Franklin & Marshall College Row

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Aimee Bashore

The Pennsylvania State University
Department of Architectural Engineering
Construction Management ~ Dr. Messner

Senior Thesis ~ Spring 2007

Aimee Bashore

Construction Management
Franklin & Marshall College Row
Lancaster, PA
http://www.arche.psu.edu/thesis/eportfolio/2007/portfolios/ALB358/

Primary Project Team:

Owner:
Franklin & Marshall College
Developer:
Campus Apartments, Inc.
Architect:
Elkus|Manfredi Architects, Ltd.
Construction Manager:
Alexander Building Construction, LLC
Landscape Architect & Civil Engineer:
Derck & Edson Associates
Structural Engineer:
McNamara Salvia
MEP/FP Engineer:
AHA Consulting Engineers

Project Features:

Project Cost: $13.5 million
Project Size: 111.641 sf
Dates of Construction: 5/06 to 7/07
Occupancy: Retail on first floor and apartments on upper five floors
Project Delivery Method: CM at Risk with a GMP

Historical:

Site preparation included demolition of two old buildings, which required approval from the PA Historic Museum Commission. Site is located adjacent to railroad tracks and other factory-related facilities, which will be reflected in the façade of the new building and in the awning-style of the windows.

Mechanical:

~3 Roof top air conditioning units - direct expansion (total of 4200 CFM)

Electrical:

~800A, 480/277V, 3-phase, 4W Distribution Panel
~¾" to 2-4", 60-800A copper feeders
~Dry type transformers: Primary – 480V, Secondary – 208/120V, and ranging 9-500kVA
~40kW engine emergency generator

Lighting:

~Fluorescents and halides used, ranging from 120-277V

Structural:

Foundations - spread footings with selective compaction grouting for soil improvements, prior to footing installation, and strip footings for masonry foundation walls (frost walls)

Structural Steel - composite slab on deck for second floor slab and load-bearing block and precast concrete plank from the second through to the roof

Exterior Façade - structural stud metal framing with brick veneer and metal panels

Roof - fully-adhered thermoplastic membrane system

Table of Contents

Executive Summary

Through the completion of this thesis report several areas of the Franklin & Marshall College Row project in Lancaster, PA were analyzed. The report is broken down into four main parts.

In the first part of the report is the project overview. Here the project is introduced and includes general information such as client information, project and staffing organization, delivery method, existing conditions, site plans, schedules, and estimates.

Following is the first analysis looking into Building Information Modeling (BIM), with a focus on the owner. This analysis looks into what a BIM is capable of and how an owner can utilize the tool. Included are an industry questionnaire, a look at Penn State and its approach to BIM, looking at BIM from an owner perspective and how it can compliment an operations and maintenance program, and finally a software review that focuses on Autodesk's FMDesktop.

The next analysis compares the flooring systems, composite metal deck and precast concrete plank, both used on College Row. Both methods will be analyzed with a look at design details, cost, and schedule issues, including a redesign of the reinforcement for the slab on deck.

In the final analysis, construction during cold, winter weather conditions is studied. Here the focus is on concrete activities and how they are affected, with a look into scheduling and cost concerns and the amount of heat loss.

An overall theme in this thesis was to look at areas that are specific to a higher education project. Operations and maintenance after a project completion, and budget and schedule issues are all important concerns.

Project Introduction

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Franklin & Marshall College Row is a three-building project located on the edge of campus in Lancaster, PA. The two larger buildings will contain retail on the first floor with the remaining floors being apartments. A grocery store will be held in the third, smaller building. This report will focus on the main, largest building. The building is six-stories and 111,641 square feet.

81% of the building is dedicated to residential use, with 15% to retail and 4% to management spaces. The retail spaces are street level. Also on the first floor, in the northeast corner, are the management offices. Apartments are contained on the following five floors. A total of 65 apartment units will be in the building, including 1, 3 and 4 bedroom apartments. Each floor includes a handicap-accessible unit, a common lounge, and laundry facilities.

The design of the building starts with spread footings with selective compaction grouting for soil improvement prior to footing installation. There are also strip footings, serving as frost walls, for masonry foundation walls. The building has structural steel with composite slab on deck for the second floor slab and load-bearing block and precast concrete plank for the third floor to the roof. The façade of the building is brick veneer, metal sheeting, and masonry.

Client Information

Franklin & Marshall College is building College Row as a response to increased demand for campus housing. Along with the need for more housing, they saw an opportunity in the buildings' location along Harrisburg Pike. Franklin & Marshall will be leasing the first floor of Buildings A and B and Building C will become a grocery store. In order to satisfy their wishes, Franklin & Marshall hired Campus Apartments, Inc. to help them obtain a high-end university housing building project.

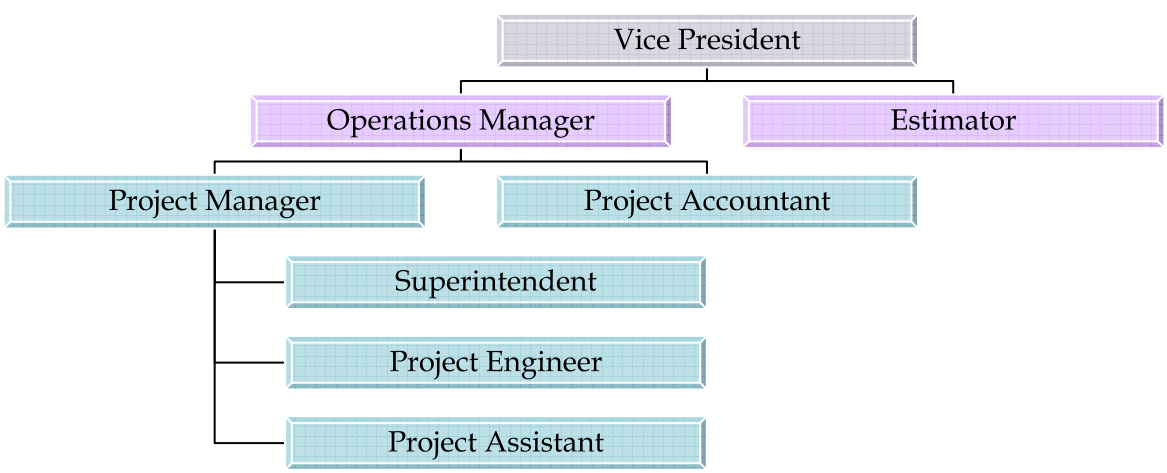
Preconstruction and design efforts on the entire project were a year-long process. During that time, Campus Apartments, Franklin & Marshall College, Elkus|Manfredi Architects, and Alexander Building Construction, LLC, worked closely to find means of minimizing costs through efficient design, while ensuring that the quality aspects of the design were not compromised. Keeping those items in mind, the construction contract came out to over $26 million. This amount reflects the costs required to complete the project. Cost overruns of any significance are not anticipated. Construction is scheduled to be sixteen months in duration, with a substantial completion of July 31, 2007.

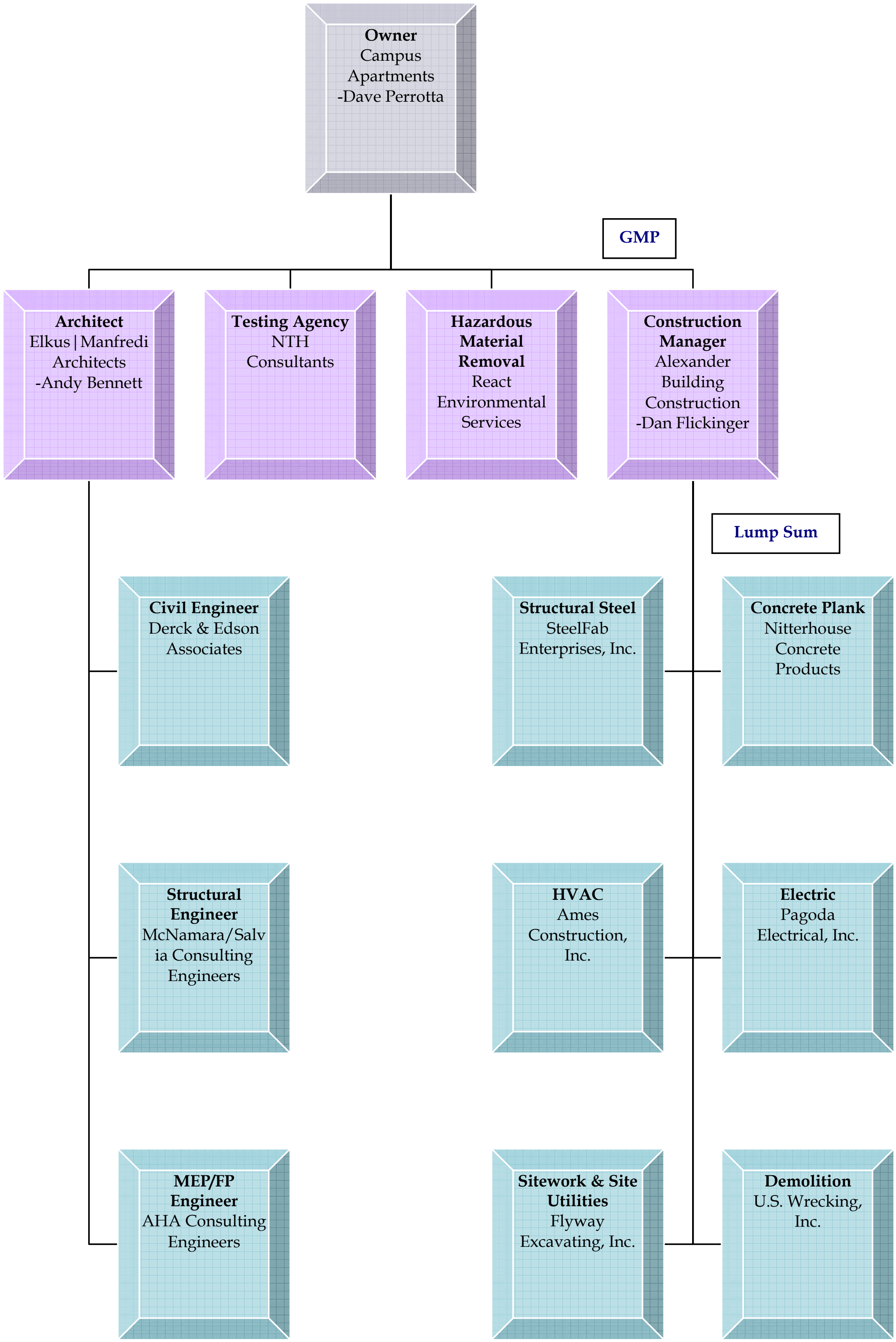
Delivery Method and Staffing Plans

The delivery of this project is construction management at risk with a guaranteed maximum price (GMP) contract. Alexander Building Construction, LLC was brought on during the schematic drawing level. With a GMP, Alexander was able to prepare early budgets and dictate part of the design and design-process. A GMP gives the price protection at an early stage in the project, allowing security in financing. This was also very important based on the need for the project to be completed by next summer.

Contractors are requested to bid by Alexander and the bids are submitted to Alexander. Scopes are then reviewed and a formal "proposal record" is prepared for the owner. With the owner's signature, Alexander enters into contract with the contractor. Acceptation or rejection of a contractor's bid can be the discretion of both Alexander and Campus Apartments. Certificates of insurance are required by each of the contractors before they can perform any work on site. A contractor is required to be bonded depending on the size of the contract.

Below are two staffing plans. The first plan is of the construction management team. Shown in the second organizational chart is the overall project team.





Owner
Campus Apartments
-Dave Perrotta
GMP
Architect
Elkus | Manfredi Architects
-Andy Bennett
Testing Agency
NTH Consultants
Hazardous Material Removal
React Environmental Services
Construction Manager
Alexander Building Construction
-Dan Flickinger
Lump Sum
Civil Engineer
Derck & Edson Associates
Structural Steel
SteelFab Enterprises, Inc.
Concrete Plank
Nitterhouse Concrete Products
Structural Engineer
McNamara/Salvia Consulting Engineers
HVAC
Ames Construction, Inc.
Electric
Pagoda Electrical, Inc.
MEP/FP Engineer
AHA Consulting Engineers
Sitework & Site Utilities
Flyway Excavating, Inc.
Demolition
U.S. Wrecking, Inc.

Existing and Local Conditions

Before construction could begin on the College Row project, two buildings needed to be demolished. The main issues here, is that one of the buildings, The Federal Mogul Building, was historical and needed the approval of the Pennsylvania Historic Museum Commission. They approved the demolition, under the condition that certain parts, including lead glass, precast sills, and moldings, were salvaged to be sold at an auction/fundraiser.

Another concern were the adjacent railroad tracks that once contained factory-related facilities. Tied into these tracks and campus was a footbridge that the community and Franklin & Marshall College did not want jeopardized because it was still in use. This was taken into consideration and will be reflected in the design of the façade of the new building in the awning-style of the windows.

Being a construction project at a higher education school, there were common safety considerations that had to be handled. The actual construction site is on the edge of Franklin & Marshall property and on the opposite side of Harrisburg Pike, so pedestrian traffic will not be a major concern. The biggest concern was that the college wanted the footbridge over the railroad tracks in the north corner of the construction site to remain open and usable. This will be covered by a tall construction fence blocking entrance for pedestrians onto the site.

There were no significant concerns from the City of Lancaster overall. Some variances had to be obtained by the City of Lancaster in order to construct the buildings preferred by Franklin & Marshall College. Such variances included that the maximum building height be increased to seventy feet, to increase the allowable unrelated persons in a non-family unit from three to four, and reduction of front yard setbacks for each of the three buildings.

Site Plans

Above is an overhead picture of the Franklin & Marshall College Row project in Lancaster, PA. The project is located on the opposite side of Harrisburg Pike from the college. Harrisburg Pike is a main route in Lancaster which has been taken into consideration with the location of the construction site fence, as well as the site entrance/exit.

Contained in Appendix A is a site plan of the existing conditions of the site. Included on that plan are the existing buildings, two which will be demolished, and the locations of the three proposed buildings. In addition to what is shown on the site plan, the following items need to be taken into consideration:

- No pedestrian traffic along Harrisburg Pike in area of construction site
- Pedestrian traffic to continue in north corner of construction site where there is an existing footbridge crossing over the railroad tracks
- Existing water and communication lines run underneath Harrisburg Pike and will branch into new building
- Existing gas and electric lines run east/west on construction site and will be relocated running parallel behind the new buildings
- Lighting along Harrisburg Pike will remain during construction

Also located in Appendix A is an overall site plan for the superstructure construction phase at Franklin & Marshall College Row. At this point, the main entrance and exit of the site is off Harrisburg Pike, past where Building C will be located, with the actual site entrance behind an operating business. Since the entrance/exit location is the same, there is ample space for trucks to turn around for delivery. The steel laydown area is centrally located behind the building, with easy access for both delivery trucks and the crane. The crane is centrally located behind the building, with access to the entire building, so it will only have to be set up the one time.

At the beginning of the superstructure phase, the trailers are located along the north fence-line, along the railroad tracks. They will later be moved closer to the site entrance, as shown on the superstructure site plan, once the demolition is complete, the temporary power set-up will be changed. At the beginning of the superstructure phase the temporary power had been rerouted from a demolished building.

Project Schedules

Completing the foundations in a timely manner is very important in order for the structural work to begin on time. In this schedule, structural work begins five weeks after foundations has commenced, giving the foundation workers enough time to have enough of their work done in order to start the structural work. These are key items that must be kept on schedule in order for finishes to be completed on time. The finishes are a six-month job and with the college pressed to be completed before the Fall 2007 semester, the project has no room to fall behind.

The project summary schedule for Franklin & Marshall College Row is contained on the next two pages.

