Wellington Condominiums

Exton PA

Extraordinary Residences Exceptional Lifestyle

Design and Construction Team:

Owner: The Hankin Group
General Contractor: Wellington Commercial Construction
Construction Manager: Wellington Commercial Construction
Architects: Minno & Wasko Architects and Planner
Engineers: Liberty Engineering

General Scope:

Size: 147,069 S.F. 4 Story luxury condominiums w/ Parking Garage
Building Cost: $18.1 million
Schedule: September 2005 thru May 2007
Project Delivery: CM @ Risk

Architecture:

-Designed in the tradition of grand estate homes
-Situated at Eagleview community town center
-8 designs with a choice of décor being “traditional” or “contemporary”
-Designated areas for concerts, shopping, dining and fun
-Building surrounded by landscaped parks and native woods
-Stylish brick and cast stone exterior veneer
-Composite slate roof and membrane roof w/ copper eave drip edge

M.E.P. Systems:

-Fire protection system includes sprinklers, fire alarms and smoke detectors throughout each residence and public areas
-Building access communication system, telephone, cable and internet ready
-HVAC is an all air gas fired furnace supplying each condominium residence
-Main Electrical Distribution switch board is 1600 Amp, 3 phase, 120/208 V
-The main electrical distribution connects to 4 meter banks which are then broken down to each individual apartments

Construction and Structural:

-Being built in a very developed commercial neighborhood
-Geotech report indicated site had variance in quality of soils
-Installed permanent dewatering system before actual construction
-Delay in Permits and architectural approvals pushed façade construction to winter
-Foundation utilizes 18” strip and column footings w/ 5” slab on grade
-First floor makes use of a 12” heavily reinforced two way flat plate concrete slab
-Other floors use innovative Hambros Joist 3” slab on deck composite system

Wellington Features:

-48 unique floor plans up to 2,300 S.F.
-Great views from large bay windows
-Hardwood floors in all living areas
-Polished Granite Countertops
-Elegant lobby entry

FLYNN STONE
Design and Fabrication
We Move Mountains To Satisfy You

Sean Flynn
Construction Management

www.arche.psu.edu/thesis/eportfolio/2007/portfolios/SRF163/

Contents

A. Executive Summary

The Wellington Condominiums project was investigated to identify areas of a project that are good candidates for research, alternative methods, value engineering, and schedule compression. Critical industry issues, research methods, problem identifications, and technical analysis methods have been recognized and are presented in this report.

A main theme that I would like to introduce into the technical analysis is “Building for the Future.” As construction managers our future is about building tomorrow today. We have to understand that our basic responsibilities are in the actual construction and management of a building project. This is only a fraction of our responsibilities of what is more vital: the building of communication, trust, and respect with other people in the industry. Our future depends on building respect and taking team work and ethics to a new higher standard. With project delivery methods more frequently utilizing better team work arrangements like design-build, it is up to us whether or not the future of the building construction industry will respect that evolving philosophy.

On October 12, 2006 at the PACE Roundtable Annual Meeting three sessions were attended to gain a perspective on critical industry issues. Industry members and senior thesis students interacted and discussed issues such as structural building systems, BIM implementation challenges, and building owners respect. Some of these topics directly affected and applied to the Wellington Condominiums project.

One critical issue that came from the PACE Roundtable discussions was the process for which manufacturers and suppliers can follow when introducing new technologies and products to the construction industry. This topic is further researched as to how this process can be improved and be implemented.

Several problematic features of the Wellington Condominiums project have been identified and are pursued through a detailed analysis of the technical building systems and construction methods. The main areas of focus are redesigning the foundation system to support a matt slab, the integration of façade components, and the restructuring of the finish trade phase. A weight matrix chart is attached to provide an illustration as to how effort will be distributed when performing the different analyses.

B. Revised Critical Industry Issues

B.1 Introduction

A PACE Roundtable meeting was held on October 12, 2006 for the interaction between industry members and senior thesis students. The main theme for the Roundtable discussions was building respect within the construction industry. The Roundtable Meeting was broken down into 3 sessions with various topics for people to choose from. A summary and description of the sessions attended during the PACE Roundtable meeting are as followed:

B.2 Session 1: Structural Building Systems - *Constructability and Construction Loads*

B.2.1 Summary of Discussion

Some of the issues that were discussed during this session are as followed:

- More standardization of products used on a project
  - Examples of using 6 KSI strength concrete rather than 14 KSI
  - Stay away from complicated add mixtures

- Coordination issues between engineers on details
  - Either the structural engineer dose all the details or none
  - Need better coordination between engineers on a project

- Owner tries to coordinate project team themselves
  - Owner tries to save money but ends up loosing in schedule and budget
  - GC / CM should be in control of coordination between all