Technical Assignment #3

Marriott Hotel at Penn Square and Lancaster County Convention Center

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Executive Summary

The Marriott Hotel at Penn Square and Lancaster County Convention Center project faced several construction issues within the first months of phase II requiring extensive redesigns of many of the systems in the building. These redesigns and construction issues make this project an excellent project to study and analyze systems that could have been designed and constructed differently. This technical report will introduce several critical issues facing the construction industry, identify several problematical areas encountered on the project, and then suggest three alternative systems to be redesigned on the project along with a critical industry issue to be researched in-depth.

Current critical industry issues were discussed on October 24, 2007 during the P.A.C.E. roundtable discussions at the Nittany Lion Inn. The P.A.C.E. roundtable included discussions among general contractors, construction managers, engineers, developers and architects to further explore and discuss the challenges facing the industry in three categories. The three categories discussed included the challenges and benefits with prefabrication, challenges facing the implementation of Building Information Modeling (BIM), and current labor shortages.

The Marriott Hotel and Convention Center faced several challenges within the early stages of construction due in part to the unknown existing conditions from an existing building on the site and that the structure needs to be constructed and incorporated into five existing surrounding structures. The challenges encountered can be summarized into, extensive redesign work, the flow of information, decision making process, the convention entry level and the caisson construction.

The alternative means and methods that will be considered in this study will be based around the convention entry level. The convention entry level is on the critical path for the convention center completion. To improve this area a new structural system will be proposed, the smoke evacuation system will be analyzed for potential changes, and the construction sequencing for the area will be analyzed to maximize efficiently particularly with the proposed changes.

Lastly, critical research will be applied to an area that will benefit the entire construction industry. Excavation and foundation work is on the critical path for every construction project, thus the need to further investigate alternative foundation methods. Micropiles are a proposed area in the construction industry that needs further research and understanding of the potential advantages, best applications for the systems, and why the micropile system is not more commonly used today.

Critical Industry Issues

This section of the report summarizes the discussions that took place during the P.A.C.E. Roundtable Meeting at the Nittany Lion Inn on October 24, 2007. The Roundtable Meeting is a discussion amongst current industry members in the construction and related design fields. This year's topics included prefabrication, building information modeling (BIM), and current labor issues. These issues will be summarized, related to the Marriott Hotel and Lancaster County Convention Center project, along with the lessoned learned by the writer and key contacts to obtain further information about each topic.

Prefabrication

Prefabrication can be applied to many different systems within a single project, such as a smart wall system, mechanical ductwork, and plumbing risers to name a few. Smart walls are a complete preassembled wall unit which includes the framing, insulation, electrical wiring and drywall. These are very beneficial for a project with a lot of repetition in the walls such a hotel building. The Marriott Hotel is 13 stories of a repeated floor plan which may benefit from utilizing a prefabricated wall system. The benefits for using this system include; faster on-site construction, possible savings from paying a lower shop labor rate to prefabricate the walls off-site compared to the prevailing wage rates required to construct the walls onsite. The Marriott Hotel may also benefit from utilizing prefabrication for the mechanical and plumbing systems. The locations of the bathrooms and fixtures are the same for the typical floor plan and the story heights are also the same throughout the hotel. The benefits of prefabrication are difficult to achieve without the proper delivery method employed for the project.

The Marriott Hotel and Convention Center is being constructed through a design-bid-build delivery method. The design-bid-build delivery method does not allow for the contractors input early enough in the design process to plan and design the systems for prefabrication, as a design-build delivery method would. To utilize prefabrication to its fullest potential the designer needs input from the contractor and thus more coordination and planning earlier in the project which also requires more money up front to compensate for the extra planning and thought. With a design build delivery method the owner can provide the money, designers, contractors and incentive to utilize prefabrication. Unlike a design-bid-build method where the money, input nor incentive is present to allow for prefabrication methods to be utilized.

There are issues that must be accounted for to obtain the positives in using prefabrication. As mentioned above, the incentive needs to be present for the design to implement the opportunity for prefabrication. Additionally inspections, local codes, union and transportation issues must also all be accounted for and planned through to obtain the positives in prefabrication. The benefits can include; a cleaner and higher quality product, less labor onsite, reduces costs, and less risk (particularly for when multiple trades are involved in the prefabrication of a single system). A leader needs to be defined make prefabrication across multiple trades a success, be it the general contractor or the mechanical contractor or whoever best fit to lead the process is.

