8.0 Composite Precast Panel Unit Implementation

Mechanical Breadth

8.1 Introduction

Composite precast wall panel units are a composite wall system that typically contains an exterior cast concrete cladding that can have a variety of finishes, metal studs, and insulation integrated into one system. These provide many construction benefits and can offer energy efficiency due to the combination of all parts of a typical wall system. Precast is generally known for greater quality and quicker erection speeds allowing owners to save time on their schedule. Due to many industry issues, precast is becoming a more readily used system as an alternative to traditional façade systems.

8.2 Problem Statement

The masonry work on the project is mainly located on the link and other various lower levels of the medical center. The masonry work starts in the winter months and can be a long, labor intensive activity. This combined with rising energy costs and other material and labor costs to complete an exterior wall system provide for a precast wall panel investigation.

8.3 Goal

The analysis will focus on simplifying the construction on the exterior façade where the brick is located by reducing the amount of activities and laborers needed to complete the exterior wall system. By incorporating the composite precast panel system I intend to reduce the schedule and the cost of the overall wall system. I also aim to enhance the thermal properties of the wall system allowing a reduction in the mechanical load on the affected areas of the building permitting me to decrease the size on the mechanical units and provide initial and lifecycle cost savings.

8.4 Methodology

The following steps will be taken to adequately research this topic:

1. Identify a proper composite precast panel system that is most relevant for this project.
2. Determine cost and schedule impacts of the precast wall panel system compared to the current system.
3. Address logistical concerns including transportation and laydown area.
4. Determine the initial and life cycle costs associated with engineering, producing, and installing the precast wall panel unit.
5. Obtain thermal properties of the wall system and compare with the current system.
6. Calculate effect of reduced loads on mechanical system.
7. Resize mechanical system units serving the affected areas and comment on initial and lifecycle costs.

8. Recommend precast wall panel unit to replace the current wall cavity.

8.5 Tools and Resources

1. Washington County Regional Medical Center Construction Documents and Specifications
2. Gilbane Building Company
3. Penn State Architectural Engineering Faculty
4. Earl Corporation's Composite System: Metal Stud Crete®
5. R.S. Means 2008/2009
6. Energy-10 v1-8

8.6 Expectations

I expect the initial cost of the composite precast panel unit system to be higher than the traditional masonry wall cavity unit. However, when looking at all the affected trades and the potential general conditions savings due to schedule reduction, I expect the precast system to be cheaper. I also expect the thermal properties of the panel unit to resist more heat transfer thereby reducing the size of the air handling units. In turn, this will reduce the project's initial and lifecycle costs.

8.7 Current Brick Cavity Wall System

The current brick cavity wall system, as shown in Appendix L, consists of the typical construction of such a wall. The drawing shows 4" face brick backed with an air space, 1" rigid insulation, an air infiltration barrier, and 16 gauge metal studs. The insulation is 6" batt insulation with a k value of 0.27. Although there is no inherent faults with the construction of the wall as designed, it can be enhanced to contain better attributes such as energy savings, less weight, and smaller cavity if another system can be utilized. The masonry is also schedule to begin work in the winter months. The cold can adversely affect the masonry crews and the rate at which they perform work. Ultimately this will affect the close-in process and the critical path of the entire medical center schedule.

The brick cavity is not completely the wrong system for the project; it does have some good features. The transportation of the brick and other components can have a much smaller impact on the budget of the project. The lead time to produce the product to be installed can also be shorter. The components of the brick cavity wall, the equipment, and crews combined need less on-site space than other systems. These issues will be addressed when choosing the alternate precast panel wall unit.

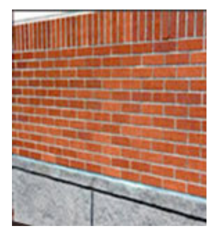
8.8 Alternative Method Analysis: Metal Stud Crete®[1]

One of the goals of The Washington County Regional Medical Center is to create a semi appealing exterior facade that flows well with the existing Robinwood Medical Center ecspecially at the connection of the two facilities. Robinwood's exterior is comprised of two different brick patterns that will be mimicked in the connection of the new facility. However, the new facility will not be a complete copy of the existing medical center, rather it will have its own identity by using a third brick pattern mainly used on the vertical elements of the stair towers. These constraints leave only one logical change to the exterior façade: precast. Precast architectural panels are currently being utilized for the three bed towers. This proves that the owner does not have any preconcieved negative notions about precast. It also helps with logistics and the need to find a contractor.

