6.0 TECHNICAL ANALYSIS #3
EIFS Panels vs. GFRC Panels

6.1 Problem Statement

The original design of the Women's Center and Inpatient Tower included Glass-Fiber Reinforced Concrete (GFRC) Panels for the majority of the façade. During the value engineering process, these GFRC panels were replaced with Exterior Insulation Finishing System (EIFS) Panels. As the EIFS was being installed, there were some issues with the termination of EIFS around the windows. This issue is very important because if the EIFS is not properly installed and sealed, water is able to seep into the building. These issues with the EIFS will most likely delay the project schedule, which may also have an impact on the project cost. Another concern with installation of EIFS is that it is labor intensive. EIFS is composed of many layers, and each of the layers is installed separately on site. The only layer of the EIFS Panel that can be prefabricated offsite is the EPS Insulation. This insulation board can be cut to size before it reaches the construction site. Because the EIFS Panels are not prefabricated, the process of installing each layer is very tedious. A third issue with EIFS involves the quality of the system. If EIFS is not properly installed, there is the potential that water will seep into the building, and there will be mold issues. Because this building is a hospital, it is crucial that the building is of the highest quality; therefore, any health issues such as mold need to be avoided at all costs.

6.2 Goal

The goal of this technical analysis is to prove that the original design using GFRC is best design option for the building. In order to prove that GFRC is the best option, this analysis will focus on comparing the thermal quality, life cycle cost, and constructability of the two systems. Because the highest quality needs to be maintained for hospitals, the thermal quality of the building is a critical issue. Because the initial cost of EIFS proves to be less than the initial cost of GFRC, a life cycle cost will be determined for the two systems to illustrate a more accurate cost analysis for the two systems. A constructability analysis will be used to focus on the constructability of the two systems, which may affect the schedule durations. The advantages of the GFRC Panels will be demonstrated by improving the installation process and decreasing the schedule duration, using the life cycle cost as an accurate cost analysis, and also by improving the thermal quality of the hospital.

6.3 Analysis Techniques:

1. Determine the square footage of the EIFS Façade that will be replaced by GFRC.
2. Use the same GFRC design that is shown in the original construction documents. Compile all information for the original GFRC panels.
3. Select the EIFS Panels from StoCorp Website that match the design used on the building.

4. Find the R-values for all of the building components for both façade systems. Calculate the U-value of the two systems using the R-Values from each material component. Calculate and compare the heat loss and gain for the two systems.
5. Analyze the structural impact of the GFRC Panels.
6. Contact various manufacturers to determine the initial costs and installation durations for the GFRC and EIFS Panels.
7. Compare the initial costs of the two systems.
8. Determine the life cycle costs of the two systems by obtaining information from various manufacturers about the maintenance of GFRC and EIFS Panels.
9. Use Engineering Economic equations and Microsoft Excel to determine the future value of the maintenance costs. Include the initial costs in the total cash outflow.
10. Compare the life cycle costs of the two systems. Relate the life cycle costs to the initial costs.
11. Create a schedule for the GFRC using the installation durations provided by manufacturers.
12. Create a schedule for the EIFS using the actual project schedule
13. Compare schedule durations of the two systems.
14. Create 4D Models of the two façade systems to show the difference in installation durations.
15. Compile and compare all the information for the two systems.

6.4 Resources and Tools

1. Whiting-Turner Team- Bruce DeLawder's Health Group
2. Clark Pacific- Sales/Technical Representative
3. Eagle Precast Company- Lynn Fred (Sales/ Project Manager)
4. Architectural Engineering Faculty (Andreas Phelps)
5. Whitney, Bailey, Cox, and Magnani- Mike Stasch
6. Dryvit- John Roam (Sales Rep.)
7. Mechanical and Electrical Equipment for Buildings 9th Ed.
8. Engineering Economics Analysis Book
9. Georgia- Pacific Building Products
10. Precast Concrete Institute (PCI) GFRC- Recommended Practice- MNl-128-01:Recommended Practice for Glass Fiber Reinforced Concrete
11. StoCorp
12. R.S. Means
13. ASHRAE Handbook of Fundamentals
14. Trace 700 (Trane)
15. Microsoft Excel
16. Microsoft Project
17. Revit Architecture
18. Navisworks- Timeliner

6.5 Existing Conditions

The alternative system chosen to replace the existing façade is Glass Fiber Reinforced Concrete (GFRC). This alternative was selected because it was the original design for the façade. The original design included the GFRC Panels with 2 ½" Spray Polyurethane Foam Insulation. The GFRC Facade consisted of a GFRC Panel that was attached to 3 5/8" metal studs. These panels were replaced with the EIFS Panels in order to save money. EIFS was chosen because its initial cost is much less than the cost of GFRC. EIFS is also known for its thermal quality because it uses Expanded Polystyrene Foam for the insulation component. The EIFS seemed to be the best solution initially. Because various colors can be selected for the EIFS and GFRC panels, the architectural appearance of the building will only slightly change. Some of the advantages of using the GFRC (original) design may include better thermal quality, cheaper lifecycle cost, quicker installation, and less waste material. The Figures 25 and 26 illustrate the building sections for the existing design using EIFS and the alternative (original) design using GFRC.