Mr. James Haller with Southland Industries is a valuable contact for further information regarding prefabrication of mechanical and plumbing systems. Southland Industries has extensive experience with MEP prefabrication in the D.C. area. Additionally Ted Border with Whiting Turner is an excellent contact for additional information regarding prefabrication. Ted has presented a presentation on modular fabrication, which WT has successfully utilized to construct a five building dormitory complex of 90 units in three months.

There are several lessons learned about prefabrication which include; the extensive planning early on in the design process required to make prefabrication a success, the challenging process of having the prefabricated items approved by the local codes, the expensive

transportation costs for potentially larger assemblies and potentially additional costs in over designing the assembly to handle the transportation stresses. These challenges are critical to consider when planning for prefabrication on a project and are needed to analyzed against the commonly thought of advantages of faster on-site erection time, higher quality, tighter tolerances and safety issues.

Building Information Modeling (BIM)

Building Information Modeling is a new tool to the construction industry. BIM is much more then a 3D model of the project, it is a model with scheduling, cost and specification information built into it. The information that can be contained in a BIM model can be used to save time and money on a project. A BIM model can be developed so that the information from the model can serve multiple productive purposes; the 3D model itself can be utilized for marketability for a project; the design information can be send directly to a fabricator for fabrication; MEP systems can be designed, coordinated and signed-off on in a 3D model; constructability issues can be recognized and dealt with before construction begins; maintenance data and facilities management information can be obtained in the model; along with other benefits. There is no code or requirement for a BIM model, thus every project can utilize BIM as much or as little, as the team sees fit. Currently the key uses of a BIM model in the construction industry lie with clash detection of MEP and structural systems along with estimating for the project.

As mentioned above, BIM is a tool, it is used to help involve decision making earlier on in the process requiring an integrated project delivery. BIM will only work with design-build delivery methods not design-bid-build for two main reasons. First, there are insurance liability issues in transforming 2D drawings from the architect and engineer and creating a 3D and 4D model. Secondly, with design-bid-build, it is not an integrated project delivery. Similar to obtaining early contractor input for prefabrication, early contractor input is critical to the success of using BIM as a successful tool for the project. In obtaining early contractor input and designing for BIM it changes the fee structure for the project to accommodate the higher upfront costs. It is believed in the industry that as more projects are delivered using BIM that more case studies will be available to analyze benefit in a numerical amount to justify the cost of implementing BIM.

The largest challenge preventing BIM from advancing is the implementation of the system in the industry. It is also believed that it is not the software requirements or the learning curve required for the industry to begin utilizing the tool but that the owner is simply not requiring BIM to be used on the project.

Some lessons learned about BIM is that with the proper delivery method utilized for a project and the use of BIM, prefabrication and fabrication can be done directly from BIM, coordination issues can be worked out faster and in 3D, better schedules can be created with the visualization of a 3D and 4D models, and estimates can be more accurate with the quantities calculated directly from the BIM software.

The Marriott Hotel and Convention Center could benefit from the abilities of BIM to coordinate MEP systems, prefabrication of smart walls or MEP risers, the fabrication of the steel to be done directly from the model, and the schedule better understood with the use of 3D and 4D animations. Additionally, industry members believe BIM will promote better flow of information for a project once the industry becomes more familiar with the software available to create BIM projects. Though, due to the delivery method used for the Hotel and Convention Center project BIM would not prove to be beneficial for the reasons mentioned above. Lastly, BIM is believed to become very prominent and used frequently in the next five years throughout the industry.

To obtain more information about BIM, Dr. Messner is an excellent contact as he is a major researcher and developer of the BIM process. Graduate students, Craig Dubler and Rob Leicht are also usual sources of information for BIM as they are performing graduate research on the effects of BIM.

Labor Issues

It is no surprise that the largest industry in the United States is affected by politics and foreign policy. With a large illegal immigration problem in the US politicians are reacting to the problem by immigration reform and limiting immigration into the country. This has a direct affect to labor market of the construction industry. The combination of fewer available workers and increasing amounts of work has made it challenging to employ enough workers to meet the needs of the industry. Thus, it is becoming a priority to employers to retain their employees. Employers are now paying higher wages and providing more benefits to retain their employees. It is critical that as an industry a shift is made to show people that the field of construction can be a career and not just a job. Laborers can advance to carpenters, foreman, and superintendents while also having the possibility to become estimators and project managers. It is critical to the industry that the negative connotations of construction industry shift towards well-paid career paths.