While researching different types of precast systems, one system appeared to be much better than alternative products. This is a composite wall panel system produced by Earl Corporation and termed Metal Stud Crete®. This system appears to be ideal for the Washington County Regional Medical Center in many ways.

8.8.1 Achieving the Brick Look

Figure 8.1 (left): Flat Brick Casting
Figure 8.2 (right): Final Panel Look



Figures 8.1and 8.2 are courtesy of Scott System, Inc. website: www.scottsystem.com. Note: NTS

Metal Stud Crete® in conjunction with Scott System Inc. can cast a flat brick panel into the composite panel unit. They can do this using any brick that the owner chooses. This means that the current brick choices for the new medical center can still be utilized and reproduced by Scott System Inc. as a flat brick. This will give the exact same appearance the facility is currently going to employ in a precast panel unit. The two figures to the right, Figure 8.1 and 8.2 respectively, show the flat brick and how it is used to be integrated into the panel, and the finished look it can produce. As the final panel picture shows the precast unit can be implemented to create a finish that is identical to traditional masonry units.

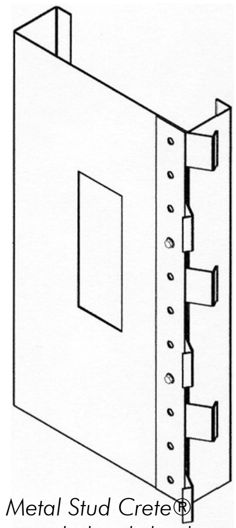
8.8.2 Green Construction

Although it is not a priority to achieve any LEED credits, Metal Stud Crete® provides numerous environmental benefits. The steel studs, Metal Stud Crete® connectors, and the wire mesh used in this panel contain between 30.47% and 80% recycled content, 23.5% to 30% post consumer scrap, and 6.4 to 70% pre consumer scrap. Metal Stud Crete® also claims they can use locally extracted materials from within 500 miles of any project site. The carbon footprint through shipping is also reduced because the panel is much lighter than traditional panels and can be shipped in a fewer amount of loads. The panels can also optimize energy performance. This will be discussed in much greater detail when this report shows thermal characteristics and compares reduced loads to the current system.

[1]Metal Stud Crete® is a registered trademark of Earl Corporation and will contain the ® emblem throughout this report. All information is courtesy of Metal Stud Crete®

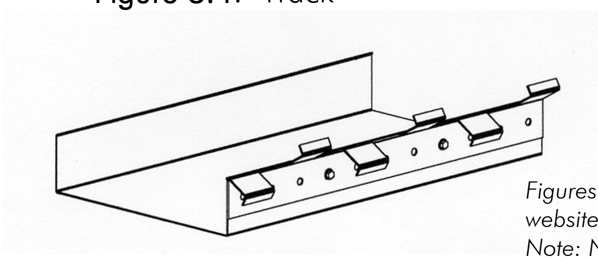
8.8.3 Technical Aspects

Figure 8.3: Web Connector



Metal Stud Crete® is a structural composite wall panel system combining hardrock concrete, approximately 2" thick, insulation, and light gauge framing. Metal Stud Crete® also has a patented structural, composite shear connecter that bonds the framing and concrete. This allows the panel to carry wind loads, frame movement, expansion, and contraction throughout the life of the panel. Figure 8.3 to the right and Figure 8.4 below, shows a detail of both track and web connectors, respectively.

Figure 8.4: Track



Figures 8.3 and 8.4 are courtesy of Metal Stud Crete® website: www.metalcrete.com/tech_typical_details.html. Note: NTS

Metal Stud Crete® is also lighter and thinner than the traditional brick cavity wall system. This will reduce loads and produce more square feet of usable space for the owner. The panel does not need any extra furring on the interior to accept interior finishes. This is included in the panel system. The panels can also be made into any shippable shape and size to fit project needs.

