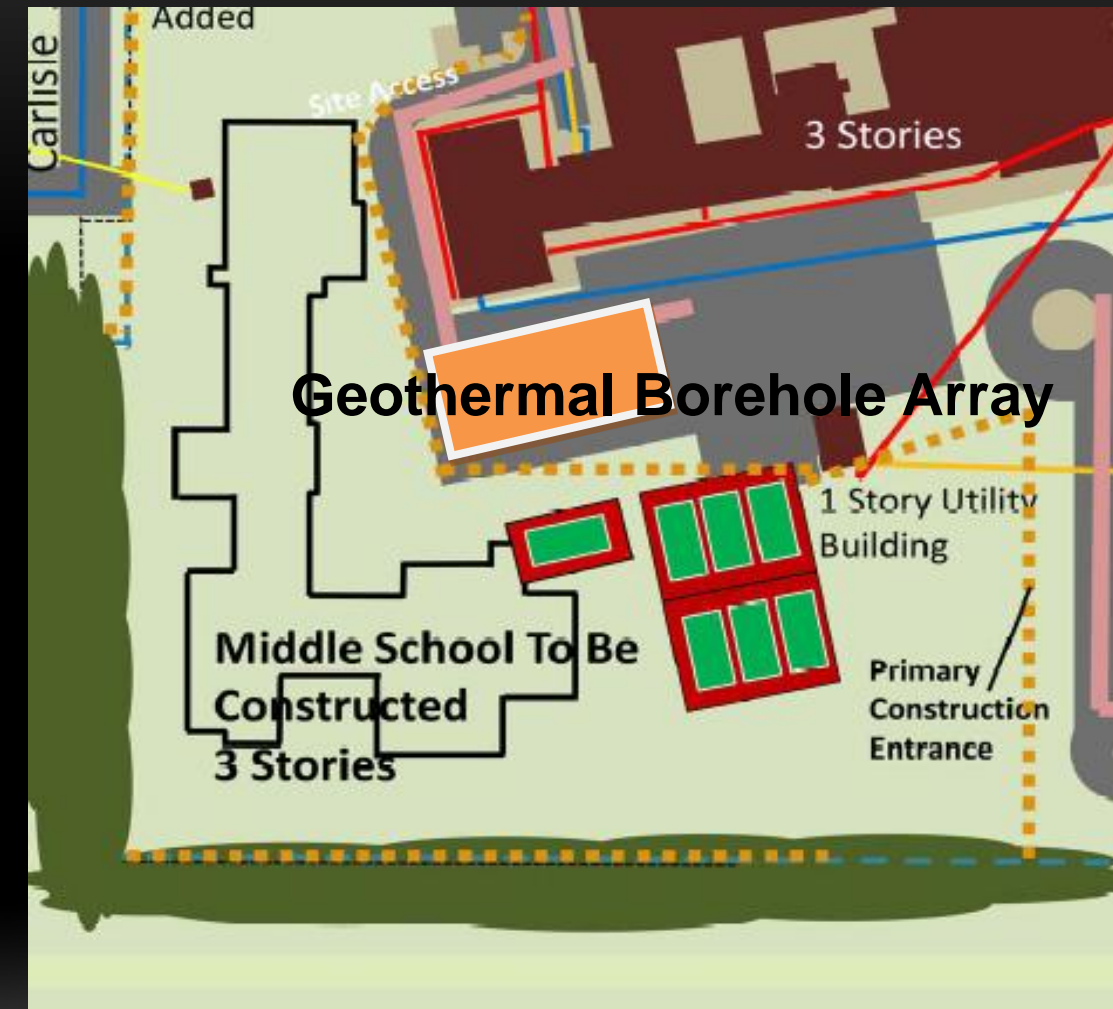
RICHARD SCHIMPF

CONSTRUCTION OPTION

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Geothermal Heat Pump System





PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Geothermal Heat Pump System

Schedule Impact

Roughly 2 boreholes a day

Takes place during site establishment and excavation

Only real schedule impact comes from excavating for pipes

Additional two weeks to critical path

Constructability Concerns

Drilling in shale commonly found in Pennsylvania can pose problems

Must relocate student parking temporarily

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Geothermal Heat Pump System

Mechanical Breadth Study

Subtracted the power consumption of the cooling towers and two boilers.

Total Annual Energy Saved: 22,053 kWh per year

Details

The two systems being compared have the same or similar heat pumps systems

Main difference comes from the heating and cooling methods.