As labor costs increase several changes are taking place. First off, it is becoming justifiable to have more equipment onsite to perform the work instead of men. Secondly, advances in labor intensive activities such as concrete construction (forming, shoring, reshoring) are being explored and implemented. The innovation in concrete construction mainly comes from Europe as that is where the supplies are manufactured.

The shortages in the labor force have not been as significant in south central Pennsylvania as much as it has been in the D.C. market. Thus labor shortages are not a problem for the Marriott Hotel and Convention Center, which can also be attributable to the fact that the project is a prevailing wage project and workers are more willing to work on a project that has a higher wage then they are normally paid.

Lessons to be learned are that the construction industry is facing a shortage of workers and is increasing the labor rates for the industry. Also it is marketable to be bilingual to be able to speak Spanish and communicate to the increasing Spanish speaking workforce. For more information about labor shortages and how it is affecting the construction market MLA concrete is a good source of information as they perform work in DC, Baltimore and on the Marriott Hotel and Convention Center in south central Pennsylvania.

Critical Issues Research Method

Background

On any project site work is always on the critical path. The time spent on the construction of the foundations directly affects the overall schedule of the project. It is very important for the success of a project to be able to identify the best appropriate foundation system to be used. There are two main types of foundation systems, shallow and deep. Among the deep foundation systems there are caissons, piles and micropiles. A critical issue to be researched further in this report is the micropile system and the opportunities available in using the system.

The first patent for the micropile (or minipile) foundation system was obtained in 1952 by Dr. Lizzi of Naples, Italy[1]. Micropiles are small diameter piles typically ranging from 8-12" diameters and up to 16". The term pile in micropile is misleading as micropiles are drilled into the ground like a caisson and not driven into the ground like a pile. Caisson diameters can range from 24" in diameter up to 90+". Today the micropile systems are generally thought of as a foundation system primarily for confined spaces, such as building additions, underpinning and inside existing structures. Though micropiles are able to support large compressive loads and large uplift loads with the integration of rock anchors. The micropiles are drilled in clusters of 2, 4, or 6+ and then capped with a pile cap to distribute the load between each pile. The smaller diameter used for micropiles make them able to be drilled much faster then caisson holes. Also the machines required to drill micropiles are smaller then caisson drill rigs and thus provides more room on site.

Problem Identification

Currently in the United States, micropiles are not commonly used even though they have some distinct advantages. Why are micropiles not used more frequently? In which new building applications do micropiles provide the largest advantage? Is there significant schedule saving to justify a potentially higher cost to use micropiles? Will the cost of micropiles decrease as they become better known and used more frequently?

The Marriott Hotel and Convention Center is located in central Pennsylvania, the study of micropiles in this report will be focused on this region and immediate surrounding areas. While a focus will be emphasized on the use in central Pennsylvania, other soils conditions will be explored as to the potential benefits for micropile construction. These soil conditions can then be employed throughout the United States wherever the soil condition is present.

Proposed Solution

When this research is complete it will be presented to owners, contractors and engineers with information about when it is a good choice to use micropiles and what the advantages will be. In presenting this information to developers and contractors alike they will become educated about the option of micropiles and will then consider using the method on further projects. It is important to not only inform engineers of the construction advantages of micropiles but by informing contractors and developers/owners they themselves can propose the system on their next project to the engineer. The ultimate goal is to improve the construction industry by implementing new techniques.

Research Steps

The following steps will be followed to research the micropile foundation system:

1. Research further information about micropile systems from ISM (International Society for micropiles), IWM (International Workshop on Micropiles) and related code, design and guideline manuals for micropiles.
2. Assemble cost and schedule information from case studies of projects that have utilized micropiles.
3. Gather input from developers, construction managers, general contractors and specialty contractors and specialty design engineers on their experiences (or lack of) with micropile construction.
    a. Sample Survey
    b. Phone Calls
    c. Emails
4. Apply the research to the Marriott Hotel and Lancaster County Convention Center project.

By obtaining input from the all of these parties it can be analyzed as to where the lack experience is coming from and why.