Project Schedule Summary

Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start
1	Design Phase	316 days	Mon 4/11/05
6	Sitework	40 days	Mon 7/17/06
2	Purchasing	57 days	Thu 7/20/06
5	Demolition	34 days	Wed 8/2/06
8	Structural Steel	42 days	Wed 8/23/06
9	Masonry	93 days	Mon 8/28/06
22	U / G Plumbing	10 days	Mon 9/11/06
7	Concrete	40 days	Wed 9/13/06
10	Precast Plank	57 days	Tue 10/3/06
3	PPL Power Relocation	1 day	Thu 10/5/06
11	Exterior Studs / Metal Framing	72 days	Tue 10/10/06
15	Miscellaneous Metal	58 days	Tue 10/10/06
16	Interior Studs and Drywall	77 days	Tue 10/10/06
17	MEP Trades	82 days	Tue 10/31/06
13	Windows / Curtainwall	81 days	Tue 11/28/06
12	Roofing	16 days	Wed 12/27/06
24	Interior Finishes	124 days	Wed 1/10/07
19	Start Switchgear Installation	1 day	Fri 1/12/07
20	Building Enclosed	0 days	Wed 1/17/07
21	Permanent Power	0 days	Thu 1/25/07
23	Elevators	30 days	Fri 1/26/07
4	Typical Apartment Mock-Up	1 day	Thu 2/1/07
14	Metal Panels	40 days	Wed 3/7/07
18	HVAC Start-Up/Test/Balance	8 days	Wed 7/18/07
25	Owner Occupancy	0 days	Thu 7/26/07
26	Interior Punchlist Complete	1 day	Wed 8/8/07
27	Exterior Punchlist Complete	1 day	Wed 8/22/07

Qtr 2, 2005: Apr May Jun | Qtr 3, 2005: Jul Aug Sep | Qtr 4, 2005: Oct Nov Dec | Qtr 1, 2006: Jan Feb Mar | Qtr 2, 2006: Apr May Jun

Project: Project1
Date: Mon 11/6/06

Task | Milestone | External Tasks
Split | Summary | External Milestone
Progress | Project Summary | Deadline

Project Schedule Summary

Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start
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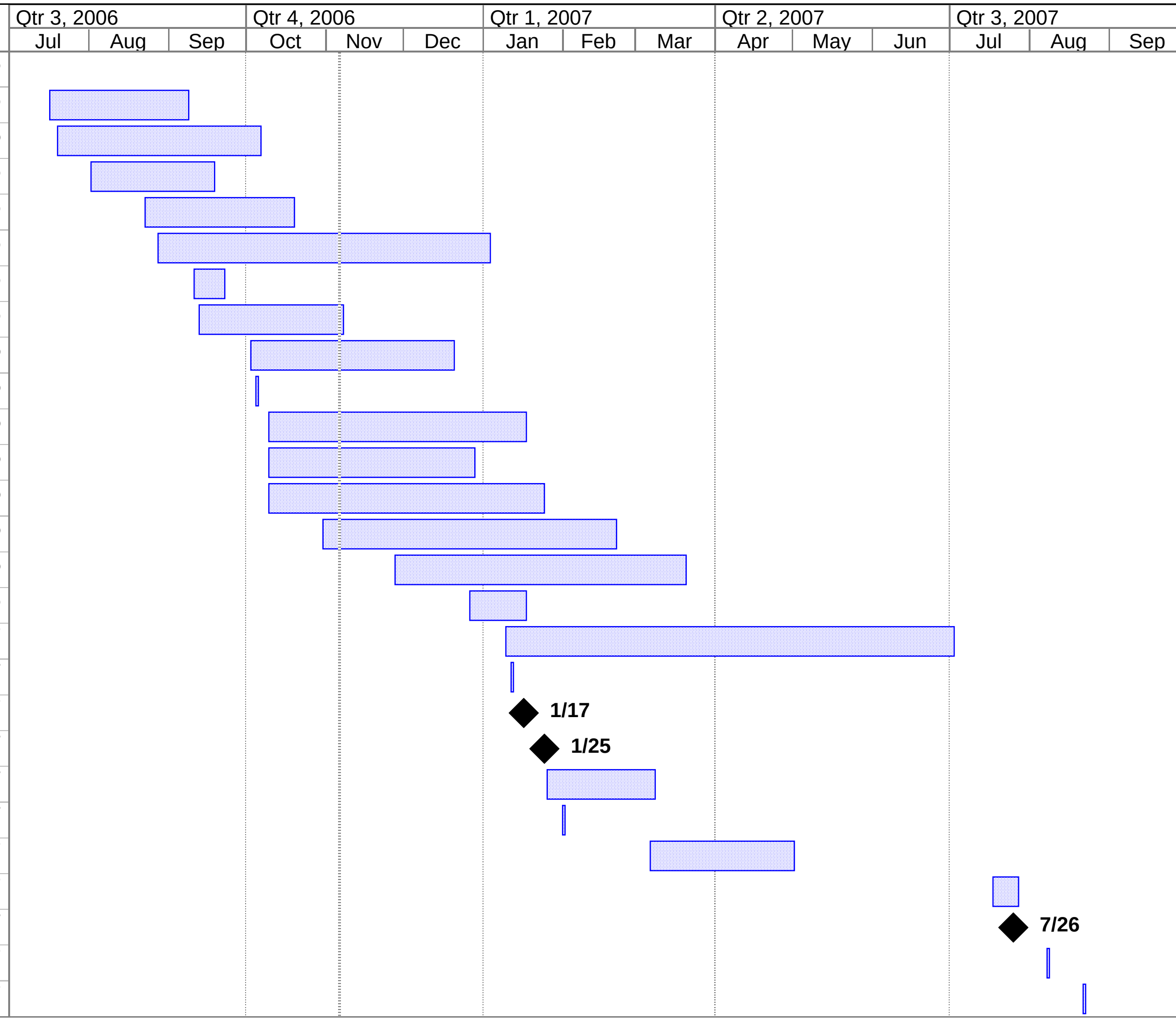


Project: Project1
Date: Mon 11/6/06

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Franklin & Marshall College requires that their College Row project be completed in time for use for the 2007/2008 school year. The resulting schedule is a 16-month construction project, starting from preconstruction in April 2006 and ending with the turnover of the building to the owner on Thursday July 26, 2007, as shown in the second schedule in Appendix B.

The project schedule is broken down into two main categories, General Construction and Construction for Building A, which are specific to the building studied in this thesis report. Within the General Construction are important milestones, demolition activities, and site work. The Construction for Building A is separated based on the type of work.

Key dates, milestones, and activity durations:

- 1/10/07 to 7/2/07 – Interior finishes
- 2/1/07 – Mock-up apartment complete
- 6/1/07 – 1st floor tenant fitout
- 6/8/07 to 6/22/07 – Life safety systems testing
- 7/9/07 to 7/25/07 – Final clean-up
- 7/26/07 – Owner occupancy
- 8/8/07 – Interior punchlist complete
- 8/22/07 – Exterior punchlist complete

Cost Estimates

The following data is a cost evaluation for Franklin & Marshall College Row in Lancaster, PA.

Actual Building Costs –
Construction Cost – $13,500,000
Square Foot Cost – $120.92/SF

Sitework Costs –
Construction Cost – $750,000
Square Foot Cost – $6.72/SF

Total Project Costs –
Construction Cost – $15,048,000
Square Foot Cost – $134.78/SF

Structural System Costs –
Construction Cost – $3,258,990
Square Foot Cost – $29.19/SF

Mechanical System Costs –
Construction Cost – $863,379
Square Foot Cost – $7.73/SF

Electrical System Costs –
Construction Cost – $1,133,976
Square Foot Cost – $10.16/SF

General Conditions Cost –
Construction Cost – $1,008,564
Square Foot Cost – $9.03/SF

Analysis 1 – Building Information Modeling

Introduction

Wikipedia defines building information modeling (BIM) as the digital representation of the building process to facilitate exchange and interoperability of information in digital format. BIM covers geometry, spatial relationships, geographic information, quantities, and properties of building components. Application possibilities of BIM include coordination of trades, activity sequencing, and scope of work details.

The institution of computerized two-dimensional drafting that took place in the 1990's, can be compared to the current transition into computer-based three-dimensional modeling. Software will need to be purchased and industry members need to be educated and trained to learn the new information. Unlike the transition into computerized two-dimensional drafting, which computerized an existing practice, three-dimensional modeling will also require new software and education and training. In addition, BIM will cause cultural changes within the industry in areas of design, staffing, fees, construction administration services, and so on.

From design to construction to operations and maintenance, BIM can provide a new way to look at a construction project. Now an owner is able to visualize their project when they may not have been able to before. Contractors can coordinate their work and let all those involved also be capable of visualizing the same product. Facility managers can ease their maintenance and operations work through an as-built model. BIM proves beneficial in multiple aspects of building and construction.

Goal

The goal of this research is simply to look into the benefits of utilizing BIM, particularly how an owner can take advantage of having an as-built model at the completion of a project. Beyond the coordination and visual aid a BIM can provide during construction, there are software programs and databases that can tag items and ease the operations and maintenance activities. These topics will be discussed in the following pages.

Outcome

Although BIM can prove to be a great aid in construction, this research has shown that an owner can greatly benefit with the use of an accurate as-built model following the completion of a project. Designers will see a benefit when trying to demonstrate their plan to the owner. Contractors will see a benefit in the field when it comes to coordinating trades. And, after a project is complete, an owner will see a benefit in future renovations and with maintenance operations.

Research

Questionnaire Results

The following pages contain a summary of the BIM questionnaire results. Responses are from various members in the construction industry. The majority of the questionnaire participants are companies within Pennsylvania, Virginia, Maryland, and Washington D.C. Job titles of questionnaire participants include: estimator, assistant project manager, project manager, project coordinator, and knowledge manager.

Questions:

1. **In general, how do you feel about utilizing BIM's on a construction project?**

   Overall, the mood in response to this generalized question on the utilization of BIM was a positive one. A common theme was concerning the size of the project. Larger projects or projects needing a high level of coordination would see a greater benefit of using BIM. Examples of such projects would include fabrication facilities, ships, power plants, remote projects, and projects that are repeatable.

   Many owners are looking at proposals to include some indication of BIM. However, a big issue in transitioning to BIM is the issue of cost. New software has to be purchased along with training on how to use this new information. If a project had enough funding that they would be able to finance the technology, it would make it easier on the members, from the owner, to the design team, to the management, and down to the subcontractors, of the project to use BIM. BIM will only be an effective tool on a project if both the design team and the subcontractor have the capability.

A difficult part of utilizing BIM in the construction industry is the industry's acceptance and transition into its use. Right now, BIM is at the beginning stages and the industry has a long way to go. This may be a long and timely step. There will be a significant learning curve the industry will need to undergo before BIM becomes common practice.

2. **What would you see as the benefits for your involvement of the construction process?**

Simply, benefits would include time, schedule, coordination and cost. During the preconstruction phase, BIM can become beneficial if there are subcontractors brought in early enough to work out trade coordination, which could also greatly reduce rework in the design. This could save time and costs and reduce design quality control and constructability reviews. Sharing of the original 3D model between the design team and subcontractors can also reduce time transferring subcontractor details. From an estimating and purchasing standpoint, projects can be priced and bought more accurately by knowing the full scope of each assembly. The more detail and coordination shown on a model, the less risk a general contractor takes on.

During the construction phase of a project, having a 3D model to verify coordination, especially in congested areas, may prove to be very useful as far as looking at underground utilities and work between different trades. Also, models reduce paper if contractors use them as a building tool. Models can give access to real-time information and would make design changes almost immediate. With the models being on the computer, that would be a way to also integrate specifications and shop details onto the computer as well. Following the completion of a project, a as-built model given to the owner will aid in and future work on that project and create a system to track and update their operations and maintenance programs.

3. **What would you see as the drawbacks?**
   Integrating new technology and software systems is always a challenge. There are initial costs for new technology and training that needs to take place to learn the new methods. The switch needs to be accepted by all parties involved; and at this point, not many subcontractors have BIM capability. Varying software among subcontractors could potentially slow down communication.

   BIM will not outweigh drawbacks versus benefits when dealing with an average project. There is not an avenue to only partially using BIM and at this point, the knowledge and capability is not enough to make BIM worth the costs involved. Does a model completely replace 2D drawings as the "Contract Document"? Who covers the fee for adapting BIM on a project and who assumes the risk? There is minimal legal precedence at this point and without a direct contract between the designer and the contractor, there will always be the issues of contractual and legal rights and responsibilities.

4. **Do you feel BIM's can be beneficial in the years following the completion of a construction project?**
   An accurate model is needed to make it fully beneficial. A knowledgeable facilities manager may see the greatest benefit. This person would need to have knowledge of the model and its applications, and be able to update the model when changes are made. Also in that respect, an as-built model

may serve useful to the general contractor for call back purposes and general reference. This could greatly reduce the volume of operations and maintenance manuals, drawings, and specifications. At this point, a model can be adapted to tag product data, warranty information, and maintenance information for specific pieces of equipment. This helps the facilities manager regulate operations and maintenance routines and would be a nice addition to consider in the contract documents.

5. **Have you worked on a project, previously or currently, which utilized a form of BIM?**
   A majority of the participants have not personally worked on a project on which BIM was used. Of those who had, some participants indicated that they had worked on a number of projects using BIM. These projects were

6. **As per your knowledge of the Architectural Engineering (AE) curriculum at Penn State, do you feel it would be beneficial for BIM to be integrated into the curriculum?**
   Yes, it should, at the very least present an introduction to the idea and software current to the industry; the principles behind BIM. Having that basic knowledge will benefit and be an advantage to AE program graduates when they become part of a project in the future that utilizes BIM. Being able to speak the BIM language and understand its uses. The information taught should also be specific to either the design option or management option of the student.

7. **Any additional comments on the utilization of BIM's?**
   The idea of utilizing BIM on projects is great. However, many projects start with the idea that they want to use BIM, but there is no follow through on documentation policies and the BIM is not realized.

Construction is a project-driven industry, like any business. BIM needs to either become a contractual agreement or prove to be a money-saving solution to a subcontractor. Money could be saved if the software and training cost less than the combination of printing cost, time wasted looking for information, and time and money spent on rework.

After the learning curve and technology investments, the BIM process should prove to be a less costly design process. Prior to that, designers believe offering a BIM is an added premium and presents legal problems. In order for designers or owners to begin requiring BIM's they are going to want to know that there is profit in its usage. The most common delivery system is Design-Bid-Build, whereas Design-Build may be more applicable to BIM such that it reduces legal and financial conflicts.

A major issue to overcome is the compatibility of the software. Just as for 2D drawing and with project management software, many options for modeling are available. How does a project team collaborate and synchronize the information?

Overall, the feedback from this questionnaire was positive. Although most persons had not personally worked on a project that utilized BIM, the participants show their willingness to move forward with this new technology. The construction industry is realizing the potential BIM has. At this time, the main benefactors are large companies with the resources to fund a BIM project and, at the end of the project, realize all the options that an as-built model provides.

Case Study: The Pennsylvania State University and The Dickinson School of Law, University Park

Project Team:

Owner – The Pennsylvania State University
Design – Polshek Partnership Architects
Construction Management – Gilbane Construction

Project Information:

Location – University Park, PA, northwest of the flower gardens off Park Avenue and east of Bigler Road Extension
Size – 113,000sf
Features - state of the art facilities for a law library, 50-seat mock courtroom, 250-seat auditorium , case study classrooms, three 75-seated tiered classrooms, faculty offices, cafeteria and all support spaces, parking for 350 cars, and outdoor gathering spaces
Design Phase: October 2005 to April 2007
Construction Phase: January 2007 to January 2009
Project Cost: $60,000,000

Penn State's Office of Physical Plant (OPP) is experimenting with the concept of Building Information Modeling (BIM), as this is their first project that will utilize the technology. The decision to use BIM did not happen until late in 2006. There are additional costs factored in to choosing to use BIM. At this point it is difficult to assess if those costs will be outweighed by "savings" such as easier coordination, less conflicts, less time lost in the field, and so on. Penn State likes to hire subcontractors from the area. At this point, there has been little difficulty finding knowledgeable subcontractors, or ones that are willing to invest their time into learning the technology. Penn State is optimistic and looks forward to learning more about BIM through the Dickson School of Law Building, University Park project.

Being a higher education owner, Penn State is very interested in the quality of their as-builts. Since Penn State will remain the owner of the buildings on campus for their lifetime, it is essential to have accurate as-builts. Future renovations of the building and the surrounding area will run smoother. An added advantage to having an as-built model is that with the correct software and the proper training of facility operators, items can be tagged and ease the maintenance operations. Penn State hopes that through this experience they will see how BIM can benefit them and will adopt it on their future building projects.

BIM from an Owner Perspective

Many owners can benefit from utilizing BIM on their projects. These benefits can occur before, during, and after construction. Prior to construction, an owner can look at their building and see what it will look like before finalizing the drawings, making changes easier than if it were to change once construction was underway. During construction, time can be saved by having coordination between trades worked out prior to installation in the field. After construction, an owner is given an as-built model. With this model, an owner has the ability to tag items that will aid in the maintenance operations. Also, future renovations will be benefited by having a working model. When well-used, BIM can be useful in the life-cycle of a building, not just in the design.

There are several characteristics that an owner must possess to be efficient. The owner must have the sophistication to understand that time equals money, enforce the training for using the technology, and be able to set standards among the design, construction, and conclusion of a project. Anyone from office buildings to research and manufacturing facilities can benefit from the utilization of BIM, however, the latter may find the money spent more worth the outcome.

Research facilities and manufacturing facilities tend to modify their environments more than office buildings, commercial, or other "non-industrial" environments. Industrial facilities are constantly pushing the capacities of their systems. For these owners, BIM is a very useful tool. Heavy petrochemical and dense piping faculties are great candidates for this application. Unfortunately, for some non-industrial owners, BIM can basically be money wasted. Owners who have trouble visualizing their facilities in 3D benefit greatly, and it keeps from surprising them during construction. They find it worth the money for the time and redesigning it saves.

