Stanton Elementary School, *Washington, D.C.*

Final Proposal for Spring Thesis Project

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Executive Summary

Throughout the course of performing research and gaining background information on the Stanton Elementary School project, there were consistently two major issues that always arose: project funding, and the lack of flexibility within the project schedule. Project funding played a major role in how the schedule could be performed, even delaying phase two of the construction by almost a full year. The project schedule was so strict due to the owner's demands and the challenges that come with construction of educational buildings. The proposed thesis depth and breadth options revolve around the project schedule and are constrained by the project cost.

In determining construction depth opportunities, attempts were made to address the issues with project scheduling. Phasing rearrangement was considered and will be a major focus on improving the construction schedule. With phasing rearrangement (switching the order of the scope of work for phases one and two) the goal will be to allow for greater flexibility in creating a schedule and having more space in the school for students while construction is ongoing. This flexibility is something the construction team and the owner have not been able to experience to this point. Additional attempts at creating a more feasible schedule will include scheduling accelerating analyses by the method of short interval production scheduling (SIPS).

Throughout the course of the project to this point, the construction manager has evaluated many different ways to implement value engineering to reduce project costs. Due to the issues with project funding, the owner has been mostly willing to perform the value engineering tactics recommended by the construction manager. An opportunity for value engineering presents itself in the building plumbing system. The existing plumbing systems for both phase one and phase two of the project include copper piping for the condensate and domestic water piping. Using PVC piping is could be a much cheaper option.

The final construction depth option focuses on both project savings and scheduling reductions. This depth will be a research focused analysis on BIM implementation for smaller projects, such as an elementary school. The research will not only focus on the benefits that a smaller BIM execution plan could bring to the Stanton Elementary School project, but also the benefits that utilization of this type of BIM plan can have for Penn State students who are taking classes that require them to implement BIM strategies.

In the report appendix, strategies for enhancing the project through a structural breadth and an acoustical breadth are approached. The Stanton Elementary School community is clearly expanding, which is why the school is seeing such a large building addition at this time. If further building expansion is required, this must occur vertically due to limitations on the school's site. Planning for a vertical expansion in the future would occur by installing stronger foundations. This opportunity will increase initial costs, but could provide cost savings in the future should the owner decide to add another addition to the building. Lastly, the owner indicated that the main objective for renovating and expanding the school was to enhance the learning experience of the Stanton Elementary School students. To ensure that the students are able to gain the most out of their learning experience, it will be important for the building to be acoustically sound. An acoustical analysis and redesign is proposed to attempt provide the students with the best possible learning experience at Stanton Elementary.

Construction Depth I: Schedule Phasing Analysis

Construction Issue

A major concern for the project team throughout the course of construction dealt with meeting the project deadline for completion. In phase one of construction, the project team was given an extremely strict deadline on when the renovation was expected to be completed. The project team was required to finish the project prior to the 2014-2015 academic year. If this deadline was not met, financial penalties would be enforced by the owner to the construction manager. This lack of flexibility occurs as a result of the lack of space to house the students if the phase one schedule was not met. Phase two of construction has an extremely strict timeline as well, for the owner expects that the project will be concluded by December 28, 2015, which is conveniently during the school's winter break period. However, there is still space available as a fallback option if the project schedule is not met. The overall expectation is that the schedule will be met; however, the option is always there just in case.

Proposal: Perform the scope of work for phase two of construction prior to the scope of work for phase one of construction.

Background Research Performed

The scope of work for phase one included demolition and renovation of the existing main building. This work was to be completed prior to the first day of classes for the 2014-2015 school year. This work did not include renovation of the existing Annex building located on the northwest portion of the site. The scope of work for phase two of construction includes a one to three story building addition on the west side of the building. Once the addition has been completed, the Annex Building will be demolished and final sitework will ensue. Phase two of the project was scheduled to take place immediately after phase one; however, issues with project funding delayed phase two from starting on time. Phase two eventually began in the summer of 2015. The building phase of phase two is scheduled to be completed on December 28, 2015, while the entire project is scheduled to be completed by April 15, 2016

Steps and Methods of Analysis

Initial analysis will include gaining an understanding of the scheduling constraints laid out by the school. These constraints may to times that the team is limited to for construction throughout the day, dates that construction must halt due to standardized testing, dealing with student drop off and pick up schedules, dealing with deliveries to the school, and many other potential issues that could affect the times of construction. The owner would like for its students to gain a positive experience during their time at Stanton Elementary School, and adhering to the owner's demands with regard to schedule will be important in order to make the owner's request a possibility. This will be important to look at in a phasing redesign. The project manager will most likely be the most effective point of contact when gathering this information. An interview related to project constraints should be performed in the early stages of analysis.

