MICHAEL FUNK

CONSTRUCTION MANAGEMENT

THESIS – SPRING 2007

FAIRFAX HIGH SCHOOL RENOVATION & ADDITION

MICHAEL FUNK
Construction Management Option
CPEP Website:
www.arche.psu.edu/thesis/eportfolio/current/portfolios/mdf178/

2006—2007

GRUNLEY construction

Fairfax High School Renovation & Addition

Fairfax, VA

PROJECT TEAM

Owner: City of Fairfax School Board

Construction Manager: BeeryRio Architecture & Interiors

General Contractor: *Grunley Construction Co.*

MEP & FP Engineers: Strickler Associates, P.C.

Structural Engineers: Ehlert/Bryan, Inc

Civil Engineers: Adtek Engineers, Inc.

PROJECT OVERVIEW

Function: School

Building Size: 410,000 S.F.

Location: Fairfax, VA

Estimated Project Cost: $45,000,000 (Lump Sum)

Construction Timeline: March '05—September '07

The project will occur in phases, and the students will occupy the building throughout duration.

ARCHITECTURAL FEATURES

• 70,000 S.F. of additional space being constructed

• State of the art classroom finishes

• Abuse resistant gypsum wallboard throughout

• CMU and Brick exterior wall systems

STRUCTURAL SYSTEM

• CMU and Brick exterior wall systems with steel framing used for new construction

• Metal Roof Decking system with expansion control and bituminous waterproofing

MECHANICAL SYSTEM

• Special System Room Air Conditioning Unit

• Rooftop Heating and Cooling Unit - Multi-Zone Gas Heating and DX Cooling

• Domestic Gas & Electric Water Heaters

• Hydraulically designed wet-pipe system covering the entire building

ELECTRICAL SYSTEM

• 1000 A capacity. 120V system

• Underground Electrical Service

• Dry-Type Transformers

• Emergency Back-up Generator

LIGHTING SYSTEM

• Performance based specification with a minimum 10 year life cycle cost.

• Sports Field Lighting

• Interior Fluorescent, Incandescent, and High Intensity Discharge lighting

Sponsored by Grunley Construction Co.

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ACKNOWLEDGEMENTS

I would like to thank the following people for all of their help and support throughout the course of this senior thesis:

Penn State Architectural Engineering Faculty:
o Dr. John Messner
o Dr. David Riley
o Dr. Michael Horman
o Professor Kevin Parfitt

Grunley Construction Company:
o Adam Swartout
o Tom Catherwood
o Greg McHugh
o Ryan Barney

All of the LEED® Rated project personnel that were contacted for my research.

My fellow AE students:
- Dan Baker
- Michael Abbondante
- Nate Paist

All of my friends and roommates and most importantly, I would like to thank all of my family, especially my Mom, Dad and Sister.

EXECUTIVE SUMMARY

This senior thesis report is a result of an in-depth study of the design and construction of the Fairfax High School Renovation and Addition. This report is broken down into five main sections.

The beginning of this report is to provide a background of the Fairfax High School that will aid the reader in the latter analyses sections. This section of the report includes a project design overview, a project team overview, existing conditions report, and project logistics details. This bulk of this information was composed during the fall semester, prior to start of our analyses.

'Going green' is a trend that continues to grow every year with projects across the country. LEED® rated buildings can be difficult to achieve. Maintaining this level of LEED® certification throughout the project's design and construction is generally a difficult task. In the spring semester, research was conducted to identify building owners' initial goals for how and why they wanted to achieve LEED®. The intent of this study was to provide owners with a guide during the planning phase and construction to assist the Project Managers throughout the duration of the project. The results of this study can be found in the second main section of this report.

The two remaining sections cover analyses that are geared towards minimizing material quantities in the building, the usage of contingencies, and schedule impacts. First a phasing re-design looks to minimize the use of contingency as well as the schedule delays. Next, an analysis of the usage of pre-cast versus cast-in-place concrete on the project looks to reduce the cost, schedule impact, as well as usage of materials.

PROJECT INTRODUCTION

Fairfax High School, located at 3500 Old Lee Highway in Fairfax, VA, is located in a beautiful area in Northern Virginia within close proximity to Washington, DC. This 340,000 ft^2 facility is being completely renovated with a 70,000 ft^2 section being added.

The renovation is designed to modernize the existing building aesthetically, electrically, and mechanically. Once complete, the building will be equipped with top of the line equipment and technology, making it a great student facility for years to come. There will be abuse resistant gypsum wallboard throughout the facility. New classrooms will be added, the administration area and library will be rebuilt and relocated, and significant improvements will be made to science labs, locker rooms, the auditorium, media room and the school's athletic facility. The 70,000 ft^2 of additional space being constructed will accommodate the growth in the area and eliminate the need for some local students to travel further distances to go to high school.

The renovation and addition, designed by BerryRio Architecture & Interiors, will be delivered using the Traditional Delivery Method with a Project Manager and a General Contractor. The construction schedule lasts for more than two years, starting in March of 2005 and completing in September of 2007.

In the following project background sections, you will find more information pertaining to the design, renovation, and construction of this exceptional school.

