



EFFECTIVENESS OF BUILDING INFORMATION MODELING IN VALUE ENGINEERING, SEQUENCING, & SITE LOGISTICS

T.C. WILLIAMS HIGH SCHOOL REPLACEMENT PROJECT



KYLE CONRAD

AE SENIOR PROJECT

– SPRING 2007

CONSTRUCTION MANAGEMENT



PRESENTATION OUTLINE

Project Background

Building Information Model [BIM]

Alternative Building Materials Analyses

Breadth Topic: **Gymnasium Acoustics**

Breadth Topic: **Heat Transfer**

Breadth Topic: **Proposed Structural Steel
Moment Frame**

Work Sequencing

Site Logistics

Conclusions & Recommendations

Question & Answer Session



PROJECT BACKGROUND

Project Site:

3330 King St.

Alexandria, Virginia



- PROJECT BACKGROUND
- BIM
- ALTERNATIVE BUILDING MATERIALS
- GYMNASIUM
- ACOUSTICS
- HEAT TRANSFER
- STRUCTURAL FRAME
- WORK SEQUENCING
- SITE LOGISTICS
- CONCLUSIONS / RECOMMENDATIONS
- Q & A



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Original T.C. Williams High School



Home of the Titans

- Over the last 50 Years existing schools condition had been degrading
- Originally designed to educate grades 9-12
- District population grew forcing 9th grade to be relocated to a different facility
- Additionally classes held in temporary classroom trailers



PROJECT BACKGROUND

New Home of the Titans

- 469,507 ft² educational facility
- Specialty classrooms (biology, marketing, chemistry, etc.)
- Planetarium
- Computer and Science Labs
- Commons Area
- Auditorium with operable partitions to create multiple lecture halls
- Main and Auxiliary Gymnasiums
- “Babies with Babies” daycare and living lab
- Music Suites
- Auto Service Technology Shops



Seeking LEED Certification

- Create sustainable building that reduces the consumption of raw materials and energy and has a low impact on the environment

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Structural System

- Geopiers - rammed aggregate soil reinforcement
- Classroom Towers – 3 story steel moment frame structure
- East Wing & Rooms at South End of Classroom Towers [Areas 5, 6, & 7] – Single story multi height spaces of Load Bearing CMU walls with structural steel roof beams and joists

Mechanical System

- 17 rooftop AHUs
 - ranging from 1,400 to 23,295 cfm
- 4 indoor AHUs
- Variable Air Volume System with 305 terminal units with reheating coils
- A 4 pipe system supplies and returns hot and chilled water to and from 12 fan coil units



PROJECT BACKGROUND

DESIGN-BID-BUILD DESIGN-BID-BUILD

OWNER:
Alexandria City Public
Schools

**ARCHITECT /
STRUCTURAL & MEP
ENGINEERS:**
Moseley Architects

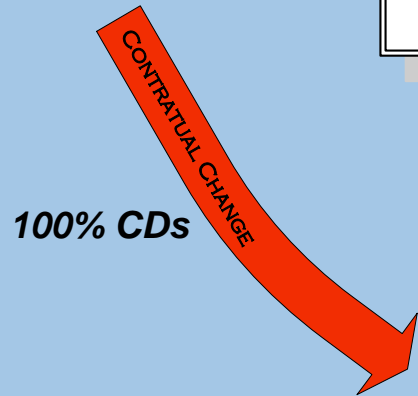
GENERAL CONTRACTOR:
Hensel Phelps Construction
Company

DESIGN-BUILD DESIGN-BUILD

OWNER:
Alexandria City Public
Schools

GENERAL CONTRACTOR:
Hensel Phelps Construction
Company

**ARCHITECT /
STRUCTURAL & MEP
ENGINEERS:**
Moseley Architects

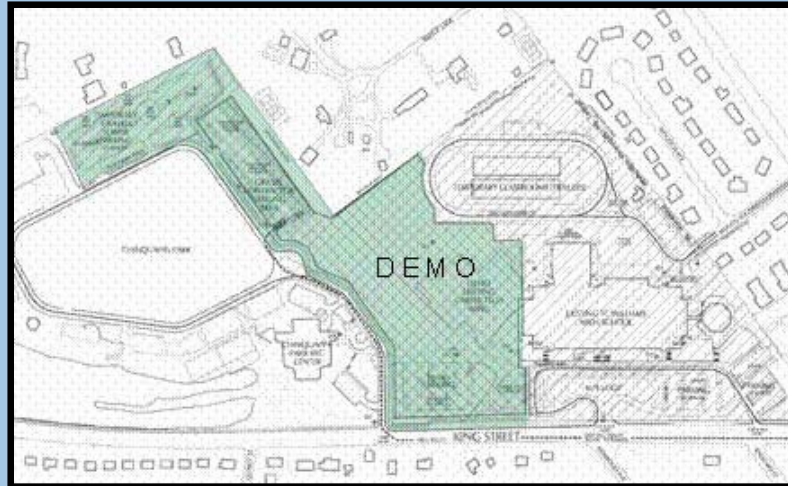


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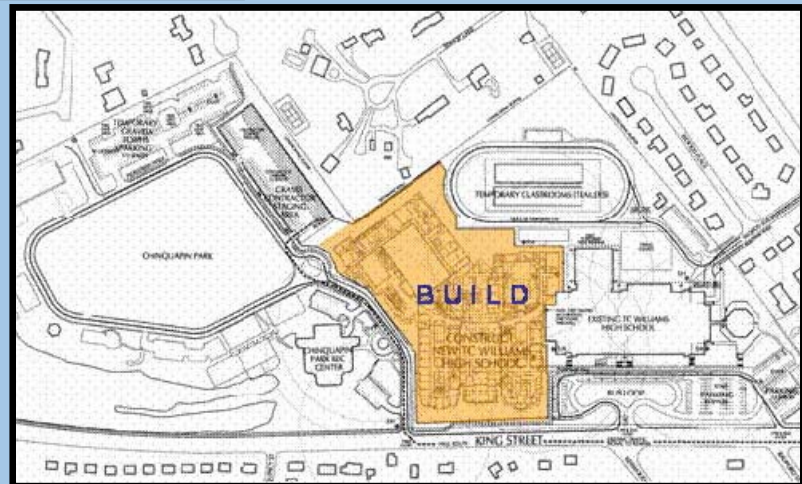


PROJECT BACKGROUND

Phase A-1



Phase A-2



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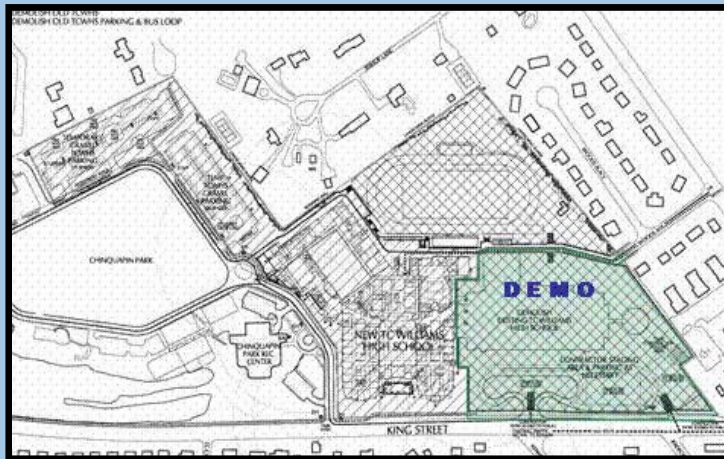
CONCLUSIONS /
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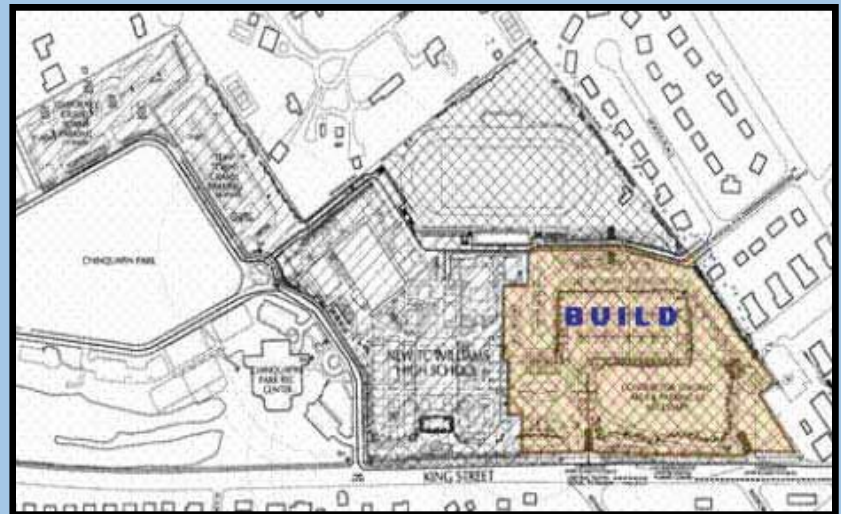