It is already well documented that the project team had trouble obtaining funding for phase two of the project. It will be important to gain an understanding of why funding as an issue and the timeline in which project funding was an issue. Additionally, it will be important to see if there

were any issues with obtaining permits. To this point, there has been no such indication that obtaining permits was an issue throughout the course of construction. Including questions with regard to funding and permit constraints should be included in the project manager interview as well.

The most important aspect of this analysis will be in understanding the existing project schedule. It will be essential to be able to identify critical path activities and identify how these activities would be affected by swapping phase one and phase two of the project. This analysis will also benefit from comparing the planned project schedule to the actual project schedule, allowing for identification of certain construction tasks that could have been performed more efficiently.

Construction Depth II: Plumbing Piping Value Engineering

Construction Issue

A major issue throughout the course of this ongoing project was project funding. Because of this, the owner and the construction team looked for a variety of value engineering tactics that could help reduce the overall cost of the project. One method of value engineering that was not approached includes substituting PVC piping for the copper piping. While copper piping may be a favored choice in the field of construction, PVC piping is also an adequate system for both condensate and domestic water piping.

Proposal: Substitute copper piping for condensate and domestic water piping with a much more cost efficient PVC piping system.

Background Research performed

Copper Piping was utilized for condensate and domestic water piping in both phase one and phase two of construction. While there is not an exact estimate for how much this piping cost on the project, RS Means data supports that copper piping is far more expensive to install copper piping when compared to PVC piping.

Steps and Methods of Analysis

The major driver for the substitution of copper piping with PVC piping systems is as a value engineering solution. A detailed estimate will need to be performed for the existing copper condensate piping and domestic water piping and also for the replacement system that would use PVC piping. The assumption can be made that the PVC piping will use the same nominal dimensions as the copper piping; however, an appropriate schedule of PVC piping will need to be determined.

Additionally, the effect on which this proposed system has on the schedule will need to be further analyzed, for the project schedule was extremely strict and already required the construction team to work seven days a week with double shifts on the majority of those days. Whether the effect is positive or negative, if this change in piping has an effect on the overall schedule's critical path, further analysis on the worth of this system must be analyzed. If there

were to be an instance in which there was a substantial difference in the schedule, additional steps of analysis may be required to prove the worth of this system. Looking at things such as increased crew size or longer hours for the plumbing crew could be analyzed. Additionally, an interview with the site superintendent could be pertinent in receiving more information with regard to the schedule of piping installation.

Construction Depth III: SIPS Utilization for Classrooms

Construction Issue

This is another issue focused around the project schedule. Short interval production scheduling in its nature allows for cutting down on a project schedule by determining repetitive tasks within construction and identifying how these tasks can be performed in an extremely similar manner. In turn, this will create a familiarity with the tasks itself, creating a learning curve and resulting in faster construction as the SIPS portion of the schedule occurs.

Proposal: Utilize short interval production scheduling for phase two of construction for similar classrooms and office spaces during phase two of construction.

Background Research performed

In general, the floor plans for the building addition are repeated from floor one to floor three. On floor one, the prekindergarten wing extends outward from the southwestern portion of the building. This wing is only one floor high. However, the prekindergarten wing features six classrooms that are nearly identical in classroom size, furniture selection, and the building systems that support within the room. This certainly allows for an opportunity for SIPS utilization.

Steps and Methods of Analysis

This type of scheduling change could have a major effect on the existing project schedule. Utilizing SIPS could result in changing some of the scheduling relationships between tasks, and will have an effect on the critical path. It will be important to be able to understand how the utilization of SIPS will reduce the critical path and how SIPS fits into the existing schedule. Understanding how scheduling constraints will be effective will be important as well. It will be important to reference the information determined from the project phasing depth (the project manager interview that will help identify scheduling constraints) when modifying the project schedule to allow for SIPS.

The major source of analysis that will need to occur will be in identifying the exact classrooms, or sections of the building that will benefit from SIPS. Furthermore, appropriate systems that will be a part of this analysis will need to be identified. Analyzing the schedule for systems/building sections that were scheduled for long durations could be initial targets. Also, analyzing systems that took longer to construct than originally planned for should be the main target of a SIPS analysis.

The current schedule provided by the construction manager is broken down by days of construction. SIPS analysis will need to be far more detailed than that, and should break down activities into fractions of hours when possible. When comparing the proposed short interval production schedule to the existing construction schedule, it will be beneficial to gain more information with regard to the executed project schedule. Interviewing the project manager and site superintendent will be an important part of this process in determining the actual benefit of utilizing SIPS. In addition, it will be important to gain this information when analyzing the appropriate amount of hours in a day to expect crews to work.

To create the most effective short interval production schedule possible, it may be beneficial to perform some research and reference some case studies for buildings that have used SIPS, specifically educational buildings. Identifying successes and failures for these types of case study projects will be important in learning how to properly administer SIPS to the Stanton Elementary School project. Additionally, analyzing how SIPS was structured around various rooms, building systems, and building sections will prove to be beneficial. Even researching how SIPS can be used in a renovation project could be beneficial, as this type of schedule would then become relevant for phase one of the Stanton Elementary School Project.

