Central Ohio Elementary School

Thesis Proposal

2013

Raymond Pell

Construction Management

Advisor: Robert Leicht

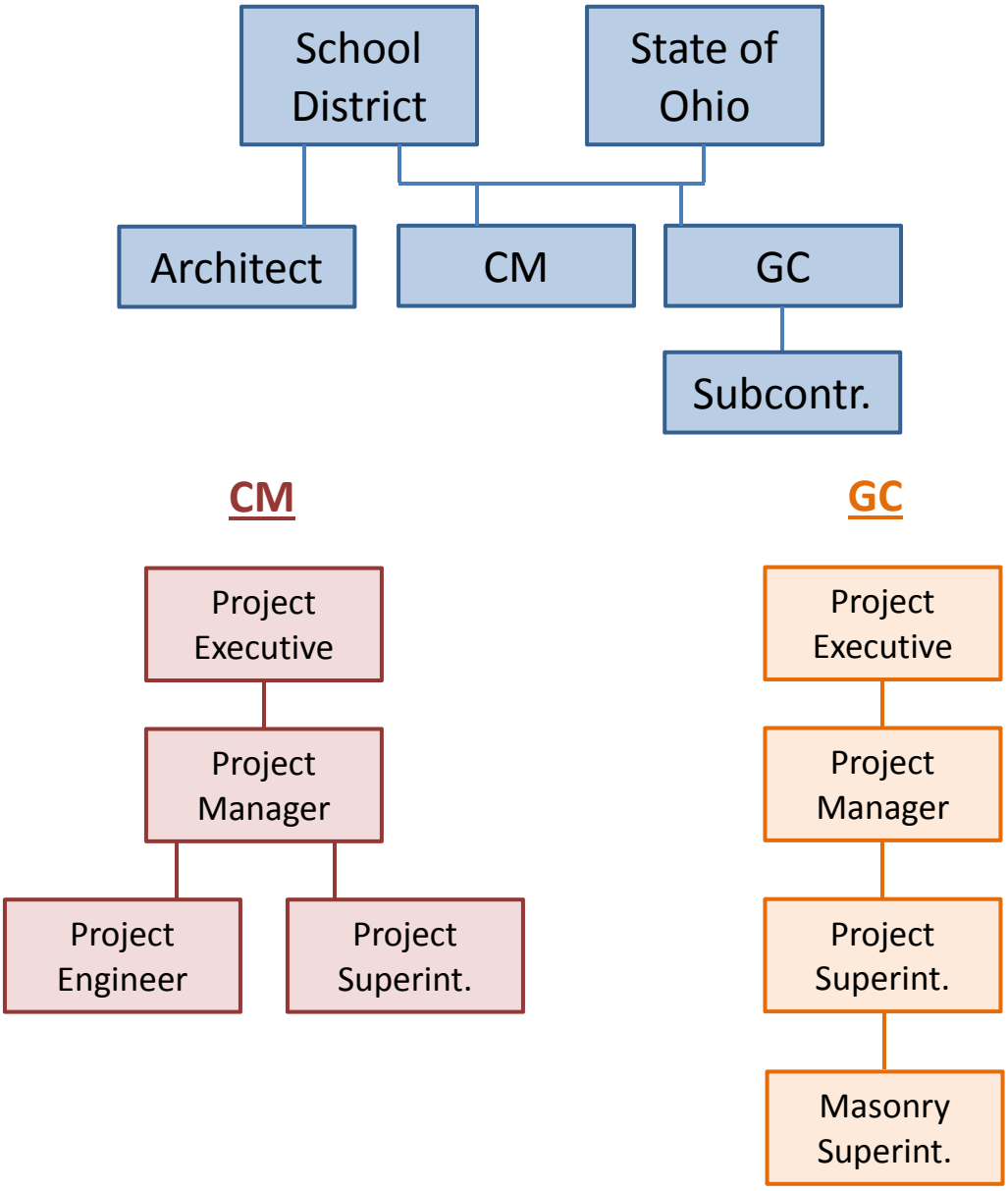
December 16, 2013

The project selected for use in this research project is an elementary school located in central Ohio. The project consists of new construction and renovation work. The original building, constructed in 1874, was damaged by fire. The building was subsequently closed. As funding became available, a plan to renovate the 28,000 square feet of existing space and add 18,000 square feet of modern amenities was developed.

The project consists of the abatement of hazardous materials, demolition of a portion of the building, complete renovation of the remaining structure, the addition, sitework and the demolition of an adjacent building. The construction costs are $9.07 million. The total project costs excluding demolishing the secondary building are $11.20 million.