The system has many ways of connection; however, only one fits the needs of The Washington County Regional Medical Center because the others contain reveals, a feature that will not relate to the clean brick look. The panel to panel connection, as shown in Figure 8.5, below, provides a smooth finish to the exterior and creates a great moisture and infiltration barrier. As seen in Figure 8.5, the exterior is sealed with backer rod and sealant. Enhancing the moisture and infiltration barrier is the bitumen that can be placed throughout the rest of the joint. Vapor barriers can also be incorporated for additional moisture protection.

Figure 8.5: Panel to Panel Connection

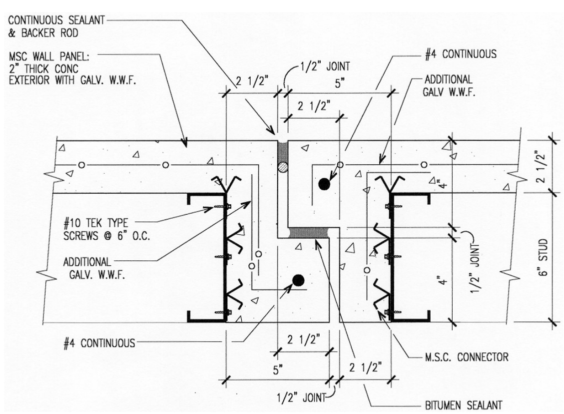


Figure 8.5 is courtesy of Metal Stud Crete® website: www,metalcrete.com/tech_typical_details.html. Note: NTS

8.9 Schedule Review

When considering the schedule review, a thourough examination of the actual construction activites and their effect on the overall progress of the contruction is crucial. In addition, evaluating leadtime for the materials is also very important and although it may not have a direct construction schedule impact, it will affect procurement planning. Table 8.1, as follows, shows a comparison of the two systems lead times and construction durations.

Table 8.1: Schedule Comparison

SCHEDULE COMPARISON				
Lead Times				
System	Quantity	Unit	Output (Unit/Day)	Total (Days)
Brick	12927.0	SF	--------	70.0
*Metal Stud Crete®	12927.0	SF	--------	103.3
			Difference	33.3
Construction Time				
System	Quantity	Unit	Output (Unit/Day)	Total (Days)
Brick	12927.0	SF	190.0	68.0
Exterior Framing	6093.0	LF	450.0	13.5
Metal Stud Crete®	12927.0	SF	853.0	15.2
			Difference	66.4

*Transportation included

The information for Metal Stud Crete® said that the panels, based on square footage, can be erected and fully connected and complete in forty-five minutes. However, the precast contractor on site can only erect one panel in about an hour. Since the system proposes using the existing contractor to for erection purposes, one hour was used. The exterior framing was also used when calculating the adjusted schedule because Metal Stud Crete® incorporates the framing into the panel. The production times for the brick were calculated using an average number of outputs for winter and summer construction since the brick façade erection begins in the winter and proceeds to the spring. Neither the brick nor the Metal Stud Crete® durations include interior drywall. The lead time for the panels works out to be just over 33 days. The bulk of this lead time comes from the special finishes required to achieve the brick look. If this panel were to have a sandblasted finish the lead time would be dramatically reduced. The difference of on site construction time worked out to about 66 days. This is 56% reduction in on site construction time. The façade is a crucial element to drying in the building. This difference helps interior trades start earlier in the building. Since the interior trades are critical to the completion of a hospital, this difference is a considerable help to the project.

8.10 Budget Review

The Washington County Regional Medical Center, like all construction projects, is concerned with maintaining a cost effective budget. Table 8.2, below, shows the cost comparison between the two systems less the activities and items included with the masonry wall. It includes the composite precast wall extra crane usage and transportaion cost comparisons.