PROJECT BACKGROUND

Phase B-1



Phase B-2



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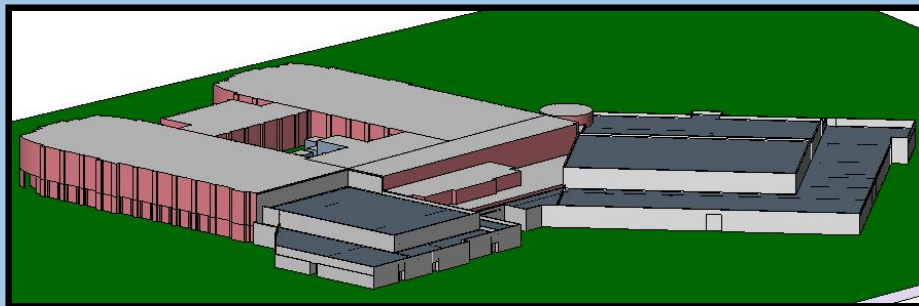
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BUILDING INFORMATION MODEL [BIM]



PROJECT BACKGROUND

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Goals of Building Information Model:

Experiment with the interoperability between programs to....

- Quickly perform quantity take-offs
- Manipulate the original design for value engineering purposes
- Design a structural moment frame
- Visualize and re-sequence the construction schedule through 4D planning

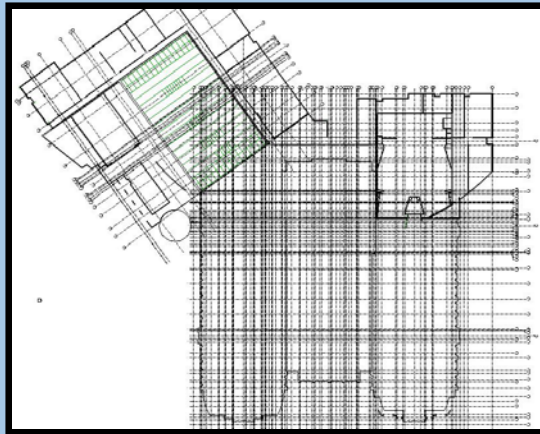
Programs Used:

- Autodesk Revit Building 9.1
- Autodesk Revit Structure 4
- RAM Structural Systems
- NavisWorks
- Timeliner



BUILDING INFORMATION MODEL [BIM]

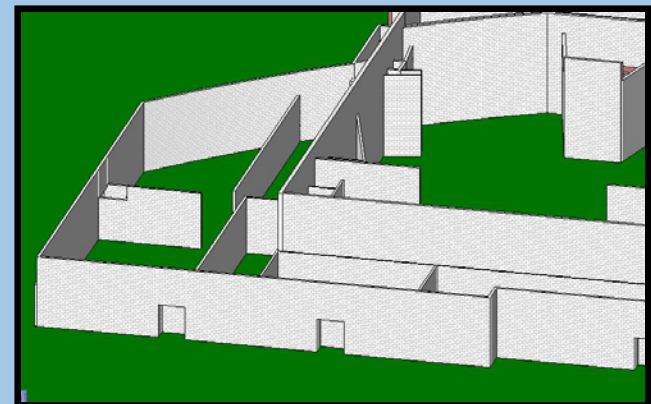
Autodesk Revit Building 9.1:



- Developed structural grid based on construction drawings provided by Hensel Phelps

- Initially generated building model with generic wall types to speed the modeling process of Areas 5, 6, & 7

- Created massing models of Areas 1-4 to accurately render the appearance of the school



- Adjusted wall types to complete a CMU and Solarcrete version

- Generated wall schedules to perform QTO of materials to be exported to Excel

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T.C. Williams High School QTO - Current Construction		
Gymnasium		
10" CMU	49,827	sf
12" CMU	14,828	sf
14" CMU	19,440	sf
6" CMU	7,469	sf
8" CMU	19,007	sf
Sub-Total:	110,571	sf
Auditorium		
10" CMU	19,046	sf
12" CMU	8,281	sf
14" CMU	13,981	sf
6" CMU	8,661	sf
8" CMU	10,857	sf
Sub-Total:	60,826	sf
Mech/Elec Wedge - Auto Strip		
10" CMU	16,587	sf
6" CMU	1,625	sf
8" CMU	5,217	sf
Sub-Total:	23,429	sf
Misc.	45	sf
Total:	194,871	sf

T.C. Williams High School QTO - Solarcrete System			
Gymnasium			
12" Panel	66,167	sf	2,595
Sub-Total:	66,167	sf	2,595
Auditorium			
12" Panel	42,367	sf	1,900
Sub-Total:	42,367	sf	1,900
Mech/Elec Wedge - Auto Strip			
12" Panel	21,383	sf	1,220
Sub-Total:	21,383		1,220
Total:	129,917	sf	5,715



BUILDING INFORMATION MODEL [BIM]

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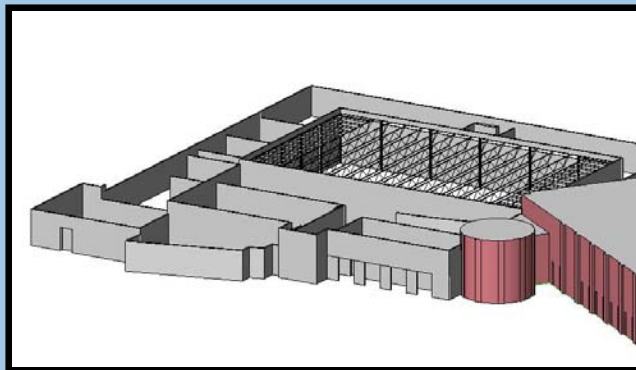
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NavisWorks:

- Exported Revit file to NavisWorks
- Used Timeliner Mode to open Microsoft Project Summary Schedule compiled from Suretrak schedule provided by HP
- Attached schedule task to building model components

Autodesk Revit Structure 4:

- Directly opened generic model created by Revit Building 9.1
- Developed generic structural steel frame for main gymnasium
- Isolated and exported steel frame to RAM for structural analysis and member sizing
- Loaded RAM model back into Autodesk Structure 4 to develop structural framing and column schedules for QTO (presented later)

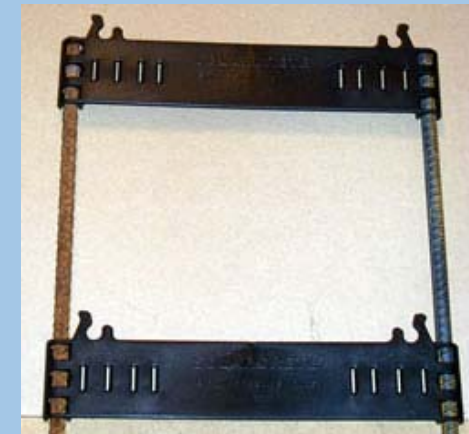


ALTERNATIVE BUILDING MATERIALS



- Structural Insulated Concrete Composite Wall Panel
- 7-1/4” expanded polystyrene [EPS] foam insulation (R-Value of 36)
- #3 Rebar (Grade 60)
- (2) 2-3/8” layers of fiber reinforced shotcrete (pneumatic application)

- Polymer alloy wall ties act as a thermal barrier compared to original steel design
- Improving energy efficiency of wall system
- Plastic straps slide through tie slots to band panels together



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ALTERNATIVE BUILDING MATERIALS

- Fabricated in controlled environment increasing worker productivity and reducing site congestion



- 2' x 4' rebar grid both sides of wall

- Vertical reinforcement runs entire height of wall

- Horizontal reinforcement 4' o.c. on alternating sides of wall

- Vertical Control joints wire tied to horizontal reinforcing at a maximum of 8' o.c.