The design process began on July 5, 2011. After the lengthy approval process, construction began on June 4, 2013. The substantial completion date is scheduled for 312 days later, on August 13, 2014. Contract completion, January 23, 2015, follows winter commissioning.

The delivery method for this project is Single Prime w/ CM advisor. The construction manager has been participating since the projects inception. The project is organized as follows:



This proposal defines five analyses topics. This research will be used to complete the spring semester AE Senior Thesis. These topics envelope a wide range of construction related issues while also exploring the breadth topics of mechanical and structural design and analysis.

Analysis 1: 3D Laser Scan Existing Structure

Problem Identification

Due to the age of the remaining structure and construction practices utilized at the time of its erection, accurate measurements of the structure are difficult. This difficulty has presented itself in the form of inaccuracies. These errors present situations that require constant attention and re-measurement.

The sloping floors and angled walls affect both the floor plans and elevations. These issues with the documents are affecting the sizing of materials as well as the coordination of trades as it pertains to penetrations.

The inaccuracies are responsible for enough complications that the architect is redrawing the floor plans and elevations. This solution, while appropriate, is causing further delays and loss of revenue to the architect.

Proposed Solution

The use of 3D laser scanning on the existing structure would generate accurate and highly detailed representations of the building. The scanning equipment captures 3D data sets of the 360-degree environment. 3D models are generated using these data sets. Precise measurements can be taken from these models and used to generate accurate construction documents.

Methodology

- Research different scanning systems, implementation of systems and 3D modeling process.
- Research the accuracy of the system by interviewing design companies that have adopted its use.
- Identify schedule delays caused by inaccurate drawings.
- Identify time used to re-measure existing structure and redraw floor plans and elevations.
- Compare cost of employing the 3D laser scanner to the cost of delays and redesign.

Expected Outcome

The use of a 3D laser scanning system to accurately model the existing space prior to design will greatly reduce the need for redesign. Schedule delays and construction changes due to inaccuracies of the drawings and the additional costs associated with these delays and changes will be alleviated. The architect will avoid the financial loss of reproducing completed work to correct mistakes.

Analysis 2: Multivista Construction Documentation

Problem Identification

Mistakes are made on most, if not all, construction projects. These errors often prove uneventful and are usually unnoticed and provide no repercussions. However, some mistakes cause construction delays and cost overruns. Others may not surface until years after the project is completed. These issues can be particularly expensive to resolve or determine the responsible party.

Proposed Solution

The use of third-party photographic documentation serves to resolve several issues associated with the construction process. Initially, this solution provides a record of existing conditions which can be used for planning purposes or proof of required changes to the design or plan.

Throughout the construction process the service provides documentation of the ongoing activities. This serves as a record should future issues arise. The high-resolution photographs can be used to pinpoint the responsible error and determine whether it is design or installation related and who may be at fault.

This ability to identify the problem without physical investigation saves time and money in unnecessary repairs. The documentation also serves to protect all interested parties by providing confirmation of competent work.

Methodology

- Review Multivista Systems, LLC's documentation to identify proposed benefits of the service and compare them to the aforementioned benefits.
- Interview Multivista contact to gain deeper insight into the service and obtain financial evidence of benefits.
- Interview Smoot Construction contacts to discuss benefits of the documentation service on this project.
- Study school projects of similar size to identify areas where this service would have resulted in time or monetary savings.

- Research the average cost of investigatory procedures that could be rendered obsolete by this service.
- Compare cost of service to projected savings and research possible insurance benefits.

Expected Outcome

The third-party photo documentation service will provide a projected savings equal to or exceeding the cost of the service. Evidence will show that the service provides quality benefits and peace-of-mind for all parties.

Analysis 3: Use Of PEX Tubing

Problem Identification

The urban setting of this and many school building projects provides challenges in securing equipment and materials. One of the most sought after materials is copper piping. The copper is stolen from storage and from installations. This issue potentially causes delays in construction and an increase in costs. Increased insurance premiums can also result from this loss. Additionally, the cost of copper pipe and its installation are high compared to other plumbing materials.

Proposed Solution

The use of cross-linked polyethylene tubing (PEX) is a cost efficient replacement for copper pipe. PEX is both less expensive to purchase and less labor intensive to install. This reduces the material and labor costs as well as the installation schedule. The installation process of PEX also lends itself to terminations at centrally located manifolds, which eases future maintenance.

The fact that PEX is not a readily recycled material also reduces the likelihood that it will be stolen from the site. Unused material is easier to store due to its coiled state and removal of installed tubing is labor intensive and would yield little profit.