PROJECT OVERVIEW

Building Name:
Fairfax High School

Building Location:
3500 Old Lee Highway
Fairfax, VA 22030
Type of Site: Suburban

Building Occupant Name:
Fairfax High School

Occupancy:
School

Size (total square feet):
Renovation ~ 340,000 SF
Addition ~ 70,000 SF

Stories above Grade:
2 stories

Primary Project Team:
Owner:
City of Fairfax School Board
www.fairfaxva.gov

General Contractor :
Grunley Construction Co.
www.grunley.com

Construction Manager :
BerryRio Architecture & Interiors
www.berryrio.com

Engineers:
MEP & FP Engineers
Strickler Associates, P.C.

Structural Engineers
Ehlert/Bryan, Inc.
www.ehlert-bryan.com

Project Dates:
Date of Award – March 23, 2005
Anticipated Date of Completion – September 14, 2007

Cost:
$45,000,000 (Lump Sum Contract)

Project Delivery Method:
Design-Bid-Build

Architecture:

The renovation is designed to modernize the existing building aesthetically, electrically, and mechanically. Once complete, the building will be equipped with top of the line equipment and technology, making it a great student facility for years to come. There will be abuse resistant gypsum wallboard throughout the facility. New classrooms will be added, the administration area and library will be rebuilt and relocated, and significant improvements will be made to science labs, locker rooms, the auditorium, media room and the school's athletic facility. The 70,000 ft^2 of additional space being constructed will accommodate the growth in the area and eliminate the need for some local students to travel further distances to go to high school.

Building Codes Implemented:

1996 BOCA National Building Code
1996 BOCA National Electric Code
2000 International Mechanical and Plumbing Codes
ADA Accessibility Guidelines and CABO A117.1-92
1992 DC Construction Codes Supplement

The City of Fairfax Office of Code Administration

The edition of the VUSBC governing the Contract Documents shall be that edition which was in force for purposes of permit review and issuance by The City of Fairfax Office of Code Administration.

AAMA, AASHTO, ACI, AGA, AISC, ANSI, ASTM, ASHRAE, AWI, AWS, BIA, BHMA, CRI, CRSI, CS, DHI, IBC, MFMA, NAAMM, NCMA, NEC, NEMA, NFPA, NIST, NRCA, NSF, NTMA, OSHA, PCA, SMACNA, SDI, SJI, SSPC, TCA, UL, VDOT, VUSBC, ADA

Zoning and Historical Requirements:

Washington DC R-4 with Variances: Height, Lot Size, Occupancy, Parking

Building Envelope:

The project has CMU and brick exterior wall systems. There is metal roof decking with expansion control and bituminous waterproofing

Construction
The project will occur in phases, and students will occupy the building during the entire renovation.

Electrical
This project has a 1000 A capacity within a 120V system. There is an underground electrical service, dry-type transformers and an emergency back-up generator.

Lighting

Performance based specification with a minimum 10 year life cycle cost. The project utilized Sports Field Lighting for the baseball and football fields. Interior Fluorescent, Incandescent, and High Intensity Discharge lighting used in the school interior.

Mechanical

The Special System room contains its own unique Air Conditioning Unit. The rooftop heating and cooling unit uses multi-zone gas heating and DX cooling. The project contains domestic gas & electric water heaters.

Structural

CMU and Brick exterior wall systems with steel framing used for new construction. Metal Roof Decking system with expansion control and bituminous waterproofing

Fire Protection

A hydraulically designed wet-pipe system is being installed to cover the entire building.

Transportation

The project contains both hydraulic elevators and surface mounted vehicle lifts and alignment systems. The main purpose of the elevators is to meet ADA disability requirements.

Telecommunications

A cable television/Broadband distribution system will be put in place during the renovation and addition. The contractor is furnishing and installing a sound and intercommunications, master

clock and program systems. They will install a microprocessor controlled voice communication system with all low voltage wiring and equipment.

Special Systems

There is a detailed engineering design of a steel support structure, point supported structural glass and accessory parts performed by the glazed steel structure contractor. This structure must support a 30 psf live load and a 30 psf superimposed dead load.

Demolition

The demolition portion of the project is extremely planned out due to the phasing and sequencing of which areas they are able to work in. The demolition work varies from phase to phase depending on what portions of the school are included, but the electrical, mechanical and specialty furnishings must all be removed prior to work starting in those areas.

Concrete

Both cast-in-place and pre-cast concrete are utilized on this project. A structural plant cast is pre-cast to be used on site.

Support of Excavation

Temporary shoring put in place to support the foundation during excavation for the addition.

PROJECT TEAM OVERVIEW

Client Information:

The Fairfax City School Board, represented by George Stepp, is a governing body of the Fairfax, VA school district. They are devoted to completing this project which is designed to modernize the school architecturally, mechanically and electrically. The renovation will get the school up to date and ahead of the game for years to come. The new addition will accommodate the tremendous growth in the area and eliminate local students having to travel longer distances, as well as the need for classroom trailers being used.

The Primary Reason for the renovation was due to the drastic increase in class sizes and the school was forced to rent classroom trailers and place them in the back parking lot to accommodate for the sudden growth. The renovation will add more updated classrooms. As Phase 3 is completed, the remainder of the trailers will be removed.