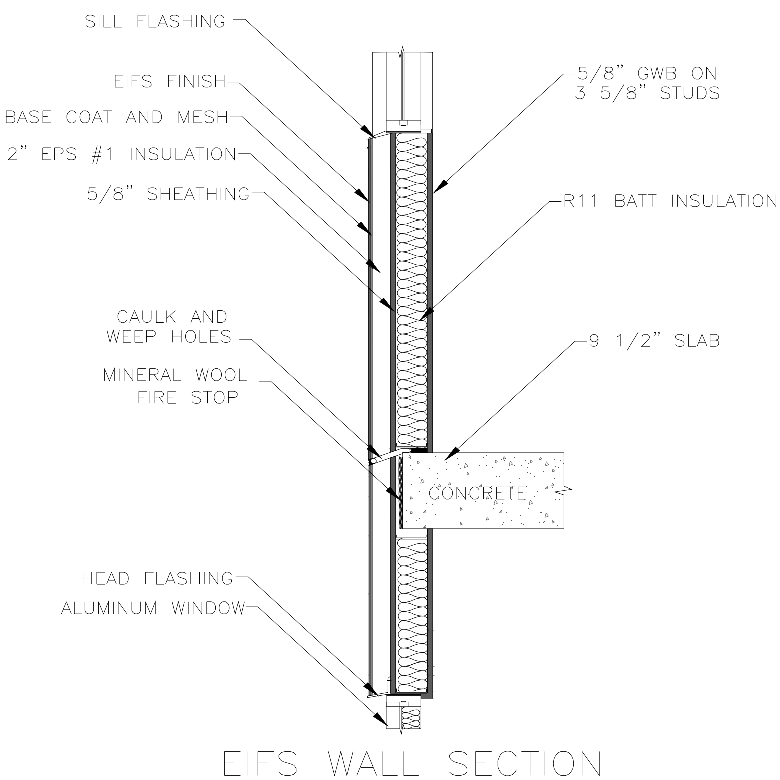

Figure 25: EIFS Wall Section

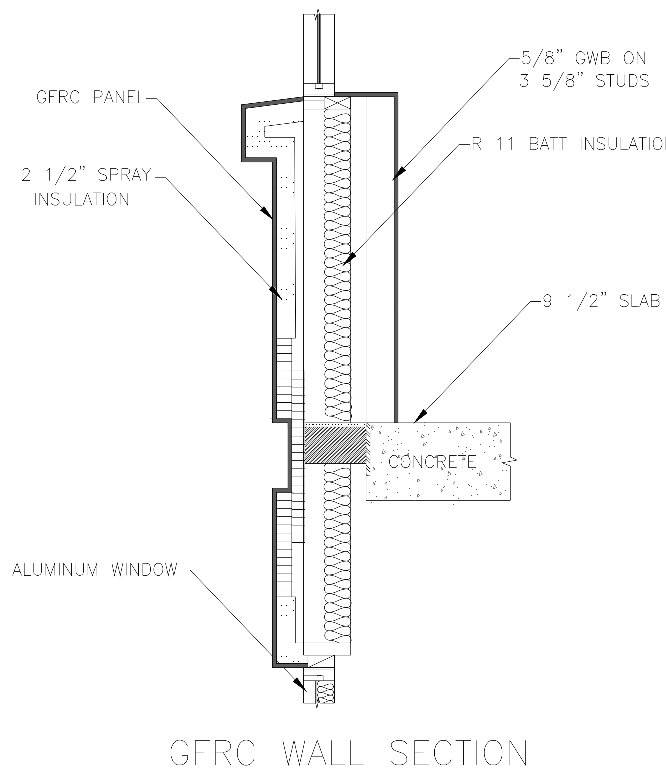

Figure 26: GFRC Wall Section

6.6 Thermal Quality Impact

The thermal quality of a building façade can vary greatly depending on the type and thickness of the materials used for a system. The R-Values of each material are used to determine the thermal impact that a façade has on the building. The R-Values are then used to calculate the U-Value for the entire façade system. The lower the U-Value, the better it is at insulating. Tables 11 and 12 show the R-Values for each component within a wall system and the U-Value for each system.