Sample Survey

See the attached 'Micropile Survey'.

Micropile Survey

1. Have you used micropiles on a project?

If YES, what was the application?

a. New Construction b. Renovation c. Addition

Briefly describe the application(s) you have used micropiles for:

(depth, approx. load sizes, soil type)

_____

_____

_____

_____

Please rate your experience in using micropiles in regards to:

	5 = excellent	4 = good	3 = average	2 = poor	1 = very poor
Schedule	5	4	3	2	1
Cost	5	4	3	2	1
Constructability	5	4	3	2	1

Briefly describe the experience you had using micropiles:

_____

_____

_____

_____

If NO, what type of foundation system do you most commonly use?

a. A shallow system b. Caissons c. Piles

Please explain if there are any particular reasons why you feel you have not used micropiles on a project? _____

_____

_____

_____

_____

2. What type of soils do you typically encounter on your projects?

_____

_____

3. Please comment about your thoughts for the following questions:

Do you believe micropiles will become more widely used?

_____

_____

_____

Do you believe that as the system becomes more prevalent the costs will decrease?

_____

_____

_____

Do you believe that micropiles are a better system then caissons?

_____

_____

_____

Do you believe that micropiles offer any schedule saving during construction?

_____

_____

_____

Do you believe that micropiles offer any cost savings over alternative systems?

_____

_____

_____

What applications do you best see micropiles used for?

_____

_____

_____

Thank you very much for taking the time to participate in this survey.

Problem Identification

The Marriott Hotel and Lancaster County Convention Center project has discovered several problematical areas during the construction and preconstruction phases. This section of the report will identify several of the main issues that have been discovered to this point in the construction of the project.

Extensive Redesign Work

The number one causes for claims in the construction industry are incomplete and poor documents to construct off. Thus far in the construction and preconstruction phases, hundreds of constructability review concerns have been addressed by the construction manager. Along with the review comments, hundreds of additional RFI's have been directed to the architect and engineers. Many of these issues have created the need for extensive amounts of redesign work that has been required. It has proven very difficult to produce accurate and complete documents while an existing building was on the site during the design phase making it impossible to identify the exact locations of the five historical structures that are to be incorporated into the building and the underground site conditions.

Structural Redesign

The locations of the interior concrete columns were designed too close to the existing façade to allow the caisson rig to drill the caissons in the required location. A major structural redesign took place to move the concrete columns in from the façade so they would all line up on top of each other. In moving the columns through the height of the structure, it changed dimensions on almost every page of the architectural and structural drawings. A few of the conflict caissons were also redesigned into large spread footings. Significant time was spent by the architect and structural engineer to complete the required redesign.

Plumbing Redesign

The contract documents call for the entire project to meet Marriott Standards. This became an issue for several contractors but particularly the plumbing contractor as they bid the project with the assumption that the DWV system could be PVC, where the Marriott Standards require a cast iron system. Negotiations, variances for Marriott Standards, and further design details needed to be worked out before construction of the system. It was then later agreed upon to utilize cast iron in sound critical areas and the PVC for the rest.

The plumbing system was discovered to be over pressurized at the beginning of phase two of the project. This redesign delayed the shop drawing and coordination process for the MEP contractors and other trades; this also provided a delay in construction.

Another plumbing redesign issue, recognized months after the first, was that there was more hot water then was needed for the project. Two hot water heaters and storage tanks were removed from the plans and the design needed to be updated to reflect the changes.

Dewatering System Redesign

During the excavation in the lowest part of the site, the museum level, a natural spring was discovered. This spring provided significantly larger water flows then what the current permanent dewatering system could handle. A delay in construction was encountered while a redesign was finalized for the dewatering system.

Lighting System Redesign

The drawings failed to provide emergency circuit designations for the lighting system. This created the need for the design to be reworked before the electrical contractor could continue running wire in the convention entry level.

Handicap Compliance Issue/Redesign

The existing grade of the road and sidewalk along the Queen St. entrance of the building slopes greater then what is allowed for ADA compliance. Again, a redesign is needed to rectify the issue and move forward with construction.

Portico Foundation Design

Under the sidewalk along King St. empty utility vaults were filled with lean concrete very early in the construction project (early in phase 1). The vaults were filled with lean concrete with no reinforcing at all. In an effort to save time and money, a structural redesign has taken place to allow for the portico entrance steel to bear on the unreinforced lean concrete fill that is 12' thick. Caissons were originally designed for the foundation of the portico steel.