- Transported to site

- Just-in-Time delivery possible to reduce the need for on-site material storage areas and double-handling of materials



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- Structurally superior to CMU – according sales representative
- High wall assemblies often require structural steel support frame to aid in the resistance to lateral loading
- Increase ease of erection of prefabricated panels

- Lightweight panels tilted-up into place via boom lifts or cranes
- Anchored into continuous footing





ALTERNATIVE BUILDING MATERIALS

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- Structural concrete without the labor intensive formwork process

- Enables curvilinear design at economical cost

- 4000 psi fiber reinforced concrete sprayed with an air pressurized hose and screeded to a thickness of 2-3/8" on both sides of panel

- Acrylic stucco most common exterior finish

- Face Brick Application

- Elastomeric or acrylic paints are the most common interior finish





GYMNASIUM ACOUSTICS

MATERIAL	SOUND ABSORPTION COEFFICIENTS						
	125HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	NRC
Soundblock [®]							
4" Type A Surface: Painted	0.12	0.85	0.36	0.36	0.42	0.45	0.50
10" Type RSC/RF Surface: Painted	0.18	0.64	1.02	0.72	0.80	0.58	0.80
Acousta-Wal [®]							
4" Type I Surface: Painted	0.18	0.82	0.40	0.35	0.43	0.36	0.50
10" Type IVRF Surface: Painted	0.21	0.78	0.97	0.80	0.68	0.73	0.80
Soft Sound [™]							
Impact Resistant 1" Fabric Acoustic Panel	0.31	0.55	0.89	1.07	1.05	1.15	0.90
Impact Resistant 2" Vinyl Acoustic Panel	0.28	0.69	1.07	1.11	1.06	1.08	1.00
Noise STOP Fabrisorb [™]							
High Impact Resistant 1-1/8" Fiberglass core / Fabric Facing	0.09	0.50	0.99	1.13	1.08	0.96	0.95
High Impact Resistant 2-1/8" Fiberglass core / Fabric Facing	0.45	0.91	1.09	1.14	1.02	0.98	1.05
High Impact Resistant 1-5/8" Fiberglass core / Vinyl Facing	0.23	0.64	1.16	1.16	1.14	1.02	1.05
Misc. Materials							
Concrete Block, Painted	0.10	0.05	0.06	0.07	0.09	0.08	0.05
Concrete, Rough	0.01	0.02	0.04	0.06	0.08	0.10	0.05
Concrete, Troweled	0.01	0.01	0.02	0.02	0.02	0.02	0.00
Acoustical Metal Roof Deck*	0.14	0.36	0.89	0.95	0.53	0.34	0.70
Wood parquet on Concrete	0.04	0.04	0.07	0.06	0.06	0.07	0.05
Steel Doors	0.05	0.10	0.10	0.10	0.07	0.02	0.10
Metal / Wood Seat - Unoccupied	0.15	0.19	0.22	0.39	0.38	0.30	0.30
Students, Informally Dressed Seated in Wood Chairs	0.30	0.41	0.49	0.84	0.87	0.84	0.65
Leather-Covered Upholstered Seats, Unoccupied	0.44	0.54	0.60	0.62	0.58	0.50	0.59
Glass, Ordinary Windows	0.35	0.25	0.18	0.12	0.07	0.04	0.15

* Acoustical Information obtained from Vulcraft Steel Roof and Floor Deck Catalog – 3NA, 3NIA Acoustical Deck
(http://itecsteel.com/images/pdf/vulcraft_steel_deck.pdf)

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GYMNASIUM ACOUSTICS

Reverberation Time Calculator

$$T_{60} = .05(V/a) = .05(V/\sum S\alpha)$$

Reverberation Time Calculation for:		T.C. Williams High School Main Gymnasium Open Gym - 3/4 Occupancy King Street - Alexandria, VA				
CMU Walls		Area (ft ²)	Absorption Coefficient		S α	
Surface	Material		500 Hz	1000 Hz	500 Hz	1000 Hz
Floor	Athletic Wood Flooring	11,979.00	0.07	0.06	838.53	718.74
Floor	3/4 Students, On Bleachers	9,438.00	0.49	0.84	4624.62	7927.92
Floor	1/4 Wood Bleachers	3,146.00	0.22	0.39	692.12	1226.94
Ceiling	3" Deep Acoustical Roof Deck	24,563.00	0.89	0.95	21861.07	23334.85
North Wall	Ground Face CMU - Painted	1,365.33	0.06	0.07	81.9198	95.5731
North Wall	3/4 Students, On Bleachers	1,969.50	0.49	0.84	965.055	1654.38
North Wall	1/4 Wood Bleachers	656.50	0.22	0.39	144.43	256.035
North Wall	Metal Doors	42.00	0.10	0.10	4.2	4.2
South Wall	Ground Face CMU - Painted	1,323.33	0.06	0.07	79.3998	92.6331
South Wall	3/4 Students, On Bleachers	1,969.50	0.49	0.84	965.055	1654.38
South Wall	1/4 Wood Bleachers	656.50	0.22	0.39	144.43	256.035
South Wall	Metal Doors	84.00	0.10	0.10	8.4	8.4
West Wall	Ground Face CMU - Painted	4,315.78	0.06	0.07	258.9468	302.1046
West Wall	Acoustical CMU	1,872.66	1.02	0.72	1910.113	1348.315
West Wall	Metal Doors	168.00	0.10	0.10	16.8	16.8
West Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56
West Wall	Windows	122.22	0.18	0.12	21.9996	14.6664
East Wall	Ground Face CMU - Painted	4,105.78	0.06	0.07	246.3468	287.4046
East Wall	Acoustical CMU	1,872.66	1.02	0.72	1910.113	1348.315
East Wall	Metal Doors	378.00	0.10	0.10	37.8	37.8
East Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56
East Wall	Windows	122.22	0.18	0.12	21.9996	14.6664
					0	0
					0	0
					0	0
Room Length (ft):	203.00 ft		a = $\sum S\alpha$		35178.95	40957.28
Room Width (ft):	121.00 ft		T₆₀ = .05(V/$\sum S\alpha$)		1.16	1.00
Room Height (ft):	33.33 ft					
Volume (ft³):	818,685 ft³					
Target Reverberation Time: Gymnasium for Teaching*					1.5 to 1.8	1.5 to 1.8

* Target Reverberation Time obtained from the M² Squared System Design Group, Inc.

Calculations Run For:

- Open Gym
- Bleachers Retracted
- 3/4 Occupancy
- Full Occupancy

Reverberation Time

- 5 seconds
- 2 seconds

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Reverberation Time Calculator

$$T_{60} = .05(V/a) = .05(V/\sum S\alpha)$$

Reverberation Time Calculation for :		T.C. Williams High School Main Gymnasium					
		Open Gym - 3/4 Occupancy					
Solarcrete System - w/o Acoustic Wall Panels		King Street - Alexandria, VA					
Surface	Material	Area (ft ²)	Absorption Coefficient		S α		
			500 Hz	1000 Hz	500 Hz	1000 Hz	
Floor	Athletic Wood Flooring	11,979.00	0.07	0.06	838.53	718.74	
Floor	3/4 Students, On Bleachers	9,438.00	0.49	0.84	4624.62	7927.92	
Floor	1/4 Wood Bleachers	3,146.00	0.22	0.39	692.12	1226.94	
Ceiling	3" Deep Acoustical Roof Deck	24,563.00	0.89	0.95	21861.07	23334.85	
North Wall	Concrete, Troweled	1,365.33	0.02	0.02	27.3066	27.3066	
North Wall	3/4 Students, On Bleachers	1,969.50	0.49	0.84	965.055	1654.38	
North Wall	1/4 Wood Bleachers	656.50	0.22	0.39	144.43	256.035	
North Wall	Metal Doors	42.00	0.10	0.10	4.2	4.2	
South Wall	Concrete, Troweled	1,323.33	0.02	0.02	26.4666	26.4666	
South Wall	3/4 Students, On Bleachers	1,969.50	0.49	0.84	965.055	1654.38	
South Wall	1/4 Wood Bleachers	656.50	0.22	0.39	144.43	256.035	
South Wall	Metal Doors	84.00	0.10	0.10	8.4	8.4	
West Wall	Concrete, Troweled	6,188.44	0.02	0.02	123.7688	123.7688	
West Wall	Metal Doors	168.00	0.10	0.10	16.8	16.8	
West Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56	
West Wall	Windows	122.22	0.18	0.12	21.9996	14.6664	
East Wall	Concrete, Troweled	5,978.44	0.02	0.02	119.5688	119.5688	
East Wall	Metal Doors	378.00	0.10	0.10	37.8	37.8	
East Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56	
East Wall	Windows	122.22	0.18	0.12	21.9996	14.6664	
					0	0	
					0	0	
					0	0	
					0	0	
					0	0	
Room Length (ft):	203.00	ft	a = $\sum S\alpha$		30989.22	37780.04	
Room Width (ft):	121.00	ft	T₆₀ = .05(V/$\sum S\alpha$)		1.32	1.08	
Room Height (ft):	33.33	ft					
Volume (ft³):	818,685	ft³					

