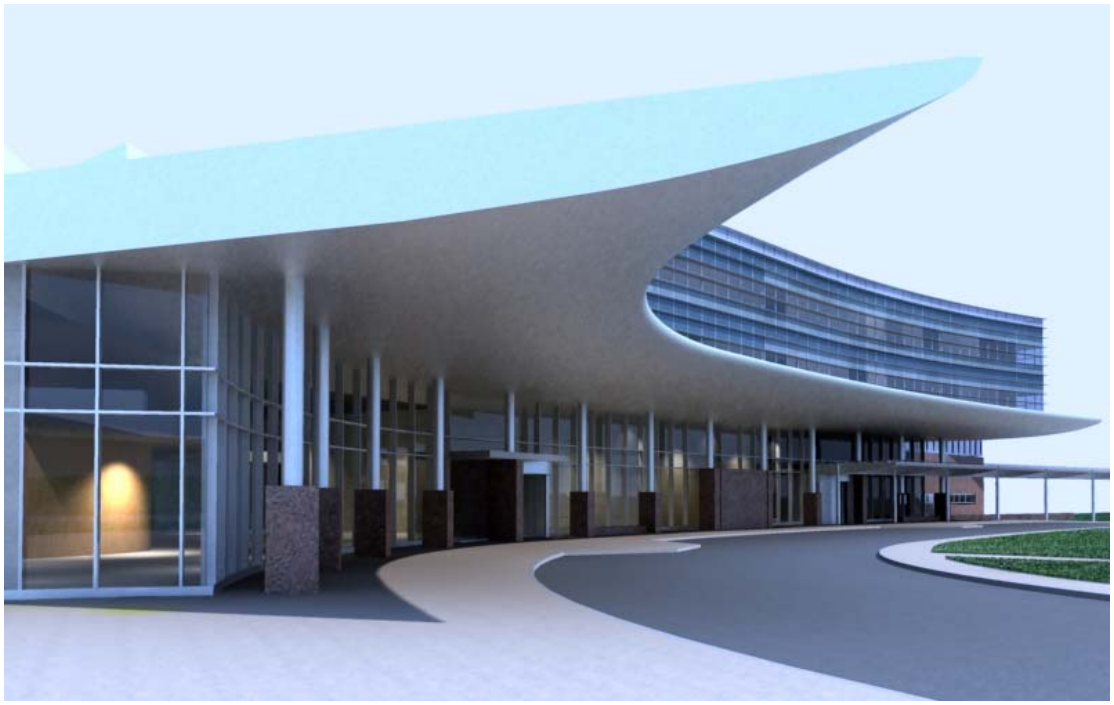
CANCER INSTITUTE

Penn State Milton S. Hershey Medical Center
Hershey, Pennsylvania

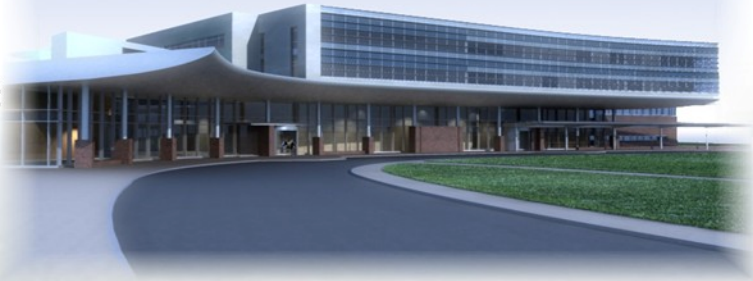


FINAL THESIS REPORT

Chris Voros
Construction Management
Faculty Advisor: Dr. David Riley
Spring 2007

CANCER INSTITUTE

Chris Voros
Construction Management



Hershey, PA
Penn State Milton S. Hershey Medical Center

http://www.arche.psu.edu/thesis/eportfolio/2007/portfolios/CAV138/

Project Team:

Owner- Penn State Milton S. Hershey Medical Center
Owner's Consultant- Centerline Associates
Architect- Payette Associates, Inc.
Associate Architect- Array Health Facilities Solutions
Structural/ Civil Engineer- Gannett Fleming
MEP Engineer- Bard, Rao + Athanas
CM Agency- Gilbane Building Company
General Contractor- Wohlsen Construction

Basic Project Information:

- 5-story, 175,000 square foot facility
- Design-Bid-Build, CM Agency Delivery
- Project Cost- $82,000,000
- Duration- October 2006- December 2008
- Function- Cancer treatment and research
- LEED Silver Rating

Design / Architecture:

- Ties in to existing hospital, requring relocation of Emergency Delivery area
- Design is coordinated with current Parking Garage project and future adjoining Children's Hospital
- Radiotherapy equipment located in basement, with patient housing, teaching and research areas located on upper floors
- Glazed aluminum curtain wall facade, aluminum-clad skylights, and glass canopy covering front entrance
- Open-air "Healing Garden" between hospital connections to aid in patient recovery

Structural System:

- Grade beams and column piers atop micropile foundation system
- 6" Slab-on-Grade, 36" SOG for radiotherapy area
- Steel bay construction with elevated concrete floor slabs on composite metal decking
- Bituminous ashpahlt roofing with EPDM membrane

Mechanical / Electircal Systems:

- Mechanical penthouse stores two 55,000 cfm AHU's, with a third 130,000 cfm AHU on the ground floor, servicing 400 CV and VAV boxes
- Electrical system is 3 Phase, 480 V / 270 V supplied by a 15kV feeder from the campus
- Emergency supply thorugh a 450 kW, 562.5 kVA natural gas powered generator on the penthouse

PENNSTATE
Milton S. Hershey Medical Center
College of Medicine

PAYETTE ARRAY healthcare facilities solutions Gannett Fleming BR+A CENTERLINE ASSOCIATES Gilbane WOHLSEN

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Ed O'Malley

Davis Construction:
Bill Moyer
David Argentieri

…and to all the survey participants.

Resources:

Das, Braja. *Principles of Foundation Engineering*, Sixth Edition.
Geopier Intermediate Foundation System Manual
Distribution System Loss Evaluation Manual

PENN STATE MILTON S. HERSHEY MEDICAL CENTER
CANCER INSTITUTE

Building Introduction

Project Background

The Penn State Hershey Medical Center (PSHMC) Cancer Institute building is a five-story, 175,000 square facility that will serve as the hospital's center for cancer treatment and research. The project began its early phasing of construction in August 2006, with the full notice to proceed following that November. Design of the building is coordinated with the current Parking Garage and future Children's Hospital projects, with all three employing similar architectural aesthetics such as the curtain wall envelope and granite masonry features. Together these buildings will bring a modernized look to PSHMC's East Campus.

Client Information

The owner entity of this facility is comprised of the Penn State Milton S. Hershey Medical Center and the Penn State College of Medicine. Central to their initiative is to serve the growing central Pennsylvania communities and provide an aging population with the latest technologies dedicated to improving the quality of life. This expansion also comes in response to concerns of a shortage of physicians in the coming years. In 2002, PSHMC developed a 10-year Master Plan for operations and facilities growth. Since its inception, the hospital has seen great progress both in construction and in student numbers. With the recent completion of the Oncology Treatment Building and future plans for the Children's Hospital, PSHMC will continue to thrive as the leading teaching hospital in Central Pennsylvania.

PSHMC's focus for the Cancer Institute project is to minimize the impact on the hospital facilities and to efficiently control expenses during construction. The building will connect to the existing emergency delivery area of the hospital, and thus reconfiguring this critical department requires a keen attention to safety. A comprehensive Infection Control Risk Assessment plan has been developed to ensure patient safety during

renovations and throughout construction of the Cancer Institute. The ICRA plan identifies four risk degree levels based on sensitivity to contamination from construction debris. Areas of the hospital within the assessment zone are assigned on of these risk levels, which then dictates the precautionary measures that must be taken when work is conducted within their vicinity. For the renovation work involved with the Cancer Institute project, a number of hospital areas were categorized as 'High' or 'Highest' risk by the study, including the existing emergency delivery, operating rooms, admissions, endoscopy lab, and dialysis center. It is critical that the necessary steps are taken to ensure patient safety during this early phase of construction.

As significant construction requires large amounts of funding, it is necessary for PSHMC to keep the project under its budget. Current construction of the nearby Parking Garage atop the three treatment facilities equals a costly investment, whose return depends upon buildings meeting their high-quality expectations. Thus, extensive value engineering analyses were performed throughout the design phase of the Cancer Institute to ensure that the quality of the building was maintained as the project cost slowly crept to budget capacity. Also of particular interest for PSHMC was to retain, at a minimum, a LEED Silver rating, which through careful planning has been achieved.

Project Delivery System

The Cancer Institute employs a different delivery method compared to the completed Oncology Treatment Building and the current Parking Garage project. While the OTB and Parking Garage utilized the Gilbane Building Company as construction manager, the Cancer Institute changes Gilbane's role to that of a construction management agency, overseeing a general contractor and its subcontractors. This method enables savings in construction costs while still providing a skilled and knowledgeable management company overseeing work. The contract in place between PSHMC and Gilbane is a cost plus fee arrangement.

PSHMC has used Centerline Associates as its representative and consultant on most of its recent significant construction projects, and will continue to do so with the Cancer

Institute. This entity takes on the role of a project manager above the general contractor, handling all cost negotiations and providing the final word on any sequencing or constructability issues.

The design firms used by PSHMC are compensated using a cost plus fee contract method. The architect on the project, Payette Associates, was an active participant in the Master Plan development project in 2002. Comprehensive designs were proposed and later selected by PSHMC for the expansion plan. Accompanying the Boston-based architecture firm on the project is Array Healthcare Facilities Solutions, acting as associate architects on the project for their experience and regional proximity. Civil and structural engineering responsibilities are handled by Gannett Fleming, while all mechanical, electrical, and plumbing design is performed by Bard, Rao + Athanas, also out of Boston.

Project Schedule Description

A CPM schedule summary is presented at the end of this section, showing key dates and milestones as scheduled by Gilbane Building Company and PSHMC. With two months of site improvements and 26 months of building construction, it is critical for this schedule to be accurate so that any changes or delays can be evaluated efficiently. Impacts to construction have a great effect on daily hospital activities, and thus it is important to identify any pertinent issues early so that the campus can plan for logistical adjustments.

Sequencing Elements

- *Foundation*- After bulk excavation to sub-grade, a 2" mud matt of 2,000 psi to 2,500 psi concrete will be poured over the entire basement floor level, which will be pitched slightly to the perimeter for drainage purposes. The overall structural bearing is placed on load-bearing micropiles that are drilled into the ground approximately 65 feet. The piles require an additional 11 feet of bond length in stable rock to resist uplift and shear forces. When the bond zone has been located, the casing is filled with grout to adhere to the threaded piles. Column

piers and grade beams are formed and placed atop these micropiles. The slab on grade will be poured in sections. First, the 36" slab for the radiotherapy area is poured. At each brachytherapy or linear accelerator unit, the slab is stepped down to provide a shell for the base. After steel erection, the remainder of the 6" slab will be formed and poured.

- *Superstructure*- Steel and metal decking will be installed in bay sections, beginning at the North end of the building and completed one floor at a time. Shear studs for the composite metal deck will be installed prior to the placement of the concrete, and will follow the sequence of the steel member erection. A mobile crane will be used to facilitate this sequence.

- *Finishes*- Interior rough-ins and finishes will follow a typical sequence, beginning with piping, then mechanical, and lastly electrical and light fixture installation. Pipe and mechanical hangers are installed as the metal deck on the floor above is completed, avoiding the need to drill into the composite floor slabs.

Building Systems Summary

Demolition

The first phase of the project includes demolition of a hospital parking lot, the helipad, and a section of the Emergency Delivery area. The existing helipad and ED will be maintained until the new helipad and ED expansion are complete. The ED work demands usage of the Infection Control Risk Assessment plan to ensure that no demolition or construction debris contaminates the existing hospital, threatening patients in surgery and recovery. As the new helipad was constructed adjacent to the existing drop-off, work stoppages were ordered whenever an emergency delivery occurred, typically carrying a 15 to 30 minute notice.

Structural Steel Frame

The superstructure utilizes steel bay construction with mostly moment frame connections. However, central to the structure and found at alternating column lines are three braced

frame systems carried from the first to the fifth floor. Girder and beam sizes vary throughout the structure. Girder sizes typically range between a W18x26 and W27x84 on the first floor, to a W18x65 and W24x76 on the upper floors, all spanning lengths of 31 feet. Beam sizes throughout all floors are predominantly W16's and span from 26 to 29 feet. Columns, meanwhile, fall between a W14x43 and W14x90. Elevated floors are composite concrete slab on metal deck. To assemble the bay sections, one mobile crane will be used, which will run along the East façade of the building beginning at the North end.

Cast-in-Place Concrete

The foundation system uses pile caps and grade beams atop load-bearing foundation micropiles. Grade beams will be poured directly with no forming, though the pile caps will require stick-built forms. Ground floor concrete pours are critical to the project, as the radiotherapy treatment area is found here. A 36" floor slab, depressed at locations for the linear accelerator and brachytherapy units, is coupled with 40" dividing walls and a 60" ceiling, both encased with lead bricks. Placement requires two successive pours and metal formwork to facilitate construction of this critical wall type. Elevated slabs will require the use of a concrete pump for placement.

Mechanical System

The ventilation system for this facility utilizes three central supply air handling units. AHU-C/A-1 is found on the ground floor and services the ground, first, and second floors, and averages 130,000 cubic feet per minute (cfm). The two remaining units, AHU-L-1 and AHU-L-2, are sized at 55,000 cfm, and both provide cooling and heating to the third and fourth floors. These units will provide air to approximately 400 constant volume or variable volume boxes located throughout the building.

Electrical System

Four 15 kV high voltage feeders service the PSHMC, branching off a substation in a centralized location at the back of the campus. The Cancer Institute will run on a 3

phase, 480V / 270V circuit. Emergency backup power will be supplied from a 450 KW, natural gas-powered generator located on the mechanical penthouse.

Project Cost Evaluation

Basic Overall Cost Information

PSHMC	Cost	Cost per Square Foot
Construction Cost	$82,000,000	$468 / sf
Total Project Cost	$96,000,000	$548 / sf

Core Buildings Systems Costs

Building System	Cost	Cost per Square Foot
Structural	$11,520,000	$66 / sf
Mechanical	$9,310,000	$53 / sf
Electrical	$6,350,000	$36 / sf
Plumbing	$4,870,000	$28 / sf

Miscellaneous Systems Costs

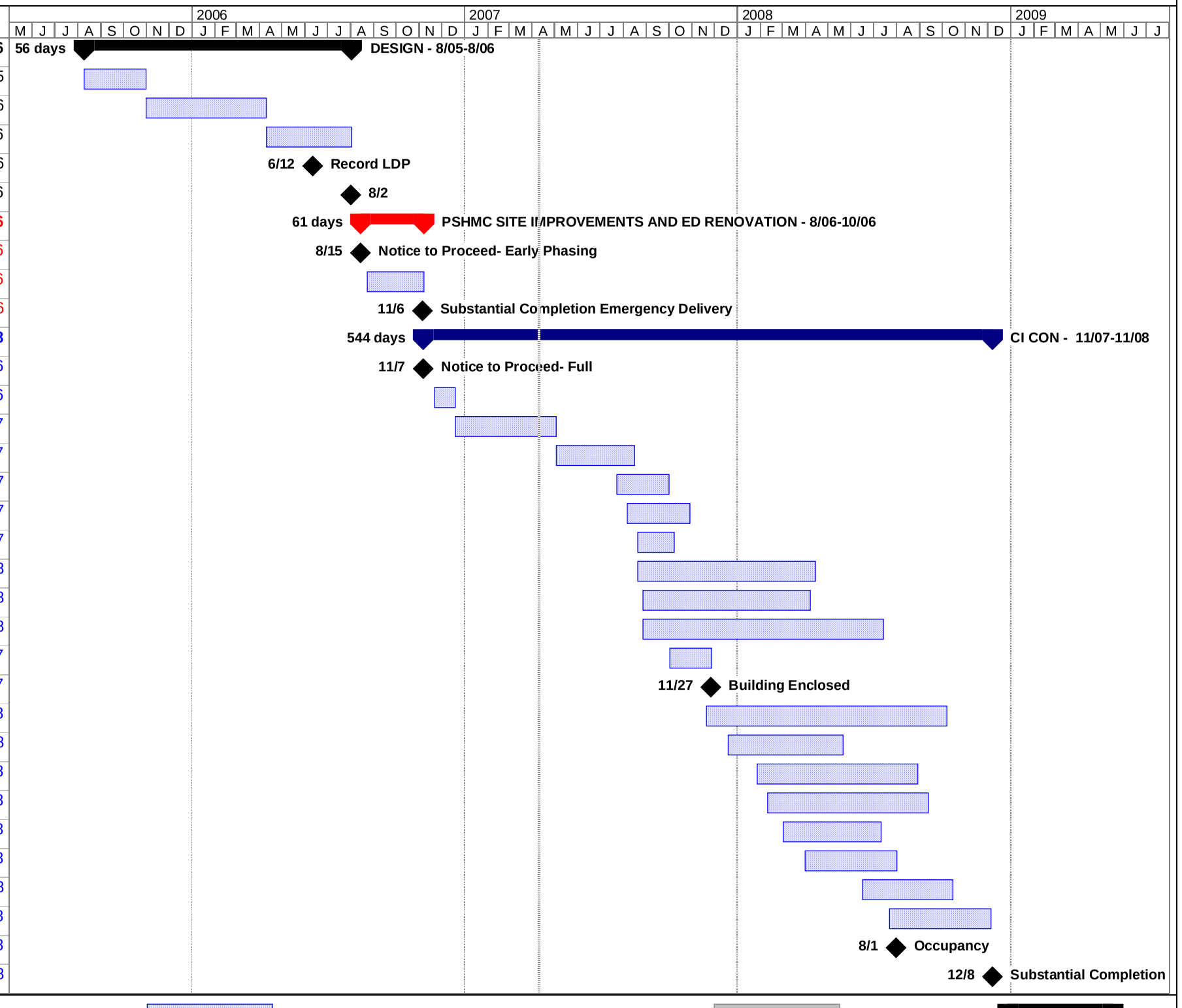
Building System	Cost
Fire Protection	$900,000
Site Work	$7,860,000
Curtain Wall	$5,720,000
Masonry	$90,000
Conveying Systems	$400,000
Building Automation	$1,960,000
Lab Equipment	$850,000

Gilbane

Penn State Milton S. Hershey Medical Center

Cancer Institute Project
Summary Construction Schedule

ID	Task Name	Duration	Start	Finish
1	**DESIGN - 8/05-8/06**	**256 days**	**Wed 8/10/05**	**Wed 8/2/06**
2	Schematic Design	59 days	Wed 8/10/05	Mon 10/31/05
3	Design Development and DD Review	115 days	Tue 11/1/05	Mon 4/10/06
4	Construction Documents	82 days	Tue 4/11/06	Wed 8/2/06
5	Record LDP	0 days	Mon 6/12/06	Mon 6/12/06
6	Complete Construction Documents	0 days	Wed 8/2/06	Wed 8/2/06
7	**PSHMC SITE IMPROVEMENTS AND ED RENOVATION - 8/06-10/0**	**61 days**	**Tue 8/15/06**	**Tue 11/7/06**
8	Notice to Proceed- Early Phasing	0 days	Tue 8/15/06	Tue 8/15/06
9	Early Phasing- Roads/ Utilities/ ED Renovation	54 days	Thu 8/24/06	Tue 11/7/06
10	Substantial Completion Emergency Delivery	0 days	Mon 11/6/06	Mon 11/6/06
11	**CI CON - 11/07-11/08**	**544 days**	**Tue 11/7/06**	**Mon 12/8/08**
12	Notice to Proceed- Full	0 days	Tue 11/7/06	Tue 11/7/06
13	Bulk Excavation	20 days	Wed 11/22/06	Tue 12/19/06
14	Piles / Foundations & Foundation Walls / Underslab Utilities	97 days	Wed 12/20/06	Thu 5/3/07
15	Structural Steel and Decking	75 days	Fri 5/4/07	Thu 8/16/07
16	Concrete Slabs and Linear Accelerator Enclosures	50 days	Tue 7/24/07	Mon 10/1/07
17	Curtain Wall	60 days	Tue 8/7/07	Mon 10/29/07
18	Fireproofing	35 days	Tue 8/21/07	Mon 10/8/07
19	Partition Walls	170 days	Tue 8/21/07	Mon 4/14/08
20	Building Mechanical - Piping	160 days	Tue 8/28/07	Mon 4/7/08
21	HVAC & Start-up MEP Systems	230 days	Tue 8/28/07	Mon 7/14/08
22	Roofing	40 days	Wed 10/3/07	Tue 11/27/07
23	Building Enclosed	0 days	Tue 11/27/07	Tue 11/27/07
24	Electrical	230 days	Wed 11/21/07	Tue 10/7/08
25	Drywall	110 days	Thu 12/20/07	Wed 5/21/08
26	Painting	155 days	Mon 1/28/08	Fri 8/29/08
27	Ceilings	155 days	Mon 2/11/08	Fri 9/12/08
28	Fire Protection	95 days	Mon 3/3/08	Fri 7/11/08
29	Owner FF&E	89 days	Tue 4/1/08	Fri 8/1/08
30	Casework & Flooring	87 days	Tue 6/17/08	Wed 10/15/08
31	Test & Balance	98 days	Wed 7/23/08	Fri 12/5/08
32	Occupancy	0 days	Fri 8/1/08	Fri 8/1/08
33	Substantial Completion	0 days	Mon 12/8/08	Mon 12/8/08



Project: PSHMC Cancer Institute
Date: 10/26/06

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary | Deadline

EXECUTIVE SUMMARY

Breadth Analyses and Construction Management Depth Study

This thesis report presents the results of a year's worth of investigation into the Cancer Institute project at the Penn State Milton S. Hershey Medical Center. With an emphasis in construction management, technical analyses are performed to assess early phasing activities associated with the project, including site utility plans and foundation systems. This is complimented by a depth study of the construction industry, which looks at building respect among subcontractors.

The first analysis looks at the deep micropile foundation of the building and proposes redesign to an intermediate, Geopier-reinforced mat slab system. To demonstrate breadth of knowledge in structures, evaluations are taken both from a design and construction perspective. Project management considerations of constructability, schedule reduction, and value engineering are all examined as well.

