# Technical Assignment 3 Table of Contents

## The Rockville Library

# Executive Summary

Technical Assignment 3 focuses on several methods in which the construction process can be improved while saving on overall costs. The categories that will be addressed in the proposed thesis are as follows:

1. Value Engineering & Cost Analysis of Curtainwall Structure
2. Implementing Building Deconstruction
3. 4D Modeling's Impact on Curtainwall Construction
4. Usage of Collaborative Project Management Technology

Each area is diverse to one another but opens up cost savings in a number of areas. The proposed thesis will also address several issues facing the construction industry today. Why innovative technology isn't used more in the construction industry? Is 4D CAD modeling is an effective tool for evaluating a construction process? Is cutting material costs the most effective method of value engineering? What is building deconstruction and how can it save projects money? All of these answers are to be addressed in the upcoming passage.

As the weight matrix on the following page shows; this thesis will balanced in a different number of areas. Instead of a heavy emphasis on research this thesis will attempt to apply new construction methods to the Rockville Library Project in order to reduce the schedule, revise the construction, and save costs in value engineering. Research will be necessary in all areas in order to fully understand and display to the audience how to implement these proposed ideas. Once these views are displayed it is the ultimate goal of this thesis to apply these views and ideas into the Rockville Library. To create a new project that will apply new innovative technology and deconstruction to create a much more efficient and sustainable atmosphere.

# Weight Matrix

| Description | Research | Value Engr. | Const. Rev. | Sched. Red. | Total |
|---|---|---|---|---|---|
| ***Analysis 1*** Curtainwall Construction | 5% | - | 10% | 10% | **25%** |
| ***Analysis 2*** Alternative Curtainwall Structural System | 5% | 15% | - | 5% | **25%** |
| ***Analysis 3*** Deconstruction | 5% | 10% | 5% | - | **25%** |
| ***Issues Research*** Innovative Technology | 15% | 5% | - | 5% | **25%** |
| ***Total*** | **35%** | **30%** | **15%** | **20%** | **100%** |

## Areas Of Breadth

**Structural** – Analysis of an alternative curtainwall system and the impact it will have on the building design along with the structural impact of designing a building for deconstruction will be addressed in this proposed thesis.

**Mechanical** – Analysis of deconstruction of the mechanical system and alternative mechanical components that will fulfill deconstruction while maintaining HVAC requirements will be addressed in this proposed thesis.

# Critical Industry Issues & The Annual PACE Roundtable

The roundtable began with the choice of attending several different discussions. The first session I attended was; Team Building I: In-House Teams and Business Development. We discussed ideas about how to form proposal teams and what technologies we could use to further enhance the team building process. Also, we spoke about how certain project teams are unique versus others and how a proper working team should function.

I chose to attend this session after hearing about several problems that the construction team faced with my thesis building. Several subcontractors, particularly the curtainwall erectors, had issues with communication, coordination, and their contract. One subcontractor left the job in the middle of the project due to this and their vacancy lead to major delays. Now, construction on The Rockville Library will have to be expedited for the remainder of the project just to catch up and finish on schedule. I hoped from attending this session I could get ideas on how this could've been prevented and offer a solution in my thesis presentation.

What this session preached was communication and relations with all members of the project team. On the Rockville site I believe that working team relationships weren't really developed with all of the project participants. If the general contractor had communicated their concerns with its subcontractors before the complaints and schedule delays, they could have avoided this major setback. Instead they hoped the problem would go away by itself, yet it didn't. I feel like if they had developed an aggressive team strategy at the onset of the project they would've been able to communicate and solve these problems in advance.

The second session I attended, Frontiers for Innovation II: New Markets for Integrated Services, discussed project innovation and how it could be adopted further in the construction industry. We discussed reasons why the construction was so far behind in technology versus other industries. We also talked about how, as construction managers and general contractors, we should attempt to use project innovation more in our own work.

I thought this conversation was the more interesting of the two sessions because it really raised the important issue of responsibility for project innovation. The construction industry really hasn't given a definitive answer to that question. As construction managers we would like to think we are responsible and should be pioneers in this field. However, we are not always given the funding or capability to use innovative technology from the owner. When our hands are tied who should lead the way? Architects, engineers, or perhaps an independent party that is a subcontractor could manage the innovative technology process on a project.

