## Analysis 2 – Exterior Wall System

## Background

When the Large Scale Manufacturing Facility first was designed, Human Genome Sciences' intent was to have the building resemble the neighboring buildings at the John's Hopkins Belward Campus. These buildings are all owned by HGS and have been built within the past two decades. The existing buildings consist of 4in. red facing brick with a multicolored helix pattern (Figure 1) towards the top of the building along with punch windows.



Figure 1: Brick Helix Pattern

Value Engineering was performed on the project early in the design phase to help reduce the total project cost. One decision made was to change the exterior wall system on three of the building's facades. All of the facades except for the front, or southern face, of the building were changed to a 2in. preformed metal wall panel with steel tube support framing. This helped reduce the overall cost of the project as well as reduce the schedule.

Value Engineering is defined as: "An organized approach to optimizing both cost and performance in a facility or to eliminating items that add cost without contributing to required function. In evaluating the quality, use, life, appearance, and required features of a facility, the consultant attempts to achieve value without reducing quality below required levels while at the same time maximizing function, cost, and worth in design."

When performing Value Engineering; the building envelope, building's structure, and the foundation system are typically analyzed first. Though there were obvious benefits to their decision, one aspect of the building was jeopardized. The main issue that arose from changing the brick to the metal wall panels (Figure 2) was maintaining the aesthetics of the building, which Human Genome Sciences is interested in. The metal wall panels provide no aesthetic value and take away from the surrounding environment.



Figure 2: Exterior Facade

The purpose of this analysis was to identify and evaluate different wall systems that could maintain the aesthetic value without impacting the schedule or cost in a negative manner. There are other types of wall systems that can be utilized such as: Exterior Insulation and Finishes System (EIFS) and Architectural Precast Concrete Panels. Both of these systems are desirable on facilities such as industrial buildings, commercial buildings, institutional facilities, and hotels.

# Description of Wall Systems

## Preformed Metal Wall Panels

### Description:

The preformed metal wall panels that are being used on the Large Scale Manufacturing Facility are a custom wall panel manufactured by Centria. The specified product is the Formwall Dimension Series Flat Panels with concealed fasteners (Figure 3).



Then panels are made in 3' high sections and can be cut to a specified length. To provide a more appealing finish, the panels

Figure 3: Metal Wall Panel

are produced with surface rolls which leave the pattern visible on both the interior and exterior faces. The embossed finish on the panels incurs a higher cost as well as a longer lead time. The support system for the panels is a  $2^{\prime\prime} \times 8^{\prime\prime} \times 14^{\prime\prime}$  steel through-tube which is offset at 7'. These steel tubes are attached to the building's floor slab and structural steel above.

The exterior faces of the panels are made with ASTM A653 22 gage stainless steel. For exposed surfaces, three coats of thermosetting fluoropolymer enamel (PVDF) are to be applied, which is highly resistant to environmental impacts. The unexposed surfaces are to be coated with a DFT polyester finish topcoat. The interior insulation consists of a urethane foam core with a density of 2.7 PCF and a compressive strength of 20 psi. To provide a weather tight seal, all vertical joints are required to have a continuous back-up flash with two beads of sealant. All of the components of the metal wall panel provide a thermal resistance for conduction, or an R-value of 14.5.

## <u>Advantages:</u>

There are many benefits to using this type of system, especially when being compared to the brick wall system initially specified. This type of system can be installed very easily and efficiently. A pulley hoist system that is attached to the roof parapet can be used to lower the panels down the façade of the building. A small scale truck crane can also be used for easier installation. In order to achieve the insulation value and weather resistance, this system is less costly as compared to a brick wall system.

Metal wall panels are designed so there is minimal maintenance required, hence resulting in a long service life. The panels are designed so that they are highly resistant to impact and damage as well as the elements.

#### <u>Disadvantages:</u>

Some of the drawbacks to this system are that due to the custom design of the panels there is a long lead time. If any panels are damaged or the wrong size it could impact the project schedule if there are deadlines for building enclosure. If damage occurs to the panels during its life, it can become costly to replace and install them. Depending on the panels that are being used, there is a specified distance that must be left between the panels during installation. If there is not enough space left between the panels, they could buckle and cause damage while the building settles.

#### Exterior Insulation and Finishes System

#### Description:

EIFS is another type of cladding system that is becoming more prevalent throughout the construction industry due to its aesthetic appeal and low cost. Today, EIFS accounts for 17% of the commercial exterior finish market and 4% of the residential market. There are two different types of EIFS systems, drainable and non-drainable.