Portico Redesign

During the value engineering (VE) process for the project, the entrance portico steel was revised and redesigned providing the owner with a $650,000 credit.

Architectural Redesign

The neighboring office building to the north of the side was discovered to be out of square and encroach on the Hotel and Convention Centers footprint during the layout of the buildings' superstructure. Again a redesign needed to take place to move the exterior wall a few inches to avoid the conflict.

These redesign issues are just a few examples that have taken place during construction. It is definite that further redesign work will be needed before the project is complete. Analysis could be performed to identify potential advantages in delivering this project with a fast track approach (design-build or a design-built lite). Potentially a fast tracked design build delivery method could design the foundation system during the demolition of the existing building, and then design the superstructure during the foundation construction and so on so forth. By delivering the project with this method more accurate documents can be produced with the more information that would be revealed by having the demolition complete. The major constraint on delivering this public/privately funded project in this manner is the inability to "lock-in" financing to a lump sum price before beginning construction.

Flow of Information

For each redesign or RFI response or response to a constructability review comment, the architect issues new drawings to be rectify the issue. These new drawings are identified as bulletins, addendums, or RFI responses. With hundreds of new drawings being issued in the first few months of construction it is clear to see that there exists confusion in the field as to who is

constructing off the most current set of prints. The architect and most of the engineers for the project are located in Atlanta, Georgia. The architect has experience with designing Marriotts and similar sized projects while the structural engineer specializes in post-tension high rises. Their experience and expertise is needed to design a state of the art facility though being in Georgia significant travel is required to view the site. The internet is a great tool; it enables instant transferring of electronic files, particularly pdf files of the drawings and photos of construction issues. Even with the internet and digital photos, it is always beneficial to see a project first hand. The travel required for the architect and engineers to meet on site to view an issue and hold a meeting is a significant portion of time, and cost. Even with the internet and instant access to view updated pdf files of the drawings on the computer, the contractors in the field are not receiving the drawings until the construction manager sends the documents to the printers to get printed, logs the documents for tracking and receiving purposes, and then gets them into the hands of the contractor. Significant time is spent transferring information through the proper channels to get from the engineer to the architect to the construction manager to the printers and back then to the contractors in the field. With the schedule required by the Owner for the completion of the project, the time spend relaying information from one party to another is significant.

It is not only the time lost in the issuance of new drawings, but a question of are the contractors actually reviewing the changes to the drawings and annotating their drawings and specifications to reflect the changes. The architect tries to outline the changes made to drawings, though sometimes it is not practical to do so or they may miss an outline – it still does not make it acceptable for the contractor to be constructing off old/incorrect drawings. If a small change is made to a drawing it is not practical to reissue a new full size sheet – just an 8.5x11 of the area on the drawing. Once several changes are made to a drawing the sheet becomes cluttered with reissued 8.5x11 and very difficult to read. Large sheets that are used to reflect changes are cleaner and easier to read though are much more expensive. The flow of information and the reassurance that contractors are constructing off the most current set of construction documents are critical issues for any construction project, though become immensely critical when the project requires extensive redesign work and the architect and engineer are not local.

Decision Making Process

The ownership structure for the project is very complicated. In its simplest explanation RACL owns the hotel while LCCCA are the owners for the convention center. The developer is a liaison to both public entities. On almost a weekly basis the developer is reporting construction updates and progress to each board. For certain change orders such as change orders over $100,000 and no cost schedule extensions the developer needs to obtain approval from each board to be able to proceed with the change order. The dual ownership on the project appears to add time to the decision making process for critical issues to the projects success.

Convention Entry Level

The convention entry level is the level above the museum level in the convention center. The museum level, as mentioned above, encountered unexpected delays with the discovery of a natural spring. The museum level also encountered issues and delays with the unearthing of historical artifacts and structures near the Kleiss Saloon (in particular a brick floor). The delays encountered in the museum level directly affects the ability to proceed with the convention entry level, as in concrete construction the slab below needs to be complete to enable the forming of the slab above.

