JOHNS HOPKINS HOSPITAL
NEW CLINICAL BUILDING

Baltimore, Maryland

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Architectural Engineering, 5th Year

Construction Management Option

Thesis Proposal

Advisor: Dr. John I. Messner

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4.1 Executive Summary

This proposal serves as an outline to what I intend to research and evaluate for the spring semester of Sr. Thesis. The over-arching theme of my proposal is managing the excessive changes on this project. Through each of my topics, I will either analyze a way to have reduced the number of changes, manage the amount of changes, accelerate the schedule to make up for lost time caused by the changes, or reduce the risk of schedule over-run on the project. The four analysis listed below are my areas of interest for improving the JHH New Clinical Building project.

Analysis 1: Alternative Project Delivery Method

Currently, the changes to the project have added $150 million and 7 months to the original contract. The design-bid-build delivery method appears to be inefficient at managing the changes because each team member has their own goals and agenda. I have proposed researching Integrated Project Delivery and Design-Build as possible alternatives. These methods will offer a more integrated team approach that would be brought in early in the design process to add value to the project. This analysis will serve as a critical industry issue and as my MAE requirement.

Analysis 2: Managing the MEP Changes

On average, 1 Construction Change Directive (CCD) is issued each week with significant changes to the MEP design. The CM and subs have had difficulty identifying the changes and their cost and schedule impact. I have proposed using Innovaya Visual Estimating with intelligent 3D models of the drawings to improve the efficiency of tracking, quantifying, and estimating the changes to the MEP systems. The project team is already developing 3D intelligent models for 3D MEP coordination. This analysis will serve as a critical industry issue and as my MAE requirement.

Analysis 3: Alternative Mechanical System

The impact of the 1st package of changes (CCD 1-38) has caused a schedule over-run of 7 months. I have proposed using a different mechanical system in non-invasive spaces that would have required less material and long-lead time equipment as a way to accelerate the MEP trades. A chilled beam system was chosen as the alternative because it uses forced air induction, chilled water for cooling and stand alone units for each room. This system will use less ductwork and will eliminate the need for massive central air handling units. This analysis will serve as a critical industry issue and as a mechanical breadth study.

Analysis 4: Resolve Concrete Over-pour on Decks Due to Steel Deflection

In some areas of the concrete decks there was up to 2" of steel deflection. This was caused by over-pouring the deck and will likely impact the MEP coordination. I have proposed using shores and increasing the steel camber to reduce the steel deflection. This analysis will serve as my structural breadth study.

4.4 Analysis 3: Alternative Mechanical System

Problem Statement:
The 1st package of changes (CCD 1-38) has been evaluated by Clark/Banks and they have determined that the schedule will need to be extended 7 months. The cost of accelerating the schedule from 7 months to 3 months by working 300 mechanical craftsmen overtime is $2 million.

Goal:
Demonstrate that an alternative mechanical system can accelerate the schedule by installing less material and long-lead time equipment with fewer labor requirements.

Potential Solution:
An active chilled beams system would be an excellent alternative system for non-invasive spaces in JHH. They could be used in offices, public spaces, exam rooms, and hospital bed rooms. This accounts for over 70% of the building's space.

The system uses forced air induction which requires significantly less ductwork. There is also no need for long-lead time equipment like air handling units. The system is self contained and could be located in the ceiling plenum where the current VAV boxes are. A 1" chilled water supply would provide the cooling energy. The result is much less ductwork and piping that has to be installed in the ceiling plenum, fewer pieces of long-lead time equipment, and less labor to install. It would also accelerate the coordination process which is currently on the critical path.

Research Methods:

- Identify a typical floor that has a large majority of non-invasive spaces
- Work with the mechanical subcontractor to get an estimate of the current mechanical system for that space
- Ask for the mechanical loads for the space from BR+A, the project's MEP engineers
- Conduct literature review of case studies of healthcare facilities that have used chilled beam systems
    - Very common in the European Union with available research material online
- Interview manufacturer of chilled beam systems such as Frenger Systems
    - Pros and Cons of system
    - Size the units
    - Size the ductwork
    - Size the chilled water lines
    - Energy usage
    - Ask for installer contacts in the D.C. area to get estimates
- Interview installer of chilled beam systems
    - Estimate of system
    - Labor requirements and durations
    - Maintenance requirements
    - Ceiling plenum impact

