Science & Technology Center
Chestnut Hill Academy
Philadelphia, PA

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Construction Management

Technical Assignment #2

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Executive Summary

The following technical report will examine areas of construction management issues of Science & Technology Center located in Philadelphia, PA. The construction duration of the project is 10 months and will begin in March of 2007 and will commence in November of 2008. The areas of consideration that will be looked at are alternative methods, value engineering, and schedule compression. Analyzing these areas have the potential to bring overall improvement to the project.

The report takes into consideration the challenges of the construction and how the project team overcame those challenges. The three areas that were covered by the report are wall construction, mechanical equipment placement and roof installation. These areas were chosen because they imposed different challenges and issues that were overcome by the project team.

The next area discusses the possible schedule acceleration scenarios. It describes the critical path of the project and what must be done to complete on time. The briefly describes the acceleration scenarios and how they might impact the cost of the project. Another area discussed that impacts the project costs is the idea of value engineering. The project implemented several ideas that decreased cost in different aspects of the project.

Every project has possible room for improvement weather it is the construction methods or design of the technical system. There will be four areas explained that have possible areas of research to improve the project in some aspect. These areas are exterior façade construction, sustainable energy, Building Information Modeling (BIM) and finally site congestion/layout.

Table of Contents

Constructability Challenges

There are several areas on the New Science & Technology Building that were found to be a challenge during construction. This section of the paper will discuss three of these constructability challenges. These challenges are wall construction, mechanical equipment placement, and roof installation.

Wall Construction

The design and detailing of the walls for the entire building had to be incredibly accurate and detailed. The reason being that the classrooms and laboratories throughout had generous amounts of casework, mechanical equipment, and electrical receptacles. The laboratory casework was specially designed for each classroom and laboratory. Due to this amount of customization, the interior and exterior walls had to be constructed 100% to plan with no margin for error. The lead time for this casework and lab equipment was 16 weeks leaving little time for alterations to the dimensions or additional orders. To acquire this amount of detail all the manufacturing of the casework was done with preplanning by the architect and manufacture. The laboratory equipment was placed in sequence with casework, some had mechanical ventilation systems which are also coordinated with the MEP trades creating another level of detail with penetrations and hangers.

The project team took this problem head on with numerous preplanning meetings with the trade foreman, as well as consistent inspections of the contractor's workmanship. Keeping scheduled quality checks will help keep contractors within the allowable limits allowing for the interior finishing contractors to have little disturbance with placement.

Mechanical Equipment Placement

The mechanical equipment for the New Science & Technology Center consists of two air handling units placed in the half story attic space above the second floor. The installation of this equipment in that location posed problematic for the project team. Due to the unit's size they had to be disassembled and placed piece by piece by a construction forklift then reassembled. Since the mechanical equipment had to be placed in the building after the majority of the building was weather proof, the exterior finishing contractors placing the stucco would be held up as well as the interior framers as the equipment was placed. Leaving relatively large hole in the side of the building to allow this equipment to be placed could cause damage to any interior finishing already in place, therefore this activity had to be planned and sequenced so once the equipment was placed the contractors could come complete the enclosure making the area water tight.

Roof Installation

The sloped roof installation portion of the building consists of asphalt shingles backed with felt paper, 4 1/2" of insulation/nail board, continuous ice and water shield all on top of 3" metal roof decking. The majority of the roof has a slope of 12:12 which is 45 degrees. The roof decking was placed in entirety before any of the remaining system was started. Construction of such a steep roof is not only difficult and challenging but is also very dangerous. Constant repositioning of personnel lifts to erect the roofing system results in time delays as well as trade coordination issues (*see figure 1*). Also constant raising and lower of the lifts to replenish roofing material was also another piece adding to the site congestion. The exterior stone façade could not begin in the area of the roof until the lifts were completely out of the area so the masons could erect the scaffolding. The stone masons would follow the roofers around the building while the stucco contractor would follow the stone mason allowing for the trades to chase each other around the exterior of the building.

Figure 1 Worker using lift for roof access

This is another instant for the project team to do consist planning and sequencing of materials and construction trades to keep the project flowing and on schedule. Safety precautions such as tying off to personnel lifts as well as keeping workers out from potential fall zones while the roof is being constructed.

In summary, constant preplanning for activities that are seen as areas that will be possible challenges will greatly increase the project flow and speed. Not accounting for these issues could possibly create great schedule delays and possibly increases in costs.