BIM when used for other applications after design are where the savings are realized. Life cycle costs of the facility needs to be considered when deciding to invest in BIM. Provided a maintenance worker knows how to navigate around the system and the information is current, it's a great tool. Old and outdated information is not useful to anyone. Database queries are also very helpful. For example, they allow someone to determine very quickly when and how many filters need replacing in a given time frame.

A facility manager needs to understand the value of this tool and be willing to train their staff in how to maintain and use it. Then they simply need to manage it like they do any other tool or resource. They need to be able to navigate around the system and keep it updated.

Owners need to understand the value of a BIM system and how it can save them money in the long run. Sophisticated clients with varying needs are great candidates. Multi-tenant faculties tend to benefit form the long term use. For example, this allows the company to charge tenants based on space, utilities, and so on. Owners that have facilities that need to operate on very tight tolerances (temperature, humidity, etc.) find it useful. Knowing your system and its limitations is very important.

Software Review

There are several software programs that are utilized in association with facilities management. These programs offer a way for the owner to maintain their as-built model. If the technology is kept up to date, they can easily alter the model anytime there are changes made to the building or the surrounding site. The owner needs to have the capacity to invest in the software and the staff to operate it in order for it to be efficient.

One of the current programs available is Autodesk FMDesktop. Autodesk FMDesktop is a suite of products based on Applied Spatial Technologies' flagship facility management product, FMDesktop, which Autodesk acquired in January 2006. Autodesk expanded its capabilities and released version 7.0 of the FMDesktop Product Suite in October 2006 to address the primary functions of facility management, such as space and asset management, project management, emergency management, and maintenance management. FMDesktop comprises four major components that are available as separate but related applications: Facility Manager, Facility Link, Facility Web, and Facility Request. This review will focus on the Facility Manager application.

www.autodesk.com

The Facility Manager application is the cornerstone of the FMDesktop product suite. It provides the operator with the ability to manage all facility drawings and data in a database environment. The information can be managed in a traditional tabular format or graphically through the integration of facility drawings and data. It allows facilities managers to view, query, pan, zoom, print, and share facility drawings without needing CAD or BIM software. Also included are tools for planning, tracking, and managing project and move information as well as project related, demand, and preventive maintenance work requests, creating and issuing work requests manually or automatically generating them from a facility drawing, assigning work to maintenance staff and vendors, and attaching related documents to database records.

Many facility operations today are still being managed through paper-based processes that include drawings and spreadsheets. For those that have been using computer-aided facilities management systems, they have been reaping its benefits and efficiencies over paper-based processes. And now, with BIM starting to reach into the facility management phase, owners stand to gain even more dramatic benefits and efficiencies.

Conclusions and Relating BIM to Franklin & Marshall College

Sophisticated maintenance personnel love using BIM because they can quickly identify impacts on the facility due to problems with equipment, proposed modifications, and so on. It also provides a great visual for contractors when they go to build, resulting in minimized change order work. When used correctly it can assist design professionals with such things as doing interference checks, generating bill of materials, square footages, and volumes.

Through interviewing with Penn State Office of Physical Plant personnel and others on the subject of BIM and owner benefits, Franklin & Marshall College (F&M) too can make the move to utilizing BIM for their construction projects. The first step for F&M would need to be the decision to invest the money into the technology. If there is not an effort and willingness put toward BIM and training or hiring knowledgeable facility managers, then there is no reason to "waste" the money. Being located in Lancaster, PA should not prove to be an issue when looking for knowledgeable designers and contractors, without having to spend extra money to expand beyond their usual locale to hire someone.

Since F&M is a higher education owner, there can be great benefits in maintaining and operating their buildings if done right and well. Having as-built models as opposed to as-built drawings eliminates storage room and simplifies the organization of the as-builts. With the as-builts computerized, F&M has the option to decide what is important to them in their maintenance operations and tag those items, which could show to simplify their current operations. Another benefit that F&M could draw on is the possibility of future renovations to the building and the surrounding area, through the accuracy of models that have been updated along with any minor reworks.

Analysis 2 – Composite Metal Deck v. Precast Plank Flooring

Problem

As designed, the floor system for College Row consists of a slab on grade, followed by a slab on deck, with the remaining four floors as precast concrete plank. There are many areas to consider with these different flooring systems, such as the schedule and cost impacts, equipment allocation, and what the owner is looking for from the flooring system. Through this analysis, the flooring systems will be studied to see how the two methods compare, and if one has a better affect on the project's tight budget.

Goal

The goal of this analysis is to look at the structural flooring system used on the College Row project, excluding the slab on grade of the tenant space. This analysis will look at why there is a combination of slab on deck and precast concrete plank used. Beyond looking at the structural aspect of these systems, cost and schedule will also be reviewed. These topics will be discussed on the following pages.

Outcome

Although precast concrete plank is a higher first-cost, that cost is combated with a reduction in schedule length and with the benefits that precast concrete plank provides over a slab on deck system. From this analysis, precast concrete came out to be almost $300,000 more expensive. However, the duration for construction was two-thirds the time of the composite metal deck's.

Research

The composite metal deck system used on the project was only for the second floor. In the building, the first floor is tenant space, with the remaining five floors repeating apartment patterns. On the four remaining floors, precast concrete planks were used.

When comparing a composite metal deck versus a precast concrete plank system, there are several areas that come into consideration. There is more work into placing metal decking, such as forming, reinforcement, and more bearing walls needed than in plank. Plank basically eliminates the prep work on site because the pieces are engineered and produced offsite in a controlled environment to a very high strength, therefore needing less support than metal decking. On these factors alone there is more money placed into the labor of metal decking than in placing and grouting plank.

A substantial cost is added to the plank system with the need for a large crane during erection. More laborers are needed for the work of the components of a composite metal deck, but the equipment used is considerably less expensive. For composite metal decking, welding equipment, torches, screw guns, saws, a smaller crane to lift the rebar, and the equipment for whichever form of pouring concrete is used, are the items needed. The caliber of the equipment needed for a precast concrete plank system is more significant, including tractor trailers, a substantial crane, and the equipment for whichever form of pouring concrete is used for the grouting work.

Weather becomes a crucial factor in the grouting and topping steps of the plank system. Similarly, the pour of the slab can also be affected by extreme weather. Plank is often supported by masonry bearing walls which is also affected by the weather. Curing times can greatly affect a project's schedule. Steel members, which are usually used for the support of composite metal deck, can be erected without problems in both warm and cold weather conditions. These factors can be combated with a good temporary protection plan.

One of the determining factors for the owner here is sound transmission. Being a residential building, noise control is very important in keeping happy tenants. Precast concrete plank provides much better acoustic benefits than a composite metal deck system does. BOCA building code requires that the construction meet a 45 STC (Sound Transmission Class), the hollow core plank used here tests to a 53 STC, exceeding the BOCA requirement. Another great feature of the precast and apartment combination is that precast is known for its longer fire safety ratings.

Composite Metal Deck System Overview

Composite metal decks have four main functions: to work as a platform during construction, to act as a form, to provide positive bending reinforcement for a concrete slab, and to provide resistance to horizontal wind or earthquake loads. This type of decking takes advantage of the high tensile strength of steel and the high compressive strength of concrete to handle gravity and lateral loads the deck may be exposed to during construction and also in service. Metal deck is usually put into service a day or two after the concrete has been placed, so this becomes an important criterion. Some of the heaviest loads these floors will ever encounter will be during the construction phase such as pallets of drywall, pallets of concrete masonry units, or various sorts of industrial lifts.

Because of these risks, it is critical to understand the stresses that the decking system may be subject to and the potential risks of cracking. These cracks can occur because of two reasons: either as a result of flexing of the metal deck or from the restraint of movement of the concrete. Concrete also has the tendency to crack both in its plastic (early-age) and hardened (long-term) state. Early-age cracks are microscopic fissures caused by the intrinsic stresses created when the concrete settles and shrinks during the first 24 hours after being placed. Long-term cracking is in part caused by the shrinkage and drying of the concrete that transpires over time. In either case, these cracks can jeopardize the overall integrity of the concrete and not allow it to maintain, or possibly ever attain, its maximum performance capability.

The normal method used to control cracks in concrete over metal deck assemblies is secondary reinforcement. Secondary reinforcement serves as shrinkage and temperature reinforcement. Shrinkage and temperature reinforcement is non-structural reinforcement used to minimize the widths of any cracks that are caused by thermal expansion and contraction. Traditionally, steel such as wire mesh or welded-wire fabric, which is used in this project, has been the primary choice for temperature and shrinkage reinforcement in composite metal deck construction.

Precast Concrete Plank System Overview

With benefits including speedy production and erection, 60 ft clear spans for floor plank, energy efficient with R-values up to 35, fire protection up to a 4hr rating and noise control, precast is the choice of many owners. In addition, unique designs, colors and textures can be created to make your new facility more than just a building. These cost-efficient units are a great benefit to owners who demand quick delivery, low cost, and high quality.

Hollow core plank is a pre-stressed concrete member primarily used for floor and roof decks. Serving as a combined deck and ceiling system, the planks erect quickly to reduce on-site labor needs and are capable of spanning long, open spaces to aid design flexibility. Continuous, interior voids add structural stability, reduce weight, and therefore reduce cost. The result is a sound-proof, fire-rated, low maintenance system with long spans and shallow depths.

Reinforcement Redesign for Slab on Deck

In the original design for the reinforcement of the slab on deck, welded wire fabric (WWF) was used. Here, calculations were performed to determine what rebar reinforcement should be used. Costs were then analyzed to compare the two methods. Rebar came out to be approximately 11% higher than the cost for WWF. Calculations can be found in Appendix C.

Reinforcement is essential in providing tensile strength to concrete, which is strong in compression. Rebar is a very common form of reinforcement used in concrete slabs. WWF offers a less expensive, but competitive, alternative to rebar for the primary reinforcement in a structural floor slab.

Results:

Original Design: 6x6 – W2.1xW2.1

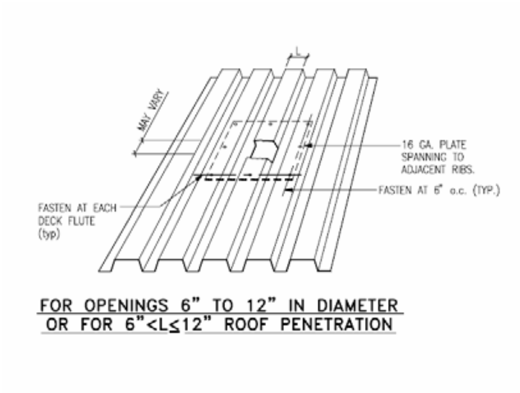
Redesign: Use #4 rebar @ 12” O.C. spacing

Grade 60 steel for rebar

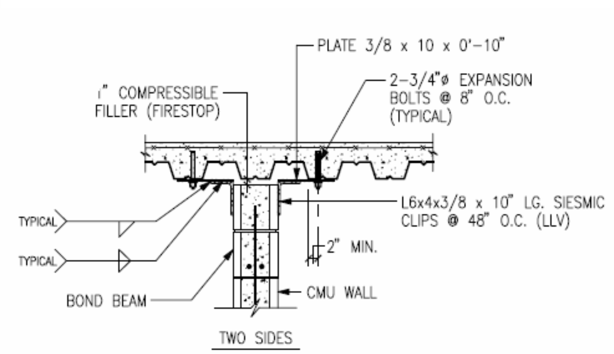
Recommendation: Use WWF reinforcement as detailed in original design.

Design Details

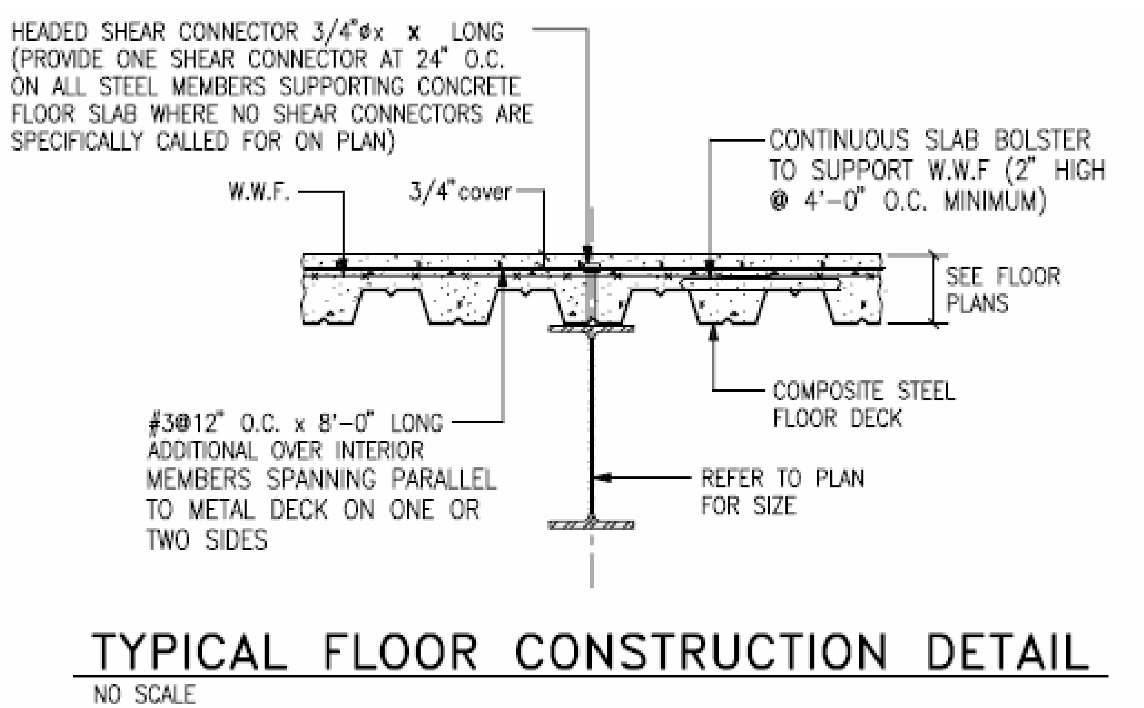
Below are details of the various connections, sections, and other items among the precast concrete plank and the slab on deck.



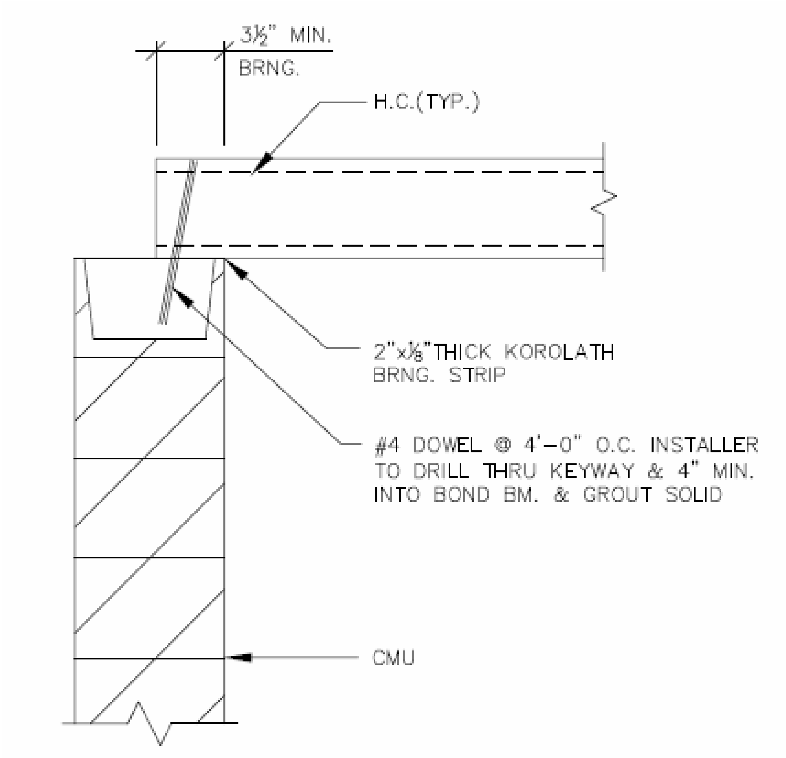
Sample of Steel Decking



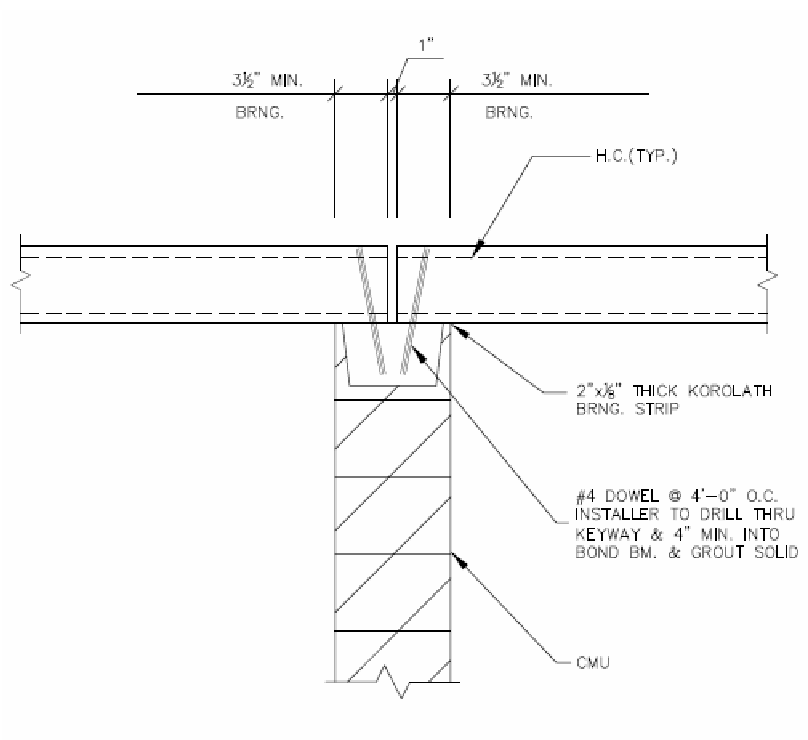
Section of Composite Metal Deck on Interior Bearing Wall