The two major factors on the project are schedule and cost. The project is working around an occupied, operational school, and every September the kids return to school. There is no other building for the kids to attend, so the site must be ready for them. Cost is also a big issue. The contract for this project is $45 million, which included $1.2 million in contingency allowance for change order work. To date, almost $650,000 in changes have been settled. Once the allowance runs out, the school board has to somehow come up with more money. This makes changes a constant struggle. Safety is also a big issue with all the students occupying the school during construction. The contract requires building a floor to deck, drywall partition between all work areas, and occupied school areas. Area G will have a construction fence surrounding the area, and there is a full partition with no entrance into the school up between the school and Area G.

The project is being completed in phases so that the school can remain occupied at all times throughout the school year. The schedule is outlined in the phasing documents, and is part of the contract, so the CPM has to mirror the contract phasing. It would be very detrimental to miss a date for the turnover of any spaces. They continue to work with the school administrators to coordinate all work activities and turnover dates, and in most cases work areas are being released earlier than expected to help facilitate the completion dates. The schedule is the main key to satisfying the owner.

Project Delivery System:

With Design-Bid-Build the owner has the option to get a fair value for the work at a low price while still being selective about the general contractor. With Design-Bid-Build the contractors achieve the lowest competitive pricing from the subs and can pass that value on to the owner. However, this project was value engineered at contract time, to remove various items of scope, and the overall value of the project was reduced from $56 million to $45 million. The architect was contracted with a lump sum. All of the subcontractor hold lump sum contracts as well.

For the Fairfax High School project, the Architect is acting as the Construction Manager, resulting in only three parties being involved:

1. Owner – Fairfax City School Board - George Stepp
2. Architect / Engineer - BeeryRio
3. General Contractor - Grunley Construction – Greg McHugh

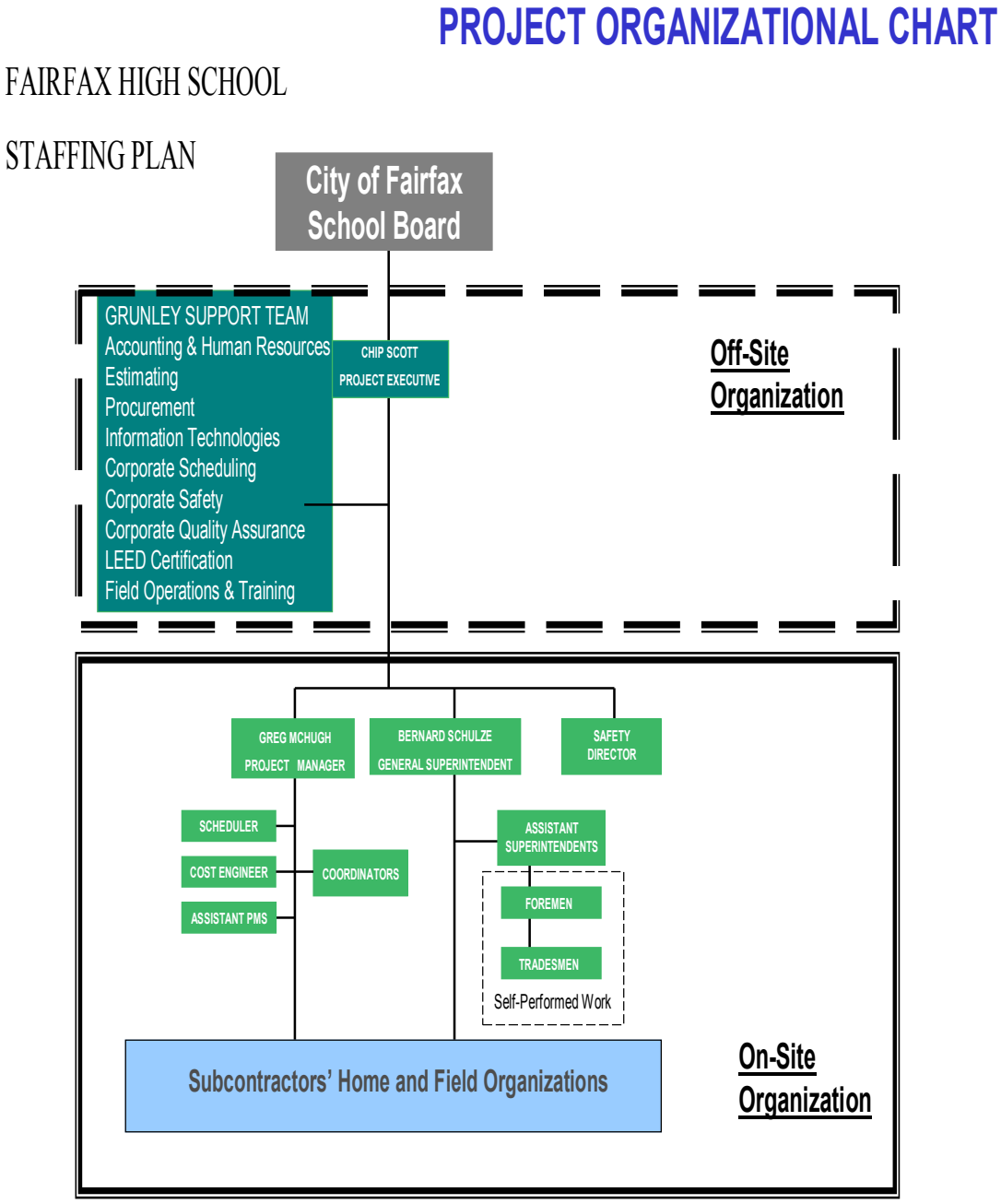
BeeryRio has a contract with the owner and has a subordinate contract with the Engineers, Ehlert/Bryant (Structural Engineer) and Strickler & Associates (MEP Engineer). BeeryRio also has a contract with Grunley Construction through the Owner.