Table 8.2: Systems Cost Comparison

COST COMPARISON				
Bare Costs				
System	Quantity	Unit	Cost ($/SF)	Total Cost
Brick	12927.0	SF	$35.00	$452,445.00
*Metal Stud Crete®	12927.0	SF	$45.00	$581,715.00
			Difference	$129,270.00
Related Costs				
Item	Quantity	Unit	Cost ($/Unit)	Total Cost
Add:				
Crane (15 Days)	120.0	hrs.	$350.00	$42,000.00
			Sub-Total	$171,270.00
Less:				
Scaffold	1500.0	SFCA	$252.00	$378,000.00
Exterior Framing	6093.0	LF	$21.00	$127,953.00
			Total Savings	$334,683.00

The main cost savings, as the table shows, comes from the the exclusion of the scaffold. In addition to the scaffold, eliminating the exterior framing also makes a significant contribution. This cost savings may be a little conservative because the current precast contractor will be performing the work. Therefore, the unit costs may be slightly lower. Overall a 29% reduction in cost was achieved.

8.11 Constructability and Logistics

The biggest constructability issue pertaining to the precast erection is the crane useage. Again, as previously stated, the current precast erector will be performing the work. This means that the same crane they used in other places of the building can be used when erecting the Metal Stud Crete®. The Metal Stud Crete® panels weigh less per square foot of panel and the current architectural precast panels will be larger. This means that the crane will have sufficient capacity to erect the Metal Stud Crete® panels. The manufacturer recommends a 70 ton crane to erect Metal Stud Crete® panels. The current crane is 250 tons. The crane will be used for about a half hour per 240 square foot panel. To replace the brick system 12,927 square feet of panel must be erected. This provides the following:

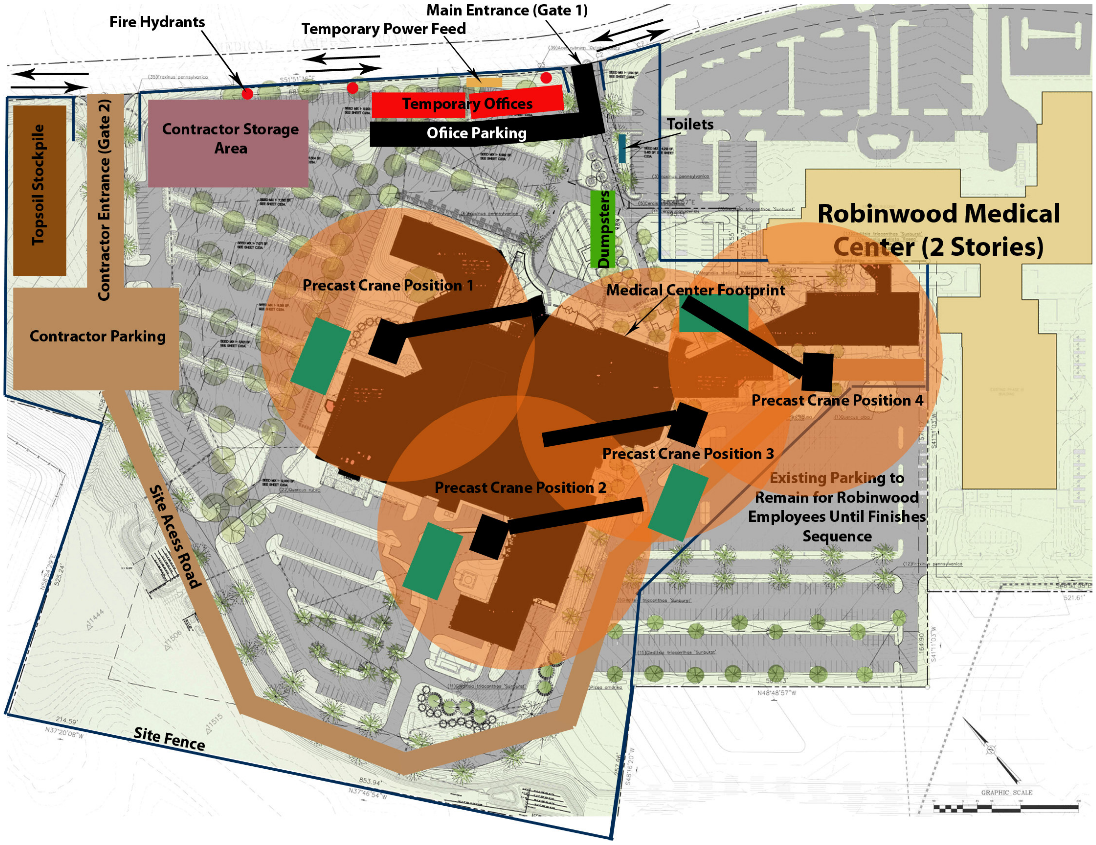
(0.5 hours / 240 square feet) x (12,927 square feet) = 27 hours
or
27 hours / 15.2 days = 1.8 hours of crane operation per day