Composite Metal Deck Detail

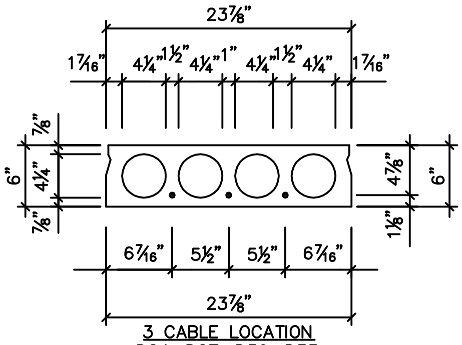


Section of Hollow Core Connection to Exterior Bearing Masonry Wall



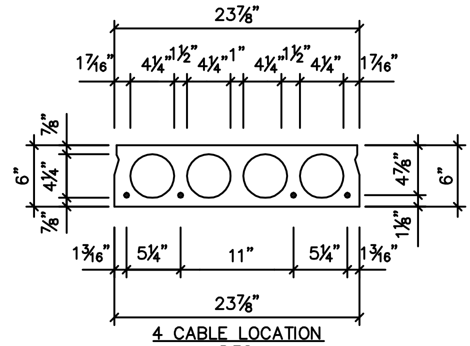
Section of Hollow Core Connection to Interior Bearing Masonry Wall

Pictures on following page are details of hollow core plank.



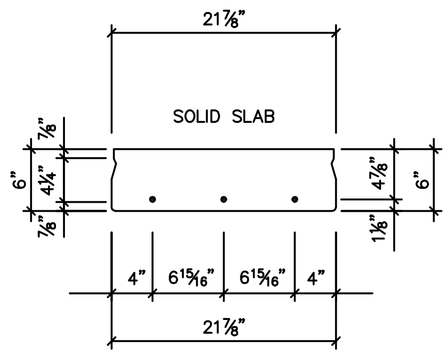
3 CABLE LOCATION
D24, D27, D30, D33

6" FLEXICORE PLANK
2'–0" PC

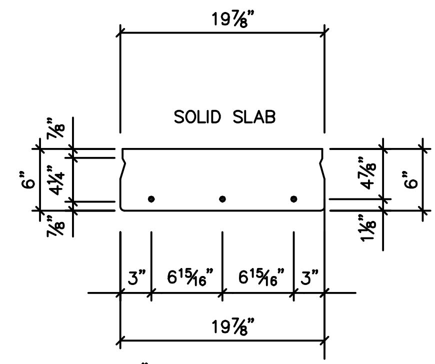


4 CABLE LOCATION
D38

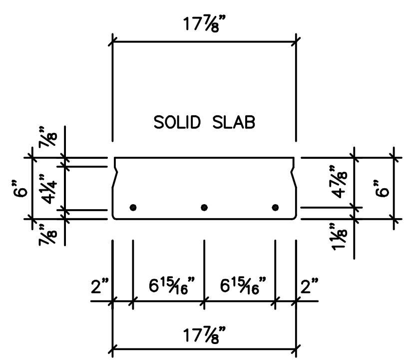
6" FLEXICORE PLANK
2'–0" PC



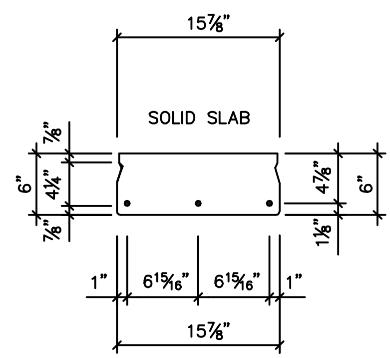
6" FLEXICORE PLANK
1'–10" PC



6" FLEXICORE PLANK
1'–8" PC



6" FLEXICORE PLANK
1'–6" PC



6" FLEXICORE PLANK
1'–4" PC

GENERAL CONTRACTOR NOTE:

1) While field core drilling for making openings for plumbing lines, care must be exercised not to cut strand in plank. Relocate openings considering the strand location indicated in the cross–sections.

2) No mechanical openings to be made without prior approval.

PCI

Molin Concrete Products Company • 415 Lilac Street • Lino Lakes, MN 55014
Office: 651.786.7722 Fax: 651.786.0229 800.336.6546
www.molin.com e-mail: info@molin.com

Cost and Schedule Analysis

The analyses below are comparisons of composite metal decking to precast concrete plank for the upper five floors of the residential section of the building. Information is based on R.S. Means Square Foot Estimates 2007 Edition. Durations for the schedule are based on the same crew size for both systems.

Composite Metal Deck System Cost and Schedule

This analysis is based on information for a floor system using composite steel beams with welded shear studs, composite steel deck and light weight concrete slab reinforced with welded wire fabric.

Cost:

Average bay area of 20 ft. x 25 ft.
Slab thickness of 5′ – ½ “
Design load for residential occupancy of 40 p.s.f.
Cost per square foot of $15.05
Square foot of five upper levels of 93,034 s.f.
Residential location factor for Lancaster, Pennsylvania is 0.92.

TOTAL COST = $ 1,288,000

Schedule:

Steel deck and studs: 6 days per floor
Pour slab: 3 days per floor

TOTAL DURATION = 45 days

Precast Concrete Plank System Cost and Schedule

This analysis is based on information for a precast plank system with a 2 in. topping, including grouting.

Cost:

Average span of 25 ft.
Plank thickness of 8"
Design load for residential occupancy of 40 p.s.f.
Cost per square foot of $18.50
Square foot of five upper levels of 93,034 s.f.
Residential location factor for Lancaster, Pennsylvania is 0.92.

TOTAL COST = $1,583,500

Schedule:

Place and grout plank: 6 days per floor

TOTAL DURATION = 30 days

Conclusions

Precast concrete plank cost almost $300,000 more than that of composite metal decking. However, the duration of the plank is two-thirds that of the decking. It is hard to take an exact look at how the schedule is affected here because the weather always plays a part. Also the duration here for the plank does not include fabrication time. If the fabrication is on time and arrives on site without delay, there is no affect on the overall schedule. The greatest change in the schedule would come with extreme weather.

There are many advantages and disadvantages that go with both flooring systems. From a cost and schedule perspective, the higher price of the plank makes up for the fast, and often eased, installation. Looking at the design, one of the reasons for the combined methods would be the difference in spaces. The first floor being tenant space, different layout and higher ceiling, has different column patterns, meaning different connection from column to the above floor. From the second through the sixth floor, the column and floor pattern is the same, easing the fabrication and installation of the precast plank. In addition, the precast plank and masonry walls provide excellent noise control and fire rating. Overall, precast in this setting was a wise choice, meeting the owner's appeal in comfort, safety, schedule, and even budget.

Analysis 3 – Cold Weather Construction

Problem

The construction schedule of the College Row project had a bulk of the cast-in-place concrete, masonry, and grouting work occurring during what is potentially the coldest time of the year, which was worsened by the almost seven week delay of structural steel. What are the additional costs for protecting the concrete activities during construction? What schedule reductions can be made if the work is rearranged, if possible?

Goal

The goal of this analysis is to collect the information needed when dealing with concrete activities in extreme weather. With this information, the requirements that need to be met will be analyzed, and the budget and schedule are affected.

Outcome

By adjusting the schedule in such a way to condense concrete activities or to expedite the work so as to have the concrete and grouting work earlier in the construction schedule, there will be cost savings on methods and materials to protect the curing from the cold weather, but not on the overtime labor. With concrete on the critical path, it is difficult to maintain a schedule without falling too far behind with the succeeding activities. This can be supported by spending the money and expediting the work. There are several effective and efficient methods available and should be taken advantage of if the situation arises.

Research

Cold Weather and Concrete

Planning and preparation are the keys to successful construction in cold weather. While some changes in procedures, equipment, and supplies are required, extension of the construction season into cold weather avoids seasonal construction delays and permits better utilization of a contractor's resources. With careful planning and implementation of an effective cold weather construction program, construction can proceed despite cold weather.

According to The Specification for Masonry Structures cold weather construction exists when ambient temperature falls below 40' F. As the temperature of mortar materials fall below normal, the water required to reach a given consistency is reduced. Also, the given amount of air-entraining agent yields more entrained air. For this project, any concrete exposed to the weather or potential freeze/thaw cycles is required to have an air content of 6% +/- 1.5%. Initial and final sets are significantly delayed in cold temperatures. Similarly, strength gain rates are reduced. Heat-liberating reaction rates between Portland cement and water are substantially reduced and become minimal as mortar temperatures drop below 40' F.

Cold masonry units lower the temperature of mortar placed in contact with those units. Wet, snow, or ice covered surfaces prevent a good bond between mortar and the masonry. In addition to affecting the performance of masonry materials, cold weather may also affect the productivity and workmanship of masons. During cold weather, in addition to attending to their work, masons are concerned with personal comfort and safety, additional materials preparation, handling, and protection of masonry. These extra activities consume more time as the temperature decreases.

College Row was fortunate that December 2006, when most of the concrete activities were taking place, was unseasonably warm. However, once the snow and windy weather started, the erection of the precast concrete planks proved to be more challenging than the cold weather. Wind is a larger concern than cold temperatures when hoisting a large piece of concrete in the air. Also difficult with the plank was grouting in cold and snowy conditions.

To combat this, a couple methods are available. One of the methods was to use a ground boiler with several hundred feet of hose, spreading the hot water throughout the building. Those hoses were then covered with insulated blankets, for two or three days. This was done prior to grouting to ensure a high enough temperature for placement and curing of the grout. Another method would be to place heaters on the floor below blanket-covered plank and heat it from underneath. This is effective but it is less efficient because the entire building needs to be enclosed and heated. Both ways, the planks are again covered in the insulated blankets following grout placement to ensure the proper temperature for curing. If the temperature was too low, the grout's strength would be reduced.

Besides insulated blankets there are other types of insulation that can be utilized such as forms of boards and slabs or loose fills. However, these methods are not as cost efficient or effective as the blankets. Some of the boards and slabs have a higher R-value per inch of insulation than the blankets; however the blankets are more common and economical.

Also utilized are admixtures, air-entrainers were mentioned above. Admixtures increase workability by adjusting the cement pastes to suite their working conditions. While accelerators are sometimes useful in cold weather, they do not eliminate the need for other cold weather construction practices. Their function is not to reduce the freezing point, but to increase the rates of early-age strength development. Admixtures should be used as directed and with caution.

Below are tables outlining requirements for protecting concrete work during cold weather.

Table 1. Strategies for Addressing Cold Temperatures during Masonry Construction	
As temperature drops	**Strategies to Integrate into Your Plan:**
	Optimize the selection of masonry materials for cold weather performance.
	Protect materials.
	Heat materials (see Tables 2 and 3).
	Protect or enclose work areas.
	Heat work areas and in-place work

Table 2. Cold Weather Practices for Masonry Under Construction				
When Ambient Temperature is:				
	32ºF to 40ºF (0ºC to 4.4ºC)	**25ºF to 32ºF (-3.9ºC to 0ºC)**	**20ºF to 25ºF (-6.7ºC to -3.9ºC)**	**20ºF (-6.7ºC) and below**
Mortar	Heat sand or water			
		Heat sand AND water AND keep mortar above freezing until it is used		
			... In addition, heat masonry surfaces under construction to 40ºF (4.4ºC) or higher and use wind breaks or enclosures when wind exceeds 15 mph (24 km/h)	
				... In addition, provide an enclosure and auxiliary heat to maintain air above 32ºF (0ºC) within enclosure
Grout	Heat materials ONLY if below 32ºF (0ºC)			
		... In addition, heat grout aggregates or water to produce grout between 70ºF and 120ºF (21.1ºC and 48.9ºC)		
			... In addition, heat masonry to a minimum of 40ºF (4.4ºC) prior to grouting	
Source: *Specification for Masonry Structures (ACI 530.1-02/ASCE 6-02/-95TMS 602-02)*				

Table 3. Heating Masonry Materials		
Material	**Notes**	**Temperature**
Water	• Water can be heated in barrels or tubs. • It is the easiest material to heat and can store much more heat (per unit mass) than the other materials used in mortar. • To avoid flash set, heated water should be combined with cold sand in the mixer before adding cement.	Heat water to a maximum of 140ºF (60ºC)
Sand	• Sand is typically used in a damp loose condition. • It may be necessary to heat sand to thaw frozen lumps when temperatures fall below freezing. • Heat with electric heating pads, over a heated pipe, or by using steam heating systems.	Heat sand to 50ºF (10ºC) and higher as needed
Masonry units	• Masonry units should not have any visible ice on bedding surfaces when used, and the units can't be below 20ºF (-6.7ºC). • Heat on pallets in an enclosure or stored in a heated area. • The units should be kept dry, very high absorption fired-clay brick may need wetted — but not saturated — prior to use.	Heat units to at least 40ºF (4.4ºC)

Heat Loss

When the ambient temperature drops below 50^{o}F, precautions need to be taken to ensure that the concrete cures efficiently. Heat loss was analyzed for the months of December, January, February, and March. From these calculations, which can be found in Appendix C, the amount of heat loss each hour was determined. Calculations were based on the 8" precast hollow core concrete plank, the 8" CMU walls, and the exterior openings being covered with polyethylene thermoplastic.

Results (for one floor):

December heat loss: 501727 Btu/hr
January heat loss: 641,096 Btu/hr
February heat loss: 557,475 Btu/hr
March heat loss: 306,611 Btu/hr

Recommendations:

From these results, it can be determined what capability the machinery should be have to combat the heat loss. The month with the coldest weather and greatest heat loss is January. From that data, an example of a temporary heater to be used on site would be the portable forced air heater, the Tradesman 155N. This heater uses natural gas, which is the power source on site. The Tradesman 155N heater emits 155,000 Btu/hr. Five machines would need to be used to heat one floor. However, the other months need less than five heaters, but it would be a good idea to keep an extra heater on site in case of unseasonably cooler weather.

Schedule Analysis

In Appendix B are two detailed schedules. The first schedule is a preliminary schedule. The second schedule is an updated schedule after steel was actually started on the project.

Even before there was the issue of the steel being delayed, some of the concrete activities were not scheduled to end until the end of December 2006 and into January 2007. This mainly was the result of a very tight time frame. The schedule was to begin at the end of the Spring 2006 semester, with the project ready to be turned over before the Fall 2007 semester. This gives a small block of time for two buildings to be demolished, one of them needing historical clearance, and three buildings to be ready in a little over a year. In order to meet these dates, some of the concrete work would have to be done with the possibility that measurements would need to be used to ensure the curing and protection requirements.

The steel erection was delayed almost seven weeks, pushing back all critical path activities. With concrete work on the critical path, this means that the concrete work would also be pushed back, resulting in concrete activities pushed even further into the cold weather season. After foundations were complete, and everyone was waiting for the steel, there was not much work to perform because of the steel being on the critical path. Fortunately, the project did not fall too far behind. This was ensured by expediting work, by increasing crews and working longer hours and weekends.

Cost Analysis

When creating a schedule for a project, concrete activities in cold weather should be avoided as much as possible. What needs to be understood is that there will be money spent on additional materials and on overtime.

If there is money available, or if there is a tight schedule with a demanding owner, then there are many options to performing these activities under adverse conditions, but it comes at a price. Heating a basically open space that is not well insulated eats a lot of money. Sometimes, it might be better to wait for the temperature to increase. The money spent on cold weather construction activities may be better spent paying overtime to make up the time lost, or to expedite activities before the weather gets too difficult to work in.