Table 11: R-Values and U-Values for EIFS

R-Values and U-Values for Exterior Insulation Finishing System (EIFS)			
Components	Thickness (in.)	R-Value / Thickness (in)	R-Value (hr ft^2 °F/BTU)
Sto Essence DPR Finish	-	-	-
Sto Primer/Adhesive-B	-	-	-
Sto Reinforcing Mesh	-	-	-
2" Sto #1 EPS Insulation	2	4.00	8
Sto Primer/Adhesive-B	-	-	-
Sto Guard Moisture Protection	-	-	-
5/8" DensGlass Gold Sheating	0.625	-	0.67
3 5/8" Metal Studs	-	-	-
R11 Batt Insulation	3.5	-	11
5/8" GWB	0.625	-	0.67
	Total R-Value	**hr ft2 °F/ BTU**	**20.34**
	U-Value (∑ 1/R)	**BTU/ hr ft2 °F**	**0.0492**

Table 12: R-Values and U-Values for GFRC

R-Values and U-Values for Glass Fiber Reinforced Concrete (GFRC)			
Components	Thickness (in)	R-Value / Thickness (in)	R-Value (hr ft^2 °F/BTU)
GFRC Skin	0.50	0.14	0.07
2 1/2" Spray Insulation	2.5	6	15
3 5/8" Metal Studs	-	-	-
R 11 Batt Insulation	3.5	-	11
5/8" GWB	0.625	-	0.67
	Total R-Value	**hr ft2 °F/ BTU**	**26.74**
	U-Value (∑ 1/R)	**BTU/ hr ft2 °F**	**0.0374**

Based on the two U-Values shown in Table 11 and 12, the GFRC seems to be the best insulating system. These two U-Values calculated above along with the outside and inside dry bulb temperatures are used to determine the heat gain in the summer and heat loss in the winter for the two façade systems. The outside and inside temperatures for Baltimore, MD shown below were determined using Trane Software.

Fig. 27: Summer Cooling Loads for Baltimore, MD

Outside Dry Bulb Design Temperature (To)	91°F
Inside Dry Bulb Design Temperature (Ti)	75°F
Change in Temperature (ΔT)	16°F

Fig. 28: Winter Heating Loads for Baltimore, MD

Outside Dry Bulb Design Temperature (To)	13°F
Inside Dry Bulb Design Temperature (Ti)	70°F
Change in Temperature (ΔT)	57°F

Using the Heat Transfer Equation, the total summer heat gain and winter heat loss from the façade systems can be determined. The heat transfer equation shown as Eq. 6 was given in the ASHRAE Handbook of Fundamentals.

Eq. 6: Heat Transfer Equation

$$qx = \Delta T * A * U$$

Table 13: Summer Heat Gain

Summer Heat Gain					
Façade System	Area (SF)	U-Value (BTU/hr ft2 °F)	ΔT (°F)	Heat Gain (BTU/hr)	Heat Gain (Tons=12,000 BTU/hr)
EIFS	45690	0.0492	16	35967	3.0
GFRC	45690	0.0374	16	27341	2.3
				Difference (Tons) :	**0.7**

Table 14: Winter Heat Loss

Winter Heat Loss					
Façade System	Area (SF)	U-Value (BTU/hr ft2 °F)	ΔT (°F)	Heat Loss (BTU/hr)	Heat Loss (Tons=12,000 BTU/hr)
EIFS	45690	0.0492	57	128133	10.7
GFRC	45690	0.0374	57	97402	8.1
				Difference (Tons) :	**2.6**

Based on the summer heat gain and winter heat loss shown in Table 13 and 14, the GFRC Façade proved to be the better system in terms of thermal quality. For the summer heat gain, the difference between the two systems was 0.7 tons, which is considered to be minimal. However, for the

winter heat loss, the difference between the systems was 2.6, which is considered to be somewhat significant. Initially, the EIFS System seems to be the best option; however, the GFRC turned out to be the better alternative overall. The GFRC System itself did not have the best thermal quality; however, the 2 ½" spray polyurethane foam insulation that was used in the original design greatly increased the thermal quality of the façade system. Without this additional spray insulation, the EIFS System would have been the better thermal system. Based on the two systems used, the original design using GFRC is the best thermal option for this building.

6.7 Structural Impact

The GFRC Panels used as the alternative system are considered to be lightweight precast panels compared to other precast concrete panels. After speaking with the Structural Engineer for the Patient Tower project, I was informed that the difference in weight between the GFRC and EIFS is minimal. In fact, when the system was changed from GFRC to EIFS in the value engineering process, the structure remained the same. Because the weights are about the same for the two façade systems and the structure did not change, there will be no structural impact from using the alternative facade.