Schedule Acceleration Scenarios

Accelerating the schedule in any project usually comes with a price. The New Science& Technology Center's construction schedule is approximately 10 months long. This is already a tightly condensed schedule. Accelerating the schedule more than it already is would result in poor quality of work and could possibly make the area to congested to comfortably perform work.

The critical path for the building is much like the critical path of most projects. The path begins with the site preparation, bulk excavation, foundation system and continues on to the structural steel followed by building envelop, HVAC ductwork and interior finishes such as framing and drywall. The final activities on the critical path are testing/balancing and the final project punch list. It is very important that the building gets "out of the ground" with the construction of the foundation and erection of the structural steel. These two activities can make or break the project at the very beginning. There is no room for delay with any of these critical path activities, if there is any it will result in project delays and possible additional costs.

Field Stone Facade & Stucco Construction

An area that could considered for acceleration would be the exterior sheathing/façade which is the longest of the building envelope activities at 12 weeks. Adding addition man power will result in faster construction times. A downfall to the faster times would be a decrease in quality of workmanship, since the bottom course of façade is field stone a change in the pace of work could easily be seen just by the finishing of the mortar joints and stone orientation. There also is a point at which speeding up the façade to much would result in downtime of workers because the stone motor must be have time set so that the weight of the stone does not crush and squeeze the mortar out of the joint. The costs associated with this would be the cost of labor only.

The schedule also has activities that were intentionally done during certain times of the year, such as phasing the heavy equipment activity during the summer months to limit pedestrian confrontation. Phasing the activities like previously mentioned adds another level of sequencing to the schedule not allowing for much play for the remaining, already tightly scheduled, activities. An idea that the schedule could be accelerated would be adding more man-hours to the 8 hour day, this would be very costly due to the fact that there would be additional overtime payment required each week. This would increase the labor cost dramatically. For these reasons any further acceleration of the schedule would result in site congestion, undesirable quality of work, and add unwanted costs.

Value Engineering Ideas

Value engineering on projects has become a staple in today's building industry. The rising costs of material prices and general construction costs leave owners and lenders looking for changes to save some cash. There are many areas of construction that value engineering ideas can be considered. Some of the areas used on the Science & Technology Center are equipment purchasing and installation, as well as material substitution.

Chestnut Hill Academy and Turner Construction discussed different ideas to save money on the project. They felt that several equipment items such as the central vacuum system, compressed air system, wind turbine, as well as the solar products such as the roof panels could be purchased and installed by the owner. Allowing the owner to purchase and install these items cuts back on contractor mark up for material and labor in return saves that amount on the projects budget. This also allows for the construction manager to sequence around these activities freeing up additional time on the project. An area of the same idea that was considered but not implemented in the project was having the owner purchase and install the unistrut system for the laboratories. This system is used by the students and faculty to display and conduct experiments. The approximated cost for the system was estimated at $30,000. It was unfeasible for the owner to install this system due to the amount of preplanning and coordination that took place with the MEP trades in the ceiling plenum. There were several instances where the unistrut grid intersecting HVAC ductwork *(see figure 2).* Special bracing needed to be designed between the installer and HVAC contractor for adequate installation. Due to this the owner and CM found it more reasonable for it to be installed regularly.

Dust Collection System

Additional areas of value engineering for the project were reducing lighting quantities in the classrooms as well as the amount of circuits that went to the laboratory casework. By reducing the light fixture quantities while still meeting the required foot candles for each area saves on material, labor, as well as future energy costs. Condensing the casework items on the circuits will allow for less wiring and also save room in the panel board for future expansion of new laboratory equipment. Turner Construction also found it to be cost worthy to replace stone flooring in the stairwells with porcelain tile. The architect and owner found that this did not take away from their desired outlook of the buildings aesthetics features due to the enclosed stairwells. The blue stone flooring was kept in the lobby and hallway areas as desired.