Target Reverberation Time: Gymnasium for Teaching*	1.5 to 1.8	1.5 to 1.8
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GYMNASIUM ACOUSTICS



Noise S.T.O.P. Fabrisorb™

- High Impact
- Fabric Wrapped

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Acoustic Panel Quote				
Acoustical Surfaces, Inc.				
Item	Quantity	Units	Unit Price*	Cost
Fabrisorb 1-1/8" High Impact Fabric Wrapped Panels	4,320	sf	7.59	\$32,788.80
Impaling Clips (10 per panel)	1,200	each	0.50	\$600.00
PSA-29 Acoustical Panel Adhesive Tubes	144	each	9.25	\$1,332.00
Packing/ Plywood Crating	2	each	125.00	\$250.00
Total:				\$34,970.80

Note:

* Based on Quote Compiled by Ted Weidman on 5/11/2007 on 3,600sf of 4' x 9' panels



GYMNASIUM ACOUSTICS

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Solarcrete System - w/ Fabrisorb™ Acoustic Wall Panels			Absorption Coefficient		Sα	
Surface	Material	Area (ft ²)	500 Hz	1000 Hz	500 Hz	1000 Hz
Floor	Athletic Wood Flooring	11,979.00	0.07	0.06	838.53	718.74
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North Wall	Metal Doors	42.00	0.10	0.10	4.2	4.2
South Wall	Concrete, Troweled	1,323.33	0.02	0.02	26.4666	26.4666
South Wall	3/4 Students, On Bleachers	1,969.50	0.49	0.84	965.055	1654.38
South Wall	1/4 Wood Bleachers	656.50	0.22	0.39	144.43	256.035
South Wall	Metal Doors	84.00	0.10	0.10	8.4	8.4
West Wall	Concrete, Troweled	6,188.44	0.02	0.02	123.7688	123.7688
West Wall	Metal Doors	168.00	0.10	0.10	16.8	16.8
West Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56
West Wall	Windows	122.22	0.18	0.12	21.9996	14.6664
East Wall	Concrete, Troweled	5,978.44	0.02	0.02	119.5688	119.5688
East Wall	Metal Doors	378.00	0.10	0.10	37.8	37.8
East Wall	AT-4 Wall Padding	288.00	0.60	0.62	172.8	178.56
East Wall	Windows	122.22	0.18	0.12	21.9996	14.6664
					0	0
West Wall	1-1/8" Fabric Impact Resistant Acoustic Panels	2,160.00	0.99	1.13	2138.4	2440.8
East Wall	1-1/8" Fabric Impact Resistant Acoustic Panels	2,160.00	0.99	1.13	2138.4	2440.8
					0	0
					0	0
Room Length (ft):	203.00 ft		a = $\sum S\alpha$		35266.02	42661.64
Room Width (ft):	121.00 ft		T₆₀ = .05(V/$\sum S\alpha$)		1.16	0.96
Room Height (ft):	33.33 ft		CMU Reverberation Time		1.16	1.00
Volume (ft³):	818,685 ft ³					

Target Reverberation Time: Gymnasium for Teaching*	1.5 to 1.8	1.5 to 1.8
---	------------	------------

* Target Reverberation Time obtained from the M²Squared System Design Group, Inc.

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HEAT TRANSFER

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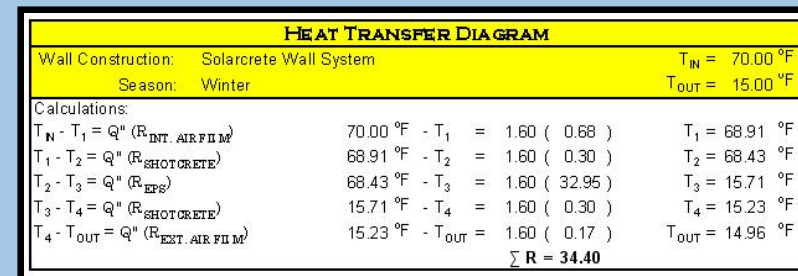
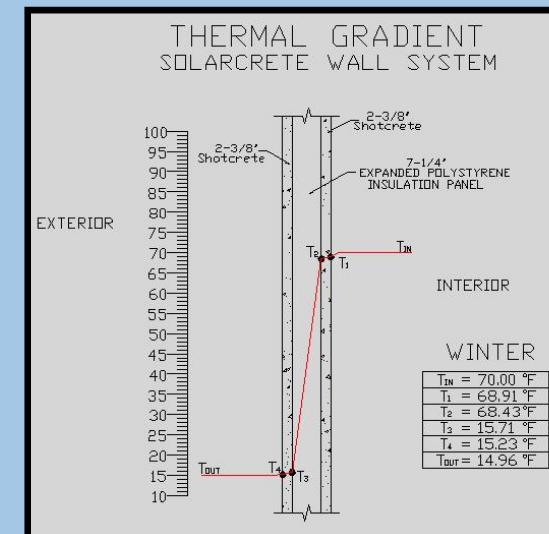
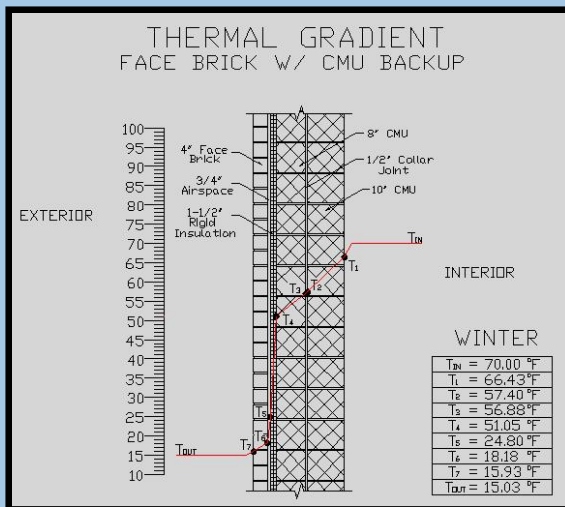
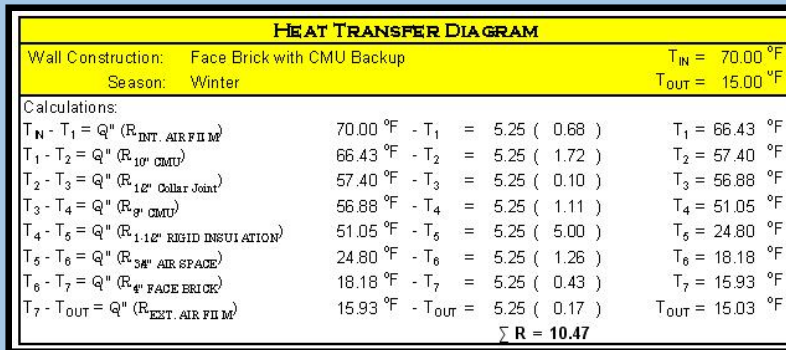
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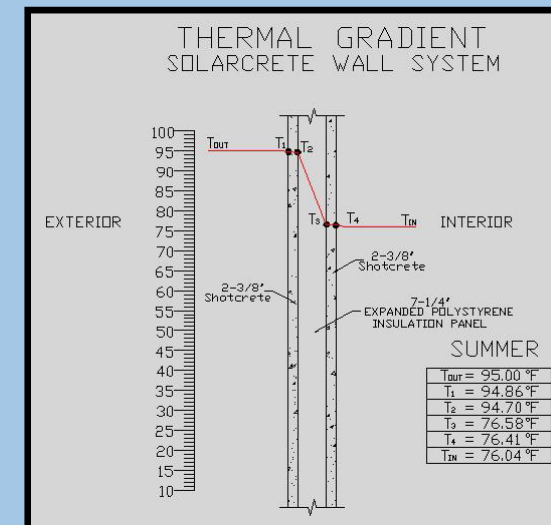
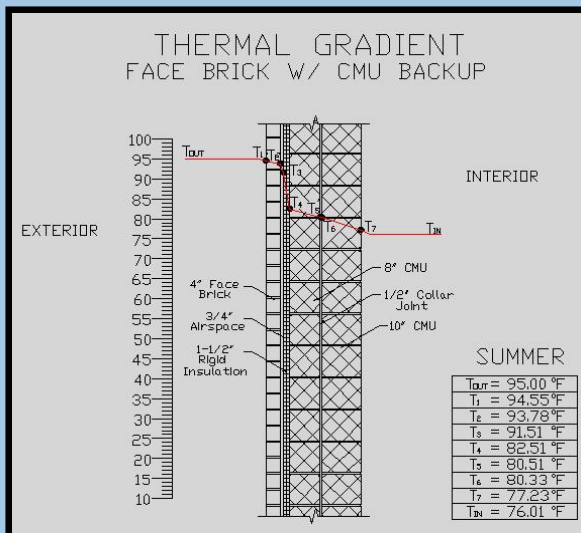
WORK SEQUENCING