Conclusions

On College Row, the construction manager ended up supplementing the concrete subcontractor to expedite the concrete activities. The crews worked longer days and weekends. Overtime has a negative connotation, but in comparison with working in adverse conditions, it pays off to take advantage of every opportunity available to expedite any work and get concrete activities done in nicer weather. There was no good choice because of the steel being delayed. After the foundations were done and before the steel arrived, there was not much work that could be done since the critical activities were affected, making it hard to rearrange the schedule in any way. A big challenge was erecting the precast concrete plank in the cold, snowy conditions. When an expensive crane is sitting on the site, there is no good choice.

Cold weather adds a few challenges for contractors. While materials won't be changed, modifying mortars may help prevent negative impacts of cold temperatures, keeping in mind that admixtures have to be used very cautiously, if at all. The greater the temperature drop, the more strategies that have to be employed to protect new construction or activities under construction.

Summary and Conclusions

Although BIM can prove to be a great aid in construction, this research has shown that an owner can greatly benefit with the use of an accurate as-built model following the completion of a project. Designers will see a benefit when trying to demonstrate their plan to the owner. Contractors will see a benefit in the field when it comes to coordinating trades. And, after a project is complete, an owner will see a benefit in future renovations and with maintenance operations.

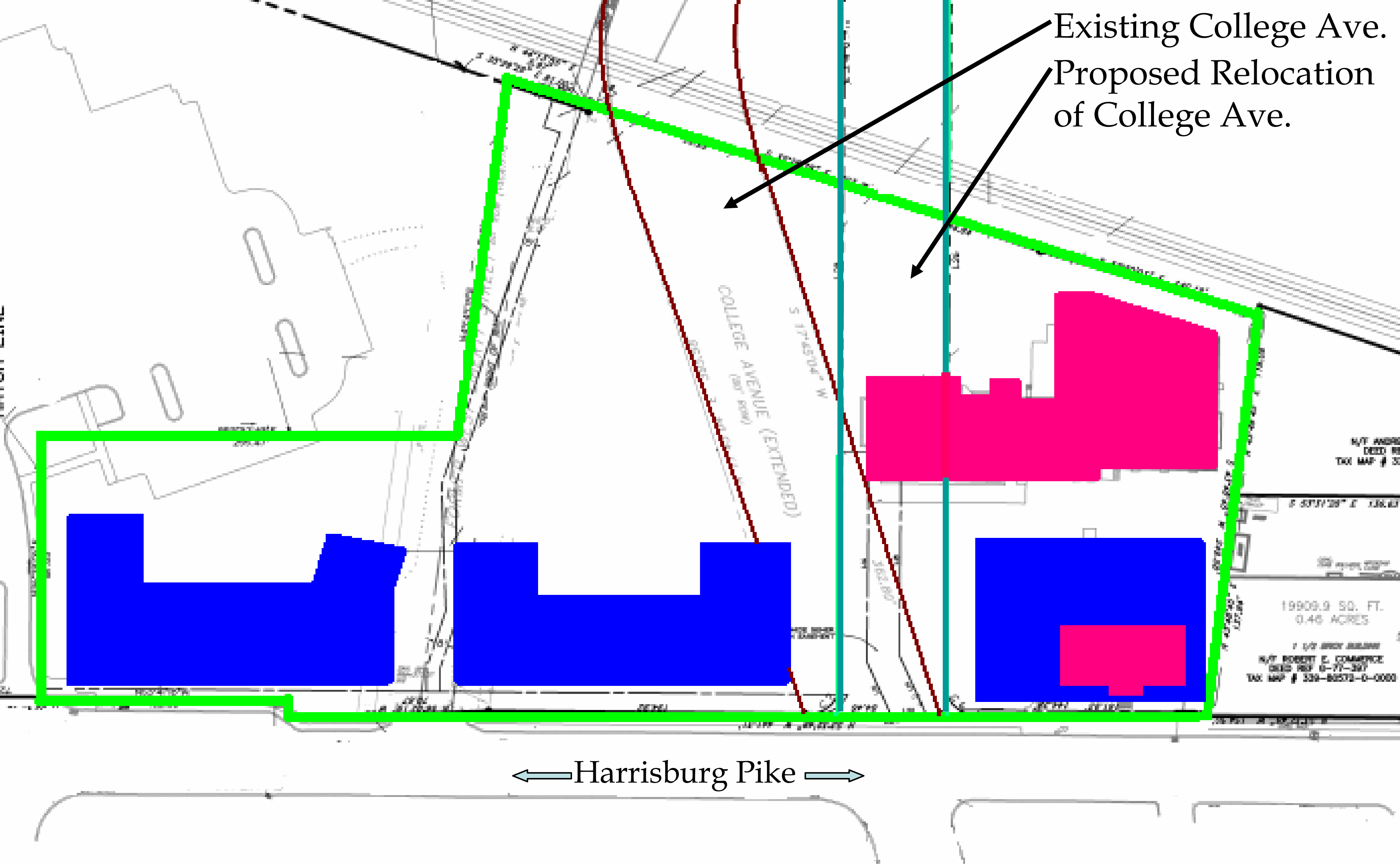
Although precast concrete plank is a higher first-cost, that cost is combated with a reduction in schedule length and with the benefits that precast concrete plank provides over a slab on deck system. From this analysis, precast concrete came out to be almost $300,000 more expensive. However, the duration for construction was two-thirds the time of the composite metal deck's.

By adjusting the schedule in such a way to condense concrete activities or to expedite the work so as to have the concrete and grouting work earlier in the construction schedule, there will be cost savings on methods and materials to protect the curing from the cold weather, but not on the overtime labor. With concrete on the critical path, it is difficult to maintain a schedule without falling too far behind with the succeeding activities. This can be supported by spending the money and expediting the work. There are several effective and efficient methods available and should be taken advantage of if the situation arises.

Overall, this thesis shows ways that a higher education owner can benefit from building information modeling, especially when it comes to operations and maintenance. When considering a flooring system, there's more to consider than just cost a schedule such as what is the final effect of the system. Even with a tight schedule, there are ways around working in adverse weather conditions.

Appendix A – Site Plans

Site Plan – Existing Conditions



Proposed Site Fence

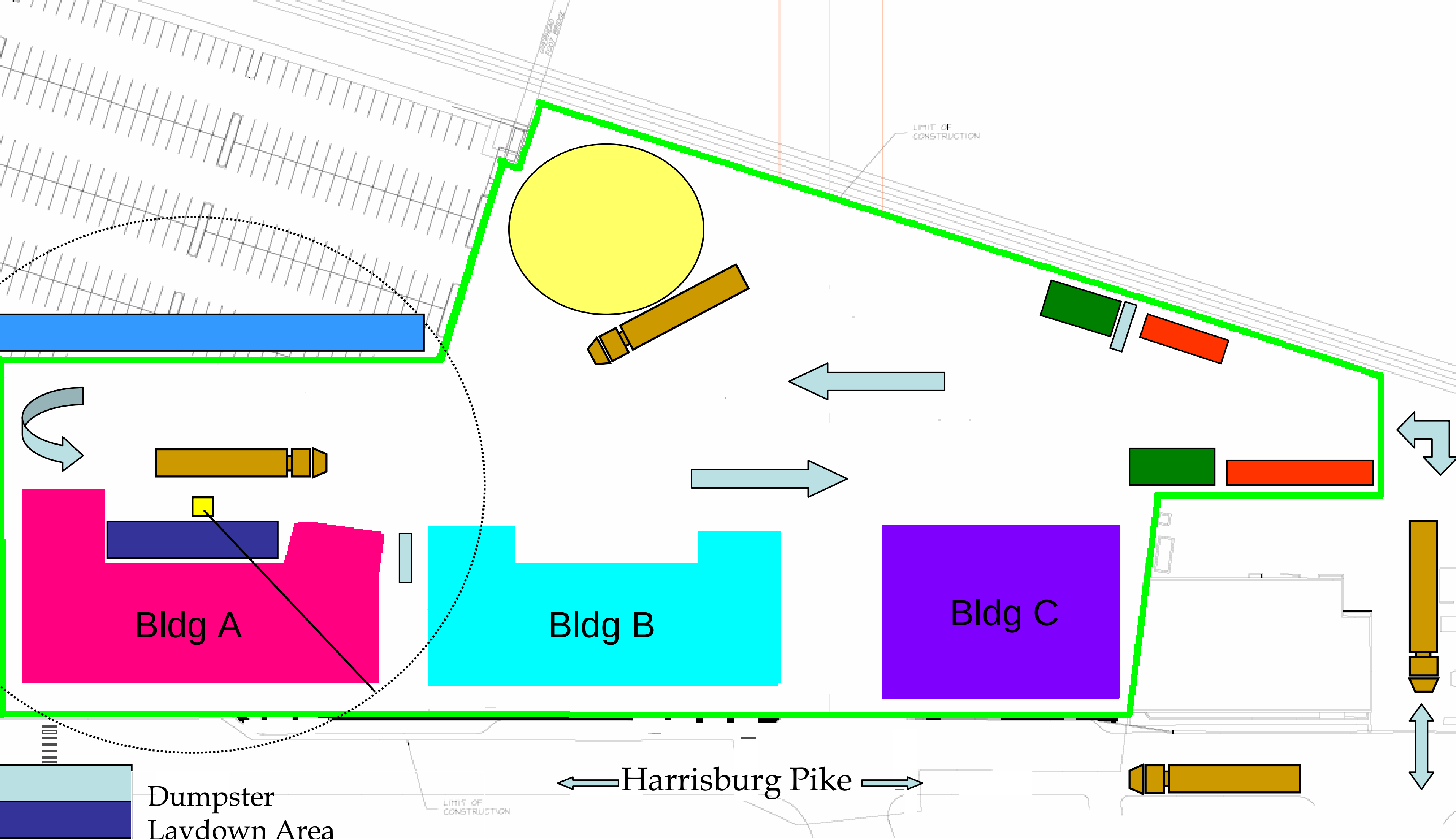
Existing Buildings to be Demoed

Proposed Buildings

Site Plan – Existing Conditions
Franklin & Marshall College Row
Lancaster ,PA

Appendix A – Site Plans

Site Layout Plan – Superstructure



Dumpster
Laydown Area
Trailers
Main Building
Site Fence
Crane
Site Parking
Construction Parking
Staging Area

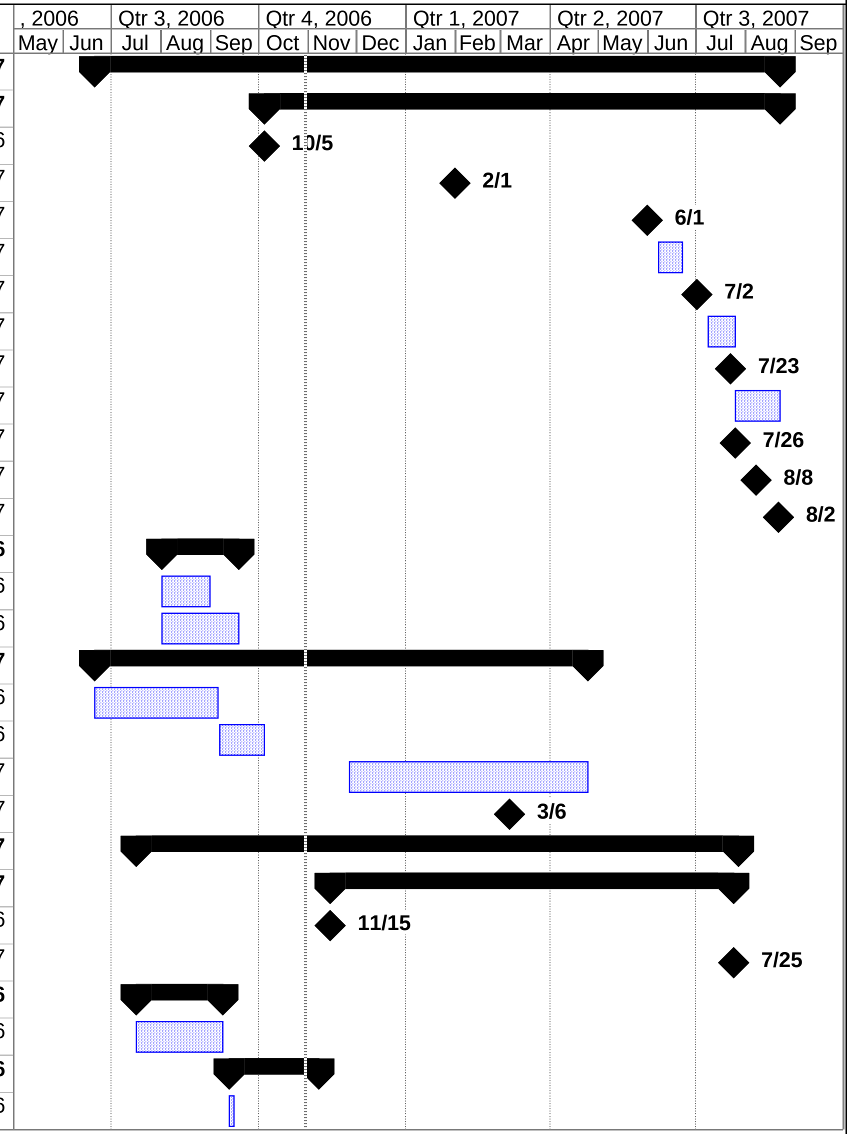
Site Layout Plan - Superstructure
Franklin & Marshall College Row
Lancaster ,PA

Appendix B – Project Schedules

Preliminary Detailed Project Schedule

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
1	**Construction**	**306 days?**	**Wed 6/21/06**	**Wed 8/22/07**
2	**General**	**230 days?**	**Thu 10/5/06**	**Wed 8/22/07**
3	PPL Power Relocation (Start)	0 days	Thu 10/5/06	Thu 10/5/06
4	Mock-up Apartment Complete	0 days	Thu 2/1/07	Thu 2/1/07
5	1st Floor Tenant Fitout Start	0 days	Fri 6/1/07	Fri 6/1/07
6	Life Safety Systems Testing	11 days?	Fri 6/8/07	Fri 6/22/07
7	Interior Finishes Complete	0 days	Mon 7/2/07	Mon 7/2/07
8	Final Cleaning	13 days?	Mon 7/9/07	Wed 7/25/07
9	Certificate of Occupancy	0 days	Mon 7/23/07	Mon 7/23/07
10	Complete Punchlist Work	20 days?	Thu 7/26/07	Wed 8/22/07
11	Owner Occupancy	0 days	Thu 7/26/07	Thu 7/26/07
12	Interior Punchlist Completion	0 days	Wed 8/8/07	Wed 8/8/07
13	Exterior/Public Punchlist Completion	0 days	Wed 8/22/07	Wed 8/22/07
14	**Demolition**	**34 days?**	**Wed 8/2/06**	**Mon 9/18/06**
15	Demo Building 1 - Federal Mogul	22 days?	Wed 8/2/06	Thu 8/31/06
16	Demo Building 2 - Warehouse	34 days?	Wed 8/2/06	Mon 9/18/06
17	**Sitework**	**220 days?**	**Wed 6/21/06**	**Tue 4/24/07**
18	Water, Sewer, and Storm Lines	55 days?	Wed 6/21/06	Tue 9/5/06
19	Underground Elec/Tele/Data Ductwork	20 days?	Thu 9/7/06	Wed 10/4/06
20	Curb/Elec/Stone/Pavement	107 days?	Mon 11/27/06	Tue 4/24/07
21	Demo Existing Sidewalk Complete	0 days	Tue 3/6/07	Tue 3/6/07
22	**Construction - Building A**	**270 days?**	**Mon 7/17/06**	**Fri 7/27/07**
23	**General**	**180 days**	**Wed 11/15/06**	**Wed 7/25/07**
24	Building Dry to Begin Finishes	0 days	Wed 11/15/06	Wed 11/15/06
25	Substantial Completion	0 days	Wed 7/25/07	Wed 7/25/07
26	**Sitework**	**40 days?**	**Mon 7/17/06**	**Fri 9/8/06**
27	Backfill Foundation	40 days?	Mon 7/17/06	Fri 9/8/06
28	**Concrete**	**40 days?**	**Wed 9/13/06**	**Tue 11/7/06**
29	Pour Second Floor Slab	3 days?	Wed 9/13/06	Fri 9/15/06