Methodology

- Identify the benefits and deficits of PEX compared with copper piping.
- Perform estimate of plumbing system utilizing copper pipe.
- Design PEX plumbing system. Perform estimate of new system.
- Schedule installation of PEX system.
- Compare material and labor costs of the two systems as well as schedule differences.
- Research insurance benefits to alleviating opportunity for stolen materials.

Expected Outcome

The use of PEX will afford both a monetary and time savings. Copper pipe can cost three times the price of PEX. It also takes significantly longer to install as pipe must be installed in smaller pieces and connected together. PEX is flexible and can be “fished” through existing or new construction. This allows for the use of manifolds and a “home-run” installation method where each fixture terminates at a central location. An installation such as this eases maintenance by consolidating all the connections in one locale.

Analysis 4: Use Of Steel Decking/ Cast-In-Place Concrete

Problem Identification

The pre-cast concrete planks called for in the construction documents are proving difficult to procure and install. This manifests in three separate issues.

1. The planks have a long lead time delaying installation as well as other activities dependent on the floor system installation.
2. The planks prove difficult to install in the existing structure.
3. The planks provide minimal penetrations for utility and system installation.

Proposed Solution

Replacing the pre-cast planks with steel decking and cast-in-place concrete solves all three issues. First, there is very little lead time in procuring steel decking and concrete. This will shorten the schedule.

Second, the unreliable measurements and misaligned structure of the 140 year old building make the pre-cast planks very difficult to accurately produce and install. Installation of steel decking into the existing structure will demonstrate an easier task than fitting the pre-cast planks. Onsite adjustments to the steel decking will occur routinely and with little difficulty.

Finally, on-site placement of penetrations will be possible with the steel decking/cast-in-place concrete solution. This will enable other trades to provide better input as to altered or new requirements.

Methodology

- Estimate pre-cast concrete plank installation.
- Identify change in equipment needed for steel decking/cast-in-place concrete system.
- Schedule installation of alternate system.
- Design and estimate new system.
- Compare costs of the two systems.
- Identify additional benefits of steel decking system.

Expected Outcome

The switch to a steel decking/cast-in-place concrete flooring system will decrease the schedule. The pre-cast solution carries a long lead time. The alternate system also provides more flexibility during installation which also decreases installation time as well as frustration.

Other trades will benefit from the steel decking system as well. The pre-cast planks come with one predetermined penetration. Additional penetrations require boring holes in the concrete. The cast-in-place alternative allows for site coordinated penetrations.

Analysis 5: Adjust Project Start Date

Problem Identification

A July start date for onsite work increases the likelihood of weather delays and a protracted schedule. Exterior activities scheduled during the fall and winter months provide additional opportunities for delays and decreased productivity. Completing these activities during Spring and Summer months reduces these opportunities. Additionally, poor weather conditions require particular accommodations, such as insulating blankets for concrete, longer cure times for mortar and site de-icing.

Proposed Solution

Accelerating the start date to mid-Spring provides increased time to complete exterior activities during good weather. A reduction in the loss of days due to poor weather and an overall contracted schedule due to higher productivity during periods of suitable conditions reduces costs. The accelerated schedule would also yield less need for temporary enclosures and heating.

Methodology

- Identify activities slowed during periods of inclement weather.
- Review historical data to determine average days lost due to weather.
- Complete new schedule with a mid-Spring start date.
- Calculate savings in construction costs due to new schedule.

Expected Outcome

An adjustment of the start date to three months prior will allow for a shortened schedule and savings in construction costs. Savings will be seen from an increase in productivity, a reduction in lost work days and a reduction in special accommodations required for working in inclement weather. The reduction in schedule will also grant earlier occupancy to the owner. With the current occupancy date of September 10, an earlier move-in date would greatly reduce stress for the approaching school year.

Appendix I: Breadth Studies

Analysis 3 - Mechanical

Material and installation cost and risk of theft warrant inspection of alternatives to copper piping. Cross-linked polyethylene tubing (PEX) is a viable replacement. The PEX provides for ease of installation and ease of repair.

This copper alternative requires a re-design of the system. Pipe sizes and material quantities will need to be recalculated. Additionally, the schedule will need to be adjusted to reflect the shorter installation time.

Analysis 4 - Structural

The current floor system is pre-cast concrete planks. A system of steel decking and cast-in-place concrete accelerates the construction process by eliminating the lengthy lead time for the planks. It also would provide more flexibility for other trades and an easier installation into existing spaces.

This new system will require structural design and analyses of the steel decking and concrete elements. In addition, a cost estimate and schedule analysis will be performed.