BeeryRio has one onsite representative who is at the job day to day for immediate coordination and to act as the owner's quality control. They also have one Architect in their main office who is also the owner's representative for approving payment and negotiating change orders in addition to normal Architect duties. Grunley Construction has superintendent staff onsite everyday as well as the project manager.

Grunley Construction was the low bid on the job and had to select the Lowest Responsible Bid. For the big sub-contractors such as Mechanical, Electrical, Structural, and Sprinkler, the sub-contractor whose number was used on bid day was bought. However, for other subs the bid day number was used as a budget and they bought the sub-contractor they felt comfortable doing the job with.

Both a Bid Bond and Performance Bond were required on this project. Grunley Construction has insurance on the project, and requires a certificate of insurance on all sub-contractors working on the project, which must be up to date. As an extra, Grunley Construction keeps an insurance policy for their sub-contractors company wide, called "Sub Guard," which has a $500K deductible on any sub-contractor.

Staffing Plan:



EXISTING CONDITIONS REPORT

Local Conditions:

The national monuments in the Washington D.C. area are the prominent features, and there are building height restrictions imposed in the District in order to not take away from these structures. Concrete construction has been the most practical form of construction, and the labor force in the area truly reflects that trend. In recent years, there are more qualified steel contractors in the area, trying to increase the use of steel as a structural system.

At the Fairfax High School site, the construction team was provided roughly 60 parking spaces located behind the gymnasium. Throughout the school year, the parking situation does not impact the project due to minimal work being conducted while school is in session. During the school year, the man power counts are between fifty and sixty. During the summer, the man power counts is up around 150, however parking is available anywhere onsite other than a few teacher's parking spaces, which work year round.

There are no requirements for recycling, or use of recycled material on this project. However, most trash is separated by Concrete/CMU, and Steel, as opposed to normal construction debris.

They have yet to incur any impacts from bad soil aside from minimal spots in the front parking where they were directed to undercut portions of the existing soil and fill with 21A aggregate. Most of the soil being uncovered has been beneath the existing building for over thirty years, which is thirty years of compaction from the building, and there has not been a problem achieving 95 - 100 % bearing.

Vicinity Maps:

Below you will find two vicinity maps. The top one shows the location of the Fairfax High School in the Virginia/Washington D.C. area, while the bottom one zooms in to show the position of the project within the community.

Site Layout Planning:

See Appendix A.

PROJECT LOGISTICS DETAILS

Detailed Project Schedule:

The schedule for the Fairfax High School project is very complex and there is little room for error due to the need for the school to stay open throughout the entire job. Notice to proceed was on April 6th, 2005 and is scheduled to be completed in September of 2007. There are a total of four Phases, each divided into its own respective Areas.

Key dates, milestones, and activity durations:

- 4/06/05 – Phase 1 Notice to Proceed
- 4/21/05 - Mobilization
- 12/16/05 – Phase 1 Finish milestone
- 1/04/06 – Phase 2 Start milestone
- 9/11/06 – Phase 2 Finish milestone
- 6/27/07 – Phase 3 Start milestone
- 9/04/07 – Phase 3 Finish milestone
- 6/27/07 – Phase 4 Start milestone
- 9/04/07 – Phase 4 Finish milestone

The detailed project schedule is located in *Appendix B*.

Estimate Summary:

An estimate of the Project Costs for the Fairfax High School can be seen in the following section.

Building Details

Size (total square feet)
Renovation ~ 340,000 SF
Addition ~ 70,000 SF

Number of stories: 2

Actual Building Construction Cost

Construction Cost: $45,000,000
Note: Not including land costs, site work, permitting, etc.

Construction Cost/Sq. Ft.: $109.76/Sq. Ft.

Total Project Costs

Total Cost: $45,000,000
Note: The total cost includes the overhead, profit, fee, and also the contingency.

Total Cost/Sq. Ft.: $109.76/Sq. Ft.