The next study looks at the high voltage distribution plan of PSHMC's East Campus with respect to three projects- the Cancer Institute, Parking Garage, and future Children's Hospital. An alternative layout is proposed that better facilitates this transformation, both from a construction and operation perspective. Breadth knowledge of electrical systems is demonstrated in a comparison of the two layouts with respect to feeder line losses.

The last portion of this report contains a depth study in construction management, examining industry influences on subcontractor bid package markups. Through two surveys, one tailored to project management professionals and one to subcontractors, the study compares industry perceptions of the major determinants of a subcontractor's markup, placing emphasis on reputations and business relationships.

STRUCTURAL BREADTH STUDY

Intermediate, Geopier-reinforced Mat Slab versus Deep Micropile Foundation System

Introduction

This analysis examines the feasibility of replacing the existing deep micropile foundation system with an intermediate solution of soil-reinforcing, rammed aggregate piers in combination with a mat slab foundation. A breadth analysis of the proposed structural system will be demonstrated through calculations on the soil reinforcement strategy as well as the design of the mat slab for three zones of the building. This is followed by a comparative analysis of the proposed versus existing systems, with emphasis on three core areas of project management- constructability, schedule reduction, and value engineering.

Existing Conditions

The Cancer Institute building is supported by a micropile foundation system in combination with cast-in-place piers and grade beams. The design employs the same system used by the nearby Parking Garage project at PSHMC, scheduled to be completed in June 2007. The structure is supported by load-bearing micropiles that are drilled into the ground approximately 70 feet, surrounded by a metal casing. The piles require 10 to 20 feet of bonding length in stable rock to resist uplift and shear forces. When the bond zone has been located, the casing is filled with grout that adheres to the threaded piles. Pile caps, column piers and grade beams are formed and placed atop these micropiles to support load-bearing walls and columns. At the Cancer Institute, non-load bearing walls and frost walls will utilize conventional shallow footings.

The issue that arises with the micropile system is the ability to find competent rock at reasonable depths. Central Pennsylvania is considered primarily karst topography; limestone-derived soil which is vulnerable to weathering. The soils at PSHMC are no exception. At the Parking Garage project in particular, significant setbacks occurred as a result of micropiles being drilled, on average, 20 feet deeper than originally estimated in

order to be set in a suitable rock. Compounding this problem was the fact that a minor fault line crosses the back of the site, causing extremely poor rock zones for any pile placement. Several piles were being drilled anywhere from 120' to 300' before ever-reaching a competent 20' of stable rock. As if this wasn't enough, several sinkholes developed during the process. In one case, a drilling team was forced to stand over a deep fissure sinkhole with the aid of wooden planks so they could finish placing a pile.

The Parking Garage project took significant losses both in schedule and cost. As the average pile depth climbed, multiple meetings had to be called involving all of the project entities. Eventually it was decided to cease drilling if a pile exceeded 120', at which point the structural engineer would redesign the pier or grade beam in that area. In all, about 20 piles were added, pile caps were enlarged and two adjacent piers were combined to form a combined footing. The extensive redesign not only halted production rates but also created a time-consuming feedback loop whenever piles exceeded the 120' maximum. When the last element was placed, the $2 million dollar pile job incurred a change order totaling $600,000. The micropile placement schedule, originally scheduled to take 73 days, ended up lasting 109 days- a 49% inflation.

Figure 1. View of Parking Garage project from CI site

Problem Statement

Unforeseen subsurface conditions can be extremely detrimental to a project, as realized by the Parking Garage. The fact that the Cancer Institute is only a short distance from this site presents the possibility that it will experience a similar setback with its deep foundation system. As the early phasing sequence of site improvements incurred its own delays, further setbacks of this magnitude can not be tolerated on the project.

Research

Analysis began by compiling a list of possible alternatives to the micropile system, with the first source being the geotechnical report. The engineers initially considered spread and continuous footings in conjunction with soil reinforcement techniques, but this presented settlement and future sinkhole issues. Keeping their suggestions in mind, a side-by-side comparison of possible alternatives was drawn up.

Figure 2. Possible Foundation Alternatives

System / Criterion	Mat Slab Only	Caissons	Engineered Fill with Mat Slab	Soil Reinforcement
Cost	Expensive	Very Expensive	Moderate	Moderate
Schedule	Slow- extensive rebar placement	Very Slow- Up to 72" diameter	Moderate	Fast
Benefits	Good in bad soils; simple design (2-way slab); Place during daytime	Little settlement; minimal vibration	Avoids deep foundations; no water table issues	Permanent lateral soil stress; Cheap and Quick
Drawbacks	Differential settlement; sinkholes over time; availability	Time consuming; Place at night (ED Sensitivity)	Adjacent spaces; added earthwork costs	Limited by load they carry; Place at night
Feasible?	Needs More Review	No	No	Needs More Review

As seen above, a mat slab foundation system alone will not be suitable for the Cancer Institute. Differential settlement needs to be minimized due to the sensitivity of the spaces and equipment, as well as to avoid issues at the Emergency Delivery and future Children's Hospital connections. Caissons, though supporting the existing hospital, are simply too costly. In reality the only feasible alternative was soil reinforcement, which was mentioned in the geotechnical report but not described in detail.

After researching soil reinforcement technologies further, it became apparent that stone columns, installed either through vibratory or auger placement, could strengthen the soil enough to enable a mat slab foundation (see Figure 3). One company in particular, Geopier Foundation Company, Inc., has a patented system of rammed aggregate piers (RAPs) that is for the Cancer Institute project in terms of pile substitutions. Geopiers were used for the recently completed 7,800 square foot Oncology Treatment Building at PSHMC in lieu of conventional stone columns. Thus, the idea evolved to replace the

deep foundation system with a Geopier-reinforced mat slab, essentially an intermediate design. Research also considered the use of excess fill on PSHMC's campus to surcharge the site for a few months prior to the foundation start date. However, this was soon eliminated due to the fact that it was not substantial from a cost-benefit perspective. To have any lasting impact on soil stability the surcharge would require years rather than the few summer months available.

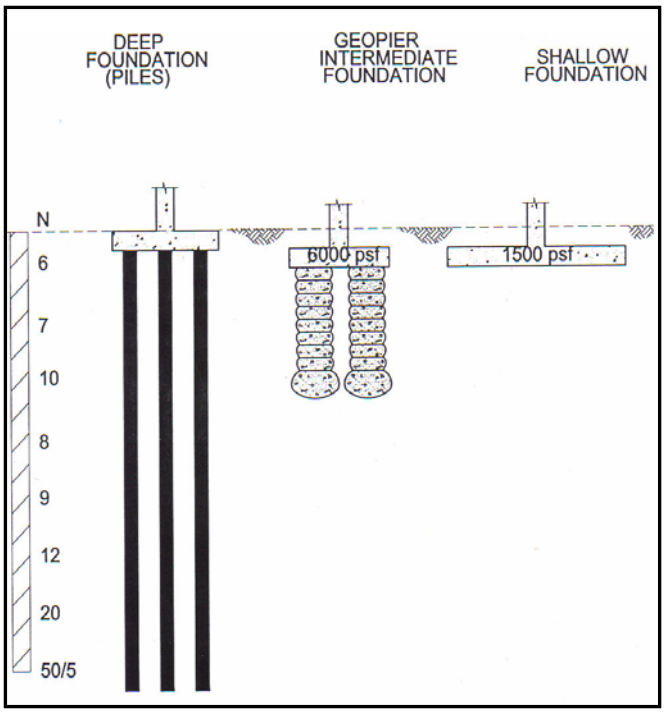


Figure 3. Foundation Alternatives- Bearing Strengths

Proposal

In order to avoid any subsurface conditions associated with deep foundation systems, I propose to replace the existing system with soil-reinforcing Geopier™ rammed aggregate piers that will support a large mat slab across the site. The remainder of this study contains structural and construction-related analyses comparing this system with the existing micropile design.

Structural Analysis

As the proposed system contains two key elements, calculations required a unique approach. The scope and complexity of this redesign requires several assumptions to achieve this uniformity:

- Two separate analyses will be performed:
  - Geopier-supported shallow foundation (GeoStructures Manual)
  - Mat slab only (Feasibility analysis)

- Analysis divides building footprint into three zones with uniformly distributed loads (illustrated on next page):
    - Zone 1- Primary Area (36,733 sf)
    - Zone 2- Radiotherapy Vaults (6,000 sf)
    - Zone 3- Shell Space (13,811 sf)

The assumptions employed in these structural calculations should be considered baseline values used to perform a meaningful design and construction-related analysis.

Geopier Mechanics

Geopiers work by pre-stressing soils both vertically at the bottom of the cavity, and horizontally during subsequent compaction of thin aggregate lifts. The RAPs in particular are beneficial in that they reduce both total and differential settlement because of their high strength and stiffness. Projects using this type of soil reinforcement typically employ a grid design to achieve homogenized results. Due to the fact that the Geopier elements are stronger than in-situ soils, it creates bending stresses in the slab between piers. Thus, floors must be treated as two-way slabs rather than a typical slab on grade.

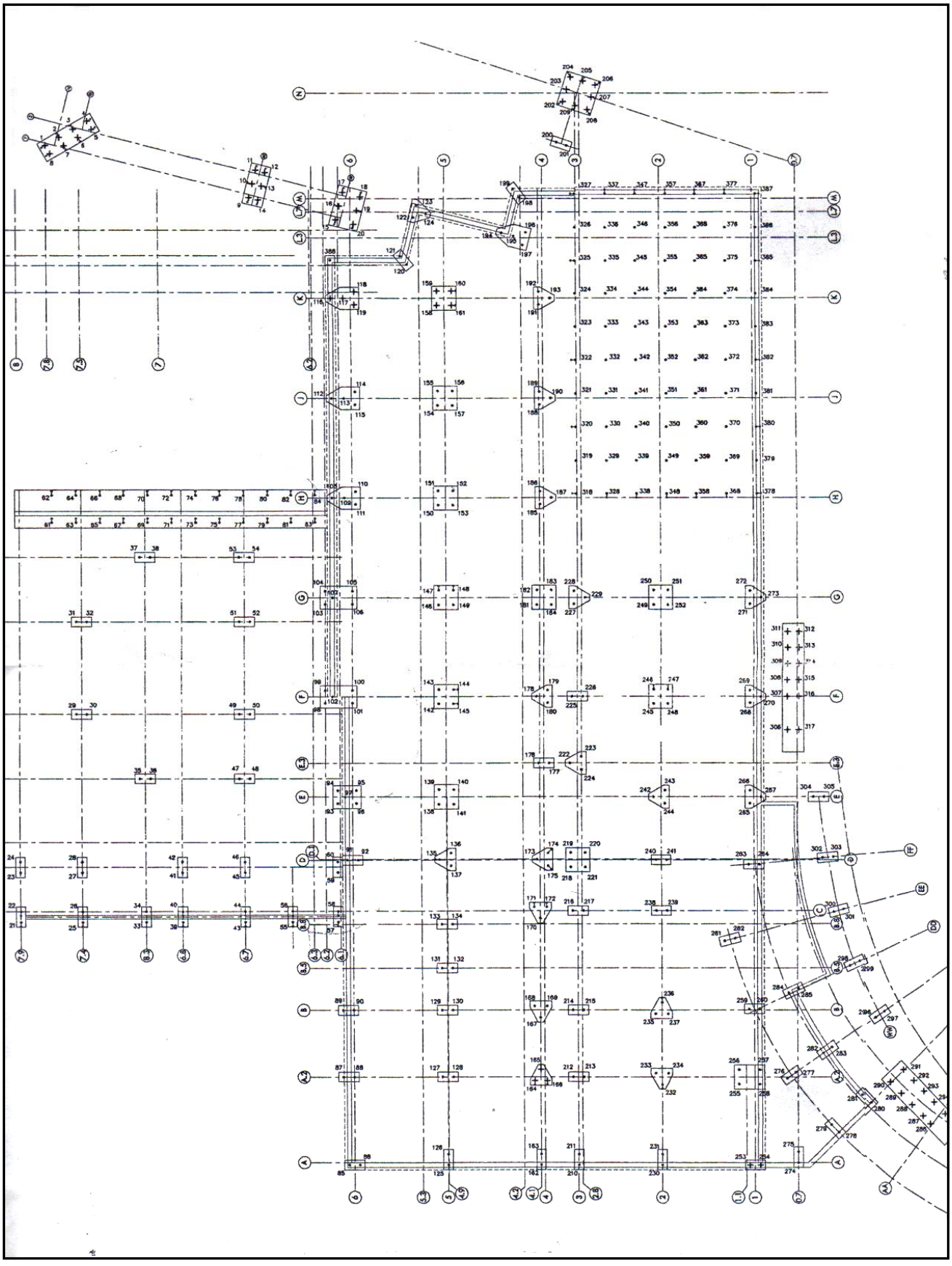
Geopier Calculation Results

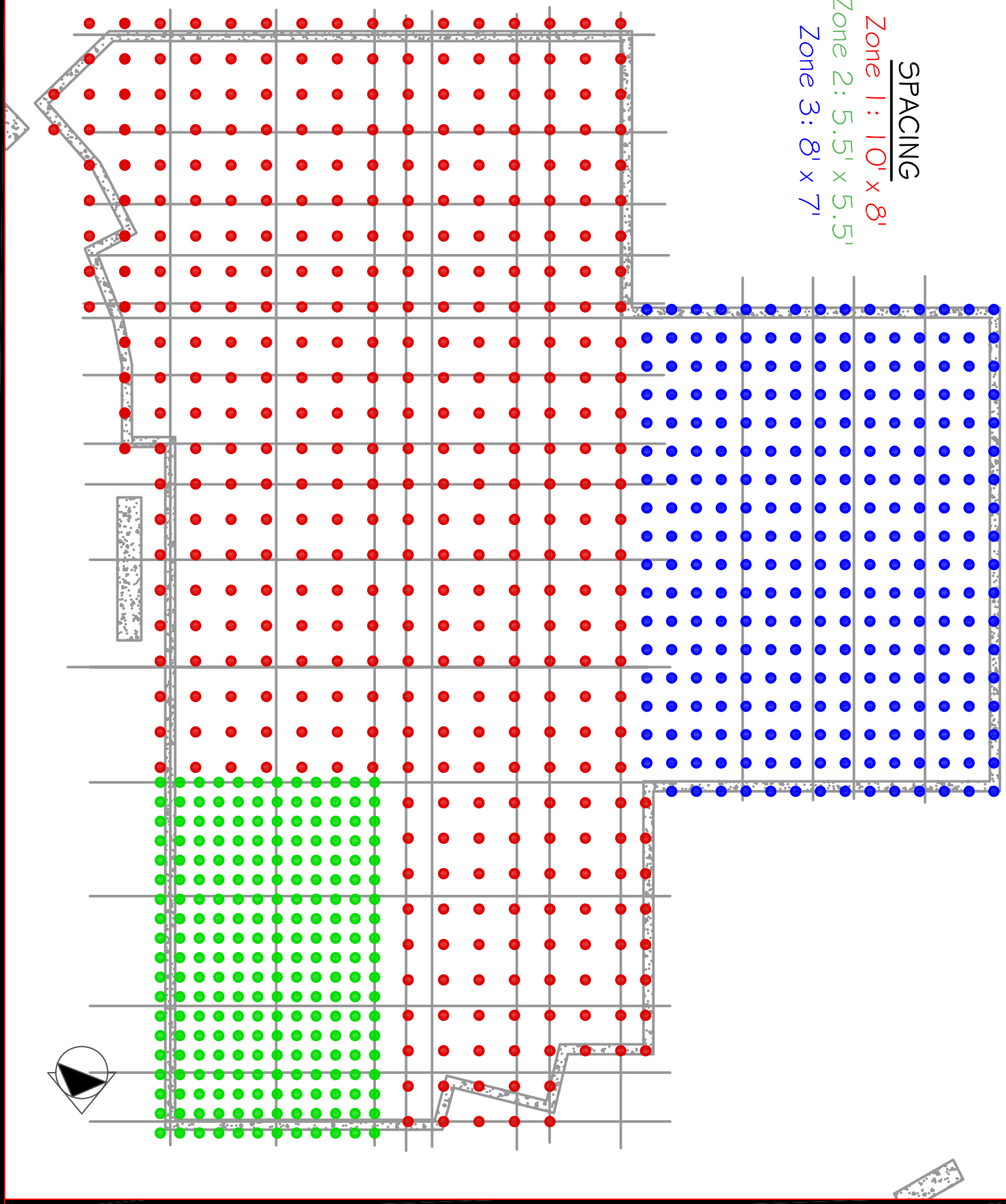
Totals for each zone's Geopier requirements are provided in Figure 4 below. The next two pages depict the pile layout plan versus the proposed Geopier grid. Design of the Geopier soil stabilization method follows the manual provided by GeoStructures, Incorporated, courtesy of CMT Labs. For full calculations, see Appendix A1.

Figure 4. Geopier Specifications

Zone	Footprint Size (SF)	Total Geopiers (30" dia., 15' Deep)	Nominal Spacing
1. Primary Area	36,733	419	10' x 8' O.C.
2. Radiotherapy Vaults	6,000	228	5'-6" x 5'-6" O.C.
3. Shell Space	13,811	269	8' x 7' O.C.

MICROPILE COORDINATION PLAN
(Courtesy of Coastal Drilling, East & Gilbane Building Company)





NO SCALE	FOUNDATION PLAN PROPOSED GEOPIER GRID	PSHMC CANCER INSTITUTE	PENNSTATE Milton S. Hershey Medical Center College of Medicine Gilbane

Mat Slab Calculation Results

An analysis of a mat slab-only foundation was performed for comparative analysis. Load distributions were again assumed to be uniform for each zone. Due to the lack of specific point load values, calculations were extrapolated from pile design capacities. While the Primary Area looks at a typical bay, the other spaces take into account the entire space because no columns are present or listed. Full results are found in Appendix A4.

Figure 5. Mat Slab Specifications

Zone	Footprint Size (SF)	Mat Slab Thickness Required
1. Primary Area	36,733	2'-9"
2. Radiotherapy Vaults	6,000	4'-6"
3. Shell Space	13,811	15"

Construction Analysis

The following section outlines critical construction issues associated with the proposed and existing foundation systems. Considering the scope of the redesign, it is necessary to perform a comprehensive review on its impact to all critical areas of construction management. Thus, the analysis is broken down into three core aspects- constructability and cost, scheduling and sequencing, and value engineering impacts.

Constructability Review

The most important consideration in this redesign is its cost implications to the project. Constructability of the two systems can be broken down into two categories:

- Micropiles versus Geopier Rammed Aggregate Piers
- Pile Caps, Grade Beams, & Slab on Grade versus Mat Slab

Analysis on each of these four categories is further broken down into material, equipment, and labor costs as defined by the trade contractors and vendors. Information not available from these sources is based on R.S. Means CostWorks software and prevailing wage data. The following costs are summarized from Appendix A6:

Figure 6. Summary Cost Comparison

Category	Cost
Piles	$1,250,000
Slab on Grade & Pile Caps	$941,552.82
Total Cost	**$2,191,552.82**

VS.

Category	Cost
Geopiers	$618,300
Mat Slab	$2,079,756.50
Total Cost	**$2,698,056.50**

Proposed System, Cost Addition = $506,504 (+ 23.1%)

As seen above, the proposed Geopier-reinforced mat slab foundation costs 23% more than the existing system. The bulk of the added costs come as a result of the mat slab pour. Though the mat slab calculations are basic from a structural standpoint, overall it was designed conservatively and may in reality be cheaper than these estimates. Also of importance is the fact that the Geopier estimate does not take into account savings accrued from using recycled aggregate, a potential alternative that benefits the Cancer Institute with respect to LEED points.