Other issues relate to logistics and sequencing. Logistically, the laydown area may be of concern. However, the Washington County Regional Medical Center has a very large and open site. In fact, the entire precast shipment could be contained on the site at once if needed. Sequencing provides different issues. Since the critical path relies heavily on the bed towers, these should remain the primary focus of the façade erection. The sequencing should then be based off the location of the crane to minimize movement. The following table, Table 8.3, and figure, Figure 8.6 (over page), shows a suggested façade erection sequence and a site layout plan.

Table 8.3: Sequencing Order for Façade

SEQUENCING ORDER	
#	Area
1	South Tower
2	West Tower
3	East Tower
4	Emergency
5	Service Building
6	Surgery
7	Ambulatory
8	Admitting
9	Admin (or Link) North
10	Admin (or Link) South

Figure 8.6: Logistics Plan for Façade



With this sequence the façade erection now has three critical crane moves. This is the least amount of moves possible. These moves can take place at the end of each section because of the downtime that will happen.

8.12 Thermal and Mechanical Analysis

8.12.1 Thermal Analysis

Another deciding factor to chose the Metal Stud Crete® system is its thermal advantages. Table 8.4, on the following page, shows a comparison of the thermal principles of each system. It shows the R value, resistance to heat transfer, and the U value, how well a material allows heat to pass through. It is also worthy to point out the extra three inch gain in space between the two systems.

Table 8.4: Thermal Wall Analysis Comparison

THERMAL ANALYSIS				
Current System - Brick Cavity Wall Unit				
Component	Thickness (inches)	Unit R-Value	Units	Total R-Value
Outside Air Layer	N/A	0.17	ea	0.17
Face Brick	4.0	0.44	ea	0.44
Air Space	1.0	1.00	ea	1.00
Rigid Insulation	1.0	5.00	ea	5.00
Sheathing	0.5	0.63	ea	0.63
Insulation (k-value = .27)	6.0	3.70	in	22.2
Vapor Barrier	N/A	0.10	ea	0.10
Gypsum Board	0.625	0.56	ea	0.56
Inside Air Layer	N/A	0.68	ea	0.68
Total Thickness (in)	13	Total R-Value (hr-sf-°F/BTU)		30.78
		Total U-Value (BTU/hr-sf-°F)		0.0325
Proposed System - Metal Stud Crete® Precast Composite Unit				
Component	Thickness (inches)	Unit R-Value	Units	Total R-Value
Outside Air Layer	N/A	0.17	ea	0.2
Concrete	2.0	1.00	in	2.0
Foam Insulation	0.75	6.50	in	4.9
Air Space	0.5	1.00	ea	1.0
Insulation (k-value = .25)	6.0	4.00	in	24.0
Vapor Barrier	N/A	0.10	ea	0.10
Gypsum Board	0.625	0.56	ea	0.56
Inside Air Layer	N/A	0.68	ea	0.68
Total Thickness (in)	10	Total R-Value (hr-sf-°F/BTU)		33.39
		Total U-Value (BTU/hr-sf-°F)		0.0300

Further thermal analysis is provided in the next table, Table 8.5. The overall heat gain and heat loss is calculated in this table. The summer and winter design temperatures are taken from a comparable area. The inside temperatures are taken from the mean radiant temperature of the average person.