Building Systems Cost

Site Work: $2,300,000
Cost/Sq. Ft.: $19.57/SF

Electrical: $6,545,000
Cost/Sq. Ft.: $6.88/SF

Mechanical: $9,470,000
Total Mechanical/Sq. Ft.: $4.75/SF

Plumbing/HVAC: $7,099,000
Cost/Sq. Ft.: $6.34/SF

Fire Protection: $990,000
Cost/Sq. Ft.: $45.45/SF

Structural: $7,600,000
Total Structural/SF: $5.92/SF

Concrete: $650,000
Cost/SF: $9.65/SF

Masonry: $1,370,000
Cost/SF: $32.85/SF

Steel: $ 2,660,000
Cost/SF: $16.92/SF

Parametric Estimate via D4Cost 2002 Estimating

The D4Cost Database had several projects that were similar to the Fairfax High School project; however, the closest project cost found was approximately $28,000,000 for Jordan High School. This project was selected due to its similarity to the Fairfax High School project. The overall selection process was based on the square footage and number of stories with direct comparison to the cost.

The results yielded for Fairfax High School: $41,871,960

Square Foot Estimate via R.S. Means

Source: *RS Means Building Construction Cost Data – 63rd Annual Addition – 2005 (pg.512)*

The following Square Foot Estimate was completed through the RS Means source listed above.

Floor Area
Cost per square foot of floor area = $108.85
Square Foot Cost = $108.00 * 410,000 SF = *$44,280,000*

RS Means Cost Estimate: $44,280,000

Compare differences between your estimates and the actual project costs.

Total Actual Cost: $45,000,000

D4Cost Estimate result yielded for Fairfax High School: $41,871,960

RS Means Cost Estimate: $44,280,000

After both estimates were compiled and compared to the actual cost, minimal difference was shown. The D4 Cost estimate came in less than $4,000,000 lower than the actual cost. D4 Cost's database had a lot of educational projects to compare to, which helped when doing the estimate. The selection process for the source buildings dealt with building use, size, number of floors, and building cost. The program then adjusted the time and location factors for construction. The RS Means Square Foot Estimate came in less than $1,000,000 lower than the actual cost. Although the two estimates were a little low, they were still fairly accurate compared to the actual project cost. The discrepancies more than likely resulted due to all of the specialty equipment for the various areas of the school.

ANALYSIS 1

LEED® Guide Depth Study

Problem Statement:

While there is more focus on green design and obtaining a certain level of LEED® certification, it is still difficult to pursue the various points throughout the construction process as well ass maintain the certification over the years. Aligning the owner's goals with corresponding LEED® points can result in a better quality building for its intended use and a more structured approach towards obtaining the initial LEED® certification level. Developing a tutorial for achieving the various points will enable more projects to not only pursue the certification, but it would make the process itself much easier.

Research Goal:

My research will be focused on developing a strategy that can be utilized from the very beginning of the project. It will be used from the very start of the design process, which will initially help them gain a working knowledge of the LEED® classification system and what type of building to design based on the certification they are looking to obtain. I am pursuing this topic based on my intern experiences the past two summers. I worked for Grunley Construction on the Eisenhower Executive Office Building project, which is looking to obtain a LEED-EB rating. I worked with a Project Manager to develop an excel spreadsheet of all of the points that we were going for and the status of what still needed to be done. This guide will allow everyone on the project to be educated on the system and how to best utilize it on their own respective projects. An open forum will be included to allow everyone to give and receive open feedback and lessons learned from various projects.

Research Steps:

Although I have some work related experience on the LEED® system, before I can compile a comprehensive guide, I will need to get an in-depth knowledge of the system. I will start researching the criteria for the various certifications. Throughout my research, I will meet with and interview Project Managers that have worked on LEED® projects to receive their input and suggestions. Once this information is collected, I will begin to develop a core outline of the guide. With the feedback from individuals knowledgeable in the area, I will develop an in-depth guide. Once finished, I will have several key individuals test out the guide. A survey will be provided so that I can obtain positive and negative feedback on the LEED® guide. Finally, I will adjust the guide accordingly based on the feedback I receive from the surveys.

Methodology

1. Literature review to become more familiar with LEED®.
2. Develop a list of interview questions to determine the owner's goals.

3. Identify and interview different owners on different LEED® Rated projects.
4. Provide a survey for owners and project managers to help further my research.
5. Develop an outline for a guide that will benefit owners and project managers from the start of a project.
6. Have several project managers test out the guide, obtain feedback, and develop a final version of the guide.

Tools:

1. U.S. Green Building Council website (www.usgbc.org)
2. LEED® Green Building Rating System for New Construction and Major Renovations (LEED®-NC) Version 2.1
3. Microsoft Excel

Outcome:

The expected results of this research will help me to develop a guide that will reduce the difficulty in obtaining a LEED® certification. This should lead to an increase in the desire for owners to pursue these certifications. This will produce buildings that are safer for the environment, increase recycling and safe owners and general contractor's time and money.

An example of a typical excel spreadsheet has been included to provide an example of what would be contained in the guide. Each point should have a list of requirements describing what needs to be done in order to obtain the point, when the work needs to be started, and who is responsible for doing the work to obtain the point.

Example Excel Spreadsheet:

The following spreadsheet shows an example of what is done for each point that is going to be pursued for a project. It includes the Specification Section, Description, Responsible Party, Material Cost, Location, Comments, and deadline for submission.