I really struggle to understand why a permanent role isn't assigned or why new technology isn't implemented on all construction projects. As a student I understand its value from everyday use in the classroom. However, I believe that owners and even some CM firms don't really grasp the time and coordination headaches that innovative technology can save. The problem could be there is a lack of understanding and training in new tools such as 4D CAD which makes it hard to implement. It could be that there is a lack of definitive proof of project savings since spending money for implementation of technology doesn't lead to immediate savings. It could simply be people don't like to change. No matter what, it is clear that as construction managers we need to try and promote innovation and break through the technology barrier.

Another problem I recently learned was faced on my site was a lack of definition and coordination of the curtainwall system. The Rockville Library uses a serpentine curtainwall which curves along the eastern façade. It ends up that these angles of curvature were not properly defined on the plans and when construction on the system began no one really knew how to define the construction process. This overlook lead to delays while information needed to be gathered on the system and how to integrate trades to complete the project. If 4D modeling had been used on the project they would've realized the lack of explanation and planning in the curtainwall system. They could've fixed this issue far in advance which would've saved a lot of time and money.

After the second meeting I managed to introduce myself to Mr. Eric Tievy, representative of Forrester Construction. Forrester is the GC on The Rockville Library construction and Mr. Tievy was recently put in as help to get the project back on schedule. He gave me a lot of insight into the project's inner workings which really

helped me get a feel for how I should approach my thesis. He informed me about particular structural changes to the tubular steel curtainwall support system. I think analyzing the cost benefits from changing the structural steel system will be interesting and worthwhile to see it was really beneficial. Also, he talked in detail about coordination and design flaws in (once again) the curtainwall system. Learning the details of this problem made me really interested in developing a 4D model that could've solved the coordination mishaps in assembling this system.

Other representatives I met were Mr. Glenn Erb of Skanska USA and Mr. Robert Grottenthaler of Barton Malow. When I mentioned my thesis and the problems that I recently learned of, they offered help. They both mentioned work they had done on 4D models in the past and said I could contact them at anytime if I had questions or issues in designing one. With all the encouragement I have gotten in this area and hearing the debates on project innovation, I feel this is the topic I wish to pursue. A study of how a project can benefit from 4D modeling versus the cost saved from not implementing this technology. The who, what, where, when, why, and how of the implementation of innovative design on The Rockville Library construction project.

Overall I was really surprised with the format and atmosphere of this seminar. I honestly expected to learn a lot about the industry and met some construction representatives, but not much more. I never excepted to develop such great relationships or have such in-depth discussions about issues that I am really interested in. I have always been baffled by the lack of technology in the construction industry, especially on the projects that I have worked on during my summer internships. Until I heard the thoughts and views of industry members, I never realized the potential for change. I hope that I could reflect these changes show the benefits in my thesis. The representatives really showed me a lot and gave me great ideas about how I should continue my thesis. Their enthusiasm and willingness to help really surprised me and made me feel a lot more optimistic about not only my thesis but the industry in general. In the future I would be thrilled to attend more of these seminars since I am sure as a professional it would be very beneficial to understand the technologies that universities are using and to try and implement these innovative ideas on my projects.

# Problem Identification

## 1. Serpentine Curtainwall Construction

The main headache on The Rockville Library project has come from the lack of planning and coordination in constructing the serpentine curtainwall system. According to the contractor, the structural plans did not properly specify the exact locations or angles for placement of the curved curtainwall. After Forrester reviewed the plans with the project team, the confusion was obvious. Both the specifications and the plans did not go into depth on how to construct this complex building feature.

Due to the lack of definition, a clear-cut plan on how to coordinate trades on site wasn't formulated. Lack of coordination caused confusion in the order, duration, and sequencing of trades in the curtainwall development. Overall the project was delayed for a couple of weeks in order to sort out the uncertainty.

One method to solve this dilemma would have been the creation of a 4D building model during the project design phase. If a 4D design would have been created before construction began, this problem would have been spotted and sorted out before ground was broken. 4D models can also aid in the coordination of trades and help improve efficiency during curtainwall construction.

## 2. Benefits to Alternative Structural System

One major change that was made to the building before construction began was changing the A36 structural steel beams around the curtainwall area to tubular steel forms. Material costs were saved in the development of this new structural system. In the long run members of the construction team are not sure if this system was more beneficial. Coordination and constructability issues occurred as a result of the change to the structural element of the curtainwall support system. An in-depth analysis should be used to see if the initial cost savings beneficial to the project in the long run.