Caisson Construction

The project utilizes 200 caissons for the foundation system of the structure. For the project, intact rock requirements needed to be met for each caisson drilled. Many of the caissons also required special requirements to account for uplift forces; such as drilling a smaller diameter caisson deeper through the bottom of a larger hole and the use of rock anchors at the bottom of the caissons. For theses caissons the caisson contractor needed to set up the drill rig for a large diameter caisson, reach the required depth then switch to a smaller diameter bit to continue to drill for the same caisson, then further drilling is required by the concrete contractor to install the rock anchors. Additionally, for several of the caissons rock was encountered at a very shallow depth, approximately 10 ft., and the structural engineer still required the depth to be increased, thus the caisson contractor spend significant time drilling large diameter holes in rock. In an effort to save money from drilling large holes in rock, the foundations for several caissons were redesigned to be large spread footings, which decreased the rock removal required but also took longer then to drill caissons.

Technical Analysis Methods

The convention entry level for The Marriott Hotel and Convention Center Project faced construction delays due to unforeseen site conditions and requirements in sequencing to place a reinforced concrete slab. The technical analyses in this report will focus primarily on the convention entry area of the convention center portion of the project.

Structural System

Problem Statement:

The convention entry level and exhibit level are both cast in place concrete; can the load requirements for these areas be met with a structural steel system?

Proposed Solution:

A detailed redesign of the structural system will be completed to come up with a steel structure to support the required loads. The majority of the convention center is already a steel structure and in designing the convention entry and exhibit levels to be steel, schedule reduction can be achieved. A cast-in-place concrete structure mandates a specific sequence of construction and any delay to a part of the sequence will delay the entire process. A steel structure offers more flexibility for the sequence of construction and most importantly does no rely on the museum level or under slab work to be totally complete.

Research Steps:

1. Gather loading requirements for the floor systems in the spaces of interest.
2. Determine the best steel alternative for the space allotted (all wide flange beams or beams with joists)
3. Design the steel structure to maintain the current column grid and evaluate to determine if modification to the grid would be beneficial
4. Design a complete structural system for the area
5. Calculate a detailed costs for the structural system and compare to the cast-in place concrete structure
6. Develop a schedule for the erection of the steel and compare to the schedule for concrete

Mechanical System

Problem Statement:

With a steel structure can any smoke evacuation ductwork be reduced with the change in plenum space and ceiling requirements?

Proposed Solution:

By increasing the plenum space by the switch from a concrete structure to steel structure larger more efficient ductwork can be utilized. Additionally by redesigning the ceiling, the plenum space may also be utilized as means of smoke evacuation, thus reducing the quantity of ductwork.

Research Steps:

1. Research Marriott's standards for smoke evacuation
2. Analyze the spaces requirement for smoke evacuation
3. Research ceiling type requirements for a plenum space to be incorporated into the smoke evacuation system
4. Reevaluate the ductwork sizes and quantities for the change in plenum space
5. Propose a new ductwork layout for the area
6. Calculate the possible reduction in ductwork quantity
7. Calculate possible cost and schedule savings

Construction Sequencing/Planning

Problem Statement:

In using mini-piles for the foundation system instead of caissons will there be cost savings and schedule reduction? In switching the convention entry structure to steel and in using mini-piles, can the construction sequence be reworked to accelerate work in this area?

Proposed Solution:

Mini-piles require more holes to be drilled then caissons but the holes are much smaller and can be drilled considerably faster. The mini-piles also use less material then caissons and can provide cost savings also.

In switching the convention entry and exhibit level structure to be steel there will no longer be a need for shoring and reshoring in the area and the flow of materials and workers will be improved. The steel structure can be erected in this area regardless of the unforeseen conditions in the museum level, and can be independent of the progress in that area to a certain extent.

Research Steps:

1. Determine the load requirements for the foundations in this area
2. Calculate an equivalent micropile system to support these loads
3. Calculate the cost for the mini-pile system and compare to the caisson cost
4. Evaluate the sequence of construction activities in this area
5. Develop a new sequence of activities to include activities related around the excavation, micropile construction thru steel erection
6. Compare the cost, schedule and site access to that of the existing design.

Weight Matrix

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Analysis 1 - Structural Redesign		5	10	15	30
Analysis 2 - Mechanical - Smoke Evacuation Redesign		10	5		15
Analysis 3 - Construction Sequencing			15	10	25
Analysis 4 - Micropile Research	20	5		5	30
Total	20	20	30	30	100