Critical Issue Research Topic

Construction Issue

As stated many times already, the Stanton Elementary School Project suffered from issues with project funding and a very strict scheduling timeline. One construction practice that has essentially become standard that could have helped with planning throughout the course of the project is building information modeling (BIM). BIM techniques were utilized on this project; however, it appears that more could have been done to push through with the BIM approach. The issue with BIM execution planning is that it can take up a lot of time. Determining the worth of a complete BIM execution plan compared to its benefits on a project is something that may be difficult to do in the short amount of time that is allotted to project planning.

Problem Statement: BIM execution planning on this project, one with a majority of scheduling and financial constraints, was not utilized to its fullest potential.

Goal of Research: The goal of this research will be to determine the most applicable uses of BIM technology and see how these applications can be administered to the Stanton Elementary School project in a way that benefits the project without becoming too time consuming. This research is intended to benefit the project in a hypothetical situation, but can also be used in practice by Penn State's students who are required to implement BIM execution planning for smaller academic projects throughout their studies.

Background Research performed

The Stanton Elementary School construction team uses BIM for a variety of uses, but not the extent that it could be. The current BIM execution plan does not include a BIM PxP like most of Tompkins projects. Currently, Tompkins Builders is using BIM on this project in the following areas:

- Document Management
- Mechanical, electrical, lighting, plumbing, fire protection, and low voltage modeling requirements
- Revit Model with majority of the trades (some MEP design missing)
- Estimating
- Quantity takeoffs

Further research will need to be performed to determine whether or not BIM was used for project phasing or site utilization. Certain systems were left out of the BIM model, and the opportunity to use the BIM model for the project as-built drawings was not taken. For more information regarding the BIM uses of this project, *Technical Assignment 3* provides a more in-depth summary with more information

Steps and Methods of Analysis

There are a number of topics that will need to be addressed in this research. Distributing surveys to the project team to help determine areas in which BIM implementation was successful and unsuccessful could be a good place to begin. Additionally, it will be beneficial to research case studies for various school projects and the extent to which BIM was implemented on these projects. Trying to identify a specific project that used a BIM execution plan can be instrumental in identifying the essential BIM practices for smaller projects. It will be difficult to analyze the cost of implementing a BIM strategy so finding a case study that identifies a similar BIM program that outlines the cost of its program would be extremely helpful. Further consultation of the project manager by interview may be necessary as well if an effort is made to identify the cost and potential cost savings of BIM on the project.

Additionally, it will be very beneficial to look at some of the research the Penn State has performed on BIM uses for owners. Many resources for BIM technology exist at Penn State already. Referencing Penn State's version of an adequate BIM execution planning can be an adequate starting point in this analysis. Also, utilizing the many grad students who focus in BIM research and practice will serve as a reliable resource.

APPENDIX A: CONSTRUCTION BREADTH PROPOSALS

Structural Breadth: Prekindergarten Wing Foundation Redesign

Construction Issue

The Stanton Elementary School is currently under renovation and expansion to tend to the increase in students enrolled in the school. If there were ever to be another need for expansion, the existing site is extremely cluttered (please refer to Technical Assignment 1 for more information regarding site logistics). The most reasonable solution or an expansion would occur vertically, rather than horizontally. The prekindergarten wing of the building features 6 classrooms and is only one story tall.

Proposal: Expand the size of the existing foundations of the prekindergarten wing of the building to allow for possible vertical expansion of the elementary school in the future.

Background Research Performed

The school site has been essentially maximized with the existing building addition. The parking lot cannot really be made smaller, especially with the increase in classrooms and need for more faculty as a result of the school's expansion. Roads occupy the site on three sides, and the fourth (southernmost side) is occupied by the school's athletic fields. As stated, the prekindergarten wing provides the most suitable location for vertical expansion, as it is only one story in height compared to the three stores that the remainder of the building occupies. The existing foundation system is a helical pile and pile cap foundation system with shallow continuous footings around the perimeter of the building addition. There were issues with the supporting soils during excavation, so this must be considered when designing a larger foundation system that would be capable of supporting heavier building loads. The soil bearing capacities listed on the project drawings may not be completely accurate given the unsuitable soils that were encountered during excavation.

Steps and Methods of Analysis

It is likely that many assumptions will need to be performed to determine the design for a new foundation system. If possible, it would be extremely beneficial to contact the engineer responsible for the foundation redesign to reveal the soil bearing capacity that was used.

In performing a structural redesign for the building foundations, it will be crucial to decide whether or not a redesign suitable for adding one story or two stories is the most efficient option. This will be essential in determining the amount of load that the foundations will need to support. It will be beneficial to perform analysis on both possibilities, for this will provide more options with regard to determining the most cost effective system.