Piles versus Geopiers

The pile installation process is far more labor intensive than RAPs. The Cancer Institute will utilize 387 auger-placed piles comprised of (2) #18 Grade 75 bars encased in 7” pipe and filled with 4.5 ksi grout. One threaded bar extends the full length of the pile; the second extends only 5’ above the 11’ deep rock socket. Dependent upon the soil composition, drilling can proceed very slowly and incur difficulties with the casing bending or breaking, bearing piles deflecting out of vertical, and drill heads malfunctioning. Also of importance is the fact that mobilization and equipment costs can be very expensive. The Cancer Institute project will require support items

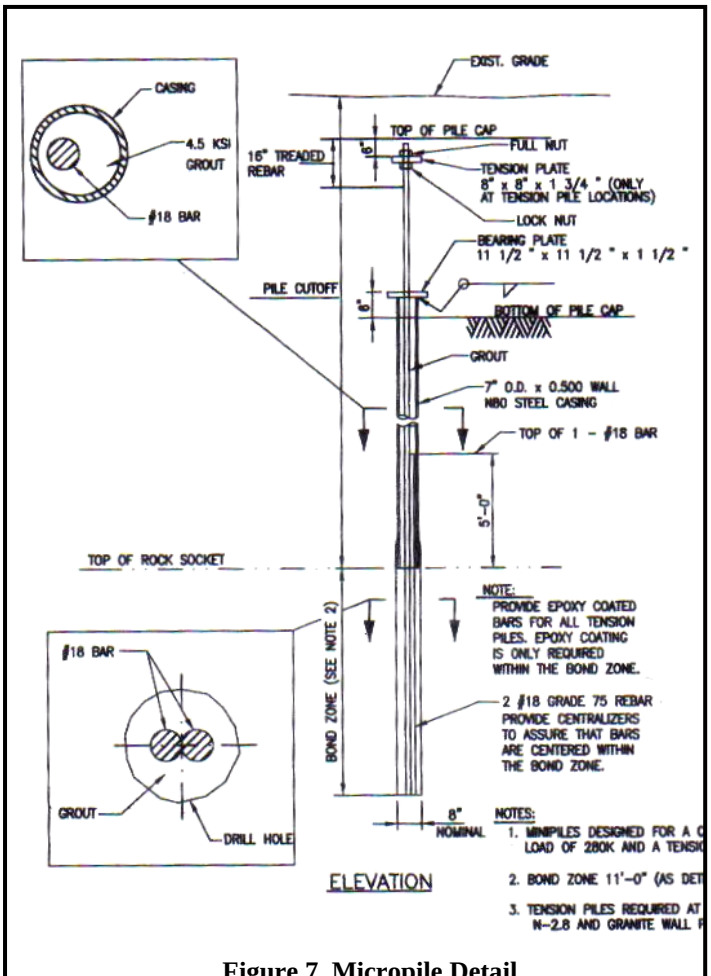
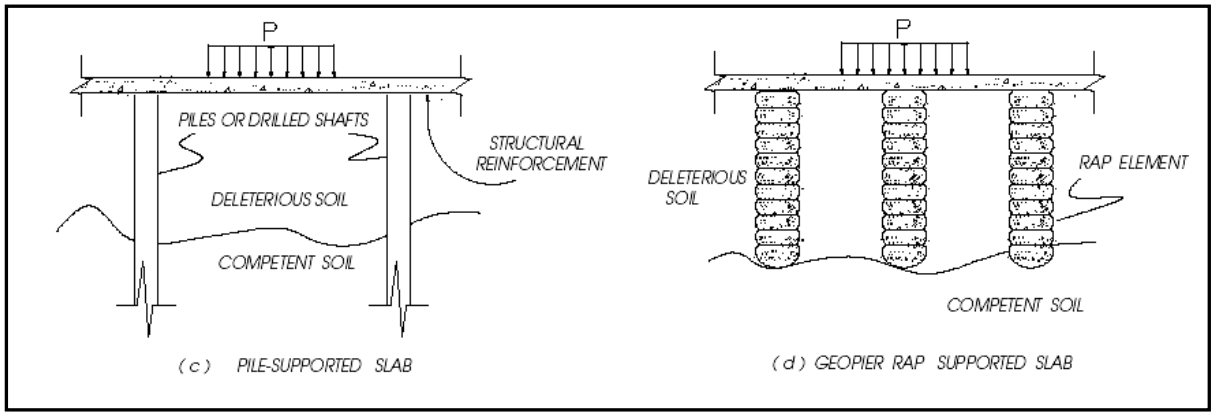


Figure 7. Micropile Detail

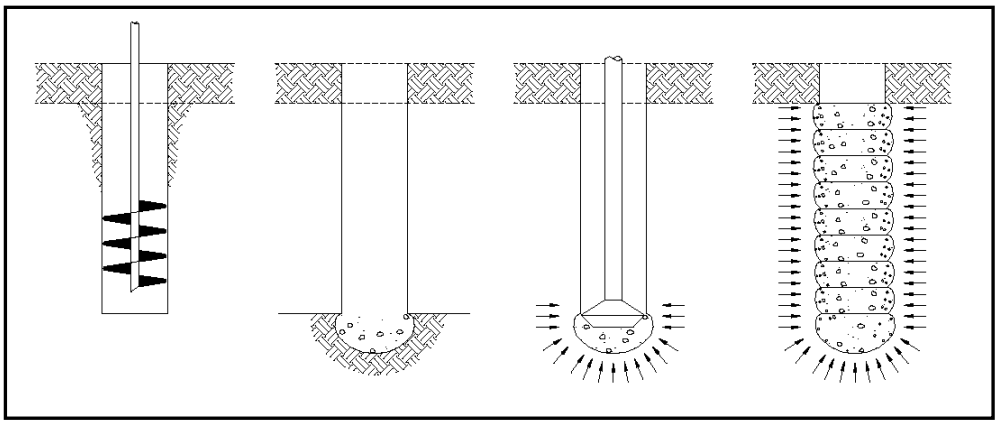
such as a cement silo, three hydraulic rigs, two forklifts, pumps and diesel compressors.

Figure 8. Pile-supported vs. RAP-supported Slab



The Geopier system, on the other hand, is significantly cheaper than the piles because they have been designed to extend only 10' feet into the ground and require fewer equipment and materials. Shallower, auger shafts also minimizes equipment sizing and strain on the subsurface soils. The proposed 30" RAPs need only #57, 3" washed aggregate for the bottom bulb and PennDOT 2A crushed stone for the remainder of the column. Not only does this free up space in terms of site logistics, but the process is simple from conception to installation (see Figure 9). It begins by making a cavity and placing the first lift of stone in the bottom. A beveled tampering rod then compacts the stone, with subsequent thin lifts placed atop one another.

Figure 9. Geopier Installation Schematic



Slab on Grade versus Mat Slab

Constructing the mat slab will be considerably more difficult than the existing slab on grade due to the extensive amount of rebar and embed placement. It is important to monitor the utility layouts closely so that slab penetrations are placed correctly through the thick slab. Whereas the current slab on grade ranges from 5" to 6" (excluding the Radiotherapy Vaults), the mat slab ranges from 15" to 33", which will be placed atop an 8" stone layer similar to the SOG.

Schedule and Sequencing Implications

The proposed system creates a major impact on the schedule and sequencing of the project. Though there are nearly three times as many Geopiers than piles, and despite the more labor-intensive mat slab pour, a significant tradeoff comes into play when considering production rates. Whereas a team of three drilling crews are scheduled to average about 6 piles a day at the Cancer Institute, a crew of only five Geopier installers will average 33 piles in the same time span. Thus, the estimated 916 rock columns can be completed in 28 days, 45% faster than the 62 day-schedule for installing the piles. In the overall structural sequence, however, this is only a fraction of the information that requires analysis.

Sequencing Impact

Currently the slab on grade is scheduled to be poured in two phases. Phase 1 consists of pouring Zone 1 only, which is the radiotherapy enclosure. The steel superstructure will then be installed, with Phase 2 of the pour starting when the steel tops out. This sequence, however, must change for the proposed mat slab foundation due to the fact that the steel needs the load-bearing slab beneath it.

With the new system, underslab utilities are an important issue to consider. Since the grid pattern of the RAPs is relatively dense, utility installation will have to precede this activity.

The following tables summarize the sequencing and duration of pertinent structural activities planned for the existing and proposed systems, respectively. A detailed CPM schedule comparison follows on the next page:

Figure 10. Schedule Comparison Summary

Micropile and SOG Installation		
Activity	**Start – Completion Dates**	**Duration (days)**
Install & Grout Piles	12/12/06 to 3/8/07	62
Pour Pile Caps and Column Piers	2/2 to 3/29	40
Pour Radiotherapy Vaults	2/2 to 4/26	60
Install Underslab Utilities / Pour Fdn. Walls	3/30 to 4/26	20
Erect Steel (All Floors)	4/27 to 8/13	91
Pour Remaining Slab on Grade	7/31 to 8/13	10
Total Duration	**12/12/06 to 8/13/07**	**190 days**

Geopier RAP and Mat Slab Installation		
Activity	**Start – Completion Dates**	**Duration (days)**
Install Underslab Utilities	12/12/06 to 1/9/07	20
Install Geopiers	1/9 to 2/15	28
Pour Mat Slab & Fdn. Walls	1/22 to 3/30	48
Erect Steel (All Floors)	4/2 to 7/23	91
Total Duration	**12/12/06 to 7/23/07**	**175 days**

It is evident that the proposed foundation reduces the construction schedule considerably when two crews are sequenced on the mat slab installation, enabling elevated slabs to be poured a full 15 working days ahead of the existing schedule. Assuming that all other activities take the same amount of time, there are two key schedule impacts that need consideration.

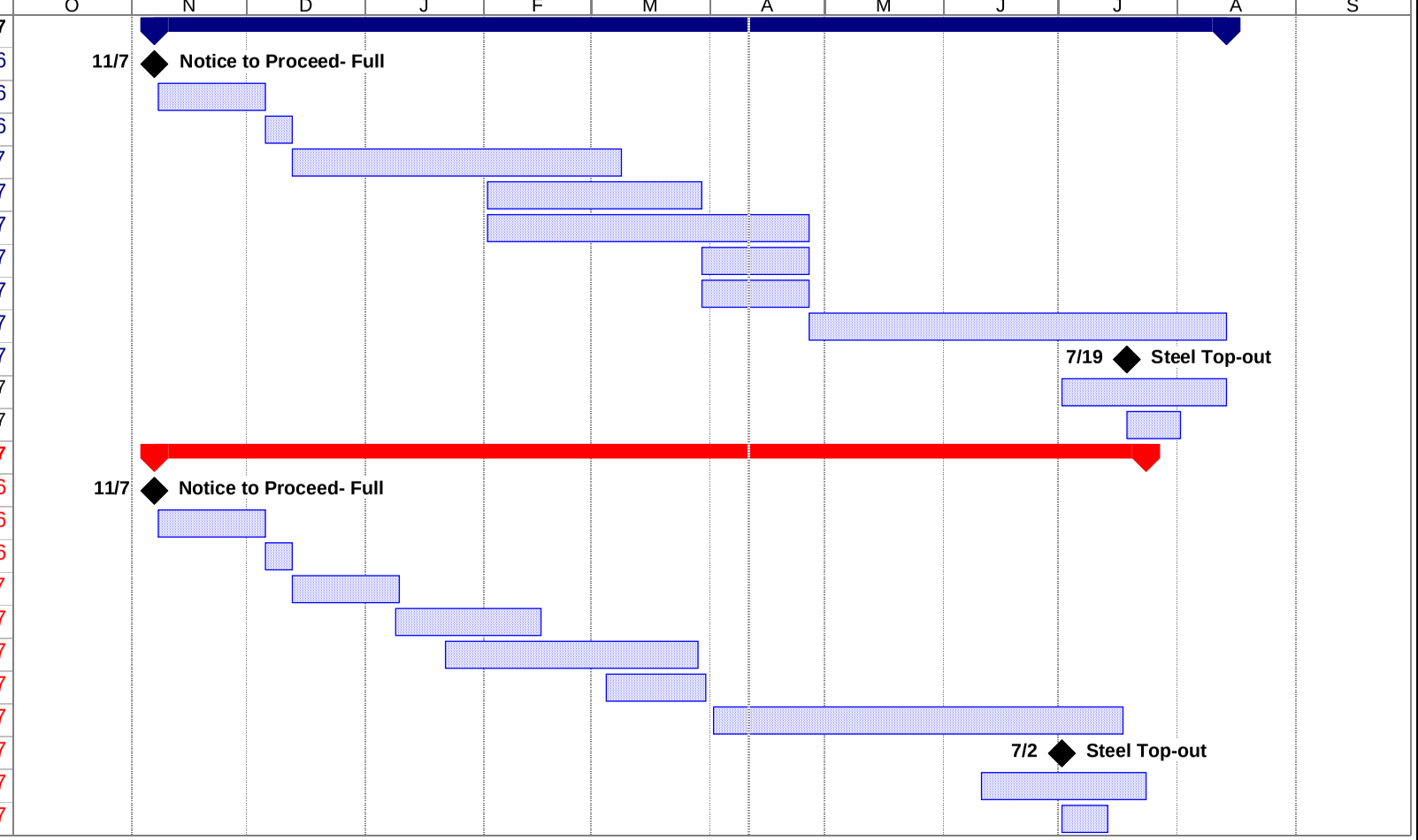
Slab Pour

A downside to the proposed system is the increased duration for the mat slab installation. However, rather than pouring the slab in phases, this process is streamlined into one activity and sequenced to follow the work of the Geopier contractors. In this scenario, the mat slab starts at about 50% completion of the Geopier elements to minimize congestion on the site. Thus, concrete placement starts on 1/22 and finishes 48 days later on 3/30. The schedule comparison ends up favoring the new system due to this more fluid construction sequence.

Penn State Milton S. Hershey Medical Center

Cancer Institute Project
Foundation Schedule Comparison

ID	Task Name	Duration	Start	Finish
1	**EXISTING FOUNDATION SYSTEM- MICROPILES & SOG**	**200 days**	**Tue 11/7/06**	**Mon 8/13/07**
2	Notice to Proceed- Full	0 days	Tue 11/7/06	Tue 11/7/06
3	Bulk Excavation	20 days	Wed 11/8/06	Tue 12/5/06
4	Sheeting and Shoring	5 days	Wed 12/6/06	Tue 12/12/06
5	Install Piles	62 days	Wed 12/13/06	Thu 3/8/07
6	Install Pile Caps/ Foundations	40 days	Fri 2/2/07	Thu 3/29/07
7	Pour Linac Enclosures	60 days	Fri 2/2/07	Thu 4/26/07
8	Install Foundation Walls	20 days	Fri 3/30/07	Thu 4/26/07
9	Install Underslab Utilities	20 days	Fri 3/30/07	Thu 4/26/07
10	Erect/ Trim Steel & Metal Decking (All Floors)	77 days	Fri 4/27/07	Mon 8/13/07
11	Steel Top-out	0 days	Thu 7/19/07	Thu 7/19/07
12	Rack and Trim Steel	31 days	Mon 7/2/07	Mon 8/13/07
13	Prep/ Pour Level 1	10 days	Thu 7/19/07	Wed 8/1/07
14	**PROPOSED FOUNDATION SYSTEM- GEOPIERS & MAT SLAB**	**185 days**	**Tue 11/7/06**	**Mon 7/23/07**
15	Notice to Proceed- Full	0 days	Tue 11/7/06	Tue 11/7/06
16	Bulk Excavation	20 days	Wed 11/8/06	Tue 12/5/06
17	Sheeting and Shoring	5 days	Wed 12/6/06	Tue 12/12/06
18	Install Underslab Utilities	20 days	Wed 12/13/06	Tue 1/9/07
19	Install Geopier RAPs	28 days	Tue 1/9/07	Thu 2/15/07
20	FRP Mat Slab & Linac Enclosures	48 days	Mon 1/22/07	Wed 3/28/07
21	Install Foundation Walls	20 days	Mon 3/5/07	Fri 3/30/07
22	Erect/ Trim Steel & Metal Decking (All Floors)	77 days	Mon 4/2/07	Tue 7/17/07
23	Steel Top-out	0 days	Mon 7/2/07	Mon 7/2/07
24	Rack and Trim Steel	31 days	Mon 6/11/07	Mon 7/23/07
25	Prep/ Pour Level 1	10 days	Mon 7/2/07	Fri 7/13/07



Project: PSHMC Cancer Institute
Date: 10/26/06

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary | Deadline

Further, complications encountered by the RAP process require much less evaluation than a bad pile. One issue that arises with Geopiers is soil collapse during the compaction process. As long as the aggregate-to-soil ratio within the column remains at 90%, the Geopier is considered structurally sound and does not require re-excavation. Issues with individual micropiles, however, have much more damaging potential, as shown at the Parking Garage project. Revisiting that situation, the micropile duration ended up taking 50% longer than planned. If the Cancer Institute experiences a subsurface situation of the same magnitude, the project would be delayed 31 days.

Value Engineering Considerations

Aside from the benefits realized in the cost and schedule analyses, the proposed foundation system adds value to the Cancer Institute in terms of predictability, stability, and environmental impact. It is in these areas that PSHMC should be particularly interested, being both the owners and operators of this high-end facility.

Avoid Subsurface Problems

The proposed Geopier-reinforced mat slab system has inherent qualities that rival the existing deep micropile foundation. Though the cost savings are not there, it is important to recollect why the system was proposed in the first place- to avoid issues associated with placing deep, end-bearing elements into unreliable soils. The change order that occurred on the Parking Garage project may be dwarfed by potential problems at the Cancer Institute. If a similar fault line is found at a critical area of the foundation, such as the radiotherapy enclosure, redesign costs will be immense. This zone contains a 70-pile grid with piles placed 5'-6" on center

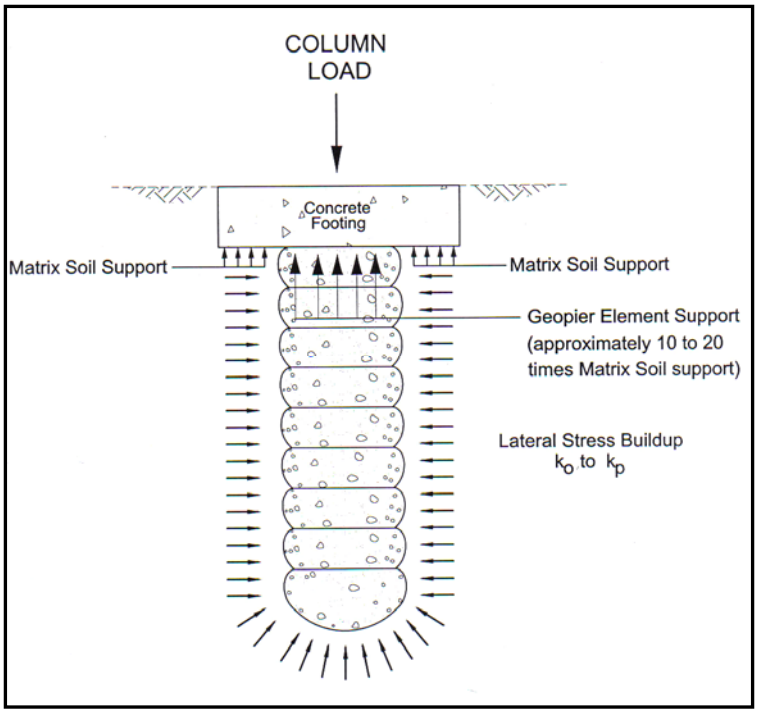


Figure 11. Soil Stabilization Effect of RAPs

placed 5'-6" on center in each direction. Competent rock issues with one pile in the grid will impact the entire layout as differential settlement must be accounted for. The sensitivity of the equipment above demands strict adherence to these tolerances.

Maintain Settlement Tolerances

Aside from the avoidance of any serious subsurface issues, there is also reassurance that the settlement of the mat slab will be contained well within tolerances due to the effectiveness of the Geopier soil stabilizers. Lateral pressures provided by the matrix of stone columns will even have a positive impact on soils of the adjoining Children's Hospital. Though initial settlement calculations of the Geopier system exceeded typical tolerances of 1", case studies of Geopier applications in the real world show that settlement is far less than the expected values. Monitoring the actual versus expected settlement of these systems is possible through the installation of electronic sensors in the slab and would be recommended for the Cancer Institute project. If in fact settlement is less than 1", it would be a good argument for using Geopiers at the Children's Hospital project as well.

ICRA Impact

Lastly, it is important to consider the impact of each system's installation process on the daily hospital operations. The micropile installation process creates a serious issue when considering the sensitivity of the Emergency Delivery area to outside air contamination. During the drilling process, displacement of subsurface water forces excess amounts to the surface. This poses an infiltration threat to critical spaces nearby, most notably the Emergency Delivery area, Operating Rooms, and Dialysis Center. PSHMC has categorized these, and several other spaces, as High or Highest Risk areas in their comprehensive Infection Control Risk Assessment plan. In order to avoid contaminates from entering the hospital, many steps are being taken to ensure that all exterior penetrations are covered and negative pressure is maintained from within. Geopiers reduce the potential for airborne contamination by avoiding the water table completely and thus eliminating dirty water particles from the air.

This is not to say that RAPs don't present a contamination threat of their own; the ramming compaction technique sends finite stone particles into the air that can travel to the ICRA-protected spaces. The difference lies in the fact that Geopier installation can proceed during the day, whereas the piles are scheduled for nighttime placement. Vibrations and noise of the Geopier installation is considerably less than what is produced during the pile-drilling process.

Recommendation

Considering the significant added costs with the proposed system, it is difficult to recommend its implementation without a more thorough analysis of the exact mat slab specifications. However, when recalling the issues at the Parking Garage, there still lies potential for a damaging change order to the Cancer Institute foundation system. If this occurs, PSHMC and Gilbane should consider the Geopier-reinforced mat slab for the Children's Hospital project. The smaller footprint of this building will be more conducive to the mat slab alternative, which in the end benefits the project from a scheduling and sequencing perspective.

ELECTRICAL BREADTH STUDY

High Voltage Utility Relocation Plan and Distribution Systems Loss Analysis

Introduction

This study looks at the feasibility of reworking PSHMC's high voltage distribution plan into an integrated design that better accommodates the Parking Garage, Cancer Institute, and future Children's Hospital projects. To demonstrate breadth knowledge in electrical systems, an evaluation of service losses from the campus substation is performed, comparing the existing and proposed layout designs. The analysis also looks at constructability and value engineering issues with respect to the two plans.

Background

The PSHMC campus receives power from a substation located behind the University Physicians Centers (UPCs) and current Parking Garage project. Four 15kV lines, designated Hospital feeders A/B and Loop feeders A/B, provide electricity throughout the complex. Hospital A and B serve the main Hershey Medical Center complex, including the Cancer Institute and future Children's Hospital. Loop feeders A and B provide electricity to support facilities, such as the student housing complex, Parking Garage, and UPC 1 and 2. With the numerous construction projects involved in PSHMC's Master Plan for expansion, utility systems engineering is a critical element of the design. One of the key goals with recent construction was to separate the A and B lines whenever encountering a manhole; thus, each new junction has two manholes designated A and B. This separation makes construction and maintenance work safer due to the fact that all lines in a manhole can be de-energized.

Problem Statement

The substation currently routs all four feeders in an 8-conduit duct bank approximately 1,200 feet before it branches the circuits. The duct travels along the South side of the Parking Garage, across Centerview Drive and into two newly placed electric manholes (EMH) identified as 2120A and 2120 B. Just before reaching the manholes, the duct

splits such that both A lines enter 2120A, while both B lines tie in to 2120B. The placement of these manholes was a difficult task. Not only is Centerview Drive a high traffic route, but there is also an abutting PP&L line, Central Pennsylvania's electricity provider.