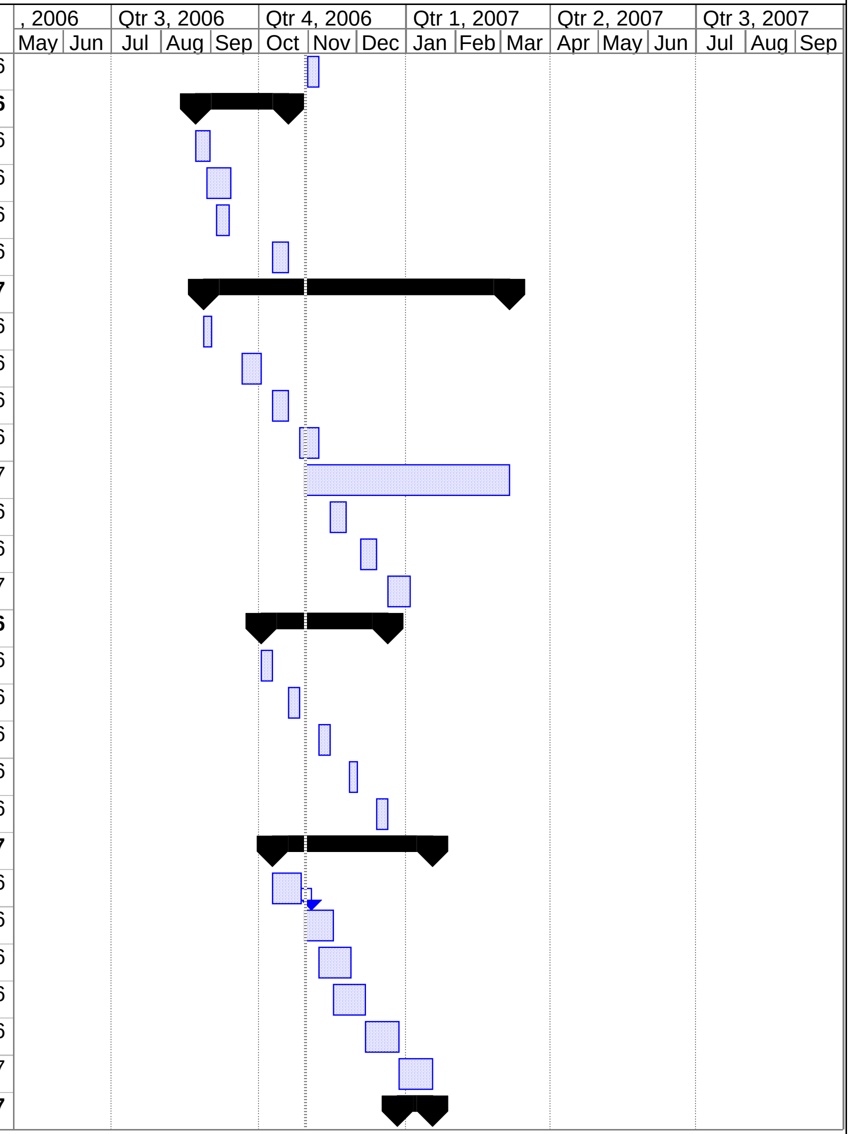


Project: Schedule.mpp
Date: Mon 10/30/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
30	Slab on Grade	5 days?	Wed 11/1/06	Tue 11/7/06
31	**Structural Steel**	**42 days?**	**Wed 8/23/06**	**Thu 10/19/06**
32	Erect Structural Steel	7 days?	Wed 8/23/06	Thu 8/31/06
33	Detail Steel	11 days?	Wed 8/30/06	Wed 9/13/06
34	Steel Deck and Studs	6 days?	Tue 9/5/06	Tue 9/12/06
35	Brick Angles / Frames 2nd Floor	8 days?	Tue 10/10/06	Thu 10/19/06
36	**Masonry**	**137 days?**	**Mon 8/28/06**	**Tue 3/6/07**
37	Masonry Foundation Walls	5 days?	Mon 8/28/06	Fri 9/1/06
38	Block Bearing Walls / Grout - 2nd Floor	8 days?	Thu 9/21/06	Mon 10/2/06
39	Block Bearing Walls / Grout - 3rd Floor	8 days?	Tue 10/10/06	Thu 10/19/06
40	Block Bearing Walls / Grout - 4th Floor	8 days?	Fri 10/27/06	Tue 11/7/06
41	Exterior Masonry	92 days?	Mon 10/30/06	Tue 3/6/07
42	Block Bearing Walls / Grout - 5th Floor	8 days?	Wed 11/15/06	Fri 11/24/06
43	Block Bearing Walls / Grout - 6th Floor	8 days?	Mon 12/4/06	Wed 12/13/06
44	Roof Masonry	10 days?	Thu 12/21/06	Wed 1/3/07
45	**Precast Plank**	**57 days?**	**Tue 10/3/06**	**Wed 12/20/06**
46	Floor Plank - 3rd Floor	5 days?	Tue 10/3/06	Mon 10/9/06
47	Floor Plank - 4th Floor	5 days?	Fri 10/20/06	Thu 10/26/06
48	Floor Plank - 5th Floor	5 days?	Wed 11/8/06	Tue 11/14/06
49	Floor Plank - 6th Floor	5 days?	Mon 11/27/06	Fri 12/1/06
50	Floor Plank - Roof	5 days?	Thu 12/14/06	Wed 12/20/06
51	**Exterior Studs / Framing**	**72 days?**	**Tue 10/10/06**	**Wed 1/17/07**
52	Exterior Metal Studs - 2nd Floor	14 days?	Tue 10/10/06	Fri 10/27/06
53	Exterior Metal Studs - 3rd Floor	14 days?	Mon 10/30/06	Thu 11/16/06
54	Exterior Metal Studs - 1st Floor	14 days?	Wed 11/8/06	Mon 11/27/06
55	Exterior Metal Studs - 4th Floor	14 days?	Fri 11/17/06	Wed 12/6/06
56	Exterior Metal Studs - 5th Floor	15 days?	Thu 12/7/06	Wed 12/27/06
57	Exterior Metal Studs - 6th Floor	15 days?	Thu 12/28/06	Wed 1/17/07
58	**Roofing**	**16 days?**	**Wed 12/27/06**	**Wed 1/17/07**

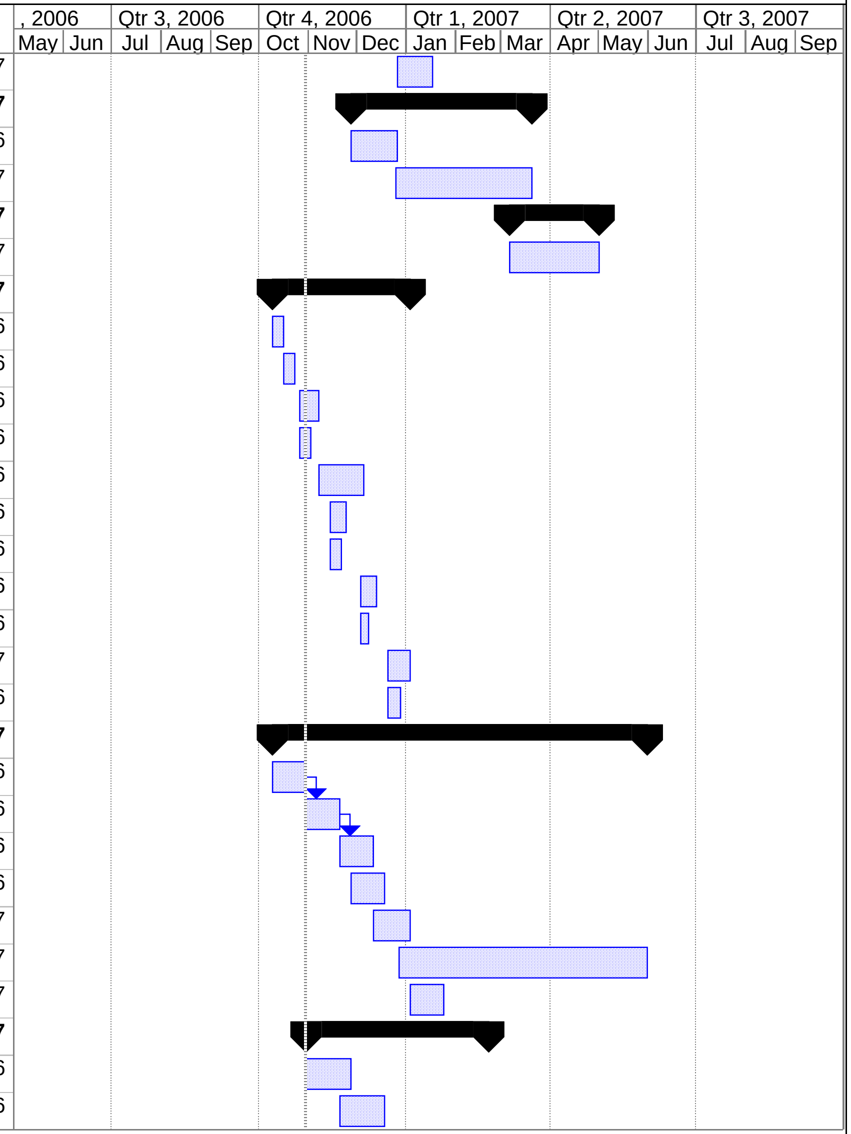


Project: Schedule.mpp
Date: Mon 10/30/06

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
59	Roofing Curb/Insulation/Membrane	16 days?	Wed 12/27/06	Wed 1/17/07
60	**Windows / Curtainwall**	**81 days?**	**Tue 11/28/06**	**Tue 3/20/07**
61	Storefront at Retail Spaces	21 days?	Tue 11/28/06	Tue 12/26/06
62	Windows	61 days?	Tue 12/26/06	Tue 3/20/07
63	**Metal Panels**	**40 days?**	**Wed 3/7/07**	**Tue 5/1/07**
64	Metal Panels	40 days?	Wed 3/7/07	Tue 5/1/07
65	**Miscellaneous Metal**	**62 days?**	**Tue 10/10/06**	**Wed 1/3/07**
66	Stairway 1 & 2 - 1st to 2nd Floor	5 days?	Tue 10/10/06	Mon 10/16/06
67	Stairway 1 & 2 - 2nd to 3rd Floor	5 days?	Tue 10/17/06	Mon 10/23/06
68	Brick Angles / Frames - 3rd Floor	8 days?	Fri 10/27/06	Tue 11/7/06
69	Stairway 1 & 2 - 3rd to 4th Floor	5 days?	Fri 10/27/06	Thu 11/2/06
70	Misc. Metal - 1st - TOW Bracing	20 days?	Wed 11/8/06	Tue 12/5/06
71	Brick Angles / Frames - 4th Floor	8 days?	Wed 11/15/06	Fri 11/24/06
72	Stairway 1 & 2 - 4th to 5th Floor	5 days?	Wed 11/15/06	Tue 11/21/06
73	Brick Angles/ Frames - 5th Floor	8 days?	Mon 12/4/06	Wed 12/13/06
74	Stairway 1 & 2 - 5th to 6th Floor	5 days?	Mon 12/4/06	Fri 12/8/06
75	Brick Angles / Frames - 6th Floor	10 days?	Thu 12/21/06	Wed 1/3/07
76	Stairway 1 & 2 - 6th Floor to Roof	6 days?	Thu 12/21/06	Thu 12/28/06
77	**Interior Studs and Drywall**	**168 days?**	**Tue 10/10/06**	**Thu 5/31/07**
78	Interior Metal Studs - 2nd Floor	15 days?	Tue 10/10/06	Mon 10/30/06
79	Interior Metal Studs - 3rd Floor	15 days?	Tue 10/31/06	Mon 11/20/06
80	Interior Metal Studs - 4th Floor	15 days?	Tue 11/21/06	Mon 12/11/06
81	Interior Metal Studs - 1st Floor	15 days?	Tue 11/28/06	Mon 12/18/06
82	Interior Metal Studs - 5th Floor	17 days?	Tue 12/12/06	Wed 1/3/07
83	Interior Drywall / Ceilings	111 days?	Thu 12/28/06	Thu 5/31/07
84	Interior Metal Studs - 6th Floor	15 days?	Thu 1/4/07	Wed 1/24/07
85	**MEP Trades**	**82 days?**	**Tue 10/31/06**	**Wed 2/21/07**
86	Mech/Elec/Plumb/Fire - 2nd Floor	20 days?	Tue 10/31/06	Mon 11/27/06
87	Mech/Elec/Plumb/Fire - 3rd Floor	20 days?	Tue 11/21/06	Mon 12/18/06



Project: Schedule.mpp
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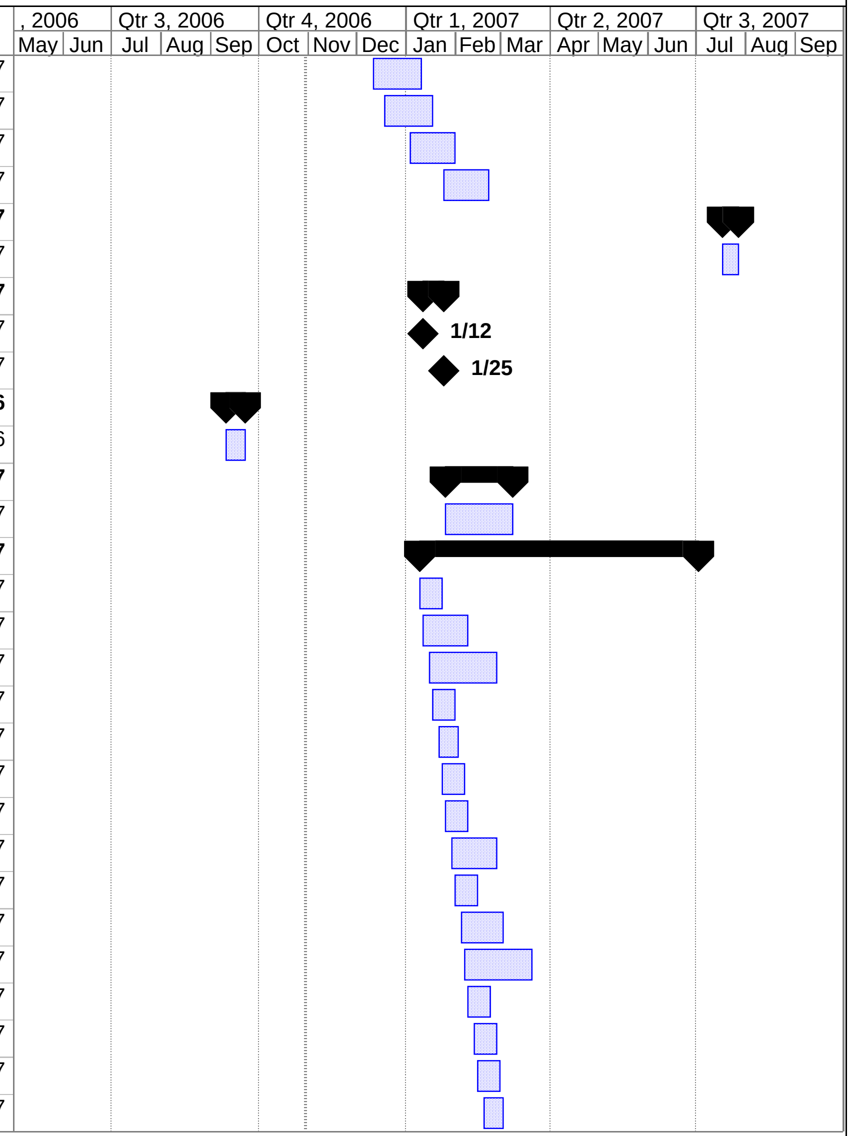
Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
88	Mech/Elec/Plumb/Fire - 4th Floor	22 days?	Tue 12/12/06	Wed 1/10/07
89	Mech/Elec/Plumb/Fire - 1st Floor	22 days?	Tue 12/19/06	Wed 1/17/07
90	Mech/Elec/Plumb/Fire - 5th Floor	20 days?	Thu 1/4/07	Wed 1/31/07
91	Mech/Elec/Plumb/Fire - 6th Floor	20 days?	Thu 1/25/07	Wed 2/21/07
92	**HVAC**	**8 days?**	**Wed 7/18/07**	**Fri 7/27/07**
93	HVAC Start-up/Test/Balance	8 days?	Wed 7/18/07	Fri 7/27/07
94	**Electrical**	**9 days**	**Fri 1/12/07**	**Thu 1/25/07**
95	Start Switchgear Installation	0 days	Fri 1/12/07	Fri 1/12/07
96	Permanent Power Available	0 days	Thu 1/25/07	Thu 1/25/07
97	**Plumbing**	**10 days?**	**Mon 9/11/06**	**Fri 9/22/06**
98	Underground Plumbing	10 days?	Mon 9/11/06	Fri 9/22/06
99	**Elevators**	**30 days?**	**Fri 1/26/07**	**Thu 3/8/07**
100	Elevator - for Construction	30 days?	Fri 1/26/07	Thu 3/8/07
101	**Finishes**	**124 days**	**Wed 1/10/07**	**Mon 7/2/07**
102	Interior Doors & Frames - 1st Floor	10 days	Wed 1/10/07	Tue 1/23/07
103	Casing and Baseboards - 1st Floor	20 days	Fri 1/12/07	Thu 2/8/07
104	Paint - 1st Floor	30 days	Tue 1/16/07	Mon 2/26/07
105	Casework - 1st Floor	10 days	Thu 1/18/07	Wed 1/31/07
106	Light Fixtures - 1st Floor	10 days	Mon 1/22/07	Fri 2/2/07
107	Door Hardware - 1st Floor	10 days	Wed 1/24/07	Tue 2/6/07
108	Plumbing Fixture - 1st Floor	10 days	Fri 1/26/07	Thu 2/8/07
109	Carpet & Resilients - 1st Floor	20 days	Tue 1/30/07	Mon 2/26/07
110	Interior Doors & Frames - 2nd Floor	10 days	Thu 2/1/07	Wed 2/14/07
111	Casing and Baseboards - 2nd Floor	20 days	Mon 2/5/07	Fri 3/2/07
112	Paint - 2nd Floor	30 days	Wed 2/7/07	Tue 3/20/07
113	Casework - 2nd Floor	10 days	Fri 2/9/07	Thu 2/22/07
114	Light Fixtures - 2nd Floor	10 days	Tue 2/13/07	Mon 2/26/07
115	Door Hardware - 2nd Floor	10 days	Thu 2/15/07	Wed 2/28/07
116	Plumbing Fixture - 2nd Floor	10 days	Mon 2/19/07	Fri 3/2/07