For both the one-story addition option and the two-story addition option, it will become important to analyze the effect on the project cost in the short term. This will most likely be the key concern given the issues with project funding to this point. Just as importantly, it will be necessary to analyze the scheduling effects of installing larger foundations. A constructability

review will be important as well, and will need to performed given the issues with the foundation soils. Further consultation of the project manager may be necessary to determine the exact issues that occurred with the foundation soils.

In an effort to provide support for such a design, it will be beneficial to interview the project manager to determine if future expansion of the elementary school has been discussed. Further research shall be performed in determining whether the community is growing and will see a potential need for yet another expansion in the future.

Acoustical Breadth: Classroom Acoustical Analysis

Construction Issue

According to the owner the elementary school renovation and additions served two purposes: 1) To expand the building to meet the needs of student enrollment, and 2) to enhance students' learning experience by bringing the building up to code and creating a more modern learning atmosphere. The owner has been quoted to have a genuine care for the students' learning experience. Elementary school is a pivotal time for students in their learning careers. Ensuring that the acoustical environment is suitable for the Stanton Elementary School students is majorly important for their learning experience. In a classroom setting, there are a number of audio distractions that can take place. Noise from surrounding rooms or hallways and outside noise can be major issues.

Proposal: Perform an analysis on the layout of classrooms with respect to other rooms and the outside environment, and perform acoustical analysis between these rooms. Enhance the acoustical systems of each classroom appropriately and determine how this would affect the project cost and schedule.

Background Research Performed

In general, it appears that classrooms are mostly separated from louder rooms such as mechanical rooms, bathrooms, the cafeteria, and the gymnasium. There are a number a rooms that are located near stairwells. Additionally, the music room is adjacent to two other classrooms, and further analysis of these two rooms may be necessary.

With regard to classrooms adjacent to the outdoors, the southern-most side of the building is directly next to the school athletic fields. The western-most wall is right next to a main road with a four-way intersection. Rooms near this side of the building will be especially pertinent to analyze, for these rooms could see the most stress acoustically. The existing classroom partition walls material is painted concrete masonry unit block.

Steps and Methods of Analysis

The first step in this analysis will be identifying the appropriate classrooms to analyze. Identifying appropriate rooms will certainly be affected by the information identified in the 'Background Research' section. However, identifying the most appropriate rooms can occur by

surveying faculty at the school. While students at this age may be too young to consider reliable occupants to survey, the teachers, who reside in their classrooms for the entirety, of the day should have a good idea of the audio distractions that occur throughout the course of a typical day. (Please reference a potential survey outline in Appendix B of the report). Prior to performing analysis, an acoustical design that is appropriate for a classroom should be determined. At this point, the acoustical analysis of the targeted classrooms should be performed. Acoustical analysis will consist of identify the level of sound absorption within a room and how that relates to the transmission of sound into other spaces by transmission loss. From that point, an STC (Sound Transmission Class) rating can be identified. This is where the comparison will occur between the identified rating that is appropriate for a typical classroom. At this point, measures will need to be taken to improve the system to the point where it is an adequate system, or to the point where it exceed typical acoustical design expectations for some justifiable reason. A justifiable reason could be as a result of the survey responses that are intended to be distributed among the teaching faculty of the Stanton Elementary School.

Just as in all other depth and breadth analyses, it will be important to perform a constructability review of the newly designed acoustical system. Additionally, the effect that this system has on the project cost and project schedule will need to be analyzed. A detailed estimate of the proposed system will be developed and used to determine the worth of implementing the system. It will also be worth noting how a revamped acoustical system will affect the existing systems within the building.

APPENDIX B: SAMPLE SURVEYS

BIM Usage Preliminary Sample Survey

This survey is meant for Tompkins project team members, BIM designers, and foreman and superintendents to key contractors on the project site

What is your role/job title on this project?

What were the most useful BIM techniques that were administered on the Stanton Elementary School Project?

Were there any BIM techniques that were used that were not helpful on this project?

How often was the 3-D BIM model utilized to help with planning? (Daily? Weekly? Monthly?)

How could the construction process be improved by BIM uses such as 3-D coordination, scheduling, and site utilization on this project? Do you feel that BIM technologies were used to its fullest potential?

Acoustical System Preliminary Sample Survey

This survey is meant for teaching faculty at Stanton Elementary School

Which room do you occupy as a teacher for the majority of the day?

Do you ever experience classroom distractions from…

Noise from the outdoors?

Hallway Noise?

Noise from adjacent classrooms or classrooms across the hallway?

Mechanical equipment?

Do you find these noises to be distracting to you as a teacher to the point that it affects how well you are able to teach your students?

Do you find these noises to be distracting to your students to the point that it affects how well your students are able to learn?