- Evaluate the impact of chilled beams on:
    - Cost
    - Schedule
    - Energy costs – lifecycle
    - Maintenance requirements
    - Ceiling plenum
        - Coordination
        - Floor-floor height
            - Building enclosure
    - Size of mechanical shafts
    - Reduction in current system size

Resources:
Moses Ling, AE Faculty
BR+A, Project MEP Engineer
Frenger Systems, Manufacture of Chilled Beams in Healthcare Environments
Jim Salvino, Sr. MEP Manager, Clark/Banks

Expected Outcome:
The chilled beam system will prove to be superior to the current system in the non-invasive spaces of JHH. Not only will the system accelerate the MEP installation and coordination, but will reduce energy costs, maintenance costs, and quite possibly the building cost by reducing floor-floor height. This system will be a perfect fit because there is already a large supply of chilled water from the central plant which eliminates the need for adding chillers. Also, there are 9 - 8'x26' mechanical shafts on each floor that would be reduced in size because the large rectangular duct would no longer be required. This would free up a lot of extra floor space.

Thesis Requirements Fulfilled:

Critical Industry Issue – Chilled Beams is an emerging technology in the USA. Commonly used in the EU with great success, the new technology is starting to be used in an effort to address the high energy costs. The benefits of this system are not commonly known by my most contractors in the US. This research topic will aim to identify the advantages and disadvantages of this system.

Mechanical Breadth – This analysis will require my mechanical engineering skills to size the system.

4.5 Analysis 4: Resolve Concrete Over-pour on Decks Due to Steel Deflection

Problem Statement:
The concrete subcontractor poured the concrete decks to finish floor elevation, not to deck thickness which is common practice. The concrete acts as a live load during the pours and on this project caused the steel to deflect up to 2" in some cases because no shoring was required. The result was over-pour of concrete as much as 2" in some areas which increased the floor dead load. Fortunately, on this project the structural engineer had enough factor of safety built into the design to allow for the extra weight.

A potential problem from this could have been overloading the floor which would have required reinforcing the structure. It is not acceptable to pour to thickness to avoid this. If the steel deflects it will cause the floor to wave and not meet the specification for floor flatness. This would require patching to meet the flatness requirement which is very labor intensive. Finally, the deflection has the potential to impact the coordination of the MEP systems in the ceiling plenum. It is not yet known if that will be a problem on this project because the MEP is not installed in the problematic areas of the building.

Goal:
Identify a cost effective method to mitigate the risk of impacting the MEP coordination, not meeting the floor flatness criteria, and over-pouring concrete without impacting the schedule's critical path.

Potential Solution:
The problem may be solved with shoring, cambering the steel or a combination of both.

Research Methods:

- Work with the project's structural engineer to understand the current design
    - Typical deflections
    - Allowable deflection by code
    - Construction loading
    - Steel camber
- Work with Dr. Hanagan to calculate deflections and necessary shoring and/or cambering required to reduce deflection
- Interview the concrete subcontractor
    - Gain a better understanding of standard concrete placing methods
    - How they typically account for over-pour
    - Cost of shoring
    - Schedule impact of shoring
    - Typical cost and schedule impact for correcting floor flatness
- Interview the steel subcontractor to evaluate the cost of cambering the steel
- Interview Clark/Banks' MEP coordinator to determine the effects of the steel deflection on MEP coordination
- Evaluate the cost, schedule, and MEP coordination impact of solution

Resources:
Zachary Yates, Project Structural Engineer, Thornton-Tomasetti
Dr. Hanagan, AE Faculty
Clark Concrete, Concrete Subcontractor
SteelFab, Steel Subcontractor
Jim Salvino, Sr. MEP Manager, Clark/Banks

Expected Outcome:
Minimum shoring at mid-span of each beam with a 1 ½" of steel camber would reduce the deflection within the 1" allowable limit. The shoring would only be necessary for approximately a week while the concrete bonds to the reinforcement which would then act in tension to resist deflection. The cost of shoring would be saved by reducing the cost of over-poured concrete. Shoring would also have minimum impact on the schedule. Each floor was broken into 3 pour sequences per tower. A pour was made every two days, with 3 days to prepare each pour. With enough shores on site to meet the schedule, an additional laborer would be able to move the shores for each pour.

Thesis Requirements Fulfilled:

Structural Breadth – The analysis will require structural load, deflection, and shoring calculations.