LEED LOG

Spec Section	Description	Resp Party	Material Cost	Location	Comments	Due By
08110	Standard Steel Doors and Frames	AG Mauro			Sent: 6/29/05 Received:	**7/8/2005**
05310	Steel Deck and Plate	AIW			Sent: 6/29/05 Received:	**7/8/2005**
10605	Hardware Cloth	AIW			Sent: 6/29/05 Received:	**7/8/2005**
04065	Stone Mortar	Atlantic			Sent: 6/29/05 Received:	**7/8/2005**
07210	Building Insulation - Product Data - STONE	Atlantic			Sent: 6/29/05 Received:	**7/8/2005**
07620	Sheet Metal Flashing and Trim - Stonework	Atlantic			Sent: 6/29/05 Received:	**7/8/2005**
07900	Joint Sealants - Stone Control Joints	Atlantic			Sent: 6/29/05 Received:	**7/8/2005**
08800	Glass and Glazing - Transom Glass	AV Smoot		Glass Manufacturer: Oldcastle Glass - Telford, PA Wood from existing/salvaged transoms	Sent: 6/29/05 Received: 6/29/05	-
07814	Interior Intumescent Fireproofing	Ballard			Sent: 6/29/05 Received:	**7/8/2005**
07900	Joint Sealants - Partition Opening Perimeter Joints	Ballard			Sent: 6/29/05 Received:	**7/8/2005**
0990	Temporary Cafeteria - Paint	Ballard			Sent: 6/29/05 Received:	
09900	Temporary Cafeteria - Epoxy Paint	Ballard			Sent: 6/29/05 Received:	**7/8/2005**
09900	Paint	Ballard			Sent: 6/29/05 Received:	**7/8/2005**
10270	Access Flooring	Bettinger-West			Sent: 6/29/05 Received:	**7/8/2005**
07210	Building Insulation - Product Data - DRYWALL	Coakley	8000.00	Inwood, WV	Sent: 6/29/05 Received: 7/11/05	-
07900	Joint Sealants - Partition Perimeter and Control Joints	Coakley	n/a	n/a	Sent: 6/29/05 Received: 7/11/05	-
09100	Drywall Metal Support Assemblies, Metal Support Assemblies	Coakley	120000.00	Baltimore, MD	Sent: 6/29/05 Received: 7/11/05	-
09250	Gypsum Board - Temporary Cafeteria, Whole Project	Coakley	54000.00	Baltimore, MD	Sent: 6/29/05 Received: 7/11/05	-
09280	Plaster Restoration	Coakley	141000.00	Baltimore, MD	Sent: 6/29/05 Received: 7/11/05	-
09510	Acoustical Ceilings, Fasteners	Coakley	5000.00 18000.00	Cloquet, MN Stony Point, NY	Sent: 6/29/05 Received: 7/11/05	-
09770	Glass Fiber-Reinforced Wall Panels	Coakley	n/a	n/a	Sent: 6/29/05 Received: 7/11/05	-

ANALYSIS 2

Phasing Layout Analysis

Problem Statement:

54% of the $1.2 million contingency was used during Phase 1. The project was set-up in four phases and fourteen areas. Phase 1 included worked in nine areas. It was heavily front loaded, which I believe caused a lot of issues.

Goal:

The goal of this analysis is to re-structure the layout of each phase and how the building was broken into Areas A through N. This will greatly benefit the project as a whole, including contingency usage, schedule and material distribution.

Methodology:

1. Analyze the phasing layout for the project.
2. Determine the best possible layout for the project.
3. Analyze the schedule change impacts to cost and schedule.
4. Select the best phasing layout for the project.

Tools:

1. Penn State Architectural Engineering Faculty
2. Grunley Construction Company – General Contractor

Outcome:

The analysis proves that if the schedule was not front-end loaded, the contingency use would be greatly reduced and impacts to the schedule would be eliminated. The new phasing layout developed spread out the work better throughout each phase, allowing for less pressure to be placed on each phase, but still allowing for the project to be completed on time if not sooner than anticipated.

Original Phasing Layout:

Phase 1 – 9 Areas

1. Area A
2. Area B
3. Area D
4. Area E
5. Area I
6. Area J

7. Area L
8. Area M
9. Area N

54% of the $1.2 million contingency was used during Phase 1.

Phase 2 – 6 Areas

1. Area A
2. Area C
3. Area D
4. Area G
5. Area I
6. Area E

Phase 3 – 2 Areas

1. Area F
2. Area I
3. Area K
4. Area J

Phase 4 – 2 Areas

1. Area H
2. Academy Work

Re-designed Phasing Layout:

Phase 1

1. Area A
2. Area B
3. Area M
4. Area N

Phase 2

1. Area C
2. Area D
3. Area E
4. Area H

Phase 3

1. Area F
2. Area G
3. Area I

Phase 4

1. Area J
2. Area K
3. Area L

Conclusions:

The new layout evenly distributes the areas amongst the four phases. This allows for less pressure to be placed on one particular phase. The set-up also places the work in a nice flow based on what work is being done and keeping in mind that the school needs to stay open and operational throughout the duration of the project.

ANALYSIS 3

Alternate method for placement of the building foundation (Additions Only)

Problem Statement:

Originally, the general contractor proposed that the entire footprint be excavated to the bottom elevation of the foundation system and then forming will be used for the pour. After the concrete pour, the footings will be stripped and then the area will be backfilled with structural fill and stone. This method (bulk excavation) not only involves more soil to be removed, it also requires more fill. This would also be more difficult considering the four areas are going to be adjoining existing areas of the building.

Goal:

The goal of this analysis is to see if pouring the foundation system into excavated pits can reduce labor costs, schedule, and the amount of material used. Trench excavation eliminates the need for forming and reduces the amount of material removed and the amount of fill.

Methodology:

1. Determine the quantities of soil to be removed for each placement method (trench vs. bulk).
2. Estimate the forming costs and labor productivity.
3. Assess the change in demand for the excavator.
4. Compare the material costs, labor costs, and activity durations.

Tools:

1. R.S. Means 2005 Edition
2. Penn State Architectural Engineering Faculty
3. Grunley Construction Company – General Contractor

Outcome:

After performing a detailed cost and schedule analysis, it has been determined that the trench excavation method for placing the foundation system is more efficient. The trench excavation method costs less and is faster than the bulk excavation method because it does not require as much material to be removed. The following pages provide a detailed view of each analysis and their results.

Cost Impacts:

In order to perform this analysis, quantities of soils to be removed were taken from the structural foundation plans. For both the trench and bulk method, it was assumed that the excavation would be performed until the bottom elevation of the footing. The difference between this elevation and

the grade elevation would provide the depth of excavation needed. Using this depth, the trench excavation method used the width of each foundation to produce the total quantity of soil. The bulk excavation quantity was determined by using the average depth of three different areas. Please see *"Table 1 – Cost Difference Summary"* below for an overview of the results.

Table 1 - Cost Difference Summary			
Item	Trench Excavation	Bulk Excavation	Difference
Material (BCY)	483.545	1310.465	**826.92**
Material (LCY)	531.9	1441.51	**909.61**
Total Costs	$13,946.96	$60,158.80	**$46,211.84**

The difference in material to be removed is significant. The bulk excavation method quantity is nearly triple that of the trench method. This is what accounts for the large difference in cost. The costs seen above include all excavation, removal, and forming costs. Concrete placement costs were not analyzed because they will not change between the trench and bulk methods, concrete will still be pumped to the location of the footing. By using the trench placement method, it will have a savings of roughly 77%.

Schedule and Excavator Demand Impact:

The impact to schedule and excavator demand in this analysis are equal. On the Fairfax High School project, only one excavator was used for removal. After determining the difference in the quantities of soils removed for both excavation methods, it was seen that the trench excavation method was shorter. It was expected that the trenching activity would take longer due to the intricate system of foundation members throughout the site. Even though the productivity rate for the trench method was less than that of the bulk method, the large difference in soil quantity was the main factor in the schedule difference. As seen below in *"Table 3 – Schedule / Excavator Demand Impact"*, the bulk method takes nearly twice as long as the trench method.

Table 3 - Schedule / Excavator Demand Impact					
Item	Equipment	Labor (hrs/BCY)	Total BCY	Total hrs	Total Days
Trench Excavation	1 C.Y. Hydraulic Backhoe	0.04	483.55	19.34	2.4
Bulk Excavation	1 C.Y. Hydraulic Backhoe	0.027	1310.47	35.38	4.4
			Difference:	16.04	2

*Assume 8 hour work day
** Productivity rates taken from R.S. Means 2006

Conclusion:

When viewing these results, it can be seen that the trench excavation foundation placement method is more efficient than the original method of bulk excavation placement. It cuts costs associated with soil removal by roughly 77%. Even though the trench placement method will take more planning and layout during the excavation phase, it is offset by the planning and layout needed during the forming activity in the bulk excavation placement method. Using the trench method decreases the activity duration and excavator demand by roughly 50%. With all of these factors in mind, it is strongly recommended that the trench excavation foundation placement method be used in lieu of the original plan of bulk excavation. Not only does it cut costs and durations, it also reduces the amount of waste material.

SUMMARY AND CONCLUSIONS

Greening buildings through the LEED® Point rating system is increasingly becoming popular in the construction industry. The Eisenhower Executive Office Building was used as prime example as it is striving to achieve a LEED-EB® certification.

The first analysis was geared towards determining common goals for achieving LEED® certification and points that can be associated with them. Research was conducted to identify initial goals for how and why a project wanted to achieve LEED®. A tool was then generated in Microsoft Excel® that outlines the requirements for each point and the party that is responsible for handling the work required. This will greatly help the Project Managers better handle the work required to obtain and maintain the certification throughout the project and beyond.

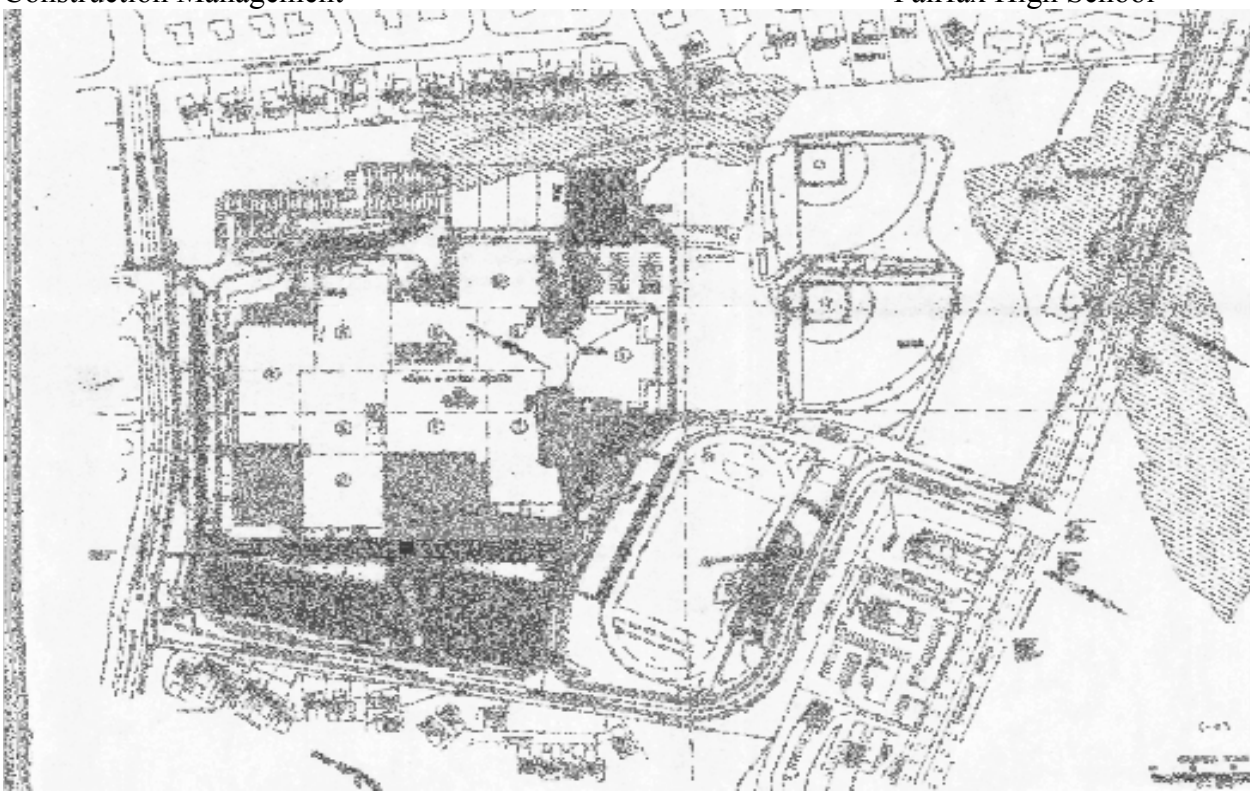
The second analysis looked into the phasing layout for the Fairfax High School project. The initial phasing layout had Phase 1 heavily front end loaded, resulting in high usage of the contingency for the project. After analyzing the various areas of the project, a new layout was set-up to balance the project and eliminate some of the errors while still keeping the project on schedule if not ahead.

Finally, the third analysis included an evaluation of the foundation placement method, geared towards minimizing the amount of soil to be removed. The original plan was to perform a bulk excavation of the entire site to below the footing elevation and then use forms for placing the concrete. This analysis checked if it was feasible to just dig trenches and pour concrete directly into the trench, without the use of forms. It was determined that the trench method would not only save money and time, it would significantly reduce the amount of soil to be removed.

APPENDIX A

SITE PLAN

Existing Conditions Plan



APPENDIX B

PROJECT SUMMARY / DETAILED SCHEUDLE

DURATION	START	January	April	June	July	August	September	October	November	December
120	1/10/2005									
110	1/20/2005									
0	4/6/2005		▶4/6/05							
19	4/21/2005									
3	6/28/2005									
4	6/28/2005									
1	7/1/2005									
7	7/7/2005									
3	7/7/2005									
13	7/12/2005									
6	7/20/2006									
6	7/25/2005									
5	7/27/2005									
4	7/27/2005									
3	8/1/2005									
16	8/3/2005									
10	8/22/2005									
14	8/24/2005									
14	8/26/2005									
10	8/29/2005									
16	9/6/2005									
2	9/16/2005									
2	9/28/2005									
4	9/30/2005									
4	10/6/2005									
16	10/21/2005									
3	10/24/2005									
17	11/2/2005									
1	11/25/2005									
10	12/2/2005									▶12/2/05

APPENDIX C

LEED® GUIDE SURVEY

Data Collection Sample Survey:

Below is the sample survey that will be handed out with the LEED® guide.

Name of Person
Company
Project

LEED® Rating - Certified, Silver, Gold, Platinum (Circle One)

Please rate the ease of use of the guide.
1 2 3 4 5

Please rate how useful the guide was in gaining knowledge of the LEED® system.
1 2 3 4 5

Please rate the usefulness of the guide regardless of an individual's LEED® experience.
1 2 3 4 5

Please rate the topics highlighted as the most important ones with respect to developing areas with LEED®.
1 2 3 4 5

Please rate the items discussed and shown on the guide. Are they directed toward their intended audience?
1 2 3 4 5

Please include any ideas or suggestions for improvement of the LEED® guide.