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HEAT TRANSFER DIAGRAM			
Wall Construction:	Face Brick with CMU Backup	$T_{IN} = 76.00\text{ }^{\circ}\text{F}$	
Season:	Summer	$T_{OUT} = 95.00\text{ }^{\circ}\text{F}$	
Calculations:			
$T_{OUT} - T_1 = Q'' (R_{EST. AIR FILM})$	$95.00\text{ }^{\circ}\text{F} - T_1 = 1.80 (0.25)$	$T_1 = 94.55\text{ }^{\circ}\text{F}$	
$T_1 - T_2 = Q'' (R_{4\text{'' FACE BRICK}})$	$94.55\text{ }^{\circ}\text{F} - T_2 = 1.80 (0.43)$	$T_2 = 93.78\text{ }^{\circ}\text{F}$	
$T_2 - T_3 = Q'' (R_{3/8\text{'' AIR SPACE}})$	$93.78\text{ }^{\circ}\text{F} - T_3 = 1.80 (1.26)$	$T_3 = 91.51\text{ }^{\circ}\text{F}$	
$T_3 - T_4 = Q'' (R_{1.12\text{'' RIGID INSULATION}})$	$91.51\text{ }^{\circ}\text{F} - T_4 = 1.80 (5.00)$	$T_4 = 82.51\text{ }^{\circ}\text{F}$	
$T_4 - T_5 = Q'' (R_{8\text{'' CMU}})$	$82.51\text{ }^{\circ}\text{F} - T_5 = 1.80 (1.11)$	$T_5 = 80.51\text{ }^{\circ}\text{F}$	
$T_5 - T_6 = Q'' (R_{1/2\text{'' Collar Joint}})$	$80.51\text{ }^{\circ}\text{F} - T_6 = 1.80 (0.10)$	$T_6 = 80.33\text{ }^{\circ}\text{F}$	
$T_6 - T_7 = Q'' (R_{10\text{'' CMU}})$	$80.33\text{ }^{\circ}\text{F} - T_7 = 1.80 (1.72)$	$T_7 = 77.23\text{ }^{\circ}\text{F}$	
$T_7 - T_{IN} = Q'' (R_{INT. AIR FILM})$	$77.23\text{ }^{\circ}\text{F} - T_{IN} = 1.80 (0.68)$	$T_{IN} = 76.01\text{ }^{\circ}\text{F}$	
	$\Sigma R = 10.55$		



HEAT TRANSFER DIAGRAM			
Wall Construction:	Solarcrete Wall System	$T_{IN} = 76.00\text{ }^{\circ}\text{F}$	
Season:	Summer	$T_{OUT} = 95.00\text{ }^{\circ}\text{F}$	
Calculations:			
$T_{OUT} - T_1 = Q'' (R_{EST. AIR FILM})$	$95.00\text{ }^{\circ}\text{F} - T_1 = 0.55 (0.25)$	$T_1 = 94.86\text{ }^{\circ}\text{F}$	
$T_1 - T_2 = Q'' (R_{SHOTCRETE})$	$94.86\text{ }^{\circ}\text{F} - T_2 = 0.55 (0.30)$	$T_2 = 94.70\text{ }^{\circ}\text{F}$	
$T_2 - T_3 = Q'' (R_{EPS})$	$94.70\text{ }^{\circ}\text{F} - T_3 = 0.55 (32.95)$	$T_3 = 76.58\text{ }^{\circ}\text{F}$	
$T_3 - T_4 = Q'' (R_{SHOTCRETE})$	$76.58\text{ }^{\circ}\text{F} - T_4 = 0.55 (0.30)$	$T_4 = 76.41\text{ }^{\circ}\text{F}$	
$T_4 - T_{IN} = Q'' (R_{INT. AIR FILM})$	$76.41\text{ }^{\circ}\text{F} - T_{IN} = 0.55 (0.68)$	$T_{IN} = 76.04\text{ }^{\circ}\text{F}$	
	$\Sigma R = 34.48$		



ENERGY CALCULATIONS

808Table 1. Annual Costs

Component	Existing School (\$)	New School (\$)
Air System Fans	6,832	3,522
Cooling	245	239
Heating	0	0
Pumps	0	0
Cooling Tower Fans	0	0
HVAC Sub-Total	7,078	3,762
Lights	3,375	3,375
Electric Equipment	1,655	1,655
Misc. Electric	0	0
Misc. Fuel Use	0	0
Non-HVAC Sub-Total	5,230	5,230
Grand Total	12,308	8,992

Carrier's Hourly Analysis Program [HAP] Analysis of Gymnasium Designs

\$7,078

-3,762

\$3,316 per AHU

3 Units

=> \$9,948 energy savings / year

Table 3. Component Cost as a Percentage of Total Cost

Component	Existing School (%)	New School (%)
Air System Fans	55.5	39.2
Cooling	2.0	2.7
Heating	0.0	0.0
Pumps	0.0	0.0
Cooling Tower Fans	0.0	0.0
HVAC Sub-Total	57.5	41.8
Lights	29.0	39.8
Electric Equipment	13.4	18.4
Misc. Electric	0.0	0.0
Misc. Fuel Use	0.0	0.0
Non-HVAC Sub-Total	42.5	58.2
Grand Total	100.0	100.0

Non-HVAC Sub-Total	0.213	0.213
Grand Total	0.501	0.366
Gross Floor Area (ft ²)	24563.0	24563.0
Conditioned Floor Area (ft ²)	24563.0	24563.0

Note: Values in this table are calculated using the Gross Floor Area.

Determine the additional cost of energy required to operate the supply fans and cooling system to compensate for energy loss through the gymnasium walls

Estimated off \$0.06 / kWhr utility cost

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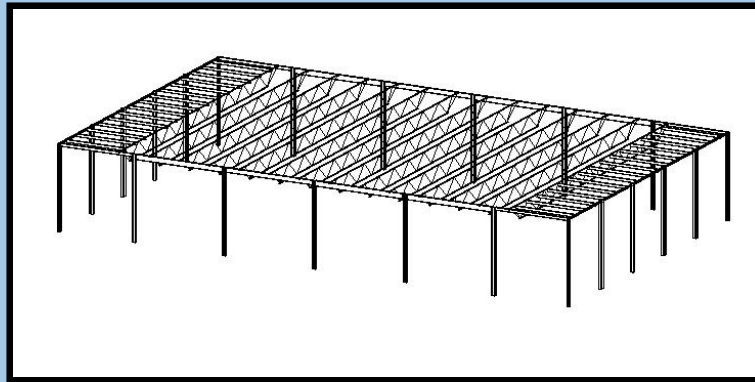
CONCLUSIONS /
RECOMMENDATIONS

Q & A



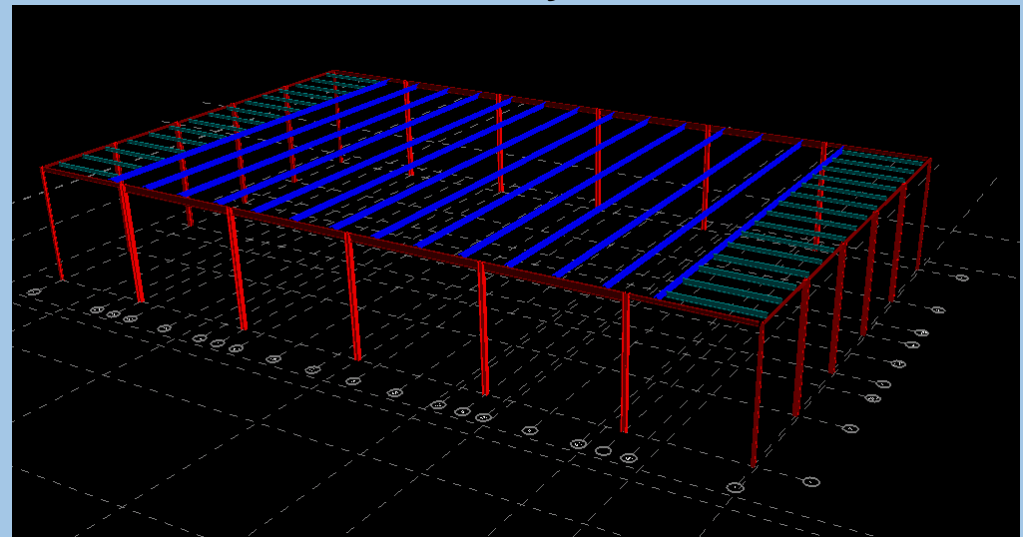
STRUCTURAL MOMENT FRAME

Autodesk Revit Structure 4



- Register with RAM International to obtain link for exporting Revit Structure 4 files to RAM
- Install Link
- Reopen Revit Structure 4 to export model to RAM