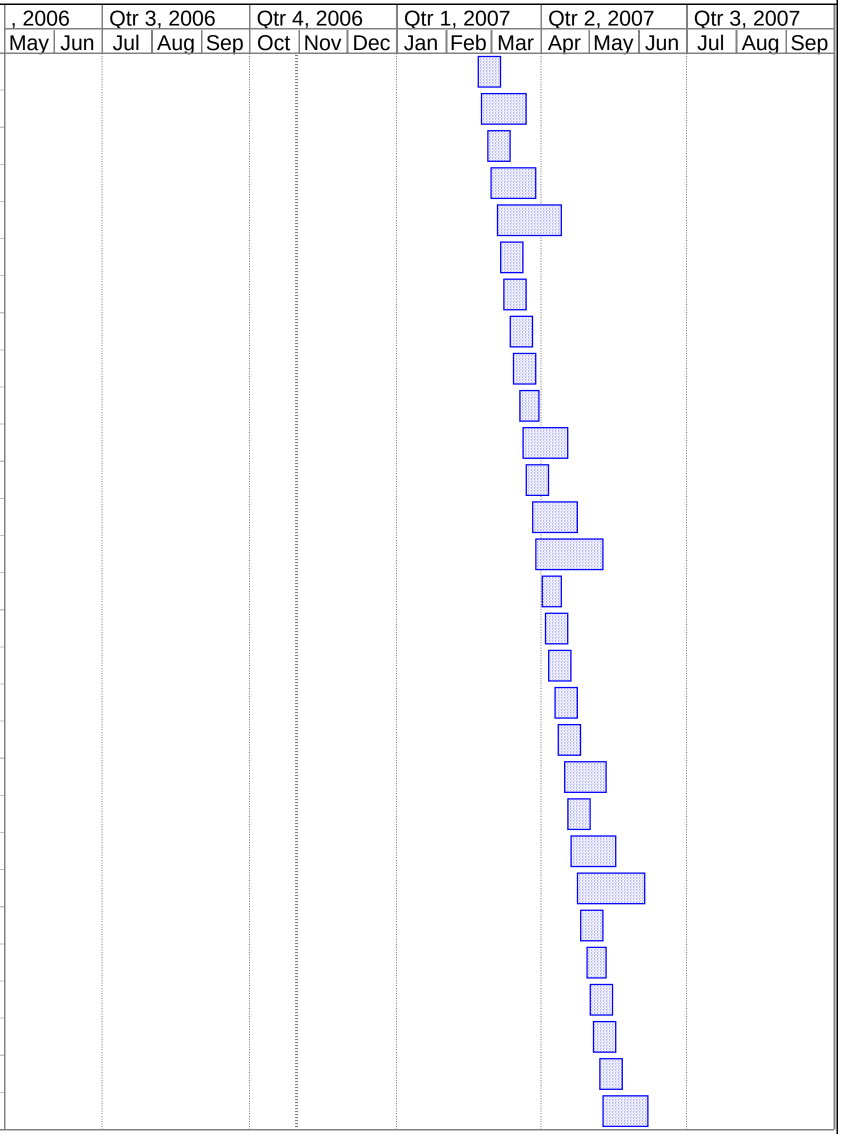


Project: Schedule.mpp
Date: Mon 10/30/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
117	Appliances - 2nd Floor	10 days	Wed 2/21/07	Tue 3/6/07
118	Carpet & Resilients - 2nd Floor	20 days	Fri 2/23/07	Thu 3/22/07
119	Interior Doors & Frames - 3rd Floor	10 days	Tue 2/27/07	Mon 3/12/07
120	Casing and Baseboards - 3rd Floor	20 days	Thu 3/1/07	Wed 3/28/07
121	Paint - 3rd Floor	30 days	Mon 3/5/07	Fri 4/13/07
122	Casework - 3rd Floor	10 days	Wed 3/7/07	Tue 3/20/07
123	Light Fixtures - 3rd Floor	10 days	Fri 3/9/07	Thu 3/22/07
124	Door Hardware - 3rd Floor	10 days	Tue 3/13/07	Mon 3/26/07
125	Plumbing Fixture - 3rd Floor	10 days	Thu 3/15/07	Wed 3/28/07
126	Appliances - 3rd Floor	10 days	Mon 3/19/07	Fri 3/30/07
127	Carpet & Resilients - 3rd Floor	20 days	Wed 3/21/07	Tue 4/17/07
128	Interior Doors & Frames - 4th Floor	10 days	Fri 3/23/07	Thu 4/5/07
129	Casing and Baseboards - 4th Floor	20 days	Tue 3/27/07	Mon 4/23/07
130	Paint - 4th Floor	30 days	Thu 3/29/07	Wed 5/9/07
131	Casework - 4th Floor	10 days	Mon 4/2/07	Fri 4/13/07
132	Light Fixtures - 4th Floor	10 days	Wed 4/4/07	Tue 4/17/07
133	Door Hardware - 4th Floor	10 days	Fri 4/6/07	Thu 4/19/07
134	Plumbing Fixture - 4th Floor	10 days	Tue 4/10/07	Mon 4/23/07
135	Appliances - 4th Floor	10 days	Thu 4/12/07	Wed 4/25/07
136	Carpet & Resilients - 4th Floor	20 days	Mon 4/16/07	Fri 5/11/07
137	Interior Doors & Frames - 5th Floor	10 days	Wed 4/18/07	Tue 5/1/07
138	Casing and Baseboards - 5th Floor	20 days	Fri 4/20/07	Thu 5/17/07
139	Paint - 5th Floor	30 days	Tue 4/24/07	Mon 6/4/07
140	Casework - 5th Floor	10 days	Thu 4/26/07	Wed 5/9/07
141	Light Fixtures - 5th Floor	10 days	Mon 4/30/07	Fri 5/11/07
142	Door Hardware - 5th Floor	10 days	Wed 5/2/07	Tue 5/15/07
143	Plumbing Fixture - 5th Floor	10 days	Fri 5/4/07	Thu 5/17/07
144	Appliances - 5th Floor	10 days	Tue 5/8/07	Mon 5/21/07
145	Carpet & Resilients - 5th Floor	20 days	Thu 5/10/07	Wed 6/6/07

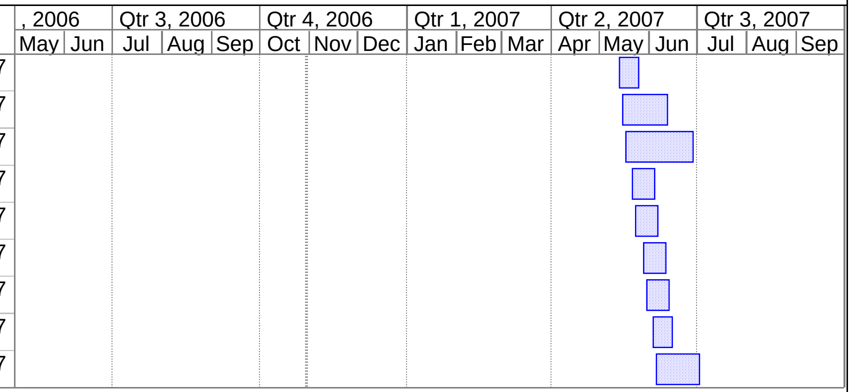


Project: Schedule.mpp
Date: Mon 10/30/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
146	Interior Doors & Frames - 6th Floor	10 days	Mon 5/14/07	Fri 5/25/07
147	Casing and Baseboards - 6th Floor	20 days	Wed 5/16/07	Tue 6/12/07
148	Paint - 6th Floor	30 days	Fri 5/18/07	Thu 6/28/07
149	Casework - 6th Floor	10 days	Tue 5/22/07	Mon 6/4/07
150	Light Fixtures - 6th Floor	10 days	Thu 5/24/07	Wed 6/6/07
151	Door Hardware - 6th Floor	10 days	Tue 5/29/07	Mon 6/11/07
152	Plumbing Fixture - 6th Floor	10 days	Thu 5/31/07	Wed 6/13/07
153	Appliances - 6th Floor	10 days	Mon 6/4/07	Fri 6/15/07
154	Carpet & Resilients - 6th Floor	19 days	Wed 6/6/07	Mon 7/2/07



Project: Schedule.mpp
Date: Mon 10/30/06

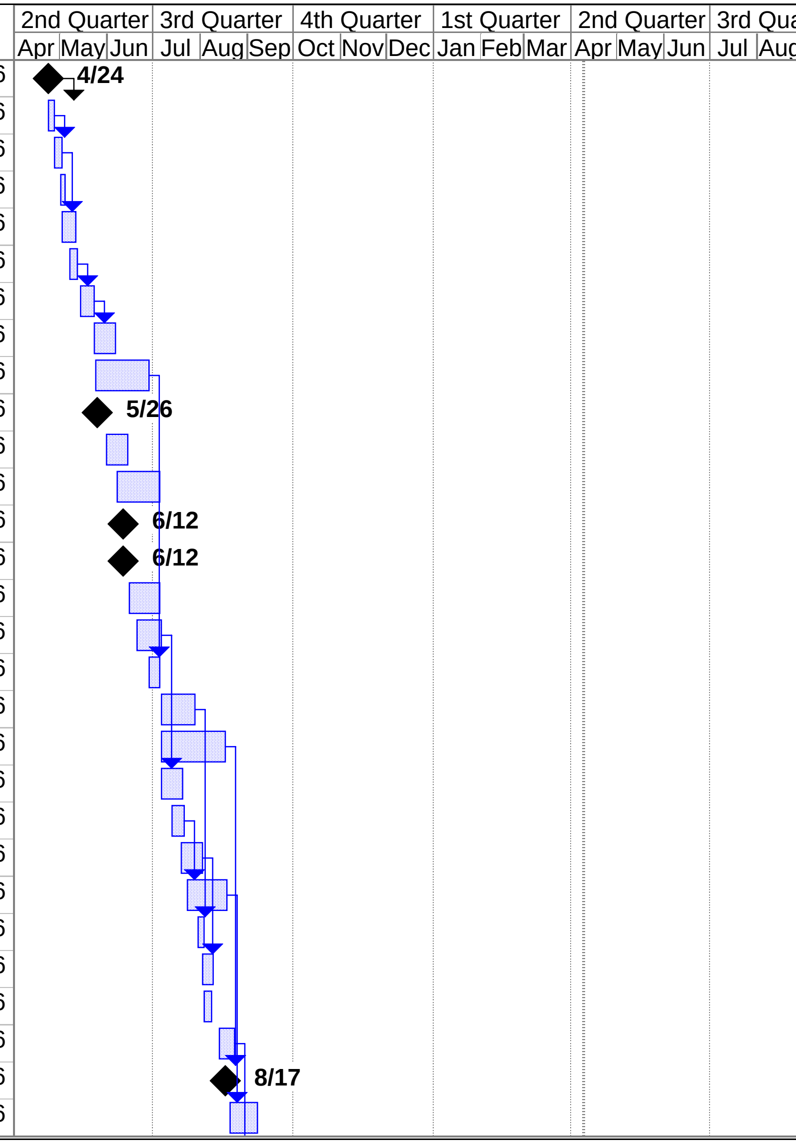
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Appendix B – Project Schedules

Updated Detailed Project Schedule

Preliminary Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	0 days	Mon 4/24/06	Mon 4/24/06
2	Site Survey	4 days	Mon 4/24/06	Thu 4/27/06
3	Site Mobilization/Layout	3 days	Fri 4/28/06	Tue 5/2/06
4	Erosion and Sediment Control	3 days	Tue 5/2/06	Thu 5/4/06
5	Site Clearing	7 days	Wed 5/3/06	Thu 5/11/06
6	Remove Asphalt Paving (West Lot)	5 days	Mon 5/8/06	Fri 5/12/06
7	Bulk Cut and Fill	7 days	Mon 5/15/06	Tue 5/23/06
8	Compaction Grouting	10 days	Wed 5/24/06	Tue 6/6/06
9	Water, Sewer, and Storm Lines	25 days	Thu 5/25/06	Wed 6/28/06
11	Obtain Foundation Permit	0 days	Fri 5/26/06	Fri 5/26/06
12	Foundation Excavation	10 days	Thu 6/1/06	Wed 6/14/06
13	Install Foundations	20 days	Thu 6/8/06	Wed 7/5/06
14	Obtain Demolition Permits	0 days	Mon 6/12/06	Mon 6/12/06
15	Obtain Building Permit	0 days	Mon 6/12/06	Mon 6/12/06
16	Demo Building 1	14 days	Fri 6/16/06	Wed 7/5/06
17	Backfill Foundation	12 days	Wed 6/21/06	Thu 7/6/06
18	Cap/Remove Storm Water Inlets	5 days	Thu 6/29/06	Wed 7/5/06
19	Demo Building 2	16 days	Fri 7/7/06	Fri 7/28/06
20	Curb/Elec/Stone/Pave West Lot	30 days	Fri 7/7/06	Thu 8/17/06
21	Structural Steel	10 days	Fri 7/7/06	Thu 7/20/06
22	Steel Deck and Studs	6 days	Fri 7/14/06	Fri 7/21/06
23	U/G Utilities	10 days	Thu 7/20/06	Wed 8/2/06
24	Misc. Metal - 1st Floor	20 days	Mon 7/24/06	Fri 8/18/06
25	Remove Asphalt Paving (East Lot)	4 days	Mon 7/31/06	Thu 8/3/06
26	Slab on Grade	5 days	Thu 8/3/06	Wed 8/9/06
27	Pour 2nd Floor Slab	3 days	Fri 8/4/06	Tue 8/8/06
28	Block Bearing Walls/Grout 2nd Floor	8 days	Mon 8/14/06	Wed 8/23/06
29	Turn Over Weat Parking Lot	0 days	Thu 8/17/06	Thu 8/17/06
30	Exterior Metal Studs 1st Floor	14 days	Mon 8/21/06	Thu 9/7/06