Table 8.5: Summer and Winter Thermal Comparison

THERMAL ANALYSIS				
Summer Heat Gain (T_o = 89, T_i = 72)				
System	Area (SF)	U-Value	ΔT (°F)	Heat Gain (BTU/Hr)
Brick Cavity Wall	12927.0	0.325	17	71421.68
Metal Stud Crete®	12927.0	0.300	17	65927.70
			Difference	137349.38
			Reduction in Heat Gain	7.69%
Winter Heat Loss (T_o = 11, T_i = 69)				
System	Area (SF)	U-Value	ΔT (°F)	Heat Gain (BTU/Hr)
Brick Cavity Wall	12927.0	0.325	58	243673.95
Metal Stud Crete®	12927.0	0.300	58	224929.80
			Difference	468603.75
			Reduction in Heat Loss	7.69%

This thermal analysis shows an overal reduction in both the heat loss in the winter and the heat gain in the summer by 7.69%.

8.12.2 Energy-10 Analysis

The previous thermal analysis based on the wall composition was then used in the energy simulation software Energy-10. Energy-10 is a comprehensive building software that analyzes the impact of different materials on a structures overall energy consumption. Two simulations were compared; one with the brick cavity wall system and one with the composite precast wall panels. No other parameters were changed so the simulation would be a true comparison of the wall systems. Since the brick is used primarily in the administration wing, the simulation was developed only on that portion of the medical center. Additionally, the following assumptions were used when inputing data into the simulation:

- The location used was Sterling, VA. This was the closest location to Hagerstown, MD.
- Office use was used because the administration wing is primarily composed of offices.
- Utility rates were gathered from Allegheny Power, the local utlity company.
- The brick cavity wall composition and the composite precast panels used inputs from the library. However, they did not exactly match the properties of the material used. Therefore, the R-Value was then adjusted based on the calculations from section 8.12.1 of this document.
- The HVAC system used was the closest representative of the actual HVAC system.
- All results are presented in percentages because it is not a representative of all the brick changing to precast.

- Inside temperture used for summer cooling was 72°F. Inside temperature used for winter heating was 69°F
- Life cycle was calculated on a 60 year life and all other parameter given in simulation.
- The life cycle cost summary page can only be used to determine utility life cycle cost because other parameter were not changed to show a true reflection of the project.

After completing all entry fields in both situations, the simulation was performed and the energy analysis was produced. The following is a summary results produced. To see complete graphical results, please refer to Appendix M. These values are shown as percent reduction.

- Annual Energy Use (kBTU/ft^2)
    - Heating – 34%
    - Cooling – 42%
    - Other – 6.2%
- Annual Energy Costs ($/ft^2)
    - Fuel – 76%
    - kWh – 20%
    - Demand – 25%
- HVAC Capacities (kBTU/h)
    - Heating – 0%
    - Cooling – 0%
- Life Cycle Cost – Utilities ($)
    - 24%

The precast performed significantly better in energy use, cost, and utilities life cycle costs. However, as the HVAC capacities show, the difference is wall system is not significant to warrant new air handling units. These chages show that the composite precast system outperforms the tradtional brick cavity wall system as it relates to energy consumption and costs.

8.13 Conclusion and Recommendations

The composite precst panel wall system is a viable choice for the Washington County Regional Medical Center. It provides significant construction schedule improvments which will help the overal schedule. Similar to the expectations, the intial bare cost of the composite precast system is higher than the brick cavity wall. However, when considering the elimination of the exterior framing contract and the scaffold the composite precast system shows a sizeable cost savings to the project. Logistically, the project is affected by new crane movements. The construction team needs to be prepared to handle crane movements and extra crane time on site. However, a useable plan is shown in the report. Laydown area is not affected because of the available space at the construction site.

The compostion of the composite precast panel system provides thermal atvantages over the brick cavity wall. The R-Value difference shows better resistance to heat transfer. Sizeable energy savings is also shown in the Energy-10 analysis. This showed that the mechanical system will use less energy and utility costs will be greatly reduced. Contrary to initial expectations, the thermal atvantages did not prove to be enough to resize the units. However, less stress will be placed on the current units and hopefully this will cause a longer life.

I would highly recommend the replacement of the brick with the composite precast system because of the major schedule and cost savings. Also, the technical aspects of the system match or exceed all the goals of the medical center. The introduction of the precast system would prove to be a good endevor for the medical center both now and in the future.