RAM Structural Systems



- Apply Loads per contract drawings
- Basic Wind Speed
 - 90 mph
 - Exposure B
- Importance Factor of 1.15 applied to loading per structural engineer's direction

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Structural Framing Schedule			
Count	Family	Type	Length
2	W-Wide Flange	W14X48	29' - 11"
3	W-Wide Flange	W24X68	36' - 0"
2	W-Wide Flange	W21X62	36' - 0"
1	W-Wide Flange	W24X68	36' - 5 15/16"
1	W-Wide Flange	W24X68	35' - 6 1/16"
2	W-Wide Flange	W12X50	29' - 11"
4	W-Wide Flange	W8X21	24' - 11"
6	W-Wide Flange	W8X18	24' - 0"
1	W-Wide Flange	W24X68	35' - 6 1/16"
14	DLH-Series Bar Joist	68DLH19	121' - 10"
30	W-Wide Flange	W12X26	23' - 11"

Structural Column Schedule			
Count	Family	Type	Length
18	W-Wide Flange-Column	W14X145	32' - 8"
4	W-Wide Flange-Column	W10X49	32' - 8"



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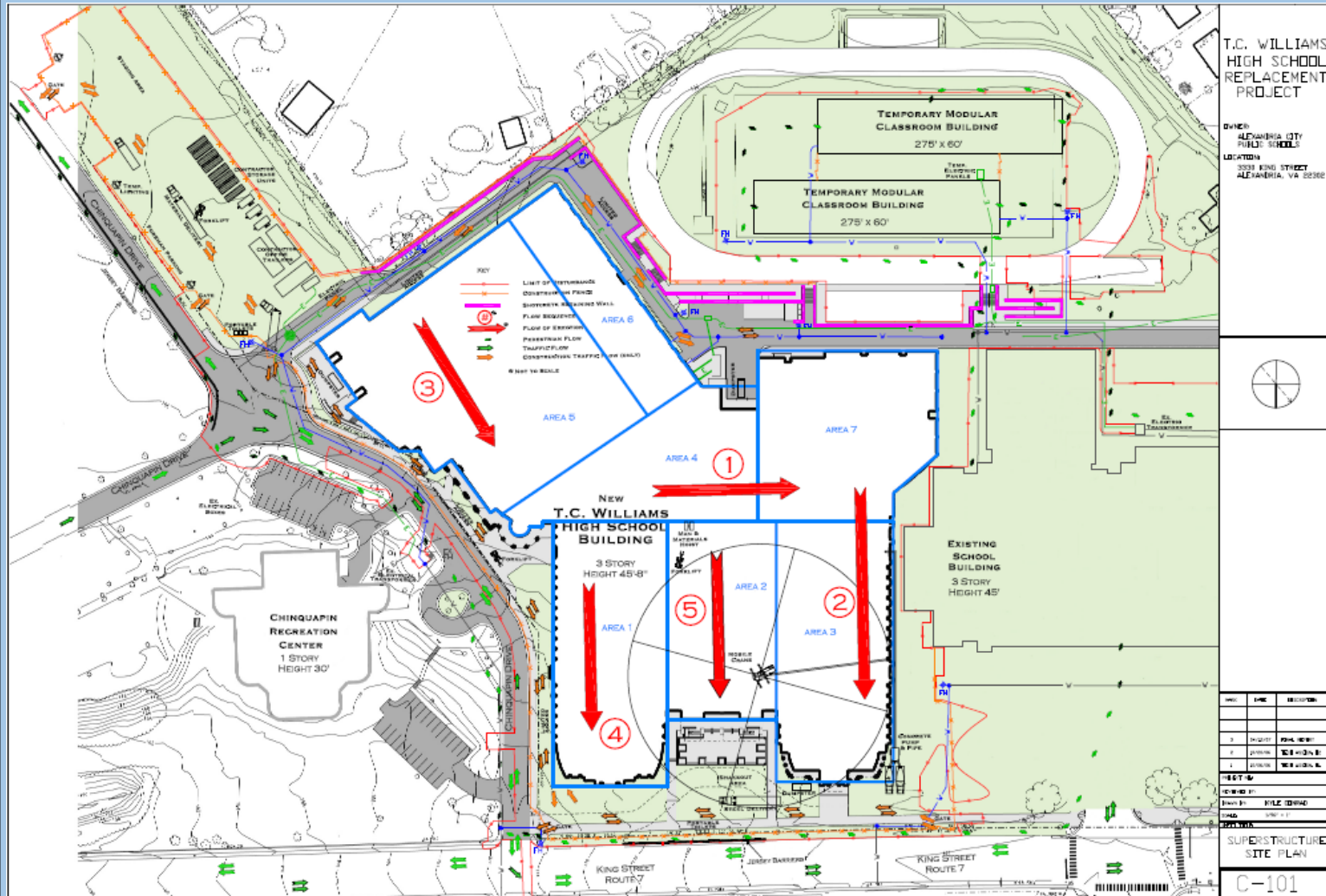
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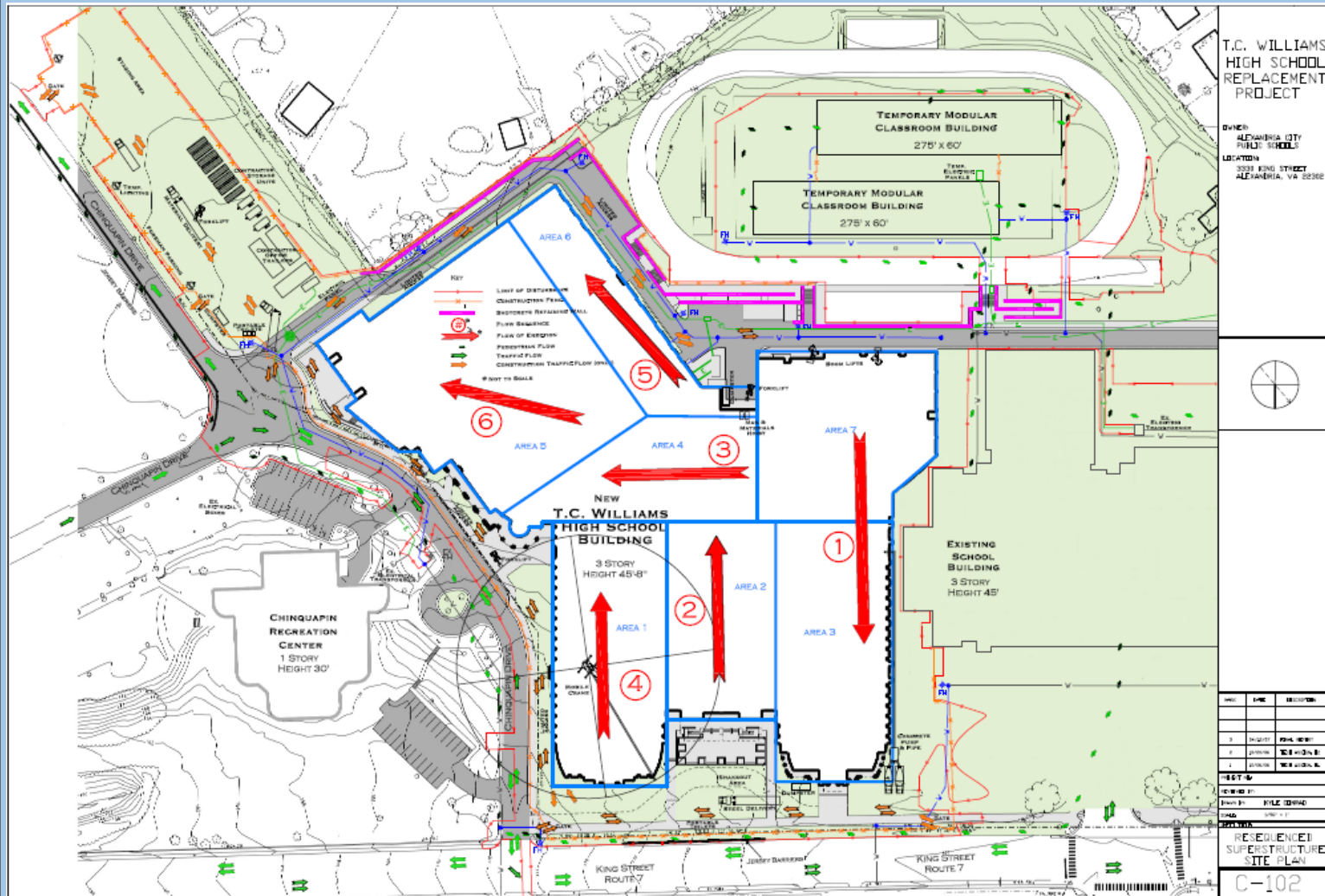
FRAME