Energy use of the equipment considered



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Geothermal Heat Pump System

Short Term Cost Impact

Original Mechanical Contract Value:	\$5,778,734.00
Subtracted Cost of Cooling Towers and Unit Heaters:	\$273,500
Added Cost of Geothermal Ground Loops:	\$972,000
Adjusted Contract Value for Proposed Change:	\$6,477,234.00
Percent Change in Total Contract Value:	112.09%

Longterm Cost Impact

Annual Energy Savings: 22,053 kWh / year

Annual Cost Saving per year: \$4,410

20 year life cycle

$\$4,410 \times 20 = \$88,214$

Payback Period: 158 years

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Geothermal Heat Pump System

Conclusion

Current system in place provides better value

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

BIM Application to Preconstruction

Problem Identification

BIM only used by architect and structural engineer

Used to model architectural and structural design

Early use in design could benefit project

BIM Execution Guide

Building Maintenance Scheduling	Design Authoring
Building Systems Analysis	Engineering Analysis
Asset Management	Sustainability Evaluation (LEED)
Space Management and Tracking	Code Validation
Disaster Planning	Design Reviews
Record Modeling	Programming
Site Utilization Planning	Site Analysis
Construction System Design	Phase Planning (4D Modeling)
Digital Fabrication	Cost Estimation
3D Control and Planning (Digital Layout)	Existing Conditions Modeling
3D Coordination	

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

BIM Application to Preconstruction

Conclusion

Processes focus on processes prior to bids going out

Reynolds Construction Management would share model with architect / engineer

Would aid owner in decision making

Project Limitations

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Building Maintenance Scheduling	Design Authoring
Building Systems Analysis	Engineering Analysis
Asset Management	Sustainability Evaluation (LEED)
Space Management and Tracking	Code Validation
Disaster Planning	Design Reviews
Record Modeling	Programming
Site Utilization Planning	Site Analysis
Construction System Design	Phase Planning (4D Modeling)
Digital Fabrication	Cost Estimation
3D Control and Planning (Digital Layout)	Existing Conditions Modeling
3D Coordination	



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Precast Concrete Facade

Problem Description

Project must be complete for 2012 – 2013 academic year

Not much room for error

Potential schedule reduction could mitigate risk

Precast concrete façade in areas B and C would accomplish this

Analysis Goals

Design Precast Facade

Determine Schedule Impacts

Determine Constructability Impacts

Cost impacts of precast facade

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Precast Concrete Facade

Current Facade

Split-face CMU's with CMU or Metal Stud backing

Requires scaffolding for construction

Not structurally significant

Current Schedule for Facade

Area B	Start	Finish
CMU Backup Masonry	3/17/2011	5/2/2011
Metal Stud Backup	4/12/2011	6/14/2011
Masonry Veneer and Clean	5/24/2011	7/19/2011
Area C		
CMU Backup Masonry	4/29/2011	5/19/2011
Metal Stud Backup	5/24/2011	7/27/2011
Masonry Veneer and Clean	7/7/2011	8/29/2011

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



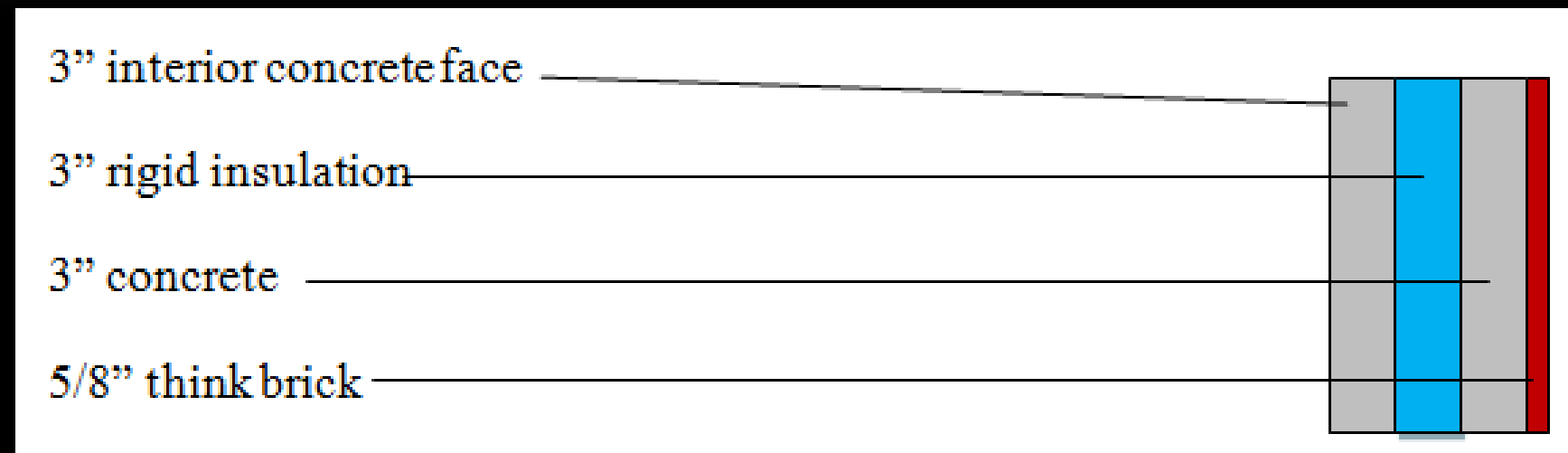
PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