The non-drainable system, also known as synthetic stucco, has become less and less common. This is due to the fact that it does not have a drainage cavity or a weather-resistive barrier, and there is a limited drying potential. This allows water to become stuck inside the system damaging the materials, which can cause mold. In order to prevent this, the system must be installed perfectly which is never the case.

The drainable EIFS system (Figure 4) consists of::

- 2" x 4" framing stud wall
- Substrate (plywood, OSB, or cement board)
- Adhesive
- Insulation w/adhesive (extruded polystyrene EPS)
- Base coat with reinforcing mesh
- Finish coat (Acrylic)

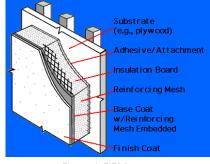


Figure 4: EIFS System

The EIFS system would also require the steel tubing that the metal wall panels require in order to meet the 90 lb/sf wind load.

#### <u>Advantages:</u>

This system is preferred over the non-drainable system for the simple purpose of providing a water resistant exterior surface. The EIFS system has become popular because the continuous insulation board not only prevents water penetration but improves energy efficiency. Also, the insulation board allows easy construction of architectural details like corners. The exterior finishes are very versatile allowing various textures and colors, and is less prone to surface cracking then traditional stucco. Figure 5 shows a detailed example of a building that uses an EIFS system, and the exterior finish was designed to look like facing brick.



Figure 5: EIFS Brick Facade

EIFS is a high-end product which has installation prices similar to those of basic brick veneer. Drainable EIFS can cost anywhere between \$4.50 and \$7.50 per square foot depending on insulation type and detail of exterior finish.

Though many materials go into constructing an EIFS wall system, it is one of the lightest forms of cladding. A typical EIFS system can impose a 4 psf. load on a buildings foundation as compared to brick veneer which can impose a load of 40 psf. This can allow for a smaller foundation design as well as reduce the size of a buildings beams and columns.

#### Disadvantages:

There are also disadvantages to this system. Since there is no drainage cavity on the interior of the system, care must be taken during application to prevent moisture from being captured inside which can cause mold. EIFS systems are more susceptible to damage than other cladding systems. They are typically dented rather than shattered or cracked, but can be easily repaired.

#### Architectural Precast Concrete Panels

#### Description:

Precast concrete wall systems provide designers, owners, and managers a solid wall construction system. These systems consist of three basic product types: sandwich wall panels (which will be analyzed), hollowcore, or double tees for walls. Since the panels are manufactured in a shop, they can be produced to an exact tolerance in a wide variety of dimensional choices to meet buildings specifications. The precast wall systems come with a limitless variety of finishes,



Figure 6: Precast Building

varying colors, and textures. Precast wall systems have demonstrated high value and versatility in serving the food processing, warehousing and distribution, industrial / commercial / manufacturing and retail markets, which would make it an ideal system for the LSM Facility. Figure 6 shows and example of a building that incorporates architectural precast concrete panels.

The sandwich wall panels are manufactured in  $20' \times 10'$  sections with a smooth gray finish. The panels consist of 2'' on concrete, then 2'' of polystyrene insulation, and then another 2'' of concrete.

#### <u>Advantages:</u>

There are numerous benefits associated with this type of wall system. In climates where there are issues with rain and cold temperatures there are no delays in the schedule due to the fact that the concrete is not poured on site. The panels are shipped to the site and are then installed with a crane. With proper coordination the panels can be cast simultaneously with site preparation, and can then be delivered to site at the exact time required. This can greatly reduce a project's schedule. Another benefit associated with the panels being manufactured in a plant has to do with quality assurance; the panels can be made with minimal to no defects and meet the exact project specifications. Any finish can be applied in the plant to meet the architects and owners needs, which cannot easily be done on site. Plus, precast wall systems can be load-bearing which opens up a whole new range of opportunities for designers to reduce foundation and framing costs. This wall system is also more durable than the previous wall systems, and requires little to no maintenance over the life of the building.

#### Disadvantages:

A major disadvantage of this system has to do with the cost of manufacturing the product. One of the most costly aspects of a precast system is the initial cost of making the forms. Once the forms are made, each additional piece becomes less expensive. Another issue has to do with bringing the product onto site. The wall planks must be shipped to site, so the cost of trucking them could drive up the total cost. Along with that, if the building is on a constricted site there could be difficulty getting the planks close to the building to eliminate crane movement. If the building requires special sizes there could be issues with lead time, and if a panel is damaged or the wrong size the project could be delayed.