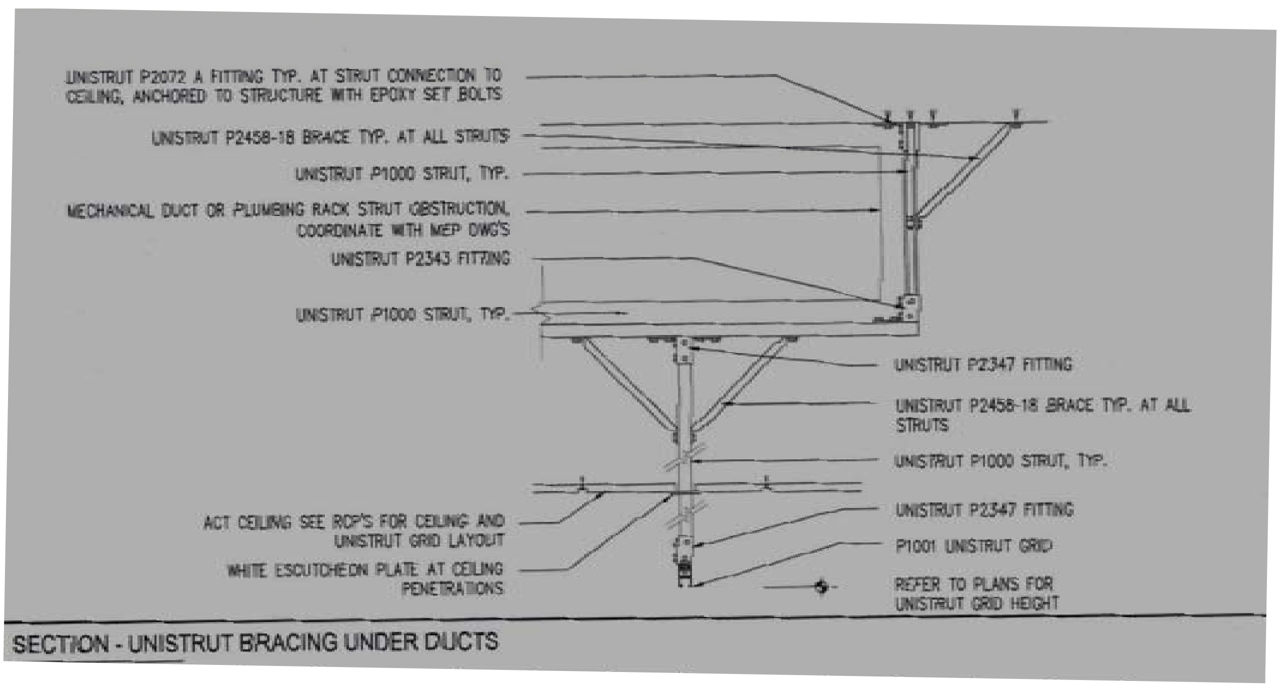

Figure 2 Unistrut Hanger intersecting ductwork

Problem Identification

There are several areas of the New Science & Technology Center that could be redesigned or researched further to improve the quality, costs, schedule of the project, or make it easier to build. These issues will be discussed briefly in the following section.

Exterior Façade Construction

The façade of the building consists of field stone masonry and stucco. The lower portion of the exterior wall is made up of various sized ashlar patterned stone masonry units. The construction of this must be done by experienced masons and done so that the weight of the stone does not crush the mortar joints, which limits the number of rows of stone that can be placed before the mortar sets. This slows down production of the activity which also slows down the remaining façade activities like the upper stucco portion.

Sustainable Energy

The building's main energy source is a connection from the campus infrastructure. Since the Science & Technology Center is seeking LEED Silver it has a couple areas for sustainable energy. These areas are the roof mounted wind turbine, solar roof panels, and photovoltaic cells. These produce minimal amounts of energy to be reused inside the building. One value engineering topic that was implemented in the project was reducing the amount of lighting fixtures. This could possibly hinder the classroom environment for experiments and ordinary classes.

Building Information Modeling

The implementation of 3D modeling in building construction provides visualization, coordination, and optimization for all participating companies. 3D modeling helps mediate site questions and RFI's, which will help the project run smoothly. The Science & Technology Center did not utilize a 3D model, the only images of the building was the architects sketched renderings. Combining a 3D model with the project schedule can produce a time activated 4D model which can show the trade sequencing and conflicts.

Site Congestion & Layout

The building is located on the campus of the Chestnut Hill Academy in Philadelphia, PA. The site is being constructed on an existing parking lot and grass field. There is an existing building with in close proximity of the site approximately 75 feet away. To the opposite side of the existing building there is a track field. The area around the building being constructed is limited for movement and storage. It also must be completely fenced off due to student and pedestrian traffic. There also are two adjacent roads with limited site access.

Technical Analysis Methods

Analysis 1: Exterior Façade Construction

The exterior walls consist of a portion of heavy field stone masonry. This area of the wall itself takes 12 weeks to erect and is the longest activity of the building envelope. The masons must construct the wall in lifts so that the stone masonry weight does not crush the mortar joints. This not only slows the masonry masons down but the rest of the exterior façade, as well as adding to site congestion from the scaffolding and material lay down. The remaining trades must follow the stone mason around the building finishing each portion of their work at a slow pace.