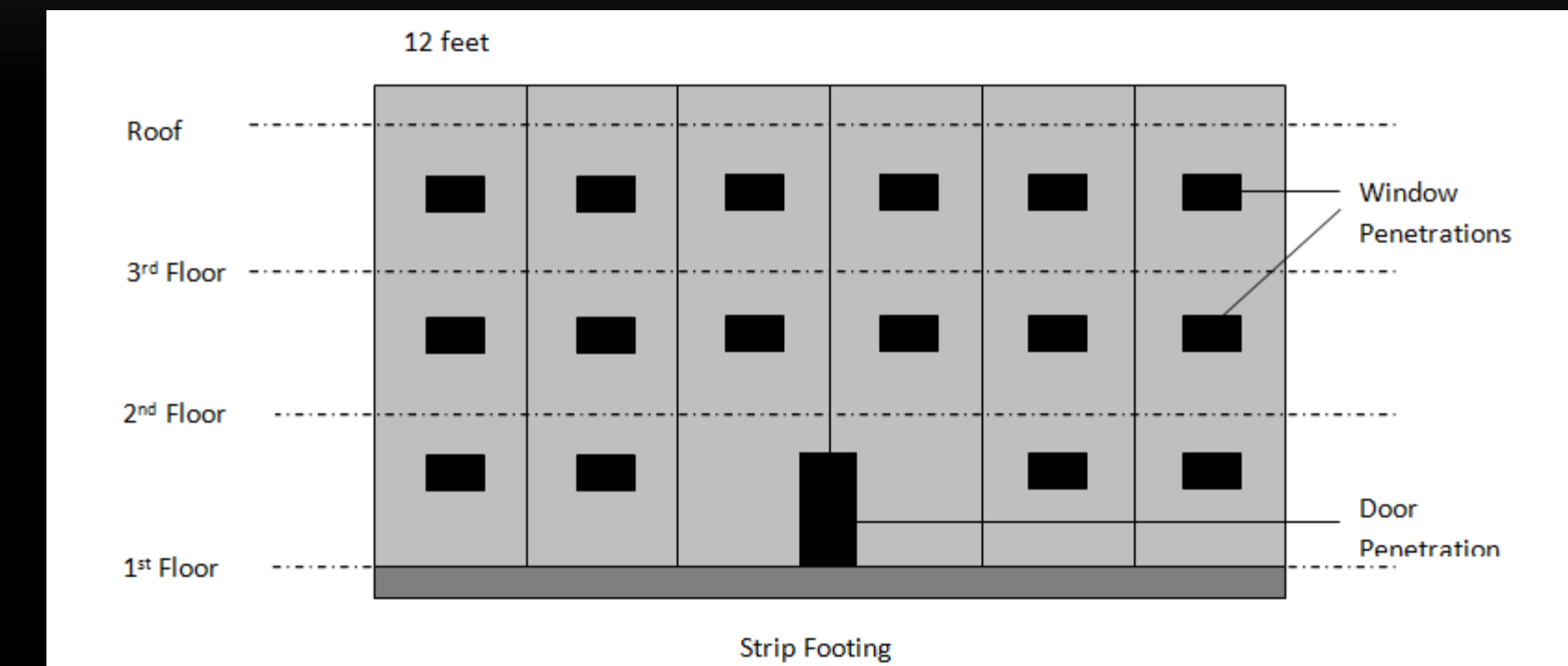
CONSTRUCTION OPTION

Precast Concrete Facade

Precast Cross Section



Example of Elevation



PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

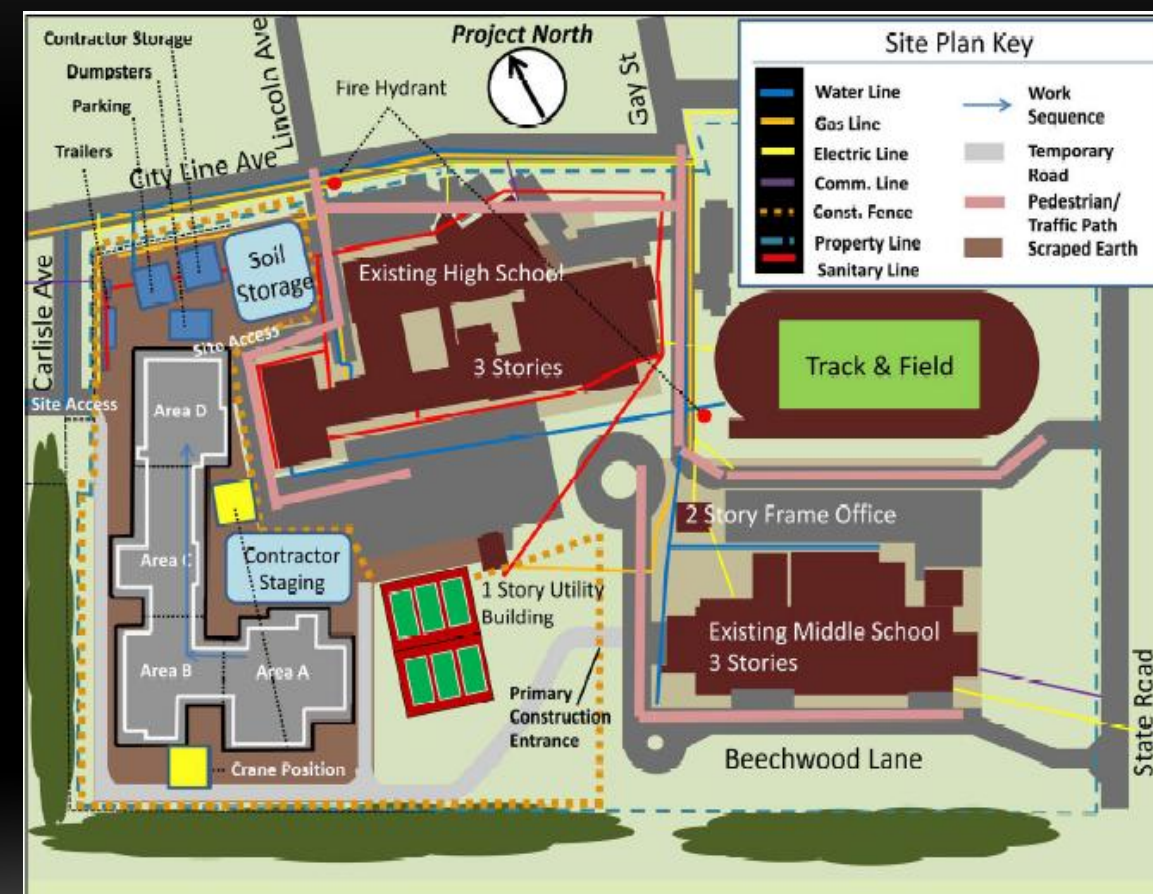
CONSTRUCTION OPTION

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Precast Concrete Façade

Construction Sequence



Schedule Reduction

Roughly 20 days taken off of total project duration



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

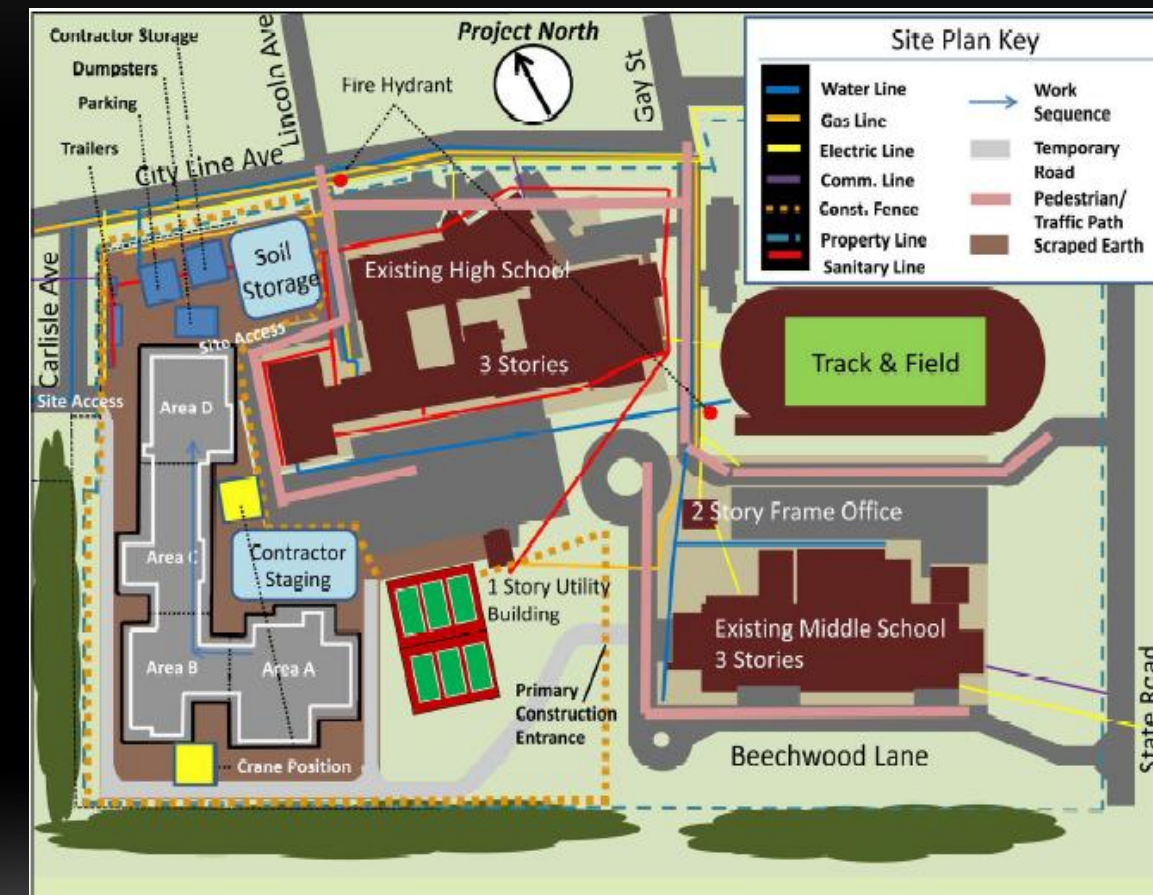
CONSTRUCTION OPTION

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Precast Concrete Façade

Construction Sequence



Schedule Reduction