## Cost and Schedule Comparison

In order to compare the impacts of each wall system on the LSM project, an estimate was performed using the appropriate materials for each system. The values used for the preformed metal wall panels were obtained from Centria and A.C. Delovade whom are the manufacturer and contactor for the project respectively. In order to obtain cost and duration values for the EIFS and Precast Concrete Wall Systems, values were obtained from the R.S. Means Assemblies Estimate and Building Construction Costs Data books.

Located below in Table 1 are the overall cost, duration, and R-Values for each of the wall systems. At this point the R-Value is irrelevant; it will be discussed later in this analysis. A detailed estimate can be found in Appendix E.

| Table 1 - Analysis of Exterior Wall System |             |             |           |
|--|-------------|-------------|-----------|
| Preformed Metal Wall Panel                 |             |             |           |
| Description                                | Total Cost  | Total Weeks | R - Value |
| Wall Panel                                 | \$892,500   | 12          | 14.5      |
| Steel Tubing                               | \$357,000   | 12          | 0         |
| Total                                      | \$1,249,500 | 24          | 14.5      |
|  |             |             |           |
| Exterior Insulation and Finishes System    |             |             |           |
| Description                                | Total Cost  | Total Weeks | R - Value |
| EIFS System 4" EPS                         | \$335,580   | 24          | 16.83     |
| Premium Finish                             | \$65,331    | 6           | 0         |
| Steel Tubing                               | \$357,000   | 12          | 0         |
| Total                                      | \$757,911   | 42          | 16.83     |
|  |             |             |           |
| Architectural Precast Concrete Panels      |             |             |           |
| Description                                | Total Cost  | Total Weeks | R - Value |
| Insulated Precast Concrete                 | \$910,350   | 4           | 10.4      |
| Steel Tubing                               | \$73,661    | 1           | 0         |
| Metal Studs                                | \$71,370    | 9           | 0         |
| Total                                      | \$1,055,381 | 14          | 10.4      |

The only value located in the table which can be manipulated with proper coordination is the "Total Weeks" column.

For the metal wall panels, the steel tubing is installed first and then the wall panels.
The wall panel installation can begin 1 -2 weeks after the steel tubing is installed to speed up the process if needed. This would reduce the total duration to 14 weeks.

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- For the EIFS system, the steel tubing is installed first and then a week later the EIFS can be installed reducing the schedule to 25 weeks. The premium finish can be installed in a manner so that the last section of EIFS installed can receive the finish the next day, hence keeping the schedule to 25 weeks. The EIFS system itself could be sped up by increasing the crew size, which in turn would increase the total cost to \$901,425. This would reduce the schedule to 13 weeks.
- The concrete panels can be coordinated so that the steel tubing is installed first and once the first two columns are installed the precast panels for that section can be installed. Once the panels are installed the metal studs can be set into place. This would reduce the schedule to approximately **10 weeks**.

The EIFS system clearly will take the most time to install. This is not an issue because the exterior wall system was installed during the warmer months, so there was no rush to have the building enclosed. Along with that, there was no pressure to have the building enclosed early to assist with indoor air quality because the clean rooms were not yet constructed.

Cost is the biggest concern to Human Genome Sciences, and if this is taken into account the EIFS system is the most efficient. If there was some issue with closing up the structure and more crews were needed to install the system, the cost would still be noticeable less than the other two systems.

Below is a cost and schedule relationship between the proposed metal wall panels and the other two systems. (+ is more, - is less)

EIFS: Cost impact: -\$491,589 Schedule impact: + 11 weeks

Precast Concrete Panels: Cost impact: -\$194,119 Schedule impact: - 4 weeks

The EIFS system provides a great cost savings, but will increase the schedule by more than 2 months. As stated earlier, the schedule is not of importance to an extent for enclosing the

building. If there were to be an issue the crew size could be increased and still provide a cost saving of \$348,075 and reduce the schedule by 1 week. The precast concrete panels provide advantages in both cost and schedule, but the EIFS system could save HGS approximately \$350,000 and be under schedule by 1 week if the crew size is doubled.

With respect to cost and schedule the EIFS system would provide great savings to the owner as well as not impact the overall project schedule.