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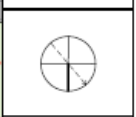
CONCLUSIONS / RECOMMENDATIONS

Q & A



T.C. WILLIAMS HIGH SCHOOL REPLACEMENT PROJECT

OWNER: ALEXANDRIA CITY PUBLIC SCHOOLS
LOCATION: 3333 KING STREET, ALEXANDRIA, VA 22306



NO.	LINE	REVISION
1	1	ISSUE FOR PERMITS
2	2	ISSUE FOR PERMITS
3	3	ISSUE FOR PERMITS

SEQUENCE I SUPERSTRUCTURE SITE PLAN
C-102





WORK SEQUENCING

T.C. Williams High School																		
CMU Estimate																		
QTO - Current Construction		Schedule Impact				Labor				Cost Impact								
Wall Area	Units	Daily Output*	Units	Duration	Units	Rate	Units	Labor Hours	Units	Material	Units	Cost	Labor	Units	Cost	Total Cost		
Gymnasium																		
10" CMU	49,827 sf	280 sf / day		178.0 days		0.143 hours / sf		7,125 mhrs		6.35 \$ / sf		318,401	5.31 \$ / sf		264,581	580,983		
12" CMU	14,828 sf	265 sf / day		56.0 days		0.181 hours / sf		2,684 mhrs		6.95 \$ / sf		103,055	6.05 \$ / sf		89,709	192,764		
14" CMU	19,440 sf	255 sf / day		76.2 days		0.188 hours / sf		3,655 mhrs		7.45 \$ / sf		144,828	6.95 \$ / sf		135,108	279,936		
6" CMU	7,469 sf	325 sf / day		23.0 days		0.123 hours / sf		919 mhrs		4.94 \$ / sf		36,897	4.22 \$ / sf		31,519	68,416		
8" CMU	19,007 sf	300 sf / day		63.4 days		0.133 hours / sf		2,528 mhrs		5.75 \$ / sf		109,290	4.57 \$ / sf		86,862	196,152		
Sub-Total:	110,571 sf			396.5 days				16,910 mhrs				\$710,471			\$607,780	\$1,318,251		
Auditorium																		
10" CMU	19,046 sf	280 sf / day		68.0 days		0.143 hours / sf		2,724 mhrs		6.35 \$ / sf		120,942	5.31 \$ / sf		101,134	222,076		
12" CMU	8,281 sf	265 sf / day		31.2 days		0.181 hours / sf		1,499 mhrs		6.95 \$ / sf		57,553	6.05 \$ / sf		50,100	107,653		
14" CMU	13,981 sf	255 sf / day		54.8 days		0.188 hours / sf		2,628 mhrs		7.45 \$ / sf		104,158	6.95 \$ / sf		97,188	201,326		
6" CMU	8,681 sf	325 sf / day		26.6 days		0.123 hours / sf		1,065 mhrs		4.94 \$ / sf		42,785	4.22 \$ / sf		38,540	79,335		
8" CMU	10,857 sf	300 sf / day		36.2 days		0.133 hours / sf		1,444 mhrs		5.75 \$ / sf		62,428	4.57 \$ / sf		49,016	112,044		
Sub-Total:	60,826 sf			216.9 days				9,360 mhrs				\$387,867			\$334,568	\$722,435		
Mech/Elec Wedge - Auto Strip																		
10" CMU	16,587 sf	280 sf / day		59.2 days		0.143 hours / sf		2,372 mhrs		6.35 \$ / sf		105,327	5.31 \$ / sf		88,077	193,404		
6" CMU	1,625 sf	325 sf / day		5.0 days		0.123 hours / sf		200 mhrs		4.94 \$ / sf		8,028	4.22 \$ / sf		6,858	14,885		
8" CMU	5,217 sf	300 sf / day		17.4 days		0.133 hours / sf		694 mhrs		5.75 \$ / sf		29,998	4.57 \$ / sf		23,842	53,839		
Sub-Total:	23,429 sf			81.6 days				3,266 mhrs				\$143,353			\$118,776	\$262,129		
Total:	194,826 sf			695.0 days				29,536 mhrs				\$1,241,690			\$1,061,124	\$2,302,815		
Note:											City Cost Index**							
* Based on Labor Output Displayed in Labor Column											Alexandria, Virginia		0.923		0.713			
													\$1,146,080		\$756,582		\$1,902,662	

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- WORK SEQUENCING
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Q & A

T.C. Williams High School																					
Solarcrete Estimate																					
QTO - Solarcrete System				Schedule Impact - EPS				Schedule Impact - Shotcrete				Labor - EPS				Labor - Shotcrete					
	Wall Area	Units	Wall Length	Units	Daily Output*	Units	Duration	Units	Daily Output*	Units	Duration	Units	Rate	Units	Labor Hours	Units	Rate	Units	Labor Hours	Units	
Gymnasium				Gymnasium				Gymnasium				Gymnasium									
12" Panel	66,167 sf		2,595 lf		200 lf / day		13.0 days		2000 sf / day		66.2 days		0.48 hours / lf		1,246 mhrs		0.048 hours / sf		3,176 mhrs		
Sub-Total:	66,167 sf		2,595 lf				13.0 days				66.2 days				1,246 mhrs				3,176 mhrs		
Auditorium				Auditorium				Auditorium				Auditorium									
12" Panel	42,367 sf		1,900 lf		200 lf / day		9.5 days		2000 sf / day		42.4 days		0.48 hours / lf		912 mhrs		0.048 hours / sf		2,034 mhrs		
Sub-Total:	42,367 sf		1,900 lf				9.5 days				42.4 days				912 mhrs				2,034 mhrs		
Mech/Elec Wedge - Auto Strip				Mech/Elec Wedge - Auto Strip				Mech/Elec Wedge - Auto Strip				Mech/Elec Wedge - Auto Strip									
12" Panel	21,383 sf		1,220 lf		200 lf / day		6.1 days		2000 sf / day		21.4 days		0.48 hours / lf		586 mhrs		0.048 hours / sf		1,026 mhrs		
Sub-Total:	21,383 sf		1,220 lf				6.1 days				21.4 days				586 mhrs				1,026 mhrs		
Total:	129,917 sf		5,715 lf				28.6 days				129.9 days				2,743 mhrs				6,236 mhrs		
Total Schedule Impact:							158.5 days					Total Labor:					8,979 mhrs				

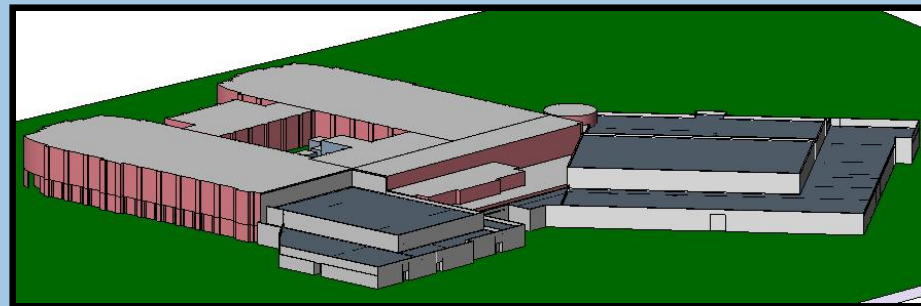
Note:
 * Based on Labor Output Displayed in Labor Column
 ** City Cost Index for Concrete

