Analysis 2

Precast Architectural Brick façade in lieu of Norman Bricks on South Wall

Problem

The south wall of the Columbia Heights Community Center runs parallel to the adjacent apartment complex at a distance of roughly 10'-0" away (see Site Plan in Existing Conditions Report). Approximately 1/4 of the south wall lies directly alongside the complex. The close proximity of the apartment restricts any deliveries of material to this wall from the south, and the east is restricted by the existing park. Space is very limited for material staging and most of it will be located within the building footprint. In this configuration, bricks will have to be fed to the masons from the inside, decreasing production.

Goal

The goal of this analysis is to see if replacing the bricks with Architectural Precast Brick Panels can reduce the construction time, labor costs, and the amount of wasted material. The analysis will focus on impacts to cost, schedule, and quality. Also, since the panels are prefabricated in a factory, material waste is generally less. This analysis will look at this issue as well.

Methodology

1. Determine the quantity of brick to be replaced by the panels.
2. Select an Architectural Precast Brick Panel to replace the brick.
3. Contact the panel manufacturer to determine costs and typical erection times.
4. Compare cost and duration to those in estimating tools (R.S. Means).
5. Analyze the impact on the structural system.
6. Compare costs, durations, and material amounts between the existing brick façade and the proposed panel system.
7. Analyze the impact on mechanical loads through a heat-loss analysis.
8. Assemble the data.

Tools

1. The Blue Book of Construction (http://www.thebluebook.com/)
2. R.S. Means 2006 Edition
3. Penn State Architectural Engineering faculty
4. Smith-Midland™ Precast Manufacturer
5. 1997 ASHRAE Handbook of Fundamentals

Outcome

After research into solid precast panels, it was decided that ordinary architectural brick panels would cost and weigh significantly more than the existing brick. Further research led to the discovery of the Slenderwall® System (see *image* below*)* by the manufacturer Smith-Midland™. The Slenderwall® System is comprised of architectural precast concrete (reinforced with hot-dipped galvanized welded wire), insulated Nelson® anchors (THERMAGUARD™), and heavy gauge galvanized or stainless steel framing backup. It is much lighter and less expensive than the traditional solid precast panels.

After a full analysis that addressed the impacts to cost, schedule, structural loads, and mechanical loads, the Slenderwall® is viewed to be better than the original brick face in all categories except cost. The sections on the following pages will give a detailed view of each analysis and their outcomes.

Cost Impacts

Precast assemblies have a higher initial cost, which is associated with the manufacturing of the panels offsite. This higher cost is somewhat offset by the erection speeds and the reduction in the schedule. In this case, the Slenderwall® initially costs roughly 41% more than the original brick façade. Please see *"Table 1 – Cost Comparison"* below for the quantities and costs of each system. Any assumptions are italicized below each chart.

Table 1 - Cost Comparison

Item	Dimension	Quantity (SF)	Unit Material Cost ($/SF)	Total Material Cost	Unit Labor Cost ($/SF)	Total Labor Cost	Total Unit Cost ($/SF)	Total Cost
Norman Brick (to be removed)	110'x52'	5720	$5.25	$30,030.00	$8.55	$48,906.00	$13.80	**$78,936.00**
						x D.C. Location Factor (.97)		
						+ 5% Waste Factor		
						+ 5% Productivity Factor		
						Total Cost:		**$84,416.13**

** Prices taken from R.S. Means 2006 Assembly Estimate*

*** Price includes brick, bonding materials, backer rods, control joints, sealers, shelf angles, and flashing*

**** Assume 5% Waste Factor*

***** Assume 5% Productivity Factor due to brick placement methods - see the "Problem" section of Analysis 2*

****** Assume no Time Modification Factor since construction is in currently in progress*

Panel Takeoff

Item	Dimension	Quantity
First Floor	12'-8" height	110 LF
Second / Third Floor	27'-0" height	110 LF
Fourth Floor / Roof	12'-4" height	110 LF