### 3. Coordination w/ Surrounding Job Sites

The Rockville Library project faces a unique situation in having to constantly coordinate with several different job sites surrounding their own. The town center renovation has many different remodeling, demolition, and construction crews working in the same vicinity at one time. While the library project has its own private site, there are several spaces surrounding the site that Forrester could utilize to help in the construction process. Extra space for project parking, steel staging, excavation space, and equipment parking could all help free up the site and make the construction process on site much more efficient. However, there has not been a lot of coordination present between neighboring project teams and some space has been lost. If a plan could be developed and communicated to ensure full utilization of free space around the entire complex, a lot of time and resources could be gained.

### 4. Lack of LEED Rating in Construction Process

The Rockville Library construction process has never considered attempting to make their project LEED rated. This may be due to several reasons; money, resources, schedule, lack of space, or lack of an effective plan. While recycling is attempted on site as much as possible, more could be done in order to attempt to secure a LEED rating on the project. If there was a plan put into place and coordinated throughout the construction team it could be done. While this would require resources to investigate and develop of suitable plan and possibly additional costs to the construction budget, LEED certification can be achieved.

### 5. Project Management Miscommunications w/ Subcontractors

During the onset of the project miscommunication between the first curtainwall fabricator and the project management staff lead to the subcontractor leaving the job. They left due to confusion over the contract and bond requirements for the job. After they left it took time for Forrester to find a new subcontractor that could fabricate and deliver the curtainwall to site. All of these setbacks lead to the fabrication and delivery being off schedule and the project being delayed by weeks. This problem could've easily been solved through project team building. If Forrester had properly communicated with the curtainwall fabricator then the issues that arose could've been averted. This communication is essential in trying to develop the project team before the start of the construction process.

# Technical Analysis Methods

## 1. Serpentine Curtainwall Construction

One of the main features of the Rockville Library project was an elaborate serpentine curtainwall system. The curtainwall was created by the architects Grimm & Parker in order to represent a double helix which was symbolic of the research done in the mapping of the human genome nearby. This complex system was attempted to be constructed using project drawings and specifications created during the design and development phase of the project. Construction was delayed for weeks due to confusion about the curtainwall's erection and how to sequence trades in order to complete this task. This was due to insufficient information in the plans about how to angle the serpentine curtainwall sections and how to communicate the proper construction plan to trades on site.

Innovative technology such as 4D CAD could've been used in order to improve coordination and expedite the construction process. A four dimensional CAD building model would've given the subcontractors a three dimensional building plan in order to clearly view the curtainwall sections and how to construct them. Sequencing could've also been communicated by orienting each trade into the 4D plan according to their role in the curtainwall construction schedule.

The main question is; would the delays that were caused by confusion in the curtainwall erection and trade sequencing be settled by implementation of a 4D curtainwall model and how much cost savings would be created by making a 4D curtainwall model? It is the goal of this proposed thesis to show how the implementation of a 4D model would take away confusion in the curtainwall erection by clearly showing its design and each trades orientation in the construction plan. Then a cost analysis would have to be made in order to reflect the costs of creating this model versus the cost of lost time on the project.

First it is necessary to understand why a delay occurred in the first place. After speaking with members of the general contracting staff it was clear that the plans did not entirely show how the erect the curtainwall. This was due to a lack of a 3D model which in detail would've shown the angles and connections necessary to construction the elaborate serpentine system. This proposed thesis will have to go deeper in order to find exactly which details in which sections were unclear so that an effective 3D model could be created. Contacting each subcontractor in order to find their individual problems with the old project drawings and specifications will be necessary in order to fully grasp the problems with this building system.

The next step after determining what the problems exactly were is how they were fixed. To understand how each subcontractor changed their plans in order to construct the curtainwall correctly will be essential in order to create an accurate 4D model. By interviewing the general contractor and analyzing their method of sequencing the trades on site will show how the trades will be integrated into the 4D model.

Once a proper 3D and 4D curtainwall model can be created through understanding of the construction and sequencing issues on site this proposed thesis will create a working 4D model. The model will clearly reflect the new construction plan and how the curtainwall should have been designed and coordinated. Using AutoCAD and Revit software a model can be created that will display the curtainwall erection in 3D and the trade orientation over time in this process.