In an effort to speed up this activity as well as save money, the stone masonry system will be examined in its worth compared to a precast stone wall panel. The precast stone panels have the potential of savings in the areas of material cost as well as schedule time. Erecting precast panels could possibly cut the original stone duration in half therefore the schedule acceleration impact will be studied. Quality control will also be a bonus due to the automated manufacturing processes, therefore the area for human error and variability will reduce In order for these panels to work, the owner and architect would need to approve of the aesthetic qualities in comparison to the natural field stone. The structural capabilities of the precast walls must be studied, weather they may be used as load bearing or only a veneer. As well as the insulation properties and available manufactured sizes. Due to the projects sustainability background the LEED issues must also be investigated in the areas of recyclability and local manufacturer availability.

Contact must be made with manufacturers of the product for the technical information as well as availability and costs. Several experienced contractors will be interviewed for erection times and the overall ease of construction. The owner and architect will be contacted for opinions of material change.

Figure 2 Example of Precast Stone Panel

Areas of Research:

Prefabricated Stone Walls

- -Cost
- -Structural Properties
- -Architectural Properties
- -Standard Sizes & Dimensions
- -Proper Installation Sequence
- -Estimated Construction Time
- -Insulation Properties

Analysis 2: Sustainable Energy

Sustainable energy in LEED rated buildings is a common method to gain rating as well as conserve energy consumption. Researching additional areas of sustainable energy products can be another added value to an already green conscious building. A value engineering idea used on the project was reducing the lighting fixture quantities to minimize energy consumption. Calculating the foot candle requirements for the different areas throughout the building could possibly limit more lighting fixtures or possibly find that more fixtures should be added. The use of green technology such as the dimmable ballasts to factor in outside lighting also can be accounted for with these calculations. Additional areas that were not considered are the use of solar shingles and solar exterior lighting. Given the location of the building in the North East of the United States the use of solar energy products can be a valuable asset if done correctly.

Reviewing the calculations and various light fixture layouts can aid with reducing lighting quantities. Calculating the amount of energy savings from the use of the ecosystem dimmable ballasts can also be valuable information. Finding an initial cost for these various materials and equipment ideas will give a base cost of investment, then calculating the amount of time that the energy products will eventually pay for themselves by producing energy. These investments could be a valuable commodity with the rising prices in the energy market.

<u>*Areas of Research:*</u>

Lighting Considerations

-Day lighting Effects

-Energy Savings from dimmable ballasts

- Foot candle requirements

Sustainable Energy Products

<u>Solar Shingles</u>

-Energy Production

-Installation procedures

-Life Cycle Durations

-Architectural Appeal

<u>Solar Exterior Lighting</u>

- Specifications

- Costs

Figure 3 Solar Shingles

Analysis 3: Building Information Modeling

The use of Building Information Modeling (BIM) is becoming an ever growing asset to construction designs. Some advantages are better coordination, greater productivity, ability to visualize what is being constructed and many others. The Science & Technology Center does not implement BIM technologies, this could greatly help in project coordination as well as serve the school as a teaching tool for the academy. The contractor RFI's and misunderstandings would be reduced with the ability to see the project in additional dimensions. The construction manager would be able to use the programs to assist in site layout as well as sequencing.

Designing a 3D computer generated model. Implementing preplanning project meetings utilizing the constructed model will greatly increase the understanding and expectations of the project. Research on how the building components will be compiled during construction. Interviewing construction professionals for their opinions on BIM technology and if it would be a good investment for a project of this size.

Areas of Research:

Components of a Model
Construction methods of a 3D model
Examples existing models
Survey of construction professionals

Analysis 4: Site Congestion & Layout

Constructing buildings on condensed sites adds many challenges of site logistics, deliveries, and personnel management. Due to the site being located inside of a preparatory school's campus limits the amount of heavy construction traffic on and around the site. The location of the site in Philadelphia also adds to delay problems with potential traffic congestions possibly delaying the activities. The use of a crane on a small site practically closes down large areas of the site for safety reasons as well. The surrounding existing building and track greatly limits the available lay down and storage areas.

Reviewing the project schedule and discussing possible changes to site layout plans may increase productivity and project quality. Better understanding of the trade contractor's requirements for material and equipment storage can help dismiss some areas of congestion. After reviewing the possible changes to the building façade construction it may also change issues involving the scaffold congestion and material lay down, freeing up space for addition trades to occupy.

Area of Research:

Site Layout
Trade sequencing
Site Delivery
Scheduling and Phasing