** Precast Slenderwall® Paneling (6" Thick)*

Panel Size (b x h)	Panel Type	Quantity	Square Feet	Cost / SF	Total Cost
10'-0" x 39'-8"	A	11	4363.33	$25.00	$109,083.34
10'-0" x 12'-4"	B	11	1356.66	$25.00	$33,916.58
					$142,999.92

** Panel A to be from Grade to top elevation of 4th Floor Deck*

*** Panel B to be from top elevation of 4th Floor Deck to Roof coping elevation*

**** Price per SF - direct quote from manufacturer to be from $22/sf - $33/sf. Price here was used due to simple façade*

Price Difference:	**40.97%** ↑

Schedule

As stated previously, precast assemblies are quicker to install than traditional face-brick. After consulting R.S. Means 2006 and Smith-Midland™, unit rates for the assembly of each system was determined. When entered into the equation, it was found that the Slenderwall® System was almost 14 days less than the brick on the south wall. That is over two weeks saved in the construction schedule, which is a significant gain. This would account for a General Conditions savings of roughly $21,000 (see *Tech Report 2* for General Conditions costs). A trade off for this advantage would be the amount of lead time. Talks with the manufacturer revealed that the typical lead time for the Slenderwall® System is 6 weeks for shop drawings and 6-8 weeks for fabrication. Therefore, increased planning upfront will be needed to coordinate the fabrication and delivery of this system. The erection of the Slenderwall® Panels is expected to be done concurrently with the steel framing in that area, so as not to extend the crane's reach any more than was planned. Erecting the panels during this time will give the construction team over four months to coordinate the delivery of the paneling, which is more than required. Please see *"Table 2 – Schedule Comparison"* below for the full results and assumptions.

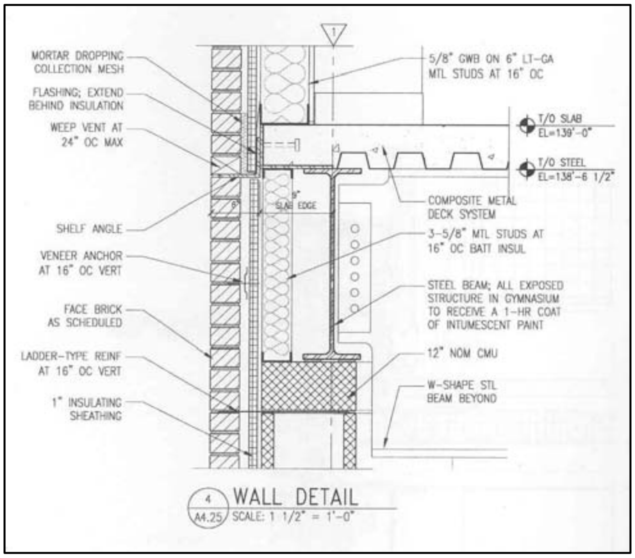
Table 2 - Schedule Comparison

Item	Quantity	Man Hours / Quantity	Total Hours	Total Days
Brick	5720 SF	0.125	715	15.0
Slenderwall® Panels	22 Panels	0.5	11	1.4
			Difference:	**13.6 ↓**

** As per Slenderwall® manufacturer, productivity is 15-20 panels per day.*
*** Assume 16 panels per day since structural connection is simple*
**** Assume 8 hour work days*
***** Brick productivity rate taken from R.S. Means 2006*
****** Existing brick crew is 6 Masons - total time will be divided by 6*