T.C. Williams High School																
Solarcrete Estimate																
QTO - Solarcrete System					Cost Impact											
	Wall Area	Units	Wall Length	Units	Material	Units	Cost	Labor	Units	Cost	Equip.	Units	Cost	Total Cost		
Gymnasium					Gymnasium											
12" Panel	66,167 sf		2,595 lf		9.8 \$ / sf		648,437	5.23 \$ / sf		346,053	1.06 \$ / sf		70,137	1,064,627		
Sub-Total:	66,167 sf		2,595 lf				\$648,437			\$346,053			\$70,137	\$1,064,627		
Auditorium					Auditorium											
12" Panel	42,367 sf		1,900 lf		9.8 \$ / sf		415,197	5.23 \$ / sf		221,579	1.06 \$ / sf		44,909	681,685		
Sub-Total:	42,367 sf		1,900 lf				\$415,197			\$221,579			\$44,909	\$681,685		
Mech/Elec Wedge - Auto Strip					Mech/Elec Wedge - Auto Strip											
12" Panel	21,383 sf		1,220 lf		9.8 \$ / sf		209,553	5.23 \$ / sf		111,833	1.06 \$ / sf		22,666	344,052		
Sub-Total:	21,383 sf		1,220 lf				\$209,553			\$111,833			\$22,666	\$344,052		
Total:	129,917 sf		5,715 lf				\$1,273,187			\$679,466			\$137,712	\$2,090,365		
Chicago, Illinois:					City Cost Index**											
					Alexandria, Virginia											
					1.088											
					0.797											
					\$1,385,227											
					\$534,740											
					\$137,712											
					\$2,057,679											
City Index (Concrete)																
					15.03											



WORK SEQUENCING / SITE LOGISTICS

Using NavisWorks Timeliner



Current CMU Construction Simulation

- 395 day structural system construction duration

Resequenced CMU Construction Simulation

- 695 day structural system construction duration
- 252 day project schedule extension

Proposed Solarcrete System Construction Simulation

- 158.5 day structural system construction duration
- 17 day project schedule reduction

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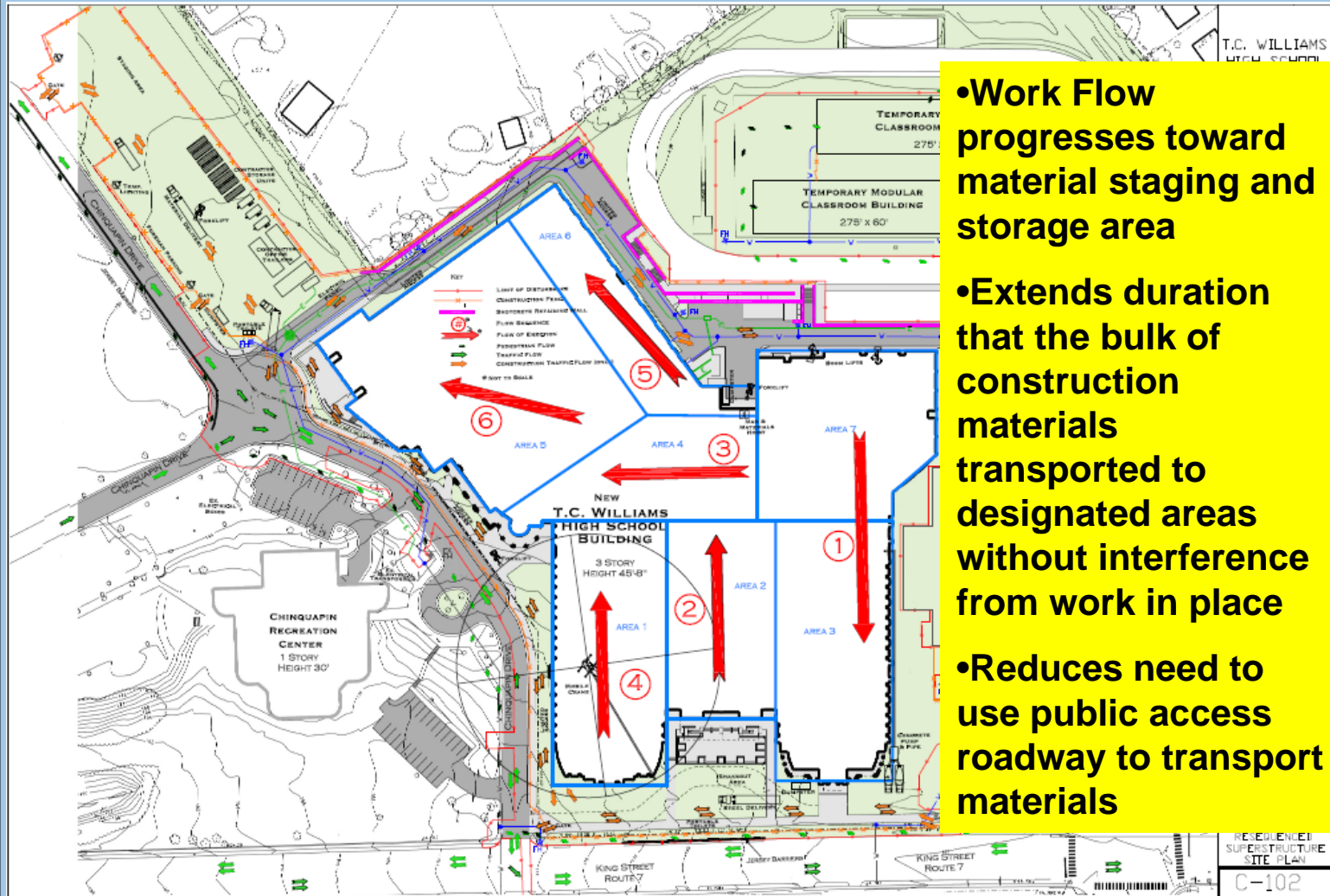
CONCLUSIONS /
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Q & A



SITE LOGISTICS

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- CONCLUSIONS / RECOMMENDATIONS
- Q & A



- **Work Flow** progresses toward material staging and storage area
- **Extends duration** that the bulk of construction materials transported to designated areas without interference from work in place
- **Reduces need** to use public access roadway to transport materials



CONCLUSIONS / RECOMMENDATIONS

T.C. Williams High School		
System Comparisons		
Description	Solarcrete Construction	CMU Construction
System Costs		
Solarcrete Panels	\$2,057,679.00	\$0.00
CMU	\$0.00	\$1,902,662.00
Additional Structural Steel	\$132,547.00	\$0.00
Fabrisorb Acoustic Wall Panels	\$34,970.80	\$0.00
Sub-Total:	\$2,225,196.80	\$1,902,662.00
Cost Difference:	\$322,534.80	
Energy Savings		
Cost Savings on Supply Fan Load per Year	\$6,532.00 \$9,930	\$0.00
Heat Transfer Through Wall* - Winter	1.60 BTU/(hr ft ²)	5.25 BTU/(hr ft ²)
Heat Transfer Through Wall* - Summer	0.55 BTU/(hr ft ²)	1.80 BTU/(hr ft ²)
Schedule		
Schedule Impact**	158.5 days	695.0 days
Re-Sequenced Schedule Savings***	17 days	-252 days
Manhours		
Areas 5, 6 & 7 Labor Hours	8,979 mhrs	29,536 mhrs

20,557 reduced mhrs

Note:
 * Analysis of Gymnasium Walls
 ** Based on Material Estimates
 *** Current Structural System Schedule Duration = 395 days

•Further Analysis to reduce HVAC System

PROJECT BACKGROUND

BIM

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ACOUSTICS

HEAT TRANSFER

STRUCTURAL

FRAME

WORK SEQUENCING

SITE LOGISTICS

CONCLUSIONS / RECOMMENDATIONS

Q & A



QUESTION & ANSWER SESSION

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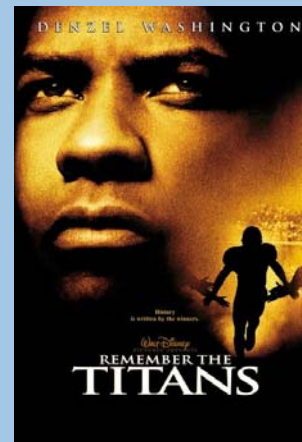
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PROJECT
BACKGROUND

BIM

ALTERNATIVE
BUILDING MATERIALS

GYMNASIUM

ACOUSTICS

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