6.8 Initial Cost Analysis

One of the main reasons that the GFRC was replaced with EIFS is due to the huge difference in initial cost. The EIFS is considerably cheaper than the GFRC when looking at the initial cost. In order to have the most accurate costs for the two systems, most of the cost data was obtained from various subcontractors and manufacturers. The price of the EIFS Panels shown in Table 15 was provided by the same subcontractor that is installing the EIFS System on the Patient Tower. Because the GFRC price varied significantly depending on the location, the estimate shown in Table 16 was calculated using the average cost of three estimates provided by various subcontractors. None of the estimates for the GFRC included the additional spray insulation that was used in the original design so this cost needed to be added to the GFRC estimate. The other costs were found using cost data from R.S. Means.

Table 15: EIFS Cost Estimate

EIFS Estimate									
Item	Units	Quantity	Unit Mat'l	Mat'l Cost	Unit Labor	Labor Cost	Unit Equip.	Equip. Cost	Total Item Cost
EIFS	sf	45690	$10.00	$456,900	$1.00	$45,690	$1.50	$68,535	$571,125
Non-Structural Metal Framing	sf	45690	$0.34	$15,535	$0.76	$34,724	$0.00	$0	$50,259
Exterior Sheathing (1/2")	sf	45690	$0.52	$23,759	$0.55	$25,130	$0.00	$0	$48,888
								Total Cost :	**$670,272**

Table 16: GFRC Cost Estimate

GFRC Estimate									
Item	Units	Quantity	Unit Mat'l	Mat'l Cost	Unit Labor	Labor Cost	Unit Equip.	Equip. Cost	Total Item Cost
GFRC Panels	sf	45690	$45.00	$2,056,050	$0.00	$0	$0.00	$0	$2,056,050
2 1/2" Spray Polyurethane Foan	sf	45690	$1.03	$47,061	$1.48	$67,621	$1.27	$58,026	$172,708
								Total Cost :	**$2,228,758**

When comparing the initial costs of the two systems as shown in Table 17, the cost of the EIFS System is significantly lower than the GFRC System. In fact, the GFRC is more than three times the cost of the EIFS System. In terms of initial cost, the EIFS proved to be the best value engineering solution. However, the initial cost does not include any maintenance costs; therefore, the best way to compare the two systems in terms of cost is a life cycle cost.

Table 17: Cost Comparison of Façade Systems

Cost Comparison of Façade Systems	
Item	Cost
Exterior Insulation Finishing System	$670,272
Glass Fiber Reinforced Concrete	$2,228,758
Difference in Cost=	**$1,558,486**

6.9 Life Cycle Cost Analysis

*Please see Appendix F for Life Cycle Costs of EIFS and GFRC

As shown above, the EIFS System appeared to be the best solution when comparing the initial costs of the two. This initial cost does not provide an accurate estimate over the life time of these two systems. The life cycle costs are shown for a duration of 25 years. The costs that are shown in Table 18 and 19 include all types of maintenance and the cost estimates associated with each type of maintenance. The various types of maintenance and costs were also obtained from various subcontractors in order to have accurate life cycle costs. In order to calculate the future value of all maintenance, the future value equation was used. This equation shown as Eq. 7 was taken from the Engineering Economic Analysis Book. The interest rate (r, rate) that is assumed for this calculation is 3.0%. After comparing the life cycle costs, the EIFS System proved to still be the cheapest system overall.

Eq. 7: Future Value Equation by Hand

$F = P\,(1+r)^n$

F = Future sum of money
P = Present sum of money
r = Nominal rate of interest
n = number of interest periods

Eq. 8: Future Value Equation by Excel

FV(rate,nper,pmt,pv) in Microsoft Excel

FV= Future sum of money
Rate= interest rate per period
Nper= number of interest periods
Pmt= payment made each period
PV= Present sum of money

Table 18: Life Cycle Cost for EIFS

Life Cycle Cost for EIFS							
EIFS	Year 0	Year 5	Year 10	Year 15	Year 20	Year 25	Cash Outflow
Initial Cost of System	-$670,272						-$670,272
Description of Maintenance							
Cleaning		-$15,890	-$18,421	-$21,355	-$24,756	-$28,699	-$109,122
Re-coat Panels					-$165,042		-$165,042
Replace Joint Sealant			-$16,127		-$21,673		-$37,800
						Total Cost :	**($982,237)**

