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## **Revised Thesis Proposal**

<b>Executive Summary</b> .....	2
<b>Analysis 1 -Construction Research</b> .....	3-5
<i>Implementation of Building Information Modeling at the Construction Phase</i>	
<b>Technical Analysis 2</b> .....	5-6
<i>Pre-fabricated Metal Stud Crete® Panels-Structural Breadth</i>	
<b>Technical Analysis 3</b> .....	6-7
<i>Alternative Grade Beam Placement Method</i>	
<b>Technical Analysis 4</b> .....	7-8
<i>Acoustical Analysis of Interior Partitions- Breadth</i>	
<b>Weight Matrix</b> .....	8

## **Executive Summary**

The Final Thesis Proposal includes summaries of Construction Research, Technical Analysis 2, Technical Analysis 3, and Technical Analysis 4. This report is intended to give the reader an idea of how the research and technical analyses will be performed in the spring semester of 2007.

The Construction Research section sets a plan for developing a set of implementation guidelines and demonstrating how Building Information Modeling (BIM) can be used for trade coordination at the construction phase. This research will show how a Building Information Model can be utilized after design and prior to construction.

Technical Analysis 2 looks at using architectural pre-fabricated panels on the façade to accelerate the schedule. Late owner decisions have made the dry-in date critical for starting interior partitions and finishes. This analysis also analyzes the structural impacts of changing the façade system.

Technical Analysis 3 addresses an alternative grade beam placement method. The current method uses stick built forms that are backfilled after stripping formwork. This analysis looks at cost and labor savings of earth forming grade beams.

Finally, Technical Analysis 4, investigates the acoustics of interior partitions. The TETC project has various learning and instructional spaces that require good architectural acoustics that don't hinder the learning process. This analysis looks to make recommendations to improve these acoustics.

## Analysis 1- Construction Research- *Depth* *Implementation of Building Information Modeling at the Construction Phase*

### **Background & Goal**

During the 2006 PACE Seminar, it was obvious there was a high level of uncertainty from industry members regarding Building Information Modeling (BIM) implementation. Industry members struggled to answer the question of how a BIM should be used during the construction phase of the project. Other topics that didn't have clear cut answers were how risk and contractual relationships are affected using a BIM and how a BIM affects project teams.

Building Information Modeling is such a new topic that it has forced construction companies to develop their own implementation approaches with some trial and error. Contractors in the beginning stages of BIM, have a lot of questions with regards to legal, risk, and responsibility issues. Many contractors do not understand that BIM risk can be dealt with in a very simple manner and that BIM doesn't have to mean throwing out all of your old coordination processes. The goal of this research is to gain feedback from construction companies successfully using BIM at the construction stage and be able to write some guidelines for other construction companies.

The end goal of this research is to provide construction companies with a clear implementation plan that presents some options that could be tailored to their company or project. To achieve this goal, interviews will be conducted of multiple BIM experienced general contractors and Penn State faculty acting as a consultant to a general contractor. The results of these interviews will be used to compare and contrast implementation strategies.

On the following pages several typical interview questions and the answers are listed.

### **Research Method**

The Associated General Contractors of America has formed an initiative to write a guide for Building Information Modeling to contractors. This guide defines BIM, gives an overview of tools, the process, and addresses risk. After reading this guide, it was determined that specifics of BIM use for construction coordination were lacking. Specific

information on dealing with subcontractors and the coordination process needed to be elaborated on more.

To develop more detailed guidelines, general contractors with BIM implementation experience were targeted. Interview questions were drafted for both phone and personal interviews. The use of the interview process versus a survey allowed the interviewee to elaborate more on the processes.

In addition to the interview process, research into necessary contract literature was carried out. Examples of this language are included in this report for the reader's reference.

### **Research Interview Questions**

#### *Implementation of Building Information Modeling at the Construction Phase*

1. From a contractual standpoint, how are you requiring subcontractors to use BIM while still considering legal implications?
2. In general, what are the varying levels of modeling capabilities of subcontractors? Is one particular trade more advanced than another?
3. E-mail has difficulties with large file transfers. What options are you using for file transfers between subcontractors?
4. How does using a BIM impact typical weekly on site coordination meetings?
5. Specifically, how do you utilize a BIM for weekly coordination meetings? Are there any additional tools needed?
6. When an architect does not provide an architectural model, is your company using outsourcing or in house modeling to develop it?

7. Does the delivery method dictate whether a BIM can be utilized for a project?  
Which delivery method is preferred?
8. From an organizational standpoint, how do you deal with coordinating all the modeling efforts from various team members?
9. What are some technical issues that need to be looked out for?

## **Expected Outcome**

I hope to conclude that BIM can be implemented at the construction phase with some simple modifications to the current coordination system. At the end of this analysis, case study & interview results will help to make some conclusions and write some guidelines for future General Contractor use.