## Heat Transfer Comparison

## Description

In order to further research the benefits of the EIFS system, the operating cost of the building can be evaluated. Each type of wall system has a respective R - Value, which is the resistance to heat transfer. This number is derived by taking each component of the wall system and adding up each respective R - Value. This rating is very useful when comparing exterior envelopes because the higher the R - Value, the more effective the insulator.

Taking a look at Table 1, the R - Value for the preformed metal wall panel is 14.5. The EIFS system has a higher R – Value of 16.83 due to the thickness of the insulation used.

## Calculations

The R - Value ( $R_{tot}$ ) is used with the outside ( $T_{\infty 1}$ ) and inside ( $T_{\infty 2}$ ) ambient air temperatures and the surface area of the wall to determine the heat transfer rate ( $q_x$ ). The equation for heat transfer rate is:

 $q_x = (T_{\infty 1} - T_{\infty 2}) * A / R_{tot}$ 

For metal wall panel:

Heating:  $q_x = ((70 - 8) * 35,700) / 14.5 = 152,648$  Btu/h Cooling:  $q_x = ((94 - 70) * 35,700) / 14.5 = 59,090$  Btu/h

## For EIFS:

Heating:  $q_x = ((70 - 8) * 35,700) / 16.83 = 131,516$  Btu/h Cooling:  $q_x = ((94 - 70) * 35,700) / 16.83 = 50,909$  Btu/h

In order to find the amount that both the heating and cooling loads can be reduced the difference in the heat transfer rates for the metal wall panel and EIFS system must be calculated. The total heating load is 8,000,000Btu/h, and the total cooling load is 3,000 tons.

Heating: 152,648 Btu/h - 131,516 Btu/h = **21,132 Btu/h** Cooling: 59,090 Btu/h - 50,909 Btu/h = **8,181 Btu/h** = **0.68 tons** 

The total heating load can be reduced by 21,132 Btu/h, which is 0.26% of the total heating load.

The total cooling load can be reduced by 0.68 tons, which is 0.02 % of the total cooling load.

## Conclusion

By changing the exterior wall system, the savings that could be achieved in cooling and heating are very miniscule. Over a span of 50 or more years there could be some cost savings related to the reduction of the heating and cooling load, but when compared to the operation costs of the building and the amount of money HGS makes annually, these saving would not benefit HGS substantially. In order to efficiently analyze which system would be the most desirable, the cost and schedule impacts should be looked at instead of the mechanical impacts.

## Conclusion / Recommendation

Originally the LSM Facility was designed to have an exterior wall system consisting of facing brick only. Through the process of Value Engineering, all of the facades excluding the front facade were then changed to use a 2" preformed metal wall panel. The purpose of this analysis was to research different exterior facades in order to increase the aesthetic value while reducing the overall cost and or reducing the installation as compared to the preformed metal wall panels.

From my research it is evident that the preformed metal wall panels used is not the best system that HGS could have chosen. Both the architectural precast concrete panels and the EIFS system would benefit HGS in terms of their needs and wants. There are advantages and disadvantages to both systems, but there needs to be a one that will benefit HGS the most.

I feel that the EIFS system is the best exterior wall system for the LSM Facility. With EIFS the architect would be able to design the exterior coating to resemble that of the surrounding buildings and the front façade of the building. This was the initial intent of the architect, until the building was VE'd to reduce costs. By using an exterior insulation and finishes system the aesthetic value of the building will once again be renewed.

Along with aesthetic value, the EIFS system also will provide a great reduction in total project cost. It would cost roughly \$500,000 less to install the EIFS than the metal wall panels. There is one disadvantage linked with this low cost. The building would not be enclosed for another 11 weeks as compared to the metal wall panels. If the project remains on schedule this would not be a great issue because there is no immediate need to get the building enclosed any earlier than this date.

If for some reason the EIFS system would need to be installed at a faster rate, the crew size would be doubled. The resulting effects would be a cost savings of approximately \$350,000, and reduce the schedule to 1 week less than that of the metal wall panels. By implementing the EIFS system with either one crew size or by doubling the crew size the advantages are much better than that of the metal wall panels or the architectural precast concrete panels.

Though the wall system has more insulation and hence having a higher resistance to heat transfer through the wall, the savings that HGS could obtain from heating and cooling are very miniscule. The major savings are in the total cost of the exterior wall system itself.

In conclusion the Exterior Insulation and Finishes System would aesthetic value to the building while reducing the total project cost and not impacting the project schedule. This system will perform the same functionally, and hence not take away from the building's performance.