Table 19: Life Cycle Cost for GFRC

Life Cycle Cost for GFRC							
GFRC	Year 0	Year 5	Year 10	Year 15	Year 20	Year 25	Cash Outflow
Initial Cost of System	-$2,228,758						-$2,228,758
Description of Maintenance							
Replace Joint Sealant					-$21,673		-$21,673
Cleaning						-$68,879	-$68,879
						Total Cost :	**($2,319,310)**

6.10 Schedule Durations

*Please see Appendix B for more images of the Facade 4D Models.
*Please see Appendix E for project schedules of the two different systems created in Microsoft Project
*Please see Appendix G for Façade Duration Calculations

When comparing the two systems in terms of schedule durations, the GFRC Panels can be installed much faster than the EIFS Panels. Because the GFRC Panels, which include metal studs, are prefabricated in a factory, the duration for erecting these panels is very short. In order to receive these panels on time, there is a lead time of around 8 months. The EIFS Panels cannot be fabricated in a factory; therefore, each layer of the panel needs to be installed onsite. This process of installing each layer onsite is considered to be very tedious and labor intensive. Due to this onsite installation, the durations are considerably longer than the GFRC Panels. In Table 20, the schedule durations are compared for the two systems. The schedule durations for the EIFS Panels were taken directly from the project schedule. In order to have accurate schedule durations for the GFRC Panels, a few durations were obtained from various subcontractors and were averaged together. Both façade systems were sequenced by face of the building. The window installation began as soon as the façade was finished on that particular face of the building.

Table 20: Façade Schedule Duration Comparison

Façade Schedule Duration Comparison	
	Duration (Days)
EIFS	122
GFRC	29
Difference (Days)=	**93**

As shown in Table 20, the EIFS will take an additional 93 days to install when compared to the GFRC System. This significant difference between the duration can have a huge impact on the overall project duration. This duration is very important because it dictates how quickly the building can be enclosed. This is a huge milestone on the project schedule because the chance of mold and other issues is greatly reduced once the building is enclosed. With the GFRC System, the building can be enclosed much faster than the EIFS. Along with the building being enclosed early, change in duration may also have an impact on the overall project completion date. If the project schedule can be reduced, the cost of the project can potentially be reduced. In terms of schedule duration, the GFRC System is the best solution.

6.11 Conclusion and Recommendations

From the facade analysis on EIFS versus GFRC, I have found advantages and disadvantages for both systems. The advantages found with using EIFS are a lower initial cost and also a life cycle cost. I expected to find the initial cost to be significantly lower for the EIFS since this was the main reason for switching to the EIFS system; however, I was surprised by the huge difference in costs for the life cycle costs. I had expected to find that the life cycle costs of the two systems were not as drastic as the initial costs. The cost is the major advantage for the EIFS system. Even though this is a huge advantage for using EIFS, it is really the only advantage found. Some of the disadvantages found with using EIFS are the amount of time it takes to place the façade system, and also the labor intensity involved with placing the system. Also with EIFS, there is a greater potential for water problems if the system is not properly installed. Any problems with water damage or mold issues could have a huge impact on the project. Another disadvantage was found on the actual project. There were problems with the installation process, which may affect the overall project duration. If the project is delayed, there may be extra costs incurred from the delay. These are some of the advantages and disadvantages found with using EIFS.

The advantages found with GFRC mostly involved the construction process for installing the façade. The GFRC proved to go up much faster than the EIFS system, and also the constructability of the GFRC was better than the EIFS. The fact that the GFRC panels were already prefabricated when they reached the site allowed the GFRC to go up rapidly and easily. With the EIFS, the various layers are installed directly on the faces of the building; therefore, it takes longer and is considered more tedious. With a quicker schedule, the building may be enclosed much faster than with the EIFS system. If this is the case, the potential for weathering damage will be greatly reduced. Also, if the façade schedule affects the overall project schedule in the fact that the project can finish earlier, there may also be a potential for cost savings. The GFRC also proved to be the best insulated system. In most cases, EIFS proves to be the best system because it is mostly composed of insulation; however, the original design of the GFRC used an additional 2 ½" spray insulation. The difference in the summer heat gain was minimal; however, the winter heat loss between the two systems was somewhat significant. With the GFRC being the better thermal system, there may also be energy savings. The major disadvantage for the GFRC was the initial and life cycle costs that were calculated. The GFRC costs were significantly higher the EIFS; however, there may be some cost savings with the other advantages of the GFRC.

Based on the advantages and disadvantages of the two systems, I find the GFRC system to be the best in quality; however, the EIFS system is the best for this project considering the budget that is required for the project. In most circumstances, I would recommend the GFRC because I believe it is a better quality system. The EIFS is being recommended for this project based on the huge cost savings that it provides.