The final step of this analysis will be to reflect the costs of implementing a 4D CAD model. The goal of this area of the thesis will be to show how creating this model ahead of time would've eliminated all of the construction and coordination issues that ended up costing weeks on site. First an analysis of the money lost from the delays on site will need to be evaluated by consulting with the general contractor. Then, the costs of creating and communicating the 4D building model will have to be researched and evaluated. The anticipated results will be that creating and

communicating the 4D model will be far less costly than the money lost from the delays on site in the curtainwall erection.

## 2. Benefits to Alternative Structural System

The Rockville Library is designed to have an elaborate curtainwall system. The original design for the project was to have a structural (tube) steel support system for a shallow depth (4 1/2") curtainwall system. The value engineering suggestion was to eliminate the tube steel support system, and instead use a self-supporting, 12" depth curtainwall system. This value engineering created initial material cost savings in eliminating the steel supports. However it is not clear that eliminating the tubular steel in favor of a larger curtainwall was the proper value engineering decision.

The main question is; Did eliminating the tubular steel supporting the curtainwall system really create value engineering? The elimination of the tubular steel supporting the curtainwall system may have cut initial material costs, however due to additional complexity in the construction process and additional girth to the curtainwall system, this decision did not create value engineering.

It will first be necessary to evaluate material costs for each curtainwall system. For analysis purposes, structural steel is currently pricing at $2,500 to $2,800 per ton, fabricated and installed. There is, however, a complexity factor associated with this work that makes it less like structural steel work and more like miscellaneous metals work. Therefore, the price to provide (or in this case, delete) this work could end up being upwards of $3,500 per ton. The curtainwall is a more complex issue, as the upcharge is largely dependent upon the manufacturer of the system. In order to gather accurate cost data the curtainwall fabricator, Galaxy Glass and Aluminum, will have to be contacted. The question will be; what is the approximate cost per square foot for the 12" system vs. the 4 1/2" system? Then calculation of the square footage of curtainwall and the differential for the project will need to be done.

Afterwards the general contractor will have to be consulted in order to estimate the costs in constructing the original curtainwall system versus the modified system. The equipment, time, and labor rates will have to be evaluated for each system in order to get a final price evaluation for each system.

The final step of this analysis will be to reflect the costs of the shallow depth (4 1/2") curtainwall system versus the self-supporting, 12" depth curtainwall system. Cost comparisons will be clearly shown in the materials, labor, time, and equipment costs for each system. These costs will be compared side by side and evaluated to find the true value engineering system. This proposed thesis believes the original curtainwall will yield the true cost savings due to less complexity in the construction process with the use of a smaller curtainwall with tubular steel supports.

## 3. Building Deconstruction

Deconstruction is the process of dismantling a building in order to salvage the materials for reuse. Unlike demolition, which generates waste that can only be landfilled or recycled, deconstruction produces materials that can be used again or remanufactured into higher-valued goods.

The disposal savings and resale income that deconstruction generates can make the process less costly than demolition. It also reduces environmental impacts by cutting down on the use of heavy machinery and saving landfill space. Deconstruction earns LEED credits and can give a competitive advantage to contractors by projecting anticipated savings and revenues from implementing this process.

The Rockville Library is a prime candidate for building deconstruction due to its location, function, and materials. The library is located in a confined space so future demolition would create several problems due to restrictions in space and the noise it

would create for future neighbors. Montgomery County will own this property for years to come and will desire to maintain and adapt the library space in order to keep it state of the art. Implementing deconstruction will allow the building owner to change the interior layout, exterior façade, and the mechanical system without major demolition or renovation costs.

The main question is; in which areas of the Rockville Library can building deconstruction are successfully implemented and how can this thesis reflect cost savings from proposed construction in terms of future demolition and renovation costs? The Rockville Library has several components which are eligible for building deconstruction and by implementing building deconstruction in the structural and mechanical systems of the building can create significant cost savings in future demolition and renovation costs.

After analyzing the Rockville Library site there are 3 areas in particular which make deconstruction very practical. First, is in the size and scope of the mechanical system. The Rockville Library is controlled by an Automatic Temperature Control / Energy Management System which is designed to be flexible, functional, and responsive to the changing needs of the facility. The mechanical system was designed to be easily accessible by being centered in spacious utility closets on the 2$^{nd}$ and 3$^{rd}$ floors in addition to open rooftop units. The access of this system to be easily repaired along with its ability to adapt to the changing needs of the library makes it a prime candidate for deconstruction.