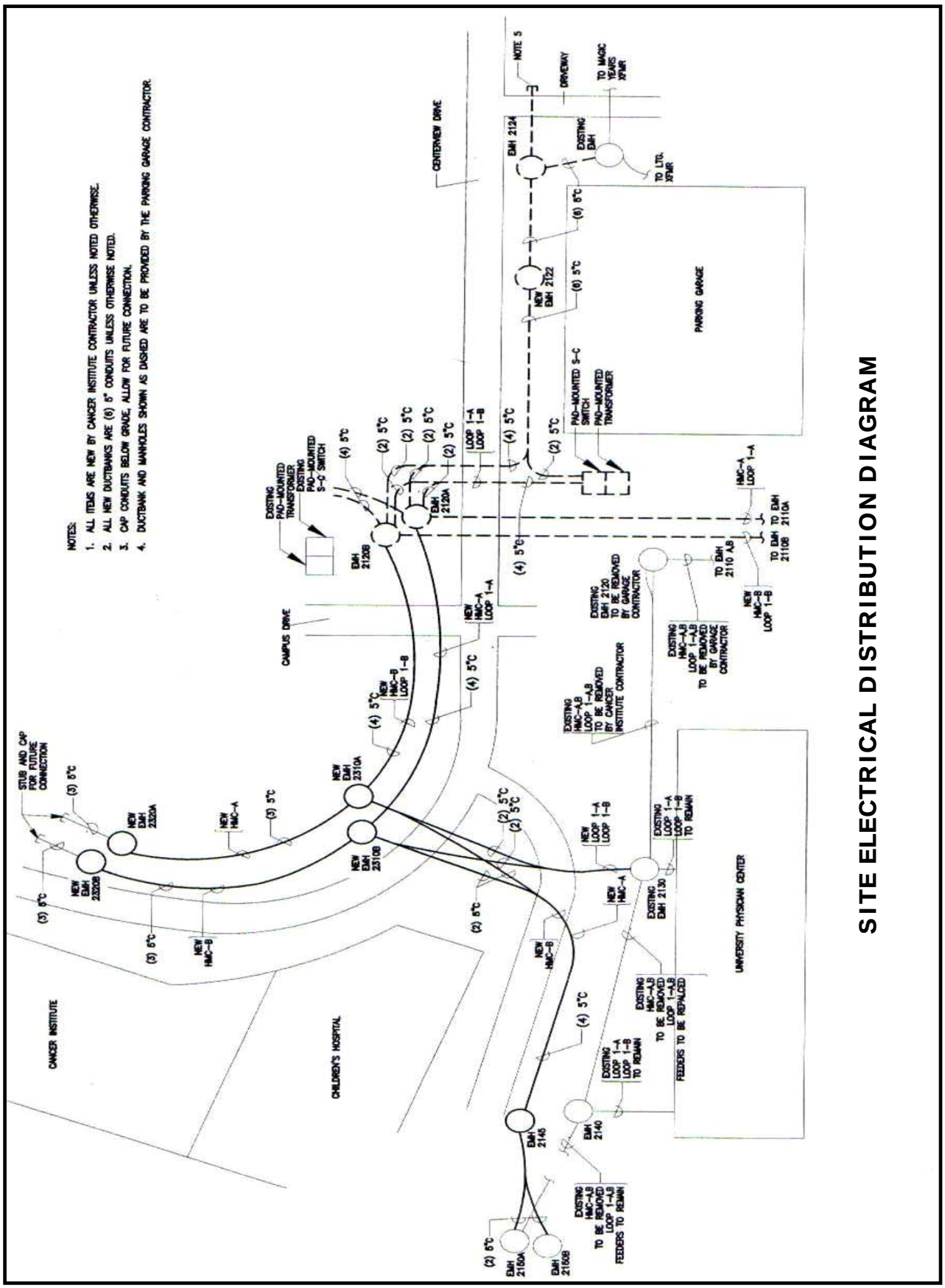
The overall site distribution plan calls for installation of seven new manholes to service the Parking Garage, Cancer Institute, and Children's Hospital. Aside from this there are three road crossings, one of which was completed in July, and extensive earthwork required. All of these issues contribute to an already logistically-strained campus. PSHMC and Gilbane have had to coordinate numerous plans for traffic and pedestrian rerouting for the Cancer Institute and Parking Garage projects. When the Children's Hospital gets underway, yet another road crossing will be required for the utility tie-in.

Proposal

To provide a more efficient means of servicing the current and upcoming construction projects at PSHMC, I will devise a new electric distribution plan that reduces the overall feeder distance from the central substation. This plan will consolidate construction costs by reducing the number of new manholes required, eliminating a road crossing and decreasing the overall linear distance of the new conduits. The shortened length will in turn decrease yearly costs incurred from power and voltage losses.

Preliminary Analysis

In order to develop a feasible and efficient site distribution plan, it is critical to gain a thorough understanding of the relationship between the feeders and the existing buildings and projects, as well as how they are distributed in each conduit. The following page depicts a comprehensive line diagram of the existing power plan, negating scale and dimensions.



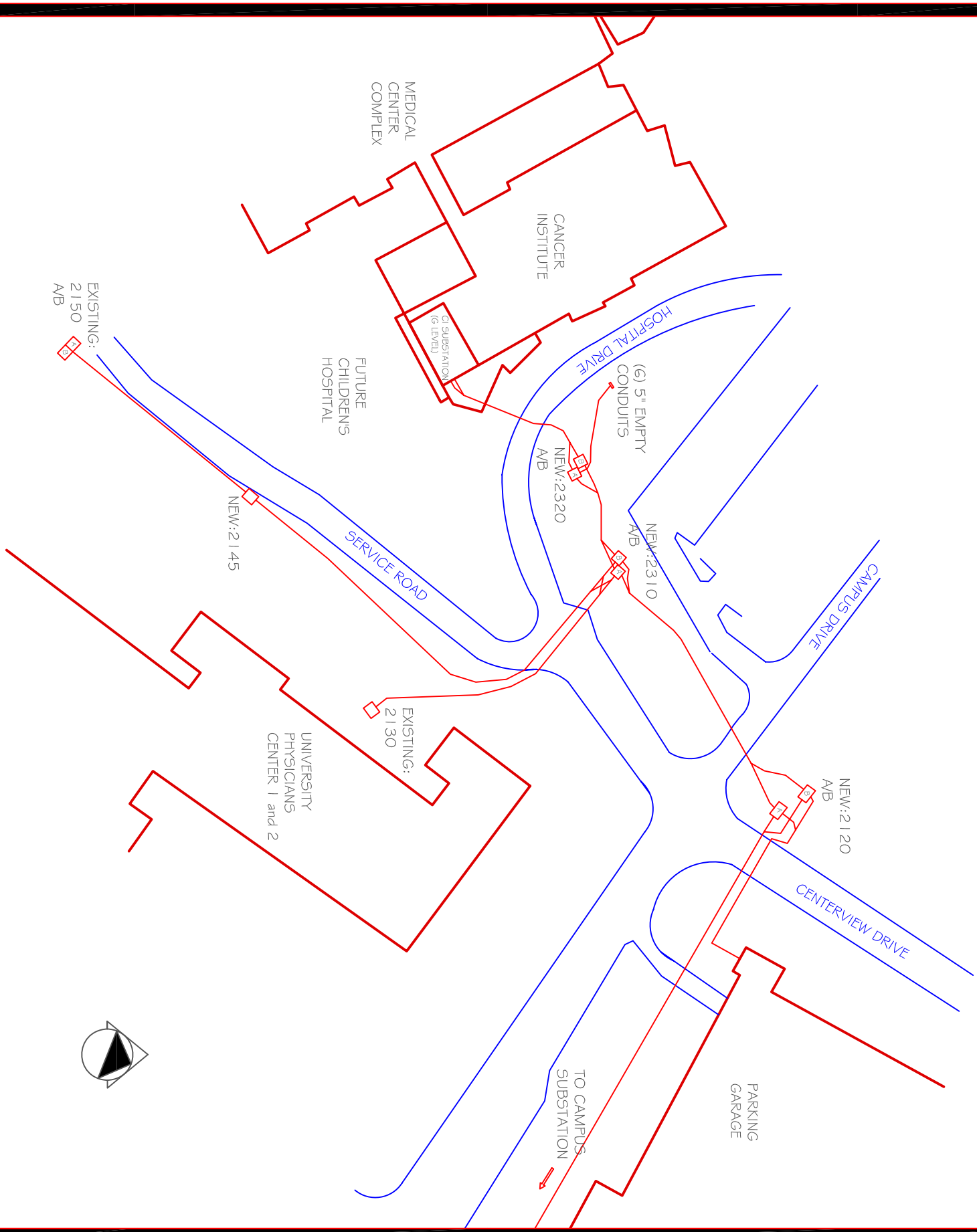
SITE ELECTRICAL DISTRIBUTION DIAGRAM

Existing Layout

The next page in this section shows the exact layout of the high voltage distribution plan in a manner that more accurately illustrates duct bank and manhole locations. PSHMC's East Campus feeders will be installed in phases corresponding to each new buildings' construction. The Parking Garage, now nearing completion, began the first phase of the distribution plan by installing EMH 2120 A and B. This required the first weekend road shutdown of Centerview Drive. The bulk of the utility work will be done with the Cancer Instititute phase, where the remaining five manholes and connecting duct banks will be placed. During this project, Hospital Drive will be taken over by site logistics. However, the active Campus Drive requires a weekend closing to install the ductbank connecting 2120 A/B to the new 2310 A/B. The last remaining step, which has yet to be coordinated, involves tying Children's Hospital into either 2310 or 2320. As of yet, no preliminary conduit is planned for installation across Hospital Drive during the Cancer Institute project. Thus, this road will require yet another temporary shutdown to install the duct bank. The table below summarizes the specifications for each duct bank segment of the existing layout, including the number of conduits and feeder routing schedule.

Figure 2. Existing Layout- Feeder Distribution Summary

DUCT BANK SEGMENT	CONDUITS PER SEGMENT	FEEDER DISTRIBUTION PER SEGMENT			
5" Conduit		Hospital 'A'	Hospital 'B'	Loop 'A'	Loop 'B'
Substation to EMH 2120 A/B	**8**- (4) Active, (4) Spares	X	X	X	X
2120 A/B to 2310 A/B	**8**- (4) Active (4) Spares	X	X	X	X
2120 A/B to Parking Garage	**4**- (2) Active (2) spares			X	X
2310 A/B to 2130	**4**- (2) Active (2) spares			X	X
2310 A/B to 2150 A/B (via 2145)	**4**- (2) Active (2) spares	X	X		
2310 A/B to 2320 A/B	**6**- (2) Active (4) spares	X	X		
2320 A/B to Cancer Institute	**6**- (2) Active (4) spares	X	X		
2320 A/B to Empty Termination	**6**- (6) spares				



SCALE	EXISTING SITE ELECTRIC DISTRIBUTION PLAN	PSHMC CANCER INSTITUTE
¼" = 40'		

PENNSTATE Milton S. Hershey Medical Center College of Medicine

Gilbane

It is questionable why the current plan does not include empty conduits across Hospital Drive for the future Children's Hospital building. The unused conduits branching off of 2320 towards the front of the Cancer Institute building are being installed in anticipation of future construction. The same principle could easily have been applied here for Children's Hospital. OPP offered the reasoning that, since this project is still in the schematic design phase, installing empty conduits may simply be a waste of time if the electrical room does not mesh with the duct bank's location.

Proposed Layout Synopsis

On the next page is a full site plan showing the proposed high voltage distribution layout. Several improvements are made in this system. The design looks at PSHMC's East Campus from a broad perspective, rather than just focusing on one construction project at a time. Phasing all of the utility runs at once enables a better grasp of how each feeder is distributed throughout the new buildings and how they can be efficiently managed. Figure 3 presents a summary of the new plan's ductbank segments.

Figure 3. Proposed Layout- Feeder Distribution Summary

DUCT BANK SEGMENT	CONDUITS PER SEGMENT	FEEDER DISTRIBUTION PER SEGMENT			
5" Conduit, 3 Phases per Conduit		Hospital 'A'	Hospital 'B'	Loop 'A'	Loop 'B'
Substation to EMH 2120 A/B	**8**- (4) Active, (4) Spares	X	X	X	X
2120 A/B to Parking Garage	**4**- (2) Active (2) spares			X	X
2120 A/B to 2130	**4**- (2) Active (2) spares			X	X
2120 A/B to 2150 A/B	**4**- (2) Active (2) spares	X	X		
2120 A/B to 2310 A/B	**6**- (2) Active (4) spares	X	X		
2310 A/B to Cancer Institute	**6**- (2) Active (4) spares	X	X		
2310 A/B to Children's Hospital	**6**- (6) spares				
2310 A/B to Empty Termination	**6**- (6) spares				

SCALE	PROPOSED SITE ELECTRIC DISTRIBUTION PLAN	PSHMC CANCER INSTITUTE	Gilbane / PENNSTATE Milton S. Hershey Medical Center College of Medicine
1/4" = 40'			

Comparative Analysis

The remainder of this study compares the existing and proposed layouts with respect to three core concerns for PSHMC and Gilbane: energy losses, constructability, and value engineering. Data and calculations are detailed further in Appendix B.

Systems Loss Comparison

With two feasible options, it is necessary to evaluate their performances with respect to energy costs. This analysis in particular is based on the direct relationship between distance and resistance; the longer a feeder has to travel, the greater the accumulated resistance and ultimately the greater the losses. Both voltage drop and power losses are examined, as voltage is pertinent to operating conditions and electricity costs are charged per kilowatt-hour used. Load demands and thermal conductance between conduits are considered constants in this study due to the fact that loading will not change, and any thermal impact is negligible compared to resistance losses.

High voltage lines, such as these four feeders, are installed to minimize losses. However, a side-by-side comparison is still necessary due to the fact that small losses can accumulate over time to equal a significant impact on energy costs.

Values herein are based on distribution plan take-offs, usage data from OPP's electrical monitoring system, and empirical specifications for the copper feeder wires. Since each line runs on a different amperage, and because the Hospital and Loop lines differ in total lengths, the study required analyzing each of the four feeders separately. Although usage data is for a 1-week period, it has been assumed to represent feeder averages for a year's time. The results of the study are summarized on the following page.

Figure 4. Line Loss Comparison

FEEDER DESIGNATION	CONDUIT LENGTH (linear ft.)	RESISTANCE (All Three Phases)	AVG. AMPS	AVG. VOLTS (kV)	VOLTAGE DROP (V)	AVG. LOSSES (Watts)	AVG. LOSSES PER YEAR (Watts)	ANNUAL COST OF LOSSES ($.0877/kWh)
Existing Layout								
Hospital A	2496	0.1662	86	14.06	14.30	1229.46	8526.47	$747.77
Hospital B	2496	0.1662	90	14.09	14.96	1346.49	8675.86	$760.87
Loop A	2007	0.1337	115	14.06	15.37	1767.74	10282.51	$901.78
Loop B	2007	0.1337	77	14.09	10.29	792.51	5364.92	$470.50
Total Length:	**9006' of conduit**				**Total Losses:**	**5136.2**	**32849.76**	**$2880.92**
Proposed Layout								
Hospital A	2331	0.1552	86	14.06	13.35	1128.49	7962.83	$698.34
Hospital B	2331	0.1552	90	14.09	13.97	1235.90	8102.34	$710.57
Loop A	1822	0.1213	115	14.06	13.95	1640.02	9334.69	$818.65
Loop B	1822	0.1213	77	14.09	9.34	735.25	4870.40	$427.13
Total Length:	**8306' of conduit**				**Total Losses:**	**4739.66**	**30306.43**	**$2635.79**
Estimated Energy Savings, Proposed Layout:								
Conduit Savings = 700 ft								
Wiring Savings = 700 linear ft. * 4 Wires = 2800 ft								
kWh Savings per Year = 2560.00 kWh								
Cost Savings per Year = $224.51								

It is evident from this analysis that, for four feeders, small distances add up to equal a significant amount of accumulated resistance in the copper wire. Taking a week's usage data from March 29th to April 4th and extrapolating over 8,760 hours (or 365 days), shortening the 3-phase conductor lines by a total of 2100' translates into $223 deducted each year from the electricity bill. Though this may not seem very substantial from PSHMC's perspective, it provides a good selling point in favor of the proposed layout.

Constructability Review

The new layout achieves three things with respect to constructability and initial costs. Though no single aspect saves a great deal of money, together these improvements can be considered highly beneficial from a construction and maintenance perspective.

Reduced Duct Bank Lengths

The first clear advantage of the proposed layout is the total reduced length for new duct bank installation. The distribution begins by having the (8)- 5" conduits coming from the substation run across Campus Drive as they reach the Southwest corner of the Parking Garage. The conduits then travel South to EMH 2120 A/B, moved from its original location at the corner of these two roads. The Parking Garage connection, containing both Loop feeders, is run back alongside the 8-conduit duct bank and installed during the Campus Drive shutdown. These are the only two segments that are lenghtened in the new plan. Figure 3 below summarizes the cost and schedule impact of the new layout with respect to duct bank installation and wiring costs.

Figure 5. Duct Bank, Conduit and Wiring Cost Comparison

Activity	Existing Layout (incl. O&P)	Proposed Layout (incl. O&P)
Duct banks (incl. excavation, pour)	$310,300	$313,563
PVC Conduit	$87,102	$84,636
Wiring (feeders & ground conductors)	$361,326	$314,880
Totals	**$758,728**	**$713,079**
Proposed Layout Savings- Duct Bank, Conduit and Wiring = $45,649		

Elimination of Manholes

By consolidating the duct banks, the new plan eliminates three manholes from the site. Manholes 2120 A and B serve as the hub of distribution throughout the site. As with the original plan, feeders split into their designated manholes and exit in an array of conduit that takes the necessary lines to their destinations. Also stemming from MH 2120 A/B is the Loop feeder connection to UPC and the Hospital feeder connections to EMH 2310 A/B. EMH 2145 is reduced to a simple handhole since the span between 2150 A/B and 2120 A/B is under the maximum 600' distance between manholes. Lastly, EMH 2320 A/B are able to be deleted completely from the plan, as approved by OPP's utility systems engineer during this study. These changes amount to a total savings of $9,050 in construction costs.

Fewer Road Crossings

The existing site power plan involves three road crossings- Centerview Drive, Campus Drive, and the intersection of Service Road and Hospital Drive. Installing the duct banks is a time-consuming process which requires temporary shutdowns of the routes, typically scheduled for weekends. Each crossing thus demands proper coordination between the hospital management and construction team so that traffic patterns can be reworked, permits obtained and notice given to hospital staff and visitors.

The new plan eliminates one of these road shutdowns by rerouting the main 8-conduit ductbank across Campus Drive before reaching the intersection with University Drive. What was once a right-angle crossing of two roads is reduced to a single shutdown of the less traveled route. Though cost savings are not significant here, benefits are realized to the schedule and logistics plan.

Value Engineering Considerations

The new layout takes utility systems engineering to a higher level of program management. Rather than waiting for plans to be finalized for these three projects, a comprehensive site plan is established that enables freedom in design, while still minimizing the extent of subsurface utilities work.

When looking at high voltage distribution from a broad perspective, the current total cost of construction amounts to $782,179, excluding any future costs for the Children's Hospital tie-in. The proposed system, which includes this empty conduit, costs $727,480, decreasing the high voltage package by 7%. Thus, advance planning would not be a waste of time as savings are still realized with the new layout. Further, as shown in the electrical study, added savings of $225 a year are realized as a result of the reduced conduit lengths. With the cost of energy continually growing, simple evaluations of distribution layouts can prove to be effective means of reducing the price of electricity incurred by large consumers such as PSHMC.

Lastly, sequencing the installation scheme all at once creates a streamlined approach that benefits the construction sites. Since the Parking Garage and Cancer Institute projects are running concurrently, it is possible to compress the activity to a couple weeks rather than months, without harming production rates for either project.

Recommendation

The proposed site power plan has its distinct advantages over the existing layout from both a construction and operation perspective. Benefits to cost, schedule, and sequencing is realized from a project management side, while value is added through savings in electricity costs. It is the recommendation of this analysis that the alternative site layout plan be adopted by PSHMC.

DEPTH STUDY

Building Respect: Industry Influences on Subcontractor Markups

Background

The investigation herein was started during my internship with Gilbane at PSHMC, and directly correlates to the theme of the 2006 PACE Roundtable held in November 2006. The focus for PACE this year was on building respect among construction project entities, including owners, designers, builders, and vendors.

This research topic focuses on the relationship between project managers and subcontractors by examining subcontractor markups on bids for their work. More specifically, it examines the value added above the allowable contract markup, sometimes referred to as a "multiplier."

Problem Statement

Bid package markups of individual subcontractors are typically consistent from one project to the next, provided there is similar risk associated to the jobs. However, a much different relationship can exist between a subcontractor's markup and the construction management (CM) or general contracting (GC) company overseeing the job. This variation results from the practices and structure of different CM and GC companies as perceived by the subcontractor. Not only does this impact the overall bid to an owner, but it also creates tension in the industry when builders have difficulty of subs returning for work. Economics plays a key role in the bid process; still, CM/GC companies need to be aware that maintaining positive relationships with their subs is critical to the markup values.

Research Goal

To aid CM and GC companies in evaluating their bid package markups, I will attempt to identify the key elements of their organizations that differentiate themselves in the eyes of the subcontractor. Through two different surveys, one tailored to the CM and GC

companies and one to the subcontractors, I expect to discover the defining characteristics that cause subs to vary their markups dependent upon the management team that is on the job. It is my ultimate goal that the industry takes this information to internally examine their subcontractor management methods. Positive relationships result in competitive bids, successful projects, and a level of respect that is paramount in the construction industry.

Research Plan & Methodology

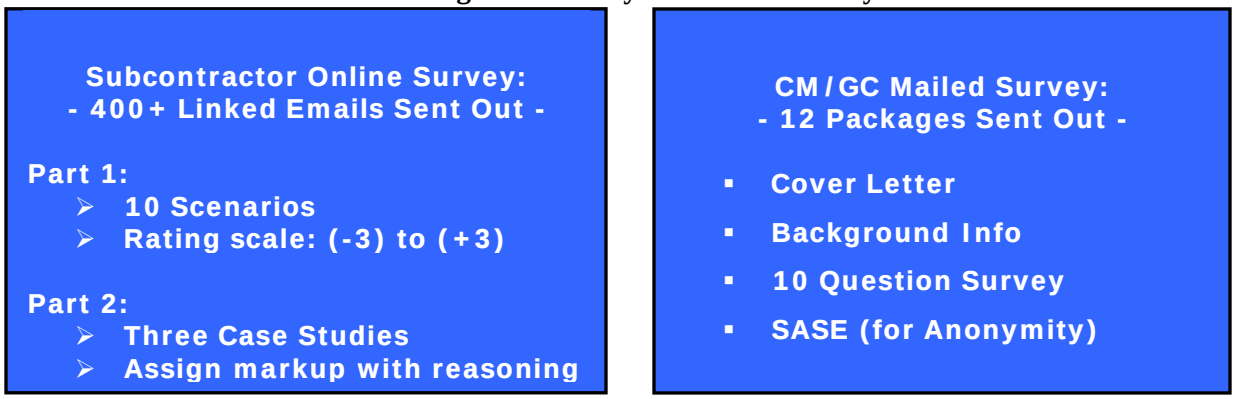
To produce a comprehensive analysis on subcontractor markups, both project management professionals and subcontractors needed to be interviewed during this study. Thus, research began by developing a comprehensive survey for the CM/GC, with questions designed to elicit the aspects of their management methods that ultimately impact a sub's bid package markup. In early February, a dozen project management professionals were provided with a packet of information that included a cover letter, contextual background, a 10-question survey, and a self-addressed stamped envelope. Anonymity was essential for this research so as to avoid bias in my evaluations and to encourage the professionals to respond openly and honestly. The goal was not to make an example of one company over another; rather, it was to identify the common and not-so-common management practices that influence their subcontractor relationships.