## **Analysis 2**

### *Pre-fabricated Metal Stud Crete® Panels-Structural Breadth*

## **Background & Goal**

The current façade design calls for stick built 3-5/8” masonry on a 7 5/8” metal stud back-up with exterior sheathing board, 1” cavity board insulation and sheet membrane water proofing. Masonry is attached to the structure using 6”x6” continuous clip angles welded to pour stops which are attached to spandrel beams. 4”-9” Architectural Pre-Cast Concrete spandrels are featured at each floor level and rest on the 6”x 6” angles as well. Due to owner delays, completion of the façade has dictated the start of interior partitions due to dry-in issues.

## **Methods**

- Perform Quantity Take-Off of Existing Façade
- Complete Cost & Schedule Comparison of Two Systems
- Analyze attachment detail
- Perform Structural Analysis of Spandrel Beams for Feasibility (Breadth)
- Resize any spandrel beams where necessary

## **Resources**

- Holder Construction Company
- Metal Stud Crete® Panel Company
- Architectural Engineering Faculty
- Endicott Clay Products Company

## **Expected Outcome**

- Pre-cast panels will accelerate the schedule significantly that the increased cost of the panels will be justified over traditional stick built curtain wall
- Structural impact will be minimal
- No major architectural impact

## **Analysis 3**

### *Alternative Grade Beam Placement Method*

## **Problem**

The general contractor originally proposed that all grade beams be excavated and formed using stick built forms. After concrete placement, the forms were to be stripped and the grade beams were to be backfilled. This method requires more labor and material cost for excavation and added costs and schedule time for formwork.

## **Goal**

The goal of this analysis is to determine placing concrete into excavated trenches can significantly reduce schedule time, labor, and material costs. The proposed placement method eliminates the need for formwork and decreases the volume of excavation. It is important to note that although very little excavated material will be hauled off site, this method could reduce the need for backfill when formwork is stripped.

## **Methods**

- Concrete Quantity Take-Off
  - Determine the quantity of concrete in Cubic Yards
  - Apply waste factor for waste concrete
- Estimate Formwork Savings
  - Labor & Material
- Calculate Schedule Reduction

## **Resources**

- Holder Construction Company
- R.S. Means Cost Works 2005

## Expected Outcome

The use of earth formed grade beams will have its largest impact on formwork material and labor. Labor savings from formwork is accelerated the schedule.

## Analysis 4

### *Acoustical Analysis of Interior Partitions- Breadth*

## Problem & Background

Good classroom acoustics are vital when the teaching and learning process relies strongly on verbal communication. Transmission of noise from one learning environment to another can hinder learning when speech communication from an instructor is difficult to understand. When concentration on speaking and listening can be removed teaching tends to be more effective. Good classroom acoustics can reduce repetition by instructors and reduce the number of questions by students. Classroom acoustics have impacts on typical students' ability to learn and even more of an impact on students with disabilities.

The American National Standards Institute has written a standard for Acoustical Performance in school buildings. This standard defines acceptable Sound Transmission Class (STC), Impact Isolation Class, and Reverberation Time values for school buildings. Table 1 includes STC values for three spaces below. STC, evaluated in this analysis, is a single number rating for sound transmission loss through construction assemblies. The goal of this analysis is to calculate the required STC & Transmission Loss values for four receiving spaces, compare the values to the existing wall assemblies, and make appropriate recommendations.

<b>American National Standards Institute Acoustical Performance Criteria for Schools( ANSI Standard S12.60)</b>		
<b>Receiving Space</b>	<b>Adjacent Space</b>	<b>STC Required</b>
Classroom	Bathroom	53
Classroom	Mechanical Room	60
Classroom	Classroom	50

*Table 1- ANSI STC Criteria for Schools*

## Resources

- Penn State Architectural Engineering Faculty
- Textbook: Architectural Acoustics by M. David Egan

- Acoustical Society of America: American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools-ANSI S12.60
- Textbook: Architectural Acoustics by Marshall Long

## Methods

- Determine Noise Criteria values for critical receiving space
- Determine absorption coefficients of floor, wall, ceiling, & materials
- Calculate the following
  - Floor, wall, & ceiling area of critical receiving space
  - Total acoustical absorption of critical noise receiving space
  - Required Noise Reduction & Transmission Loss Values
- Compare existing to required Transmission Loss values
- Compare ANSI S12.60 required Sound Transmission Class values to existing values
- Make an recommendations for improvement if necessary
- Check acoustics of water flow at bathroom space

## Expected Outcome

I expect that the acoustics of the interior partitions for the TETC project can be approved upon by utilizing additional wall board or insulation material.

## Weight Matrix

Table 1 below is intended to show how I will distribute my efforts for the analyses described above.

<b>Description</b>	<b>Research</b>	<b>Value Engr.</b>	<b>Const. Rev.</b>	<b>Sched. Red.</b>	<b>Total</b>
<b>Foundation Placement</b>		5%	10%	10%	25%
<b>Pre-Fab Panels</b>			15%	15%	30%
<b>BIM Implementation</b>	35%				35%
<b>Partition Acoustics</b>		10%			10%
<b>Total</b>	35%	15%	25%	25%	100%

Table 1 – Weight Matrix