Materials like the high-quality brickwork, the glass curtainwall, and interior architectural moldings are all eligible for building deconstruction. By creating a plan to dismantle these building components rather than demolish them, the appearance of the Rockville Library can be completely changed without major renovation which would create significant cost savings.

The next step after determining if deconstruction is sensible is to set the waste reduction goals for each system that is to be dismantled. Using the information gathered in the site survey, this proposed thesis will set an overall goal for diverting waste from landfills and recycling goals for each of the materials in the building.

After reducing waste with a deconstruction plan in the mechanical and structural systems of the library it is essential to create of construction plan which describes how each system should be constructed in order to be conducive to disassembly. Examination of the mechanical system of the library will be the focus of this section of the thesis in order to analyze the ability for its components to be disassembled and adapted.

This thesis will research where changes can be made in the current system order to create a mechanical system that is more conducive to being dismantled. In order to find how deconstruction can be applied to the mechanical system, in-depth research into the methods of HVAC disassembly will have to be done. Since deconstruction has been a growing topic in the construction industry several companies and students have begun intense research into this field of construction. With societies like the Deconstruction Institute, Used Building Materials Organization, and the Environmental Protection Agency all committed to analyzing the different areas of building deconstruction, there are many different sources to tap. With the existing conditions and slight changes that could be made, it will be proved that deconstruction is a construction method that can yield very relevant cost savings.

# Critical Issues Research Method

A critical industry issue that this proposed thesis will confront is an analysis of the costs and the benefits of using innovative technology in the construction process. Overall the construction industry is behind the technology curve and there is vast room for improvement in the construction process if new innovative technologies would be implemented. In particular collaborative project management software could be used by any general contractor in order to organize and analyze the construction process.

Collaborative project management software fully integrates and handles accounting, jobs, equipment, materials, project management, human resources, document imaging, service, remote connectivity, and data sharing tasks. Accurate and timely monitoring of job costs and profitability can make or break any company. Collaborative project management software provides an easy way of monitoring profitability on any job with completely up-to-date information.

The main question is; how to fully display the benefits of implementing innovative technology such as collaborative project management software and how to overcome the boundaries for applying these tools? This proposed thesis hopes to display the benefits and cost savings that come from implementing collaborative project management software while addressing the boundaries in the industry for applying these technologies and how to overcome them.

First a full investigation will need to be done into the many different types of software and tools that take advantage of collaborative project management. The goal is to find the program that is most efficient to use in terms of cost and a learning curve to use. Forrester Construction did not implement any types of this innovative technology on this project due to the lack of sophistication of the subcontractors. Thus a system will have to be selected that is simple to implement and communicate to all parties on site. An analysis will also have to be done into the inner workings of a contracting firm like Forrester to see what type of collaborative project management software would best fit

their technology demands. Through the help and advice of the members of the Rockville staff a desired system will be discovered that will tailor to the needs of the project and Forrester Contracting in general.

The next step after determining which collaborative project management system would be the best for Forrester to implement would be to access how much this will cost to do. This would require evaluating costs of purchasing software, integrating it into the computer systems, personnel training, and time using the software on site. All of these costs can be gained from questioning software personnel and contractors whom previously integrated this software. By analyzing their costs I can modify them to fit the size and scope of Forrester's system.

The savings of implementing a collaborative project management system will need to be made clear in order for this thesis to successfully recommend implementing this technology. In order to reflect these savings research will have to be made into case studies that have evaluated the savings of applying this innovative technology. After a full analysis of the types of savings that have been created is done, this work will have to be translated to the Rockville Library Project. This proposed thesis will have to accurately find the savings from using this technology and display it to the audience. It is the belief that once an accurate comparison of case studies to the Rockville Project has been made that the cost savings will be significant and will be obvious to any observer.

Finally this thesis would like to get opinions of industry members towards the idea of using this innovative technology. A survey would have to be made in order to access the validity of using a chosen collaborative project management software system. This survey would have to be targeted specifically at construction management firms and clearly define the type of technology used.

After I had gathered all my information I would attempt to make conclusions about the use of innovative technology in the construction industry. They would be based off of my findings in the survey and looking at Rockville Library. The anticipated conclusion is that the construction process can benefit greatly from innovative

technology. This thesis will confront the boundaries present and attempt to discover solutions to implementing collaborative project management software. This study will be geared more towards industry members in order to try and get them to understand the benefits of these technology types.