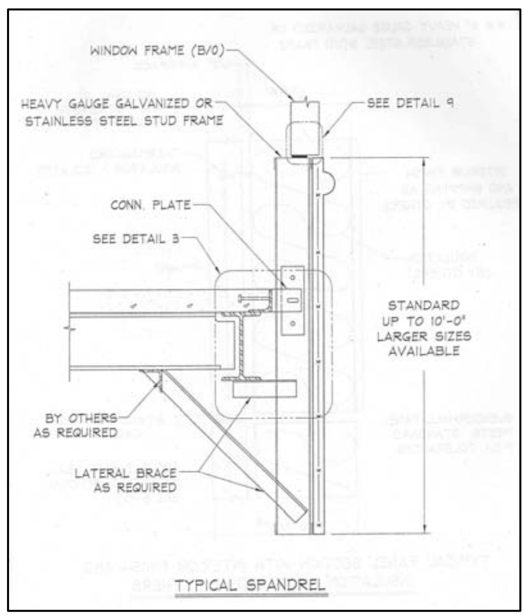
Structural Impacts

The original 5,720 square foot brick system was designed to be supported by a shelf angle which was welded to another steel angle that served as the pour stop for the slab on metal deck (see *Wall Detail* - left). The entire brick system weighed roughly 228,800 lbs. The Slenderwall® System is supported by a connection plate that is welded to the steel angle pour stop and braced by a connection plate welded to the bottom of a steel beam (see *Typical Spandrel* detail – below right). These connection plates are to be bolted to the stainless steel framing, which is spaced at 16” O.C.



4 A4.25 WALL DETAIL SCALE: 1 1/2" = 1'-0"

This bolted assembly allows the building frame to move independently of the exterior skin, isolating it from loads associated with expansion and contraction. The Slenderwall® System was found to weigh 30% less than the brick at approximately 160,160 lbs. Despite the fact that the brick is supported along a continuous shelf angle, the many point loads from the 16” O.C. Slenderwall® connection plates could be treated as a distributed load. Taking this approach, the Slenderwall® has no negative impact on the structural system. When considering wind loads, the Slenderwall® is designed to handle loads outlined in the LRFD Manual, and it is still attached to the steel frame at the same location as the brick. Therefore, no impacts to wind loading is seen. Please see *“Table 3 – Structural Impacts”* on the following page for a summary of the structural data. The table *“Table 4 – Crane Impact”* is also included on the following page to show that there are no impacts to the crane size.



TYPICAL SPANDREL

Table 3 - Structural Impact

Item	Quantity (SF)	Weight / SF (lbs./sf)	Total Weight (lbs.)
Brick	5720	40	228,800.00
Slenderwall® Panels	5720	28	160,160.00
		% Difference:	**30% ↓**

** Assume Brick weight 120 lbs./cf → 40 lbs./sf since brick is 4" thick*

*** Panel weight taken from manufacturer's specifications*

Table 4 - Crane Impact

Item	Square Feet	Weight / SF (lbs./sf)	Total Weight (tons)
10'-0" x 39'-8" Panel	396.67	28	5.55

** Panel weight taken from manufacturer's specifications*

*** Panel above is the largest and heaviest panel*

**** Maximum crane load is 80 tons*
***** Crane Manufacturer specifications show a 5.5 ton lift with 115'-0" boom and 90'-0" radius (Grove® TMS900E Crane)*

Mechanical Impacts

Impacts to the mechanical loads were analyzed by viewing the impacts to the insulation values of each wall system. In this analysis, the R-Values were compared from the exterior face of each system to the interior face of the CMU blocks. Each system would still include the interior 12" CMU's. The original brick assembly included a 4" thick face brick, 1" air space, and 1" thick extruded polystyrene rigid insulation. The Slenderwall® System includes a 2" thick architectural concrete layer, ½" air space, and 6" steel frame supports filled with fiberglass batt insulation. Obtaining typical material R-Values from the *1997 ASHRAE Handbook of Fundamentals,* it is seen that the Slenderwall® will reduce heat loss and gain. Impacts to the mechanical system itself will be mainly visible in the gymnasium, since this area is heated by a constant air volume supply, and will be seen as a reduction in the demand for heating and cooling. This could result in lower energy costs, adding to the LEED® aspect of Columbia Heights. *"Table 5 – System R-Values"* (below) outlines each system's insulation values.