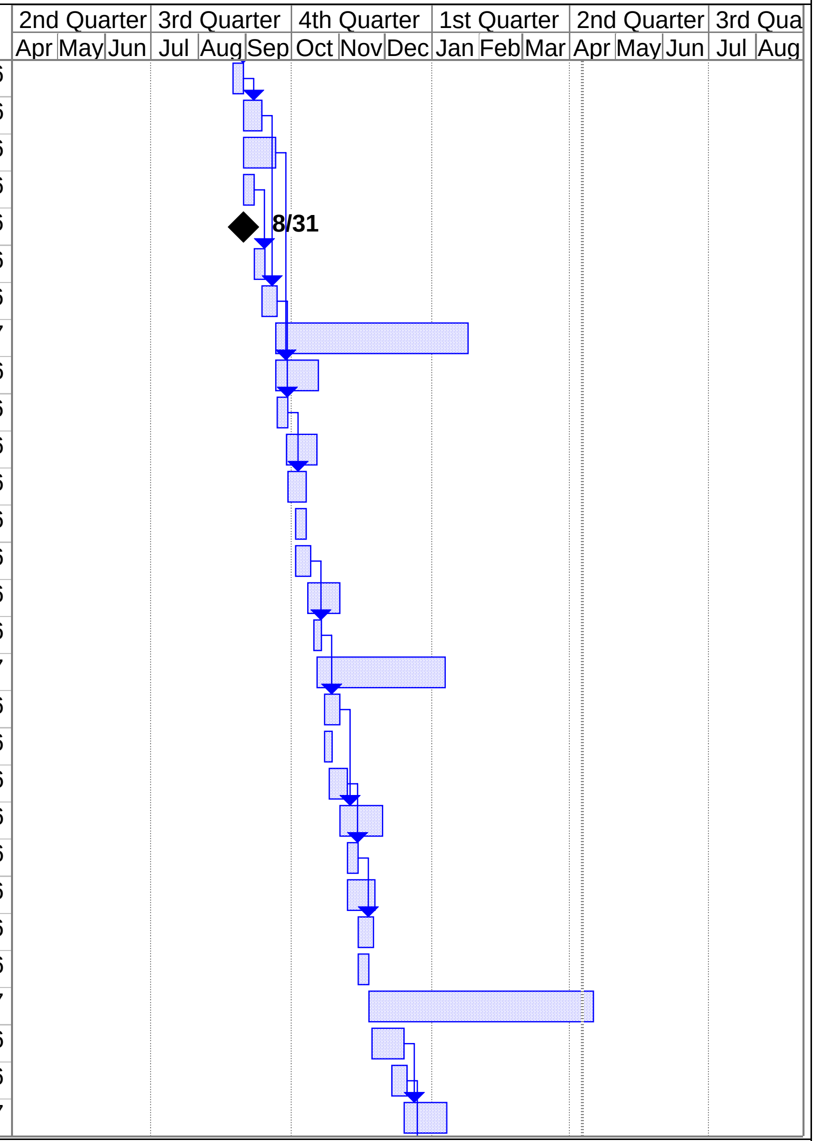


Project: Preliminary_Schedule.mpp
Date: Mon 4/9/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Preliminary Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
31	Floor Plank 3rd Floor	5 days	Thu 8/24/06	Wed 8/30/06
32	Brick Angles/Frames 2nd Floor	8 days	Thu 8/31/06	Mon 9/11/06
33	Interior Metal Studs 2nd Floor	15 days	Thu 8/31/06	Wed 9/20/06
34	Stairways 1 & 2 (1st to 2nd Floor)	5 days	Thu 8/31/06	Wed 9/6/06
35	Start Switchgear Installation	0 days	Thu 8/31/06	Thu 8/31/06
36	Stairways 1 & 2 (2nd to 3rd Floor)	5 days	Thu 9/7/06	Wed 9/13/06
37	Block Bearing Walls/Grout 3rd Floor	8 days	Tue 9/12/06	Thu 9/21/06
38	Exterior Masonry	90 days	Thu 9/21/06	Wed 1/24/07
39	Mech/Elec/Plumb/Fire 2nd Floor	20 days	Thu 9/21/06	Wed 10/18/06
40	Floor Plank 4th Floor	5 days	Fri 9/22/06	Thu 9/28/06
41	Exterior Metal Stud 2nd Floor	14 days	Thu 9/28/06	Tue 10/17/06
42	Brick Angles/Frames 3rd Floor	8 days	Fri 9/29/06	Tue 10/10/06
43	Stairway 1 & 2 (3rd to 4th Floor)	5 days	Wed 10/4/06	Tue 10/10/06
44	Block Bearing Walls/Grout 4th Floor	8 days	Wed 10/4/06	Fri 10/13/06
45	Interior Metal Studs 3rd Floor	15 days	Thu 10/12/06	Wed 11/1/06
46	Floor Plank 5th Floor	5 days	Mon 10/16/06	Fri 10/20/06
47	Aluminum Store Front & Windows	60 days	Wed 10/18/06	Tue 1/9/07
48	Brick Angles/Frames 4th Floor	8 days	Mon 10/23/06	Wed 11/1/06
49	Stairway 1 & 2 (4th to 5th Floor)	5 days	Mon 10/23/06	Fri 10/27/06
50	Block Bearing Walls/Grout 5th Floor	8 days	Thu 10/26/06	Mon 11/6/06
51	Mech/Elec/Plumb/Fire 3rd Floor	20 days	Thu 11/2/06	Wed 11/29/06
52	Floor Plank 6th Floor	5 days	Tue 11/7/06	Mon 11/13/06
53	Exterior Metal Studs 3rd Floor	14 days	Tue 11/7/06	Fri 11/24/06
54	Brick Angles/Frames 5th Floor	8 days	Tue 11/14/06	Thu 11/23/06
55	Stairway 1 & 2 (5th to 6th Floor)	5 days	Tue 11/14/06	Mon 11/20/06
56	Curb/Elec/Stone/Pave and Conc East Lot & Hbg	105 days	Tue 11/21/06	Mon 4/16/07
57	Interior Metal Studs 4th Floor	15 days	Thu 11/23/06	Wed 12/13/06
58	Block Bearing Walls/Grout 6th Floor	8 days	Wed 12/6/06	Fri 12/15/06
59	Mech/Elec/Plumb/Fire 4th Floor	20 days	Thu 12/14/06	Wed 1/10/07

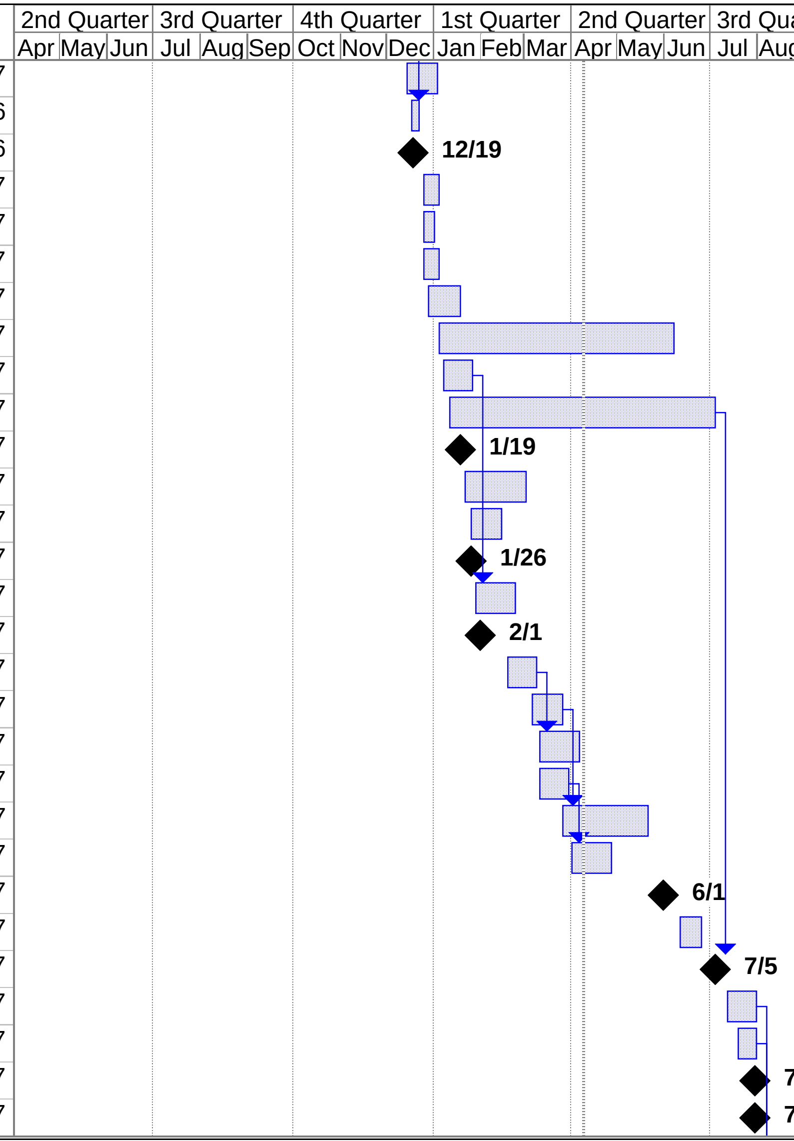


Project: Preliminary_Schedule.mpp
Date: Mon 4/9/07

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Preliminary Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
60	Exterior Metal Stud 4th Floor	14 days	Fri 12/15/06	Wed 1/3/07
61	Floor Plank Roof	5 days	Mon 12/18/06	Fri 12/22/06
62	Permanent Power Available on site	0 days	Tue 12/19/06	Tue 12/19/06
63	Brick Angles/Frames 6th Floor	8 days	Tue 12/26/06	Thu 1/4/07
64	Stairway 1 & 2 (6th Floor to Roof)	5 days	Tue 12/26/06	Mon 1/1/07
65	Roof Masonry	8 days	Tue 12/26/06	Thu 1/4/07
66	Roof Curb/Insulation/Membrane/Misc	15 days	Fri 12/29/06	Thu 1/18/07
67	Interior Drywall	110 days	Fri 1/5/07	Thu 6/7/07
68	Interior Metal Studs 5th Floor	15 days	Mon 1/8/07	Fri 1/26/07
69	Interior Finishes	124 days	Fri 1/12/07	Wed 7/4/07
70	Permanent Power Available in Building	0 days	Fri 1/19/07	Fri 1/19/07
71	Elevator (For Construction)	30 days	Mon 1/22/07	Fri 3/2/07
72	Exterior Metal Studs 5th Floor	14 days	Fri 1/26/07	Wed 2/14/07
73	Demo Existing Concrete Sidewalk Complete	0 days	Fri 1/26/07	Fri 1/26/07
74	Mech/Elec/Plumb/Fire 5th Floor	20 days	Mon 1/29/07	Fri 2/23/07
75	Mock Up Apartment Complete	0 days	Thu 2/1/07	Thu 2/1/07
76	Interior Metal Studs 6th Floor	15 days	Mon 2/19/07	Fri 3/9/07
77	Exterior Metal Studs 6th Floor	14 days	Wed 3/7/07	Mon 3/26/07
78	Mech/Elec/Plumb/Fire 6th Floor	20 days	Mon 3/12/07	Fri 4/6/07
79	Interior Metal Studs 1st Floor	15 days	Mon 3/12/07	Fri 3/30/07
80	Metal Panels	40 days	Tue 3/27/07	Mon 5/21/07
81	Mech/Elec/Plumb/Fire 1st Floor	20 days	Mon 4/2/07	Fri 4/27/07
82	1st Floor Tenant Fitout Start	0 days	Fri 6/1/07	Fri 6/1/07
83	Life Safety Systems Testing	10 days	Tue 6/12/07	Mon 6/25/07
84	Interior Finishes Complete	0 days	Thu 7/5/07	Thu 7/5/07
85	Final Cleaning	13 days	Fri 7/13/07	Tue 7/31/07
86	HVAC Start-Up/Test/Balance	8 days	Fri 7/20/07	Tue 7/31/07
87	Certificate of Occupancy	0 days	Tue 7/31/07	Tue 7/31/07
88	Substantial Completion	0 days	Tue 7/31/07	Tue 7/31/07

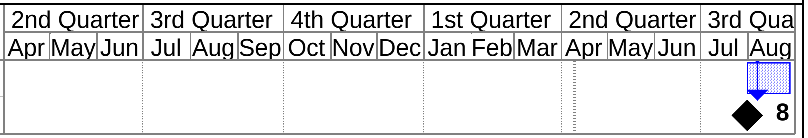


Project: Preliminary_Schedule.mpp
Date: Mon 4/9/07

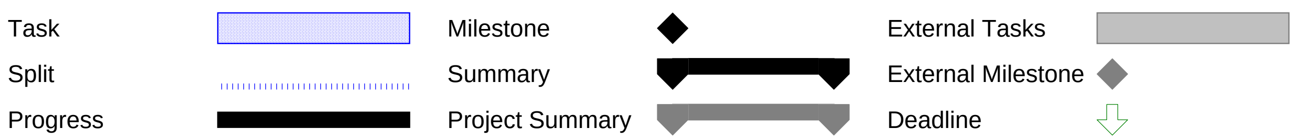
Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Preliminary Detailed Project Schedule
Franklin & Marshall College Row
Lancaster, PA

ID	Task Name	Duration	Start	Finish
89	Punchlist	20 days	Wed 8/1/07	Tue 8/28/07
90	Owner Occupancy	0 days	Wed 8/1/07	Wed 8/1/07



Project: Preliminary_Schedule.mpp
Date: Mon 4/9/07



Appendix C – Calculations

Reinforcement Redesign for Slab on Deck

Calculations for Minimum Rebar in Slab on Deck

LOADS

Live Loads:

Apartments = 40 psf
Corridors = 100 psf
= 140 psf

Dead Loads:

Partitions = 20 psf
Slab weight = 100 psf
120 psf

Design Load $= 1.2D + 1.6L = 1.2(120\text{psf}) + 1.6(140\text{psf})$
$= \underline{368\text{psf}}$

MOMENT

$$M_{max} = \frac{wl^2}{10} = \frac{368\text{psf}(25')^2}{10} = \underline{23^{k}}$$

STEEL

$A_{S,min} = 0.0018bd = 0.0018(12'')(7'') = 0.15\text{in}^2$

*assume #8 bars ⇒ $d = 8'' - 0.79 - 0.5(0.79) = 6.815''$

$d \simeq 7''$

∴ try #4's @ 12'' O.C. ⇒ $A_S = 0.2\text{in}^2$

$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{0.2 in^2 (60000 psi)}{0.85(4000 psi)(12'')} = \underline{\underline{0.29}}$$

$$\phi M_n \geq M_{max}$$

$$\phi M_n = \phi A_s f_y (d - a/2) = 0.9(0.2'')(60ksi)(7'' - 0.29''/2)$$

$$\phi M_n = \underline{\underline{74}}^{1k} \geq 23^{1k} \therefore ok$$

*** Ok to use #4's @ 12" O.C.**

Cost Comparison of Rebar vs. WWF

For one floor:

WWF (original design): 6x6-W2.1xW2.1

$53.50/csf (R.S. Means)

CSF = 12405 csf

cost/floor = $53.50/csf (12405 csf) = $663,700

Rebar (redesign): #4's @ 12" O.C.

$1800/ton (R.S. Means)

tons = 416 tons

cost/floor = $1800/ton (416 tons) = $748,000

* WWF is approximately an 11% cost savings for slab reinforcement

Appendix C – Calculations

Heat Loss during Winter Construction

Calculations for Required Temporay Heat

For one floor:

floors = 18607 sf
walls = 6855 sf
openings = 4992 sf

R-Values:

reinforced polyethylene thermoplastic = 0.85
8" CMU block walls = 1.71
8" Precast hollow core concrete plank = 0.64

$U = \frac{1}{R} \Rightarrow U = 1.18,$ respectfully
$= 0.58$
$= 1.56$

Average Temperatures:

December = 32°F
January = 27°F
February = 30°F
March = 39°F
$T_{ambient}$ = 50°F

Heat Loss:

$Q = UA(T_{in} - T_{out})$

December Heat Loss:

floors: $Q = 0.64 (18607 sf)(50°F - 32°F)$
$= 214352.64$ Btu/hr

walls: $Q = 1.71 (6855 sf)(50°F - 32°F)$
$= 210996.90$ Btu/hr

openings: $Q = 0.85 (4992 sf)(50°F - 32°F)$
$= 76377.60$ Btu/hr

$TOTAL_{DEC} = \underline{501727.14}$ Btu/hr

January Heat Loss:

floors: $Q = 0.64 (18607 sf)(50°F - 27°F)$
$= 273895.04$ Btu/hr

walls: $Q = 1.71 (6855 sf)(50°F - 27°F)$
$= 269607.15$ Btu/hr

openings: $Q = 0.85 (4992 sf)(50°F - 32°F)$
$= 97593.60$ Btu/hr

$TOTAL_{JAN} = \underline{641095.79}$ Btu/hr

February Heat Loss:

floors: $Q = 0.64(18607\,sf)(50°F - 30°F)$
$= 238169.60\ Btu/hr$

walls: $Q = 1.71(6855\,sf)(50°F - 30°F)$
$= 234441.00\ Btu/hr$

openings: $Q = 0.85(4992\,sf)(50°F - 30°F)$
$= 84864.00\ Btu/hr$

$TOTAL_{FEB} = \underline{\underline{557474.60\ Btu/hr}}$

March Heat Loss:

floors: $Q = 0.64(18607\,sf)(50°F - 39°F)$
$= 130993.28\ Btu/hr$

walls: $Q = 1.71(6855\,sf)(50°F - 39°F)$
$= 128942.55\ Btu/hr$

openings: $Q = 0.85(4992\,sf)(50°F - 39°F)$
$= 46675.20\ Btu/hr$

$TOTAL_{MAR} = \underline{\underline{306611.03\ Btu/hr}}$

Appendix D – Acknowledgements

I would like to thank those who took their time to guide and assist me throughout this thesis experience…

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  - Professor Robert Holland – AE Faculty
  - John Bechtel – OPP
  - Dick Tennant – OPP
  - Ed Gannon – OPP
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  - Dan Flickinger
  - Laura Galumbeck
  - Tim Kay

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  - Andy Bennett – Elkus|Manfredi Architects
  - Tom Walsh – Stantec Inc.

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- All my friends for their support

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  - Mom, Dad, Matt, Ashley, and Chris