Roughly 20 days taken off of total project duration



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion

Precast Concrete Façade

Structural Breadth Study

**Strip footing bearing weight of panels increased in size
from 1' x 2'3" to 2.5' x 5.25'**

Precast Quantities



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Precast Concrete Façade

Cost Impacts

Precast Façade:

74 panels @ 12' x 42': \$745,920

2 panels @ 10' x 42': \$16800

1 panel @ 9' x 42': \$7560

1 panel @ 7' x 42': \$5880

1 panel @ 6' x 42': \$5040

Total Precast Cost: \$781,200

Increase in Strip Footing Cost: \$8,625

Total Cost: \$789,825

Cost Impacts

Masonry:

Area B	Façade Back Up: Labor	\$182,391.95
Area B	Façade Back Up: Material	\$94,575.00
Area C	Façade Back Up: Labor	\$182,391.95
Area C	Façade Back Up: Material	\$94,575.00
Area B	Face CMU: Labor	\$52,000.00
Area C	Face CMU: Material	\$88,752.00
	Total Cost:	\$694,685.90

PRESENTATION OUTLINE:

I. Project Background

II. Separations Act Analysis

III. Geothermal Heat Pump

IV. BIM in Preconstruction

V. Precast Façade

VI. Conclusion



PHOENIXVILLE AREA MIDDLE SCHOOL

RICHARD SCHIMPF

CONSTRUCTION OPTION

Precast Concrete Façade

Conclusion

Added costs of precast façade not justifiable.

PRESENTATION OUTLINE:

- I. Project Background
- II. Separations Act Analysis
- III. Geothermal Heat Pump
- IV. BIM in Preconstruction
- V. Precast Façade
- VI. Conclusion