Table 5 – System R-Values

System	Item	Thickness (in.)	R-Value	Total R-Value	
Brick Assembly					
	Outside Air Film	∞	0.17 / unit	0.17	
	Norman Brick	4.0	0.8 / thickness	0.8	
	Air space	1.0	1.0 / unit	1	
	Rigid Insulation Sheathing*	1.0	5.0 / inch	5	
	CMU 12" Nom	12.0	1.28 / thickness	1.23	
	Inside Air Film	∞	0.68 / unit	0.68	
			Total R-Value	**8.71**	hr-sf-F/BTU
			U-Value	**0.115**	BTU/hr-sf-F
Slenderwall®					
	Outside Air Film	∞	0.17 / unit	0.17	
	Concrete Face	2.0	0.8 / inch	1.6	
	Air space	0.5	1.0 / unit	1	
	Fiberglass Batt Insulation	6.0	13.0 / thickness	13	
	CMU 12" Nom	12.0	1.28 / thickness	1.23	
	Inside Air Film	∞	0.68 / unit	0.68	
			Total R-Value	**17.51**	hr-sf-F/BTU
			U-Value	**0.057**	BTU/hr-sf-F

** Rigid insulation to be Extruded Polystyrene Board*

*** R-Values taken from 1997 ASHRAE Handbook Fundamentals*

Mechanical Impacts (continued)

After obtaining the R-Values for each wall system, an analysis was performed to see the exact impacts to the building's mechanical loadings. As mentioned above, the area that will mainly be affected by this change is the gymnasium, since it is located on the south side of the building. Ultimately, this mechanical analysis will determine if the existing constant-air-volume AHU, that serves the gymnasium, can be downsized due to the increase in insulation value. Please see "*Table 6 – Mechanical Analysis*" on the following page for the calculations that were performed for this analysis.

Table 6 - Mechanical Analysis

Areas:		
Gymnasium Wall:	110'-0" x 27'-0"	2970 SF

Winter Temperature	
To	15 F
Ti	70 F
Δ T	55 F

Summer Temperature	
To	95 F
Ti	70 F
Δ T	25 F

** Temperatures taken from 1997 ASHRAE Handbook Fundamentals*

Heat-loss Winter				
Item	**U-Value**	**Area (sf)**	**Δ T (F)**	**Heat-loss (BTU/hr)**
Brick Assembly	0.144	2970	55	23522.40
Slenderwall®	0.057	2970	55	9310.95
			Difference:	**14211.45**
			Existing AHU	**218700**
		% Difference of Total AHU Load:		**6.50%**

Heat-gain Summer					
Item	**U-Value**	**Area (sf)**	**Delta T (F)**	**Heat-gain (BTU/hr)**	**Heat-gain (tons)**
Brick Assembly	0.144	2970	25	10692.00	0.89
Slenderwall®	0.057	2970	25	4232.25	0.35
			Difference:	**6459.75**	**0.54**
			Existing AHU		**20.04**
		% Difference of Total AHU Load:			**2.69%**

Mechanical Impacts (continued)

Despite that the Slenderwall® system increases the insulation value of the wall by more than 50%, it only reduces heat-loss in the winter by about 6.5% of the total AHU's heating volume. It also reduces heat-gain in the summer by a value that only makes up 2.69% of the air handler's cooling tonnage. These results show that even though the Slenderwall® has a positive affect, it still is not enough to reduce the size of the air handler unit.

Conclusion

When viewing all the results, the Slenderwall® System out-performs the original brick system in all categories except cost. The Slenderwall® System saves roughly 14 days on the schedule, it is lighter and does not impact the structural system or crane, and it reduces mechanical loads in the gymnasium. Since Slenderwall® is manufactured in a more controlled environment, it *does* reduce waste quantities, but the exact amount is hard to determine. This system also solves the initial problem of the congestion along the south wall: it does not require material staging areas and scaffolding.

When looking at the immediate cost impact, it may be hard to propose the switch from brick to the Slenderwall® System. The Slenderwall® panels cost roughly $58,500 more than the brick, which is roughly a 41% increase. But, if one looks at the entire project cost, the Slenderwall® accounts for an increase of only 0.65%. Also, this increase will be moderately offset by the savings in General Conditions costs.

Ultimately, using the Slenderwall® System to replace the Norman Brick along the south wall of the Columbia Heights Community Center would be very beneficial and should be pursued.