After the CM/GC surveys were sent out, a second survey for the subcontractors was developed and programmed so that it could be administered online and consequently allow for a larger response pool. This survey was reworked numerous times so as to maintain clarity and succinctness for the subcontractors. For this reason, it was broken into two parts. Part 1 consisted of ten questions, where brief scenarios were presented and they were asked to rate the impact of each condition on a prospective markup. A seven-point scale was presented with values ranging from -3 (greatly reduce) to +3 (greatly increase). This value system allowed for a statistical analysis to be performed on each scenario after enough surveys were filled out.

Part 2 of the subcontractor survey presented three case studies designed to measure the impact of a combination of factors on their markup. Subcontractors were presented with a fictional management team and project for bid. The CM or GC on the job was given a company history, reputation in the region, and summary of the project team members. Project type and scope were also included so that an objective factor was inherent for each markup; again, these multiplier values are influenced by economics equally if not more so than business relationships. After reading the comprehensive case study, subcontractors were asked to assign a markup or multiplier for their work, as well provide a brief explanation of the major factors affecting the value.

The second part of the sub survey intended to measure how scenarios from Part 1 combined to produce an overall multiplier. Thus, when average values were achieved for the ten scenarios, a matrix could be developed to essentially predict a multiplier based on a given set of conditions on any construction project.

Figure 1. Survey Content Summary



The research concluded with a qualitative evaluation of why subcontractors vary their bid markups, and assessed the accuracy of the matrix in determining a markup. The results are highly subjective, and thus it is important to retrieve a large number of results so as to identify the key aspects of a project that influence a subcontractor's markup decision. A copy of these data collection tools begins on Appendix C1.

Analysis- CM/GC Survey

Early on it was evident that the CM/GC survey results were going to vary dramatically. This was somewhat expected, as the questions were designed to elicit a qualitative self-assessment of their experiences with subcontractors. The remainder of this section will look at select questions from the CM/GC survey and summarize the key responses. For a full list of results, see Appendix C6.

Bid Package Markup vs. Contract Markup

The first two questions of the survey inquired into the typical markup received from subcontractors on bid packages and contracts. This drew some questions from professionals as to exactly what value was desired, but it soon became clear that the "multiplier" was analogous to the bid package markup. Still, responses were flip-flopped and free interpretation was required.

Typical contracts in the industry today see a markup of 15%, with 10% devoted to overhead costs and 5% profit. The respondents typically agreed with this fact, with values ranging from 10% to 20% O&P. Bid packages, however, are assigned a separate markup, which ranged from -2% to 8% in the survey. This second value is the intended target of the study due to the fact that it ranges from negative to positive values. Markdowns are thus possible on bid packages, provided the right project conditions and a good standing relationship with the subcontractor.

Determinants of a Bid Package Markup

This question drew a large variance of responses. Whereas one professional did not have access to this information due to the nature of their contracts, other managers identified a number of influences on bid package markups. This list will be important when comparisons are made to the subcontractor survey results. Some of the more prevalent factors listed are summarized in Figure 2 on the next page:

Figure 2. CM/GC Survey- Major Determinants of a Markup

▪ Backlog of Subcontractor	▪ Definition of Work vs. Overhead
▪ Schedule Reasonability	▪ Project Size
▪ Knowledge of CM/GC Practices	▪ Contract Type/ Risk Allocation
▪ CM/GC Work Experience	▪ Other project entities- A/E/GC/Owner
▪ Competition/ Supply vs. Demand	

It is clear that, from the eyes of the CM/GC professionals, there is no way to effectively control the markups they receive on bid packages as there are simply too many variables. Further, only one respondent identified the CM/GC personnel as an influence, which can essentially be considered a subjective factor as it is based solely on past experiences and relationships. The majority of responses are objective in nature; the factors identified are concrete values that deal with economics, time tables, and assumed risk.

Company Self-Assessment

Several of the questions delved into subcontractor relationships, change order negotiation practices, perceived reputations, and typical client-base. When examined as a whole, one can characterize this group of questions as the bulk of the company self-assessment. First off, one must note that while all of the selected companies have good reputations, those interviewed were chosen for their variance in size, structure, and targeted project or client base. A broad spectrum of both construction management and general contracting firms allows for a diversified opinion base on markup influences.

When looking at subcontractor relationships specifically, all of the CM/GC professionals expressed satisfaction with subs returning for work. When asked how they approached change order negotiations, all responded the same, with half even using the same three word phrase- “fair but firm.” One response expanded on this mantra with a thorough explanation of their standard business practices:

> "Our negotiation practices are to pay a fair market value for a change order based upon market conditions. We perform an in-house estimate of every change order and compare with what the trade provides. If we differ, we discuss prior to negotiations."
>
> - Survey #4, Question 6 (Appendix C7)

From a quantitative perspective and dependent upon the type of trade, subcontractor markups typical fall within the same range. For example, one respondent noted how a sheet metal fabrication sub will have a much higher overhead than a drywall or painting sub. This is simply due to the fact that overhead takes into account not only installation, but also added fabrication, equipment, and labor costs (Survey #5, Question 4.). Other influences on markup consistency matched responses from Question 3 of the survey, such as supply and demand, or the availability of work in the area.

Further, it was interesting to see the stark contrast in perceived reputation versus repeat work with subcontractors and clients. All of the companies have great success with subs returning for work (90% to 100%) and with repeat clients (70% to 90%). Despite this fact, their company descriptions regarding reputation and potential had only one common similarity- their respective companies are relationship driven (see Question 8, Appendix C8). Thus, it can be concluded that while all of these firms have formed their own unique reputations, maintaining relationships is still the key to success. To recall the question on markup determinants, however, it was noted that only two of the surveys identified past working relationships as having an impact on a sub's markup. Even more surprising is that only 1 out of the 6 respondents felt the specific CM/GC personnel influenced a markup. It is evident that relationships, though important to CM/GC success, are not regarded as highly as basic market drivers when looking at bid package markups.

Analysis- Subcontractor Survey

Unfortunately the number of responses received was far less than expected. Though more than 400 survey links were emailed to subcontractors across the country, only 25 were filled out. Despite this circumstance, the statistical analysis proceeded. The complete results of the survey, including statistical analyses, begins on Appendix C9. A general analysis is performed below.

Part 1

The goal of the online survey was to quantify the results submitted in the CM/GC surveys with respect to markup influences. By statistically analyzing the subs' responses and assigning point values to ten key factors, a matrix would be devised that would essentially predict a multiplier based upon the incidence of the factors for a particular project at bid. Respondents were asked to respond to each of the ten questions by choosing a markup impact factor. The 7-point scale is shown below.

Figure 3. Markup Impact Scale

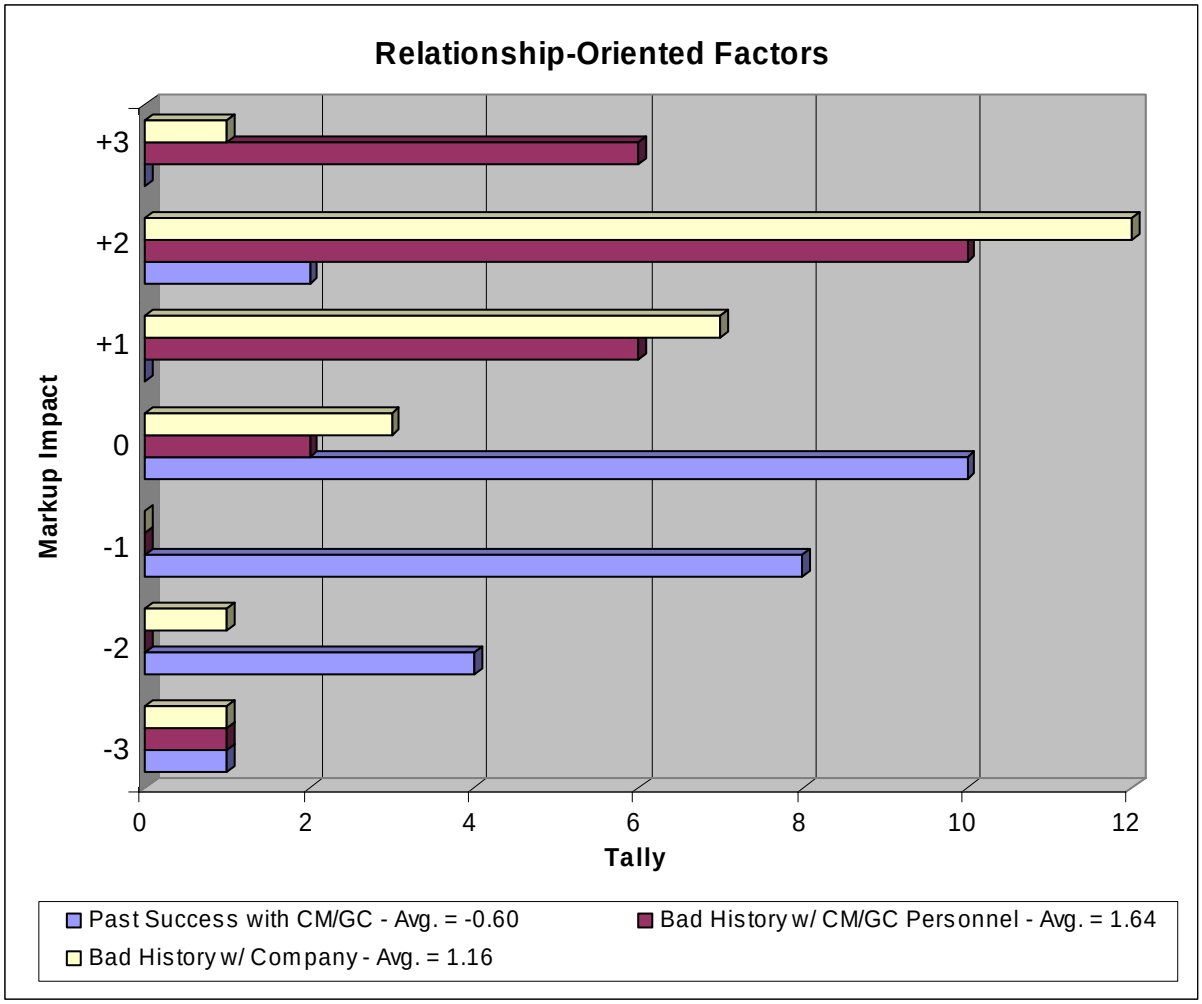
Greatly Reduce	Moderately Reduce	Slightly Reduce	Keep the Same	Slightly Increase	Moderately Increase	Greatly Increase
-3	-2	-1	0	1	2	3

The analysis of Part 1 that follows groups questions into one of three factors: relationship-oriented, business-related, and regional. The charts present response data based on the Markup Impact Scale, with a tally of each response across the x-axis. Each scenario's description also presents the average value as determined by the scale used. This value, though not an actual markup percentage, will be used as the multiplier for the markup prediction matrix.

Relationship-Oriented Factors

Three of the questions dealt with past relationships with either the CM/GC firm, specific project personnel, or both. Respondents were asked to quantify the impact of these past outcomes on a markup for a project at bid. The results were consistent with the opinion that partnerships have a major influence on future markups (see Fig. 4).

Figure 4. Effect of Past Experiences on Markups

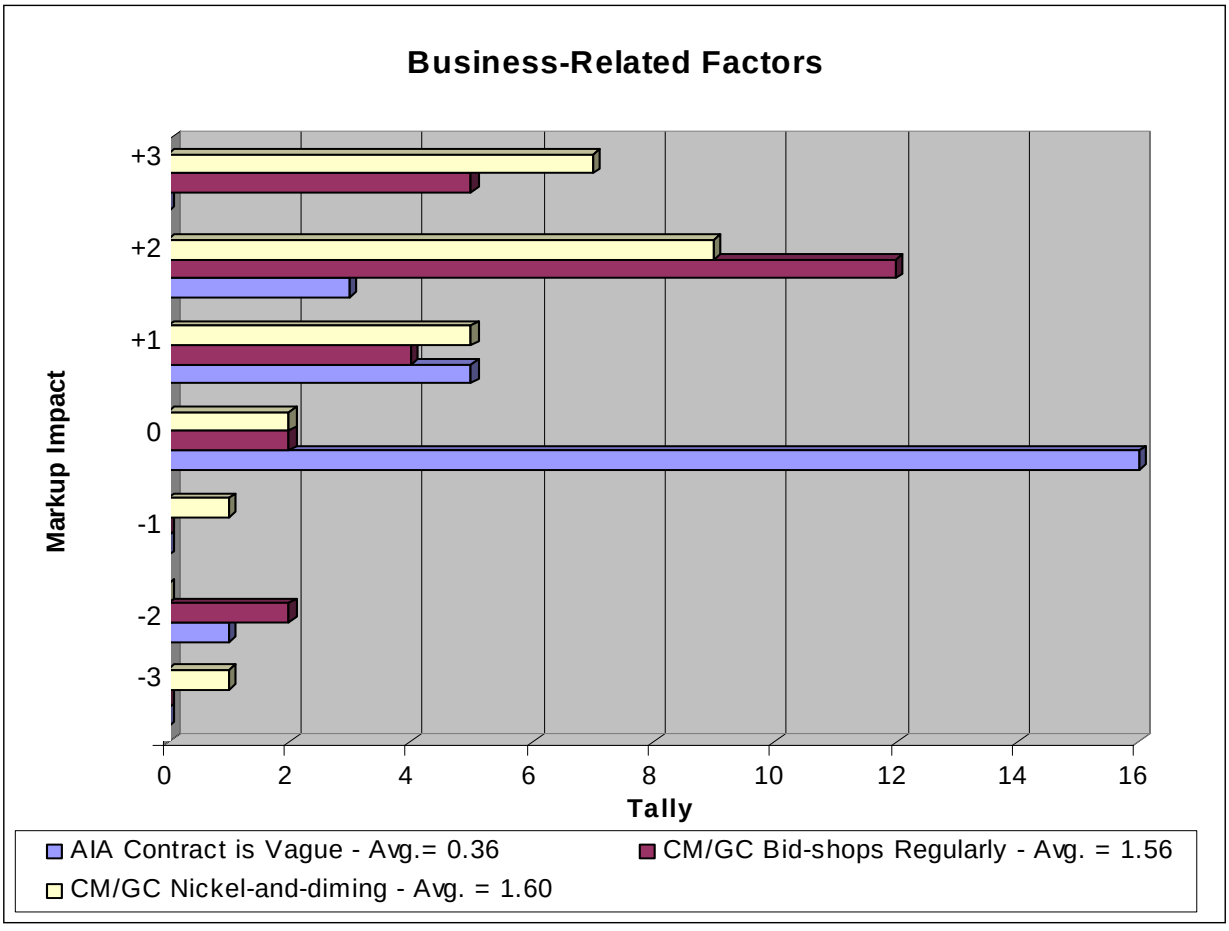


Two of the three series here are negative scenarios for the subcontractor, thus resulting in an increase to the markups. Further, while bad experiences with a project management company result in only a slight increase (1.16), similar situations with individual project team members causes a moderate to high increase in the markup (1.64). Personal relationships are valued greatly in the construction industry, reinforcing the fact that project managers need to be respectful of their subcontractors on a day-to-day basis.

Business-Related Factors

Four of the questions covered information about the CM/GC's typical business practices, including bid-shopping, change order strategies, contract documents, and scheduling. With the exception of the scheduling question, all of these factors were worded so as to elicit a negative response. Bid-shopping, "nickel-and-diming," and contract vagueness were expected to increase the assigned markup, and for the most part subcontractors responded accordingly. The data is compressed below for these three factors.

Figure 5. Effect of Detrimental Business Practices on Markups



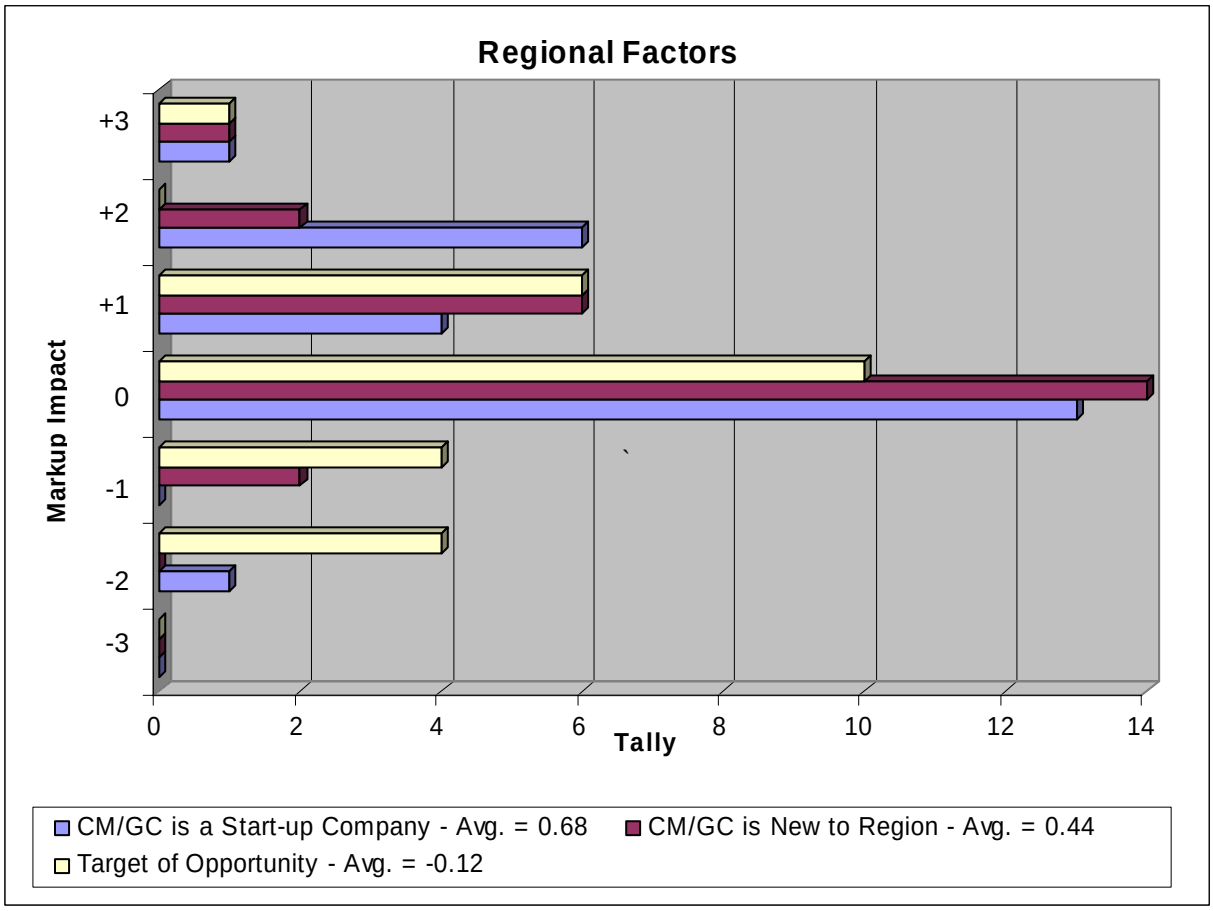
Intentionally detrimental practices of a project team have a substantial impact on a sub's markup. However, while bid shopping and penny-pinching result in a slight to moderate increase, contract vagueness has little impact on the markup. This could be partly due to

the fact that procedural ambiguity can end up being a good situation for subcontractors when it comes to change order inflations. It is also interesting to note in this graph that several respondents chose to decrease their markups with respect to bid-shopping. This proves that bid-shopping still exists in certain markets since subs were willing to decrease their markups if it means winning the contract.

Regional Factors

Lastly, three of the questions dealt with speculative situations involving the CM or GC. These presented a situation where the CM was new to the region, the CM was a start-up company, or the job at hand was a "target of opportunity," or one-shot deal. These three questions aimed to hit on some of the subjective influences suggested by the CM/GC professionals in the first survey.

Figure 6. Regional Influences on Markups



In the "target of opportunity" scenario, the subcontractor was to infer that the job does not present much room to make money. Thus, the question was expected to result in a significant increase in the markup from a CM or GC perspective. However, the result was quite the opposite, with respondents on average keeping the markup the same (-0.12). If you examine the data for this question, there is an evident bell-curve in the markup impact. This suggests that the question left more freedom with its interpretation. It is possible that respondents saw this as a competitive job and thus marked down their bid in order to give them a better shot.

Continuing with the regional data, it is shown that a prominent CM/GC company new to the region is only slightly favored (0.44) over a start-up company (0.68). Regardless, the majority of respondents did not feel either was a significant factor at a glance. This particular result will be contradicted by the results of the case studies. Below are the results tabulated into the Multiplier Matrix, which will be applied to Part 2 of the survey.

Figure 7. Multiplier Matrix

FACTOR TYPE	SCENARIO	AVG. VALUE	AVG. IMPACT
Relationship-oriented Factors	You have had difficulty in the past working with some of the CM/GC personnel.	1.64	Moderately Increase
	You have had difficulty in the past working for the CM/GC company.	1.16	Slightly Increase
	You have had past successes with the CM/GC company, including some the current team members.	-0.60	Slightly Reduce
Business-related Factors	"Nickel-and-diming" practices are common for the CM/GC	1.60	Moderately Increase
	The GC has been known to bid shop on a regular basis.	1.56	Moderately Increase
	The AIA Contract is vague with respect to markup percentages, including any sub-sub markups.	0.36	Keep the Same
	The CM/GC is recognized for staying on schedule and meeting milestones.	-0.28	Keep the Same
Regional Factors	The CM/GC is relatively new to the industry.	0.68	Slightly Increase
	Though prominent in other areas of the country, The CM/GC is new to your region.	0.44	Keep the Same
	The job is a "target of opportunity" (one-shot deal).	-0.12	Keep the Same

→ ***Using the Matrix: Choose which scenarios apply and calculate an overall average value. Then, use the Markup Impact Scale to determine the magnitude of the expected markup.***

Part 2

The second half of the survey was intended to test the matrix developed in Part 1 by providing varied combinations of the ten factors in short case-study synopses, and then asking what markup would be assigned. Company history, reputation, team profile, project type and scope were provided for each of the three situations. This mixture of objective and subjective data gave the subcontractor ample enough information to gauge their markup and identify which had the most influence.

Alpha Construction Company

This first case study introduced a generally negative scenario for the subcontractor. Though Alpha was a national firm and had high client satisfaction, their business strategies were often detrimental to their subcontractors' profitability. In addition, the subcontractor was informed that they had difficulty working for some of the CM staff, specifically the Superintendent. Though vague in its presentation of the context, Alpha was expected to result in a generally high increase in the markup simply due to the presence of these three key factors. Extracting the values from Part 1 intrinsic to the Alpha case study and taking an overall average, you get a predicted impact:

Figure 8. Alpha Construction Company- Multiplier Results

PRESENT SCENARIOS	AVG. VALUE	AVG. IMPACT
You have had difficulty in the past working with some of the CM/GC personnel.	1.64	Moderately Increase
"Nickel-and-diming" practices are common for the CM/GC	1.60	Moderately Increase
The CM/GC is recognized for staying on schedule and meeting milestones.	-0.28	Keep the Same
Though prominent in other areas of the country, The CM/GC is new to your region.	0.44	Keep the Same
Combined Average, four scenarios	**0.85**	**Slightly Increase**

Overall, subcontractors responded to the situation with negative opinion, with a markup average of 3.31% above their Overhead and Profit (see Appendix C12). One can consider this as a generally moderate increase, falling in the range of 2% to 5% above the allowable markup. Though this contradicts the predicted impact in Figure 8, it is a good

sign in reality, as it is evident that some of these characteristics outweigh others with respect to markups. Explanations by the subcontractors reinforce this fact. Alpha's disregard for the subcontractor's well-being caused a markup that assured profitability for the sub. Also influential is the fact that the Superintendent "can make or break a job," and a poor history does not bode well going into a bid.

Beta Contractors

Beta, the start-up company scenario, presented an interesting situation. Though they were new to the industry, the principals of the firm had a great deal of experience between them. Thus, reputation was founded on a personal basis rather than through their company's recognition. Further, a risk factor was made apparent, with the project being the largest job for Beta to date, and the first time working with the subcontractor. Only two of the scenarios from Part 1 were included in this case study:

Figure 9. Beta Contractors- Multiplier Results

PRESENT SCENARIOS	AVG. VALUE	AVG. IMPACT
The CM/GC is relatively new to the industry.	0.68	Slightly Increase
The job is a "target of opportunity" (one-shot deal).	-0.12	Keep the Same
Combined Average, two scenarios	**0.22**	**Keep the Same**

Results for this second case study slightly exceeded expectations with an average markup of 1.6% (See Appendix C13), showing little impact due to the experience of the principals and their commitment to success. A markup multiplier of 1.6% should be considered a relatively slight increase, again going against the prediction matrix. Still, the risk factor of Beta Contractors being a new company was reflected in several surveys, as noted by one respondent:

> "Two factors- new companies have poor cash flow and hence slow pay, [and] new companies try to make their reputation for on time and on budget at the subs expense."
>
> Sub Survey #8, Beta Case Study (Appendix C9)

Another subcontractor, however, saw Beta's freshness in a completely opposite sense:

> "The focus of individuals with talent, whose reputation is on the line would be a driving force and probably lead to a successful project. Often times, large companies spend more time overstaffed, working on sideline logistics (tracking, reporting, safety, EEOC) than they do building the building. Smaller, more focused companies often get the job done more efficiently."
>
> Sub Survey #7, Beta Case Study (Appendix C9)

In striving for client satisfaction, this respondent felt Beta would manage the project by streamlining production and minimizing protocols. Though this approach leaves room for potentially damaging consequences, the contrasting opinions show how the same project can be approached from different angles. When it comes to project risk, it all becomes a matter of perspective, experience, and confidence. However, sacrificing critical checks on safety and quality should be considered unethical practice, as it places unnecessary risk on the builders, owners and operators of a building.

Choice Management

The final case study presented a positive situation for the subcontractor. Choice Management is respected by both their clients and subs; they commit themselves to their projects, and they have assembled a project team that worked well with the respondent in the past. The only negative factor in this scenario was that a few jobs in the past did not run smoothly. With a combined three scenarios included from Part 1, Choice has the following predicted markup impact:

Figure 9. Choice Management- Multiplier Results

PRESENT SCENARIOS	AVG. VALUE	AVG. IMPACT
You have had difficulty in the past working for the CM/GC company.	1.16	Slightly Increase
You have had past successes with the CM/GC company, including some the current team members.	-0.60	Slightly Reduce
The CM/GC is recognized for staying on schedule and meeting milestones.	-0.28	Keep the Same
Combined Average, three scenarios	**0.09**	**Keep The Same**

Respondents on average assigned a markup value of 0.1% above overhead and profit, agreeing with the prediction matrix but contradictory to the majority of the written explanations. Over half of those surveyed either kept the markup the same or reduced it, anywhere from -1.5% to -5%. And while many chose to reduce the markup significantly as a result of their regional notoriety and past successes, others put more emphasis on the few bad experiences in the past or the project's risk. Another explanation provided was that, "the smaller the job, the greater the markup," due to the economies of scale and to cover management costs. Like the Beta case study, this scenario involved a situation where perspective came into play- while many value a long history of successful collaboration, there are others who never forget those few breakdowns in the past.

Sub Survey Commentary

One thing that must be remembered is that the markup impacts summarized in Part 1 are not reciprocal with respect to a given scenario. A bad experience in the past with a superintendent may cause a significant increase in the multiplier, but a positive experience does not always mean the markup will be decreased by the same magnitude.

Overall, it is evident that while the prediction matrix had good intentions, there are simply too many factors that come into play when subcontractors assign markups on bids for their work. Assigning a weighted system to the ten factors presented in Part 1 of the survey would disregard the variety of other reasons identified in the case study responses.

Comprehensive Response

The original intent of this research was to measure the impact of certain business practices on a subcontractor's bid package markup, and ultimately attempt to weigh each of these on a multiplier scale. Though the weighted matrix did not turn out as well as planned, much more was achieved in the diversity of answers. A comparative analysis of the CM/GC and subcontractor responses allows for a much more meaningful investigation.

Major Determinants of a Markup Multiplier

When looking at the responses pertaining to markup determinants, it is evident that construction managers and subcontractors have different opinions on their relative significances. Since it is not possible to rank them in order of importance, the frequency of certain factors becomes the element to consider.

For the purposes of this analysis, factors listed in the subcontractor case study responses all contributed to the tally, regardless if the respondent listed zero or a dozen. Doing otherwise would show bias with respect to the selection. Further, influences were broken down into five basic categories:

- Market Conditions- includes regional economics, competition, work availability, prevailing wages (*does not consider standard overhead and profit*)
- Project Scope- size, type, complexity, location, schedule, & risk
- CM/GC Business Practices and Regional History/ Reputation
- CM/GC Personal Relationship & Past Working Experiences
- Other Entities- Architect, Engineer, Owner; drawing & specification clarity

Figure 10. Key Influences on Subcontractor Markups (Totals)

CM/GC Survey Results	Subcontractor Survey Results
1. Market Conditions (9)	1. CM/GC Business/ Reputation (28)
2. Project Scope (7)	2. Market Conditions (26)
3. CM/GC Business/ Reputation (4)	2. CM/GC Relationship/ Past Experiences (19)
3. Other Entities- A/E/Owner (3)	4. Project Scope (17)
5. CM/GC Relationship/ Past Experiences (2)	5. Other Entities- A/E/Owner (10)

Several things become apparent from this table. Before comparing these two lists, it is important to remember that the case studies were formatted to elicit some sort of reaction with respect to each of the three fictional CM/GC companies. Despite this fact, the subcontractors were not limited when it came to the markup influences intrinsic to each case study. The two lists above should be appreciated for their differences. Whereas the CM and GC professionals emphasize objective factors, subcontractors tend to take a more subjective perspective, valuing the reputations and relationships with each of the project entities involved.

Objective Factors

If standard overhead and profit were included in the market conditions category, it would naturally rank first in both surveys. Thus, it can be noted that regional and company economics plays the biggest role in any project out for bid. The availability of work from both perspectives is critical, as competition among subs will always lower a bid. Supply and demand is a basic concept that can not be overlooked in any industry.

Project scope, the second most frequent influence listed by project managers, ranks fourth on the subcontractor list. Again, controlling for the nature of the case studies it is likely that this would rank second among subcontractors as well. Large jobs tend to decrease markups due to economies of scale, while complexity causes the opposite reaction. Further, schedule reasonability is vital for subcontractors with respect to resource availability and expected workload.

Subjective Factors

The real difference between the surveys lies in the relative significance of a company's history, reputation and business practices. Subcontractors overwhelmingly noted the importance of these factors in the case study analyses, despite the fact that they took contrasting opinions on the way it influenced their markups. This is seen in all three scenarios, but especially in the Beta Contractors study. The delivery method and structure of a project plays a crucial role, with many subcontractors increasing markups whenever a construction management company is involved due to lengthier decision processes and more logistical constraint.

Past work experiences and partnerships rank high on the subcontractor list as well, again reinforcing the point that these elements can not be overlooked from a project management standpoint. Going back to the CM/GC survey, all of the companies reported a 90% to 100% rate of subcontractors returning for work. Being highly regarded project management companies, it is evident that they are doing something right, and it directly ties back into this element. Maintaining relationships, being fair, providing last looks- all of these practices build on a company's regional reputation. Most importantly to remember is that respect does not precipitate from the top-down; rather, it requires positive interactions from project to project, and communication between leaders to reinforce these partnerships.

Conclusion- Building Respect

Construction is a unique business in that it is primarily a service industry, despite the fact that it provides a final product, a building, for its customers. Client satisfaction is paramount to a construction manager or general contractor's success, but that does not mean they can disregard their subcontractors' well-being. Since subjective elements such as business relationships cannot be quantified, it is the responsibility of the management professionals to value and actively maintain their subcontracting connections.

The goal of this research topic was to investigate respect among construction managers, general contractors, and subcontractors. If one key point is taken away from this study, it is that the construction industry places great value in a company's reputation. Among owners, it goes a long way- three good projects are required to balance out the impact of a single bad one. From a subcontractor's standpoint, it can be summarized that good reputations are built through conscientious business practice, positive communication, and the daily interactions that take place on a project.

CONCLUSION

The analyses performed in this report all connect back to the projects currently underway at PSHMC. As the Cancer Institute begins to install the micropiles, one expects communication between the owners, engineers, project managers, and subcontractors to continue at the same high degree of coordination achieved at the Parking Garage. Though this project incurred losses to schedule and cost, it is likely that the Cancer Institute will be able to avoid or at least minimize the impact of any similar subsurface issues. Respect is achieved on all levels when collaboration on this level exists.

Structural Breadth Study

The Geopier-reinforced mat slab foundation proposed in this analysis proved what was expected from the start- the initial cost is greater than the current system, but it avoids subsurface issues that may be encountered with the micropile installation. Though this may not be a convincing argument from a value engineering standpoint, this system or one like it should be considered for Children's Hospital if the Cancer Institute runs into problems similar to those experienced at the Parking Garage project.

Electrical Breadth Study

Redesigning the high voltage distribution plan proved to be a simple yet effective way of trimming construction and operation costs for PSHMC. Small adjustments can add up to equal significant savings, stressing the importance of comprehensive program management in major construction undertakings.

Construction Management Depth Study

The results of the research study on markup influences proved to be an effective means of reinforcing the importance of building respect within the construction industry. Regardless of which project entity one represents, it is critical that everyone in the process is mindful of the other's welfare. Reputations are built upon respect, more so from a subcontractor's perspective than an owner's. When respect is effectively practiced, it has a positive impact on the builders who in turn deliver quality projects and maintain strong business relationships.

Design Specifications- Micropile Foundation System

Zone	Total Piles	Average Length (ft)	Total Length
1- Primary Area	233	65	15145
2-Radiotherapy Area (Linac Valuts)	70	65	4550
3-Shell Space & ED Canopy	84	65	5460
4- Bridge Connection	20	65	1300
Total	**387 piles**	**65 ft**	**26455 ft**

Design Maximum Capacity:

End-bearing Piles = 280 kips
Tension Piles = 180
Battered Piles = 300 kips axial, 4 kips lateral

Geopier Calculations

(Based on GeoStructures Design Manual, Example Problem)

ZONE 1: PRIMARY AREA

Structural Specifications:

Column J5- 4 bearing piles, @ bearing design load of 280 kips each
4 Piles * 280 kips/pile = 1120 kips
Tributary Area = 992 sf
Distributed load = 1.13 ksf

Soil Data:

Undrained Shear strength, c(u) = 500 psf
Modulus of subgrade rxn. = 50 pci
Moist unit wt. = 120 pcf
Recommended allowable bearing capacity, shallow footings = 2000 psf

Geopier Design Values

For Silts and Clays, N=7 (Table 4.2 – Geopier Reference Manual)

Allowable composite footing bearing pressure, q_f = 6000 psf
Geopier & Footing Segment Capacity, Qqp = 85 kips
Geopier Stiffness Modulus, Kp = 210 pci

Lower Zone Design Parameter, Es = 250 ksf (From Geopier Manual backup literature)

Number of Geopiers required:

Total Design Load = [1120 kips] / [90 kips per Geopier] = 12.4 → Try 12 Geopiers

Footing Size and Composite Bearing Pressure:

Est'd. Ftg size = 1120 kips / 6 ksf = 187 sf → Try 14' x 14' ftg.
Actual Ftg. Size = 196 sf
Composite bearing pressure, q = 1120 kips / 196 sf = 5.7 ksf = 5714 psf

Upper Zone Settlement:

Area Ratio, R(a) of footing area covered by Geopiers (30" diameter → 4.91 sf)

R(a) = 12 Geopiers * 4.91 / 196 sf = 0.30 = 30.06%

Stress Ratio (Geopier to Matrix soil stiffness ratio)

Matrix soil modulus, Km= [2000 psf] / [144 in^2 per ft^2] / [1 inch] = 13.9 pci
Stress Ratio, Rs = Kp / Km = 210 pci / 13.9 pci = 15.12

Maximum stress on Geopier:

q(qp) = q * Rs / (Ra*Rs –Ra +1) = [5714*15.12] / [.30*15.12 - .30 +1] = 16482.7 psf

Upper Zone Settlement Calc:

S(uz) = q(qp) / Kp = 16482.7 / 144 / 210 = 0.545 inches

Lower Zone Settlement:

Allowable LZ Settlement, S(lz) = 1.0" – 0.545" = 0.455 inches

Footing width, B = 14', UZ + LZ = 2B = 28 feet

Try 10' Shaft Length

UZ = shaft length + 1 diameter prestress zone = 10' +30 inches = 12.5 feet
LZ = 28' – 12.5' = 15.5 feet

Lower Zone Stress, qlz at center of Lower Zone (using Westergaard Stress Dist.)

Center of LZ depth = UZ + (LZ / 2) = 12.5' + (15.5 / 2) = 20.25 feet
f(B) = 20.25' / 14' = 1.45
From Westergaard- approximately 14% of composite footing bearing pressure

Q(lz) = 0.14 * 5174 = 776 psf = .776 ksf

Lower Zone Settlement

S(lz) = q(lz) / Es * LZ * 12 in/ft = 0.776 / 250 * 14 * 12 = 0.537 in > 0.455 in

Settlement greater than 1", however still assume 10' shaft length for purposes of this investigation

Number of Geopiers required:

31' x 31' Bay @ 10' x 8' Spacing → 36,733 sf / 992 * 12 = 444 Geopiers

Not all bays 31' x 31', Therefore use spacing standard to determine number required.

Per Grid Plan → 419 Total Geopier Elements

ZONE 2: RADIOTHERAPY ENCLOSURE

70 Piles * 280 kips/pile = 19600 kips
Total Area = 6000 sf
Distributed load = 3.26 ksf

Number of Geopiers required:

Total DL = [19600 kips] / [90 kips per Geopier] = 217 → Try 220 Geopiers

@ 5.5' x 5.5' Nominal Spacing → 228 Geopiers Total

ZONE 3: SHELL SPACE

84 Piles * 280 kips/pile = 23520 kips
Total Area = 13811 sf
Distributed load = 1.7 ksf

Number of Geopiers required:

Total DL = [23520 kips] / [90 kips per Geopier] = 261 → Try 260 Geopiers

The nature of this area requires a second look: 24 of the piles are located in a grade beam at the South end, all of which are battered (angled). However, 260 Geopiers will still be installed due to ambiguity in how this load distributes over a mat slab.

@ 8' x 7' Nominal Spacing → 269 Geopiers Total

Geopier Summary:

Zone 1 = 419
Zone 2 = 228
Zone 3 = 269
Total = 916 Geopier Elements

Mat Slab Thickness Calculations

(Based on *Principles of Engineering,* Sixth Edition, Braja M. Das)

Feasibility Analysis: (uses foundation wall depth of 20' (typ.)

Soil Data**:** (from Geotechnical Report)

Undrained Shear strength, c(u) = 500 psf
Moist unit wt. = 120 pcf
D(f) = 20' + ?
Factor of Safety (shear) = 1.5 (typ.)
Φ = 22 degrees (internal angle of friction)
P = 1120 kips (from above)

D(f) calculation: q(net, ultimate) = 5.14*c(u)*[1+0.195B/L]*[1+ 0.4D(f)/B]

Zone 1: Using q(net, u) = P = 1120 kips:
Bay: 31' x 31' ftg. (B x L) (typical)

Using D(f) = 22' →3942.96 psf > 1129 psf OK- Determine Actual Thickness

Mat Slab Thickness Determination

Thickness Calculation: ΦV(c) = Φ4*sqrt(f'c)*b(0)*d
ΦV(c) = P
f'c = 4000 psi (based on structural specifications)
b = 2(b + d) + 2(c + d)
Φ = 0.85 (typical, punching shear)

Zone 1: Distributed Load = 1129 psf
Wall Depth = 20'
D(f) = ?
Column J-4: P = 1120 kips
Base Plate Dim's. = 22" x 22" (b x c)

→ d = 27" + 1" (dia. of reinforcing, 2 ways) + 3" (cover) = 33" = 2'-9" slab

Zone 2: Distributed Load = 3260 psf
Wall Depth = 20'
D(f) = ?

→ d = 49" + 2" (dia. of reinforcing, 2 ways) + 3" (cover) = 54" = 4'-6" slab
(Note, since no column point loads are in this area, b and c are assumed to be largest of base plates dimensions = 26" x 30")

Zone 3: Distributed Load = Not typical
Wall Depth = 20'
D(f) = ?
Pile Cap Q.5, 7.3: P = 560 kips
Base Plate Dim's. = 40.5" x 81" (b x c) (estimated)

→ d = 9" + 1" (dia. of reinforcing, 2 ways) + 3" (cover) = 13" → Use 15" slab

FOUNDATION CONCRETE COSTS- EXISTING SLAB ON GRADE										
CSI Code	Description	Qty.	Daily Output	Labor Hrs	Unit	Materials Unit Cost	Labor Unit Cost	Equipment Unit Cost	Total	Total, incl. O&P
3310-700-3900	Structural concrete, placing, pile caps, pumped, 6 C.Y. to 10 C.Y., includes vibrating, excludes material	562.73	200	0.32	C.Y.	$0.00	$7.10	$3.76	$10.86	$9,031.82
3310-240-4050	Structural concrete, in place, foundation mat, over 20 C.Y., includes forms(4 uses), reinforcing steel, and finishing	2614	56.5	1.986	C.Y.	$144.00	$50.00	$0.42	$194.42	$637,816.00
3310-220-0300	Structural concrete, ready mix, normal weight, 4000 PSI, includes material only	3186			C.Y.	$84.00	$0.00	$0.00	$84.00	$294,705.00
	Pile Installation									$1,250,000.00
Totals						**$228.00**	**$57.10**	**$4.18**	**$289.28**	**$941,552.82**

FOUNDATION CONCRETE COSTS- PROPOSED MAT SLAB										
CSI Code	Description	Qty.	Daily Output	Labor Hrs	Unit	Materials Unit Cost	Labor Unit Cost	Equipment Unit Cost	Total	Total, incl. O&P
3310-240-4050	Structural concrete, in place, foundation mat, over 20 C.Y., includes forms(4 uses), reinforcing steel, and finishing	5381	56.5	1.986	C.Y.	$144.00	$100.00	$0.42	$244.42	$1,582,014.00
	Geopier Installation	916			Ea.				$675.00	$618,300.00
3310-220-0300	Structural concrete, ready mix, normal weight, 4000 PSI, includes material only	5381			C.Y.	$84.00	$0.00	$0.00	$84.00	$497,742.50
Totals						**$228.00**	**$100.00**	**$0.42**	**$1,003.42**	**$2,698,056.50**

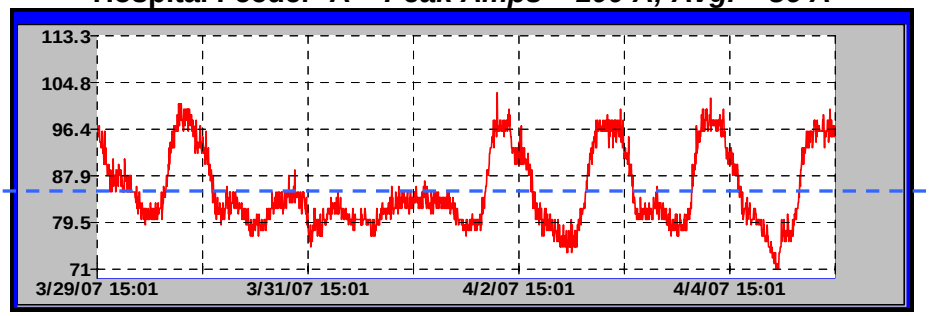
Assume: Two crews working on mat slab pour = 2x labor costs
Geopier cost/element based on rough estimate provided by Geopier professional
Pile Installation based on contract value provided by Gilbane

ELECTRICAL SYSTEMS DATA AND CALCULATIONS

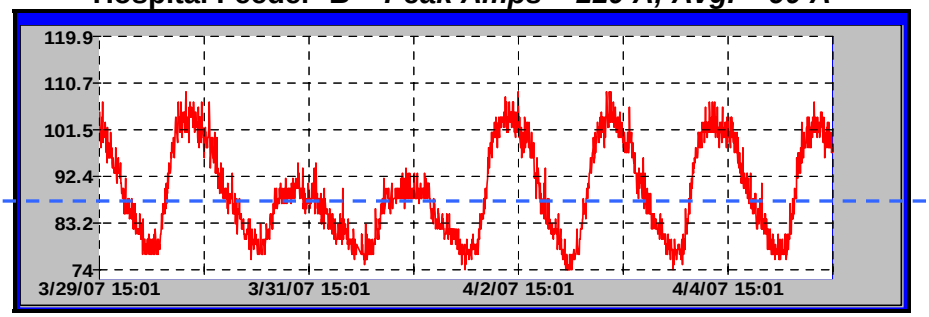
Feeder Data
Recorded from 3/29/07 to 4/4/07 (1 week period)

Amperage Outputs:

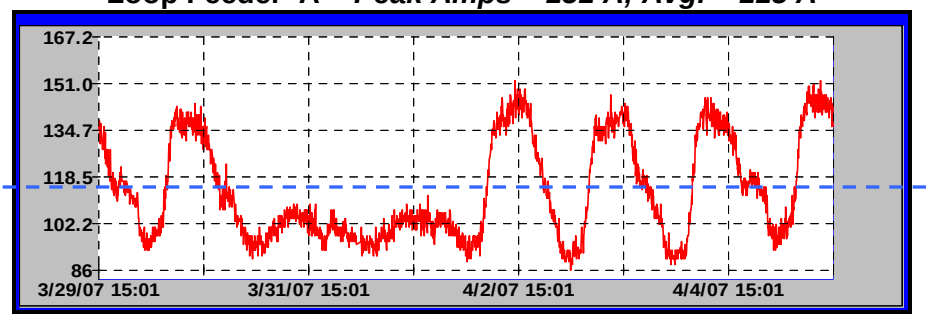
Hospital Feeder 'A' - *Peak Amps = 100 A; Avg. = 86 A*



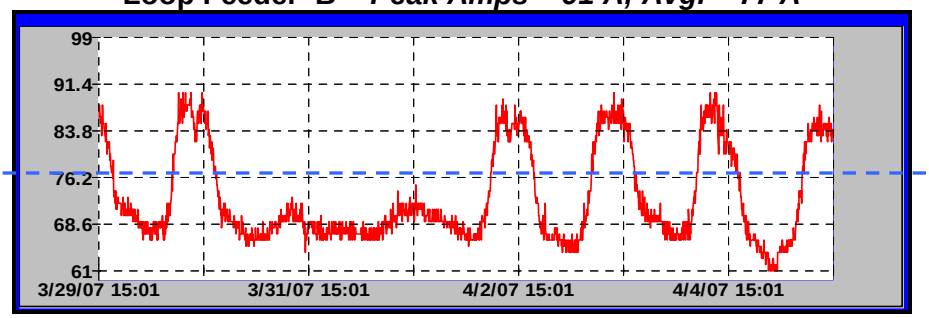
Hospital Feeder 'B' - *Peak Amps = 110 A; Avg. = 90 A*



Loop Feeder 'A' - *Peak Amps = 151 A; Avg. = 115 A*



Loop Feeder 'B' - *Peak Amps = 91 A; Avg. = 77 A*



Summary Usage Data

FEEDER DESIGNATION	PEAK AMPERAGE (A)	AVERAGE VOLTAGE (kV)
Hospital Feeders		
Hospital A	100	14.06
Hospital B	110	14.09
Loop Feeders		
Loop A	151	14.06
Loop B	91	14.09

Feeder Cable Specifications:

Okonite Company Series Conductor-

- 500 kcmil Annealed Coated Copper
- 15kV, 133% Ethylene-propylene Rubber (EPR) Insulation Rating
- DC Resistance @ 25 deg. C→ R = 0.022 Ohms/ 1000 ft

Grounding Conductor-

- 1 #4/0 AWG 600V Copper Ground Conductor

Conductor Components:

A- Uncoated, Okopact (Compact Stranded) Copper Conductor

B- Strand Screen-Extruded Semiconducting EPR

C- Insulation-Okoguard EPR

D- Insulation Screen-Extruded Semiconducting EPR

E- Shield-Copper Tape

F- Jacket-Okoseal

DISTRIBUTION SYSTEM LINE LOSS COMPARISON

	A	B	C	D	E	F	G	H	I	J	K	L
FEEDER DESIGNATION	**LENGTH (linear ft.)**	**RESISTANCE (All Three Phases)**	**AVG. AMPS**	**PEAK AMPS**	**AVG. VOLTS (kV)**	**VOLTAGE DROP (V)**	**AVG. LOSSES (Watts)**	**PEAK LOSSES (Watts)**	**LOAD FACTOR**	**LOSS FACTOR**	**AVG. LOSSES PER YEAR (kWh)**	**ANNUAL COST OF LOSSES ($.0877/kWh)**
Existing Layout												
Hospital A	2496	0.1662	86	100	14.06	14.30	1229.46	1662.34	0.74	0.59	8526.47	$747.77
Hospital B	2496	0.1662	90	110	14.09	14.96	1346.49	2011.43	0.67	0.49	8675.86	$760.87
Loop A	2007	0.1337	115	151	14.06	15.37	1767.74	3047.72	0.58	0.39	10282.51	$901.78
Loop B	2007	0.1337	77	91	14.09	10.29	792.51	1106.89	0.72	0.55	5364.92	$470.50
					Totals	**54.92**	**5136.20**	**7828.38**	**0.66**	**0.48**	**32614.60**	**$2,860.30**
Proposed Layout												
Hospital A	2331	0.1552	86	100	14.06	13.35	1148.19	1552.45	0.74	0.59	7962.83	$698.34
Hospital B	2331	0.1552	90	110	14.09	13.97	1257.48	1878.46	0.67	0.49	8102.34	$710.57
Loop A	1822	0.1213	115	151	14.06	13.95	1604.79	2766.79	0.58	0.39	9334.69	$818.65
Loop B	1822	0.1213	77	91	14.09	9.34	719.46	1004.86	0.72	0.55	4870.40	$427.13
					Totals	**50.62**	**4729.92**	**7202.56**	**0.66**	**0.48**	**30054.60**	**$2,635.79**

Estimated Savings, Proposed Layout:
kWh Savings per Year = 2560.00 kWh
Cost Savings per Year = $224.51

LEGEND OF VALUES

A: Calculated from CAD Drawings, adding 5% to each segment for manhole connections and waste
B: [R] = [L] * [0.0222] / [1000] * [3]; From Feeder Specs, DC Resistance = 0.0222 Ohms/ 1000 ft, Multiplied by 3 to account for all phases
C thru E: Based on OPP Monitoring from 3/29/07 to 4/4/07
F thru M Calculated using *Distribution System Loss Evaluation Manual*
F: [Voltage Drop] = [Avg. Amps] * [Resistance]
G: [Avg. Losses] = [Avg. Amps]^2 * [Resistance]
H: [Peak Losses] = [Peak Amps]^2 * [Resistance]
I: [Load Factor] = [Avg. Losses] / [Peak Losses]
J: [Loss Factor] = (0.2)*[Load Factor] + (0.8)[Load Factor]^2
K: [Avg. Losses per Year] = [Loss Factor] * [Peak Losses] * [8,760 hrs/yr] / [1000 W per kW]
L: [Cost of Losses per Year] = [Losses per Yr] * [Cost per kWh]; Cost of kWh taken from PP&L Website

ELECTRIC INSTALLATION COSTS- EXISTING LAYOUT

CSI Code	Description	Qty.	Daily Output	Labor Hrs	Unit	Materials	Labor	Equipment	Total	Total, incl. O&P
2315-520-0020	Fill, dumped material, spread, by dozer, excludes compaction	1096	1,000	0.008	L.C.Y.	$0.00	$1,008.32	$1,238.48	$2,246.80	$2,626.51
2315-610-0060	Excavating, trench or continuous footing, common earth, 1' to 4' deep, 1/2 C.Y. bucket, hydraulic backhoe, excludes sheeting or dewatering	2193	200	0.08	B.C.Y.	$0.00	$4,144.77	$2,807.04	$6,951.81	$10,000.08
2580-420-0380	Underground marking tape, 6" wide	3111	2,525	0.008	L.F.	$902.19	$808.86	$0.00	$1,711.05	$2,302.14
2580-420-1800	Man holes, precast w/iron racks & pulling irons, C.I. frame and cover, 4' x 6' x 7' deep, excludes excavation, backfill and cast in place concrete	7	1.8	26.667	Ea.	$12,600.00	$4,130.00	$2,415.00	$19,145.00	$23,450.00
2580-420-5840	Underground duct banks, PVC, 4 @ 5" diameter, excludes excavation, backfill and cast in place concrete	1245	70	0.229	L.F.	$11,329.50	$9,275.25	$0.00	$20,604.75	$27,390.00
2580-420-5860	Underground duct banks, PVC, 6 @ 5" diameter, excludes excavation, backfill and cast in place concrete	1866	50	0.32	L.F.	$25,470.90	$19,499.70	$0.00	$44,970.60	$59,712.00
2580-420-7830	Underground duct banks, for cast-in-place concrete, over 5 C.Y., excludes excavation, backfill and cast in place concrete, add	1096	24	2	C.Y.	$106,312.00	$47,676.00	$2,192.00	$156,180.00	$199,472.00
3310-220-0100	Structural concrete, ready mix, normal weight, 2500 psi, includes material only	1096			C.Y.	$87,132.00	$0.00	$0.00	$87,132.00	$95,900.00
16060-800-3820	Insulated ground wire, copper, stranded, 4/0	96	4.4	3.636	C.L.F.	$17,376.00	$11,424.00	$0.00	$28,800.00	$37,440.00
16120-700-2800	Shielded cable, copper, XLP shielding, ungrounded neutral, 15 kV, 500 kcmil, in conduit, excl splicing & terminations	282	3.6	6.667	C.L.F.	$205,597.20	$61,115.88	$0.00	$266,713.08	$323,886.00
Totals						**$466,719.79**	**$159,082.78**	**$8,652.52**	**$634,455.09**	**$782,178.73**

Assumes:
1. Trench sizes are 5' wide by 4' deep
2. Concrete to Backfill ratio is 1:1
3. (8)- and (6)-conduit ductbanks calculated together
4. Cost of road crossing excavation same as typical

ELECTRIC UTILITY INSTALLATION COSTS- PROPOSED LAYOUT

CSI Code	Description	Qty.	Daily Output	Labor Hrs	Unit	Materials	Labor	Equipment	Total	Total, incl. O&P
2315-520-0020	Fill, dumped material, spread, by dozer, excludes compaction	1107	1,000	0.008	L.C.Y.	$232.47	$1,018.44	$1,250.91	$2,501.82	$2,924.63
2315-610-0060	Excavating, trench or continuous footing, common earth, 1' to 4' deep, 1/2 C.Y. bucket, hydraulic backhoe, excludes sheeting or dewatering	2213	200	0.08	B.C.Y.	$0.00	$4,182.57	$2,832.64	$7,015.21	$10,091.28
2580-420-0380	Underground marking tape, 6" wide	2988	2,525	0.008	L.F.	$866.52	$776.88	$0.00	$1,643.40	$2,211.12
2580-420-0800	Hand holes, precast concrete, with concrete cover, 3' x 3' x 3' deep, excludes excavation, backfill and cast in place concrete	1	1.9	10.53	Ea.	$340.00	$335.00	$83.50	$758.50	$1,000.00
2580-420-1800	Man holes, precast w/iron racks & pulling irons, C.I. frame and cover, 4' x 6' x 7' deep, excludes excavation, backfill and cast in place concrete	4	1.8	26.67	Ea.	$7,200.00	$2,360.00	$1,380.00	$10,940.00	$13,400.00
2580-420-5840	Underground duct banks, PVC, 4 @ 5" diameter, excludes excavation, backfill and cast in place concrete	1098	70	0.229	L.F.	$9,991.80	$8,180.10	$0.00	$18,171.90	$24,156.00
2580-420-5860	Underground duct banks, PVC, 6 @ 5" diameter, excludes excavation, backfill and cast in place concrete	1890	50	0.32	L.F.	$25,798.50	$19,750.50	$0.00	$45,549.00	$60,480.00
2580-420-7830	Underground duct banks, for cast-in-place concrete, over 5 C.Y., excludes excavation, backfill and cast in place concrete, add	1107	24	2	C.Y.	$107,379.00	$48,154.50	$2,214.00	$157,747.50	$201,474.00
3310-220-0100	Structural concrete, ready mix, normal weight, 2500 psi, includes material only	1107			C.Y.	$88,006.50	$0.00	$0.00	$88,006.50	$96,862.50
16060-800-3820	Insulated ground wire, copper, stranded, 4/0	82	4.4	3.636	C.L.F.	$14,842.00	$9,758.00	$0.00	$24,600.00	$31,980.00
16120-700-2800	Shielded cable, copper, XLP shielding, ungrounded neutral, 15 kV, 500 kcmil, in conduit, excl splicing & terminations	246	3.6	6.667	C.L.F.	$179,580.00	$53,382.00	$0.00	$232,962.00	$282,900.00
Totals						**$434,004.32**	**$146,879.55**	**$6,510.14**	**$587,394.01**	**$727,479.53**

Assumes 1. Trench sizes are 5' wide by 4' deep
2. Concrete to Backfill ratio is 1:1
3. (8)- and (6)-conduit ductbanks calculated together
4. Cost of road crossing excavation same as typical

DATA COLLECTION TOOLS

Construction Manager/ General Contractor Survey:

1. What is the typical markup you receive for bid packages in today's market?
2. What is the typical markup you receive for contracts in today's market?
3. What do you feel is/are the major determinant(s) of this markup?
4. Are markups typically the same from subcontractor to subcontractor on bid packages?
5. How would you rate yourself in terms of having subcontractors return for future work with your company?
6. How would you define your negotiating practices for subcontractor change-orders?
7. How would you characterize your client base: targets of opportunity (one-shot deals), or repeat clients?
8. How would you describe your company's reputation and potential in the region?
9. How would you characterize your project teams with respect to project team turnover?
10. Please leave any additional comments or concerns regarding subcontract markups.

Also included in packet:

- Cover Letter
- Background Information
- Self-addressed Stamped Envelope (SASE)

Subcontractor Online Survey:

Found at http://test.scripts.psu.edu/users/c/a/cav138/subsurvey/index.html.

Part 1-

Rate the impact of the following variables on the contract markup for your work.	(-3) Greatly Reduce	(-2) Moderately Reduce	(-1) Slightly Reduce	(0) Keep the Same	(+1) Slightly Increase	(+2) Moderately Increase	(+3) Greatly Increase
1. Your have had past successes with the CM/GC company, including some of the current project team members.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
2. The AIA Contract is vague with respect to your markup percentages, including any of your own specialty contractors.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
3. The CM/GC is recognized for staying on schedule and meeting all milestones.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
4. The GC has been known to bid-shop on a regular basis.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
5. "Nickel-and-diming" practices are common for the CM/GC.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
6. The CM/GC is a relatively new company in the industry.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
7. Though prominent in other areas of the country, the CM/GC is new to your region.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
8. From your perspective, the job is a "target of opportunity" (one-shot deal).	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
9. Your have had difficulty in the past working with some of the CM/GC personnel.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3
10. You have had difficulty in the past working for the CM/GC company, but are unfamiliar with the current team.	○ -3	○ -2	○ -1	○ 0	○ 1	○ 2	○ 3

Scenarios:

1. Your have had past successes with the CM/GC company, including some of the current project team members.
2. The AIA Contract is vague with respect to your markup percentages, including any of your own specialty contractors.
3. The CM/GC is recognized for staying on schedule and meeting all milestones.
4. The GC has been known to bid-shop on a regular basis.
5. "Nickel-and-diming" practices are common for the CM/GC.
6. The CM/GC is a relatively new company in the industry.
7. Though prominent in other areas of the country, the CM/GC is new to your region.
8. From your perspective, the job is a "target of opportunity" (one-shot deal).
9. Your have had difficulty in the past working with some of the CM/GC personnel.
10. You have had difficulty in the past working for the CM/GC company, but are unfamiliar with the current team.

with the current team.

Part 2

Case Study 1: Alpha Construction Company

History of Company: Alpha is a national construction management firm that only recently has begun to expand into your region. They have a long history of successful jobs with repeat clients, but their unfamiliarity to owners and subcontractors in the region will slow the expansion process.

Reputation: Alpha is considered a premier CM firm in terms of delivering projects on time and on budget. However, this has been known to cause dissatisfaction among subcontractors who are often pinched for change in order to maintain budgets.

Typical Project Base: Healthcare & Healthcare renovation; Pharmaceutical & Biotech; University expansions; Medium to High Rise Offices

Current Project Information:
Project Team- With the exception of the General Superintendent, you are unfamiliar with anyone on the project team. Your experience with this Superintendent was on a job several years ago, when they worked for a local General Contractor and you didn't quite see eye-to-eye. The CM company has setup a team consisting of three Superintendents, two Project Engineers, a Safety Manager and a Project Manager, in addition to an Operations Manager.

Type of Project for Bid- Biotechnology laboratory
Complexity- High
Size- 250,000 sf
Cost- $120,000,000

Please answer the following questions in the box provided:

What total markup OR multiplier would you assign for your work?

Briefly describe this value. What is/are the decisive factors?

BETA CONTRACTORS

Case Study 2: Beta Contractors

History of Company: Beta is a start-up General Contracting company that has been in the industry for only 3 years. Though lacking a deep project history, the company is owned and operated by two very experienced individuals that have a combined 60 years of project management experience.

Reputation: The Beta owners are well-recognized throughout the industry for their individual project successes. However, it is still unclear how successful they will be as a team in the region.

Typical Project Base: K-12 Education; Low to Med Rise Offices; Retail

Current Project Information:
Project Team- The team is composed of two Superintendents, two Project Engineers, and a Project Manager, who oversees safety as well. The Operations Manager is one of the owners, who splits their time among several projects. This is the most expensive project to date for Beta, as well as the first time you have worked together.

Type of Project for Bid- Middle School (Grades 6 throuh 8)
Complexity- Medium
Size- 180,000 sf
Cost- $17,000,000

Please answer the following questions in the box provided:

What total markup OR multiplier would you assign for your work?

Briefly describe this value. What is/are the decisive factors?

Case Study 3: Choice Management

History of Company: Choice Management is a fairly large Construction Management and General Contracting firm popular to the area. They have an extensive list of projects completed in the area and are slowly expanding their regional base.

Reputation: Choice Management is known for delivering projects on schedule, and for generally receiving high owner satisfaction. They typically receive high regards from subcontractors as well. Though your company has done many successful projects for Choice, there have been a few instances of significant communication breakdowns.

Typical Project Base: Med to High Rise Offices; Office Renovations; Mission Critical

Current Project Information:
Project Team- The management team is composed of several individuals unknown to you, including two Project Engineers and the Safety Manager. You have worked on two successful jobs with the Superintendents and Project Manager, and expect this one to run equally as smooth.

Type of Project- Medium Rise Office Building (19 stories)
Complexity- Medium
Size- 500,000 sf
Cost- $75,000,000

Please answer the following questions in the box provided:

What total markup OR multiplier would you assign for your work?

Briefly describe this value. What is/are the decisive factors?

CM/GC SURVEY RESPONSES	
1. What is the typical markup you receive for bid packages in today's market?	
1	Tough to answer with absolute certainty: Range of (-2) to (2)%
2	Not identified by sub as their bids are lump sum.
3	Bid Day 7-10%; CO's 15% plus
4	10 to 20%. Can vary by trade- MEP Team Approach bids are around 13%
5	Sub markup for OH&P self-perform is 12-20%. Sub's sub is 4-7%
6	General Condition Markup- 7-10% GC, 3-5% Fee = 10% to 15% Total O&P
Average	Discrepancies with interpretation- From -2% to 8%
2. What is the typical markup you receive for contracts in today's market?	
1	GC Level- 10%, Sub Level 10 + 5 or Flat 15%
2	Fee varies (company to owner) from 5 to 6%. Changes are 10-20%
3	1.75-2.5% CM@risk; 3-5% GMP's; 1-2% CM-Agency
4	Same as above- 10 to 20%, varies by trade.
5	Range is 3 to 5%. Based on project size and risk.
6	3% to 8%
Average	**Discrepancies- Typically 10% OH + %% Fee = 15% OH&P**
3. What do you feel is/are the major determinant(s) of this markup?	
1	Current backlog of sub, schedule fore execution of work reasonable, knowledge of work practices of GC, knowledge of individual GC team members, and owner entity
2	See Above - undisclosed by subs.
3	CM vs. GC- CM reduces risk; competition, and amount of work available
4	How the trade contractors run their business- estimates of salaried associates listed as cost of work(less) or overhead (more). Supply vs demand; economics of region.
5	Proper financial return on resources; project size; contract type & risk allocation; other team members (owner, architect, CM, etc)
6	Work Load; Complexity of Project; Schedule; Dollar Value of Project
Key Words	**Schedule; Economics of Region; Project Scope; Other Entities; Risk Allocation/ Contract Type**

4. Are markups typically the same from subcontractor to subcontractor on bid packages?	
1	Fairly consistent (no way to be known for sure)
2	Unknown
3	Usually similar by trades. Will vary greatly when there is a lot of work, and be very close if market is tight (supply vs demand)
4	Not typically the same. Team approach bids (MEP) markup is crucial- result of CM/GC defining what is cost of work and what is fee.
5	70% are the same, vary by trade req'mts. (ie., sheet metal fab sub will have much higher OH for fab. Facility, equip, etc)
6	No
Key Words	**Varies by trade, but typically the same; Work availability imacts markup**
5. How would you rate yourself in terms of having subcontractors return for future work with your company?	
1	Very good.
2	90%
3	Near 100%- Very loyal subs
4	90%- all about fairness.
5	Extremely high, subs like working for us.
6	Very Good- Select pool of subcontractors that work for us.
Key Words	**Very Good- 90% to 100%**
6. How would you define your negotiating practices for subcontractor change-orders?	
1	Firm but fair.
2	Fair but firm- obligation to protect client.
3	Firm but fair. Ethical and honest company
4	Pay a fair market value for a change order base upon market conditions. In-house estimates always performed, differences addressed before negotiation.
5	Fair. Pay the correct amount for changes as allowed in agreements. Very thorough in-house review.
6	Fair- Follow the contract language and strive to balance out issues on projects
Key Words	**Firm but Fair; Ethical; Follow contract language; In-house estimates necessary**

7. How would you characterize your client base: targets of opportunity (one-shot deals), or repeat clients?	
1	Establish a sound client base with longterm, repeat owners.
2	Repeat clients!
3	Repeat 70% plus
4	80% repeat.
5	80% repeat. Majority is negotiated.
6	90%
Key Words	**Repeat Clients 70% to 90% of work**
8. How would you describe your company's reputation and potential in the region?	
1	Size of company instills "fear factor" of doing business if haven't done already. However, always known to deliver, and have great potential in region.
2	Reputation is fair to subs, potential is unlimited.
3	Great reputation, long term player
4	True team approach builder, excellent services specifically w/ regards to precon. Excited about their future in the region.
5	Small market base. Very fair contractors, perform at a very high level of service to clients. Relationship driven.
6	Strong- good client base that is expanding.
Key Words	**Varies- market base, size of company impact repuation; potential high for long-term growth**
9. How would you characterize your project teams with respect to project team turnover?	
1	On average with industry. Turnover lost is to areas other than construction.
2	Did Not Understand.
3	Very minimal, none unwanted to date. Company wide is 8%
4	Under average- result of strong corporate culture that allows national status w/ consistency of small company.
5	Very low.
6	It occurs, but turnover is minimal in the key team positions.
Key Words	**Low- all under average**
10. Please leave any additional comments or concerns regarding subcontract markups.	
3	Markups are VERY market driven, no set rules. Other factors: Reputation of Owner/GC/Developer; level of risk
4	Purely a trade contractor's business decision,markup is whatever the market can bear. Once under contract, trades bound by O&P
Key Words	**Markups market driven; Business decision of subs; Other entities and Risk important**

SUBCONTRACTOR RAW RETURN DATA

SURVEY #	
1	1|4|4|4|6|4|4|4|4|6|5|15%above cost and burden|Cost to keep in business|15%above cost and burden|Cost to keep in business|15%above cost and burden|Cost to keep in business|2007-03-07|13:18:18|
2	1|4|5|3|6|6|6|4|4|7|6|7% over our cost|Our bidding process includes extensive review of the plans and specs. We would cover our work in the normal review and might add 2% over what we normally would to cover unforeseen expenses.|5% over cost|These types of projects are cut and dried. Typically we are prime on every project of this nature. The other parties are all bonded. No concerns here.|5% over cost|Nothing in the description of the circumstances is out of the normal realm of possibility for our industry. We would use our normal mark-up and simply document any unforeseen circumstances in project meetings.|2007-03-07|13:52:08|
3	1|4|4|5|7|7|4|4|3|5|5|30%|Contractor does not CARE about the subs. No trust. Squeezing on change orders is Bull**** - as long as they are legitimate.|n/a|N/A for Mechanical work - This type of job is only built in PA with separate primes - we would be bidding direct to the owner - the GC would be a separate prime|15%|If they are popular with subcontractors - that means they are fair and that they pay. IT also means they are organized and hold each contractor accountable during the construction process. The biggest issue is Fairness - most CM's are not Fair. Additionally - they let the trust the subs and build a TEAM and practice the Golden Rule.|2007-03-07|13:58:59|
4	1|3|4|4|6|6|4|4|5|7|6|10%|Previous history.|12%|Size & type of project.|8%|Better claiber of CM/GC personnel.|2007-03-07|14:32:02|
5	1|2|4|4|5|5|4|5|3|5|5|12% for OH & Profit. 15% on extras|Smaller job may be 15%; this would be a large job for us|15%|Our standard mark-up|13% to 14%|Good repeat client|2007-03-07|15:41:49|
6	1|3|4|4|6|7|5|4|4|6|6|15%|not local, unfamiliar with their team, the guy we know has hassled us in the past|0% |Years of experience, quality, honesty, fairness of the principals is key|10%|Once again -- "the company" doesn't matter much to us. We are relationship oriented and you don't have a "relationship" with the GC -- you have one with the people who are running the job. In this case, we've had issues in the past, we might have issues in the future...|2007-03-07|17:29:05|
***7	1|0|0|-2|3|2|2|2|0|3|2|8-9% markup for a total value of around $18M (based on historical averages of our division of work for this size of project would be a standard markup. A multiplier (add of 1-2% for poor working relationship or performance would be as much as the project could afford)|Project scale dictates the relatively low percentage of markup upon entry of the project. Likely there is a relatively short bidders list of local knowledgable subcontractors of which only we (in the case of your example) had a distaste for the superintendent. Bidding the project at any higher multiplier would be a waste of time as other bidders wouldn't make consideration for this and we'd lose the job. Many jobs are performed where the personnel are sub-standard. We work around these issues. It should be noted that additional work items (extras) would require a markup of 10-20% mininum to cover the costs of changes. More so when the superintendant (or other team members) are sub-standard. The owner typically bears these costs in the long run.| 10-15% based on the project type and size. Likely no multiplier would be assigned. Again, the extras would be charged at a higher fee to cover the increased cost of administering the changes.|First, the assumption is that the project is bonded (we aren't assuming financial risk of a new company). Next, the focus of individuals with talent, whose reputaion is on the line would be a driving force and probably lead to a successful project. Often times, large companies spend more time overstaffed, working on sideline logistics (tracking, reporting, safety, EEOC) than they do building the building. Smaller, more focused companies often get the job done more efficiently.|8-9% markup for a selling price of around $8M. A markdown multiplier of 1-2% would be as much as we'd be able to afford and still maintain our margin. Extras would be charged at around 10-15% markup.|A good working history goes a long way. The project would assumably be completed in an organized manner and completed and closed out on time or ahead of schedule. This includes a smooth system for tracking changes, processing change orders and issuing timely payments.|2007-03-07|22:17:12|
8	1|0|0|1|1|0|0|0|0|1|1|15%|5% additonal due to three factors. 1. Unfamilar relationship 2. Historically CM/GC's payments are slow 3. Change orders are more difficult to get approved|15%|Two factors 1. New companies have poor cash flow and hence slow pay 2. New companies try to make their reputation for on time and on budget at the subs expense.|10%|Three factors 1. GC is a known commodity hence less risk 2. GC pays on time 3. GC builds on time and in budget so follow on work beyond this project is a strong possibility.|2007-03-08|07:25:12|
9	1|-1|0|-1|2|1|0|-1|-2|2|2|This would depend on a many variables. First, are we working directly for the CM or a GC? Do we feel we are going to get paid on time? How long is the retained amount held on our company? How desirable is the project? How good ar Please note that the Architect and Engineer play as big a role in how much we add to the markup. They really control how many change orders a project may have by the quality of their work. They also have the ability to approve or deny change orders. They
10	1|-1|0|0|2|3|1|0|0|2|2|30%|A superintendent can make or break a job from a subcontractors standpoint.|25%|There is more risk involved due to the newness of the firm, however, depending on previous relationships with the principals there may be reason to r |20%|During the course of the job you can sense when a cm/gc gives a damn whether a sub makes money or not. We realize that they represent the owner , however, it's nice to see them be an advocate for the sub when there have been errors made in the speci subs and on-site project managers and superintendents.|2007-03-09|15:29:47|
11	1|-2|1|-2|2|2|2|1|0|1|2|18%|Complexity of a Biotech building and the Superintendant. |18%|Although medium complexity, concern for the size of the project with this CM.|20%|The Cm will be very demanding to please his client and maintain his reputation. Also, this is a somewhat large project.|2007-03-10|13:54:32|

<table>
<tr><td>***12</td><td>1|-2|-2|1|-2|-3|-2|-1|-2|-3|-3|hourly rate $65.00-80.00 depending on job classification
Materual mark up 10-30%
Markup subs 10%
True markups|Prevailing wage is a big factor and is not justified in this market, but you favor it and it is out of control|same as above|We try to help new companies work within the system. Most of the time they forget when the next job comes up.|same as</td></tr>
<tr><td>13</td><td>0|0|0|1|1|0|0|0|0|0|5% Overhead & 10% Profit|We base our decisons on Overhead & Profit. Although personalities & decision do factor in to the equation we have not developed any strategies to markup a project based on this factor. The specifications and drawings dictate the intent and any legitamate changes will be addressed accordingly.|5% Overhead & 10% Profit|We base our decisons on Overhead & Profit. Although personalities & decision do factor in to the equation we have not developed any strategies to markup a project based on this factor. The specifications and drawings dictate the intent and any legitamate changes will be addressed accordingly.|5% Overhead & 10% Profit|We base our decisons on Overhead & Profit. Although personalities & decision do factor in to the equation we have not developed any strategies to markup a project based on this factor. The specifications and drawings dictate the intent and any legitamate changes will be addressed accordingly.|2007-03-14|13:25:37|</td></tr>
<tr><td>14</td><td>-1|1|-2|3|3|2|1|1|2|2|20% overhead and profit|Approximately 5% for overhead and 15% for profit. If the CM had a local positive track record, the profit portion may be trimmed to as low as 10% for a very large contract.|18% overhead and profit|5% overhead</td></tr>
<tr><td>15</td><td>0|1|0|1|1|0|0|0|1|1|1.25-1.30 depending on actual project cost. Would be on the higher end due to complexity of job as well as the specialitization of the work.|Primary decision factors would be percentage of labor to materials first. Labor is the determining factor on any of this due to the overhead costs associated. If a material-only project you could easily go 10-15% on the mark-up. Labor portion pushes this value up. Company pricing requirements may also apply.|1.20-1.25 due to complexity and easier use of change orders in a school market|This is a low bid project to start with - get the job and then manage the margin on a job like this.|1.20 to 1.25|This is a low bid project to start with - get the job and then manage the margin on a job like this.|2007-03-14|14:35:54|</td></tr>
<tr><td>16</td><td>-1|0|-1|2|1|0|0|-1|2|2|18%|Current market traits, volume of workload, location,
type of work, work restrictions, owner stipulations,
time constraints.|15%|Complexity of the project, location, contractor history.|12%|Relationships between the firms, maintaining schedules,
High owner satisfaction.|2007-03-14|16:13:14|</td></tr>
<tr><td>17</td><td>-1|0|0|0|2|0|1|-1|2|2|12% overhead and 10% profit.|Extra 2% profit for the hassle.|Do not bid school work.|N/A|12% overhead and 10% profit.|Would anticipate getting a last look.|2007-03-14|16:25:33|</td></tr>
<tr><td>18</td><td>2|2|3|3|3|3|3|3|0|10% overhead
15% profit|we do not build our overhead in the estimate. Year end statments show 10% for ovehead for example, blue prints, hydraulic calculations,fax machines, lights trucking and gas. eletrical and utility |10% overhead, 15% profit|Same as above|10% overhead 15& profit|Same as above|2007-03-14|16:46:50|</td></tr>
<tr><td>19</td><td>0|2|-1|2|3|2|1|1|2|3|20% Mark-up |Pinching subs for cost overruns, Team unfamiliarity, Negative past experience|15% Mark-up |Plus side-experienced involved owners, Negative side-may be under staffed for a project this size|10%| Reputation for treating subs well, Positive past experience, Maintain established relationship with a quality firm|2007-03-15|09:12:24|</td></tr>
<tr><td>20</td><td>0|0|0|2|2|1|1|1|3|-2|21% markup on total costs|Our overhead percentage averages from 12 to 15% depending on annual volume. We then would put 5% profit on top of 15%. 1.15 x 1.05 = 1.207 Therefore 20.7% rounded up to 21%. |Same as above|Same as above. Keep in mind that the base contract amount was probably bid with a much lower markup. Therefore, all change order work should be quoted with fair and reasonable markup as described above based on our particular business structure. We are a site work contractor which has a considerable fleet of equipment which drives our overhead support percentage higher than other specialty contractors. Further, and the inherent risk due to the nature of our work is extremely high as opposed to say a drywall subcontractor.|Again our standard markup would apply whenever we can get it.|Same|2007-03-15|09:38:00|</td></tr>
<tr><td>21</td><td>0|2|1|2|2|2|2|1|2|2|40%|Most times a construction management firm is involved in a project it causes additional paperwork for subcontractors. Typically it is an additional link in the communication chain that hinders progress on the project. They normally are hesitant to make decisions and they are hesitant to assume responsibility for their actions.|Same as previous response.|The involvement of a construction manager.|Same as previous responses.|Same as previous responses.|2007-03-16|13:10:23|</td></tr>
<tr><td>22</td><td>2|0|0|-2|-1|0|0|-2|0|0|15%|10% of our money will be held as retainage for a long period of time so we need to sell work at 15% to operate with a positive cash flow since we do not hold 10% retainage on any of our vendors and pay them in full upon completion of their work, delivery of their fabricated materials f.o.b. the job site.|20%|schools are typically harder to punch out than office buildings, healthcare and industrial projects and more management intensive (i.e. more coordination with other trades) so the additional 5% is required in a good market to cover project management overhead|25%|The smaller the project the more mark-up / profit we typically put on our bid recap to cover management costs, economies of scale, etc.|2007-03-18|20:44:01|</td></tr>
<tr><td>23</td><td>|1|-1|3|3|0|0|0|3|2|I would be a little safer than typical|If the Super was a real a**hole or if it was the job we worked on together|I never get involved with any school projects.|The schoolboards are typically a bunch of a**holes and the job never see</td></tr>
<tr><td>24</td><td>-3|0|-3|0|2|0|0|-2|1|1|Moderate|No different between them & other GC's|Moderate|Same as above|Lower End|Give advantage to GC who I know will be fair|2007-03-20|07:21:11|</td></tr>
<tr><td>25</td><td>|0|0|2|2|1|0|1|2|1|25% |standard|30% |a little extra for questions|35%|extra for problems|2007-03-21|13:44:11|</td></tr>
</table>

-SUB SURVEY STATISTICAL ANALYSIS-

Part 1:

Markup Impact	Scenario Number									
	1	2	3	4	5	6	7	8	9	10
-3	1	0	1	0	1	0	0	0	1	1
-2	4	1	3	2	0	1	0	4	0	1
-1	8	0	5	0	1	0	2	4	0	0
0	10	16	11	2	2	13	14	10	2	3
+1	0	5	4	4	5	4	6	6	6	7
+2	2	3	0	12	9	6	2	0	10	12
+3	0	0	1	5	7	1	1	1	6	1
Total Responses	25	25	25	25	25	25	25	25	25	25
Average Impact	**-0.60**	**0.36**	**-0.28**	**1.56**	**1.60**	**0.68**	**0.44**	**-0.12**	**1.64**	**1.16**

Markup Impact Scale

Greatly Reduce	Moderately Reduce	Slightly Reduce	Keep the Same	Slightly Increase	Moderately Increase	Greatly Increase
-3	-2	-1	0	1	2	3

CASE STUDIES- STATISTICAL ANALYSIS AND SUMMARIES

Alpha Construction Company			
Survey	**Sub's Definition**	**Multiplier**	**Reason**
1	**15% + cost/burden**	**0.0%**	Cost to keep in business
2	**7%**	**2.0%**	Review process is extensive. Add 2% for unforeseen conditions
3	**30%**	**15.0%**	No trust on CM behalf. Squeezing change orders unethical practice, unless justified.
4	**10%**	**0.0%**	Previous history.
5	**12% OH&P, 15% extras**	**0.0%**	Smaller job would be 15%, this is a large job personally.
6	**15%**	**15.0%**	Not local, unfamiliar with team, hassle in the past.
7	**8-9%, +1-2% markup**	**1.5%**	1.5% for poor working relationship. Low (fewer bidders, waste of time if marked up more.
8	**15% +5%**	**5.0%**	Unfamiliarity, CM/GC's are slow with payments, and change orders difficult to approve
9	**n/a**	**0.0%**	0% if complete. Depending upon completeness of project, where contract is held- many variables
10	**30%**	**5.0%**	A superintendent can make or break a job for a subcontractor
11	**18%**	**3.0%**	Superintendent, complexity of biotech
12	***	***	***
13	**10%**		For any cost overruns as a result of dealing with new people not accustomed to our company
14	**15% OH&P**	**0.0%**	no strategies to markup a project based on these factors- specs/drawings dictate
15	**20%**	**5.0%**	15 Profit, 5 OH. If CM has positive track record, profit could be trimmed to 10%.
16	**25-30%**	**10.0%**	Complexity, specialization labor to materials high. Labor costs is decisive factor due to overhead
17	**18%**	**3.0%**	Current market traits, workload, location, type of work, work restriction, owner stipulations, time
18	**10% OH, 15% P**	**0.0%**	No overhead in estimate- 10% for General conditions costs
19	**20%**	**5.0%**	Pinching for overruns, team unfamiliarity, negative work experience
20	**21%**	**0.0%**	12 to 15% annual volume, plus 5% profit --> 20.07% = 21%
21	***	***	CM involvement- paperwork, additional link, hesitant and thus hinders progress
22	**15%**	**0.0%**	10% retainage thus 5% required for positive cash flow to pay vendors
23	***	***	***
24	**Moderate**	**0.0%**	No distinction from other GC/CM's
25	**25%**	**0.0%**	Standard
	Average	**3.3095%**	**Project Scope; Market; CM (-)= hassle, bad relationship, add. link; CM (+)=none;**

Beta Contractors			
Survey	**Sub's Definition**	**Multiplier**	**Reason**
1	**15% + cost/burden**	**0.0%**	Cost to keep in business
2	**5%**	**0.0%**	Cut and dried, no issues. Usually prime on these projects and bond lower subs.
3	**n/a**	**n/a**	Mechanical work is multiple prime in PA for these jobs, thus bid is direct to owner.
4	**12%**	**2.0%**	Size and type of project
5	**15%**	**3.0%**	Std. markup
6	**0%**	**0.0%**	Years of experience, quality, honesty, fairness of principals is key
7	**10-15%, 0% markup**	**0.0%**	Talent of CM, personal risk of CM thus expect good results- smaller, more focused CM
8	**15%**	**0.0%**	New companies- poor cash flow, and build own reputation for sched/budget at sub's expense
9	**5-10% markup**	**7.5%**	Many variables- contract with G/C; approvals, drawings, payments on time?, retainage, G/C abilities
10	**25%**	**0.0%**	More risk due to newness of company, but experience with principals enables slight markdown
11	**18%**	**3.0%**	Size of project a concern for CM despite med. Complexity
12	***	***	***
13	**20-25%**		Despite experience, company has no proven track record- sub needs cover from risks and delays
14	**15% OH&P**	**0.0%**	no strategies to markup a project based on these factors- specs/drawings dictate
15	**18%**	**3.0%**	13 Profit, 5 OH. Risk is moderate
16	**20-25%**	**5.0%**	Complexity, ease of change orders in school market. Low-bid project- get job then manage margin
17	**15%**	**0.0%**	Complexity of the project, location, contractor history.
18	**10% OH, 15% P**	**0.0%**	No overhead in estimate- 10% for General conditions costs
19	**15%**	**0.0%**	Experienced, involved owners; negative side project may be understaffed
20	**21%**	**0.0%**	12 to 15% annual volume, plus 5% profit --> 20.07% = 21%
21	***	***	CM involvement- paperwork, additional link, hesitant and thus hinders progress
22	**20%**	**5.0%**	Schools are hard to punchout- add 5% for management costs
23	***	***	***
24	**Moderate**	**0.0%**	No distinction from other GC/CM's
25	**30%**	**5.0%**	Extra for questions
	Average	**1.6%**	**Project Scope; CM (+)= experience; CM (-)= no history, size/risk; Std. Markup**

Choice Management			
Survey	**Sub's Definition**	**Multiplier**	**Reason**
1	**15% + cost/burden**	**0.0%**	Cost to keep in business
2	**5%**	**0.0%**	Normat markup, typical situation. Document unforeseen conditions in mtgs.
3	**15%**	**0.0%**	CM is fair and holds subs accountable. Fairness, Team Building, Golden Rule main factors.
4	**8%**	**-2.0%**	Better caliber of CM/GC personnel
5	**13-14%**	**-1.5%**	Good repeat client.
6	**10%**	**10.0%**	CM/GC company non-issue, rather the personnel. Issues in the past thus potential for more.
7	**8-9%, 1-2% markDOWN**	**-1.5%**	Good working history. Expected level of organization to reduce schedule
8	**10%**	**-5.0%**	GC is a known commodity= less risk; pays on time; builds on time/budget so future work expected
9	**2-4% markDOWN**	**-3.5%**	Good history; aggressively help CM/GC by providing lowest price- A/E has major role
10	**20%**	**-5.0%**	CM/GC cares if sub makes money or not, esp. when owner/A/E is at fault- superintendent key
11	**20%**	**-5.0%**	CM will be determined to please owner. Project also large
12	***	***	***
13	**0%**		Confident that the job will be successful, based upon history
14	**15% OH&P**	**0.0%**	no strategies to markup a project based on these factors- specs/drawings dictate
15	**18%**	**3.0%**	13 Profit, 5 OH. Risk is moderate
16	**20-25%**	**5.0%**	Low bid project- get the job first then manage the margin
17	**12%**	**-3.0%**	Relationships between the firms, maintaining schedules, high owner satisfaction
18	**10% OH, 15% P**	**0.0%**	No overhead in estimate- 10% for General conditions costs
19	**10%**	**-5.0%**	Treat subs wells, past experience and positive relationship
20	**21%**	**0.0%**	12 to 15% annual volume, plus 5% profit --> 20.07% = 21%
21	***	***	CM involvement- paperwork, additional link, hesitant and thus hinders progress
22	**25%**	**10.0%**	The smaller the job, the higher the markup- economies of scale, mgmt. costs
23	***	***	***
24	**Low-end**	**-5.0%**	Low end- Advantage to GC who will be fair to subs
25	**35%**	**10.0%**	Extra for problems in past
	Average	**0.1%**	**CM(+)= fair, good experiences; CM(-)= problem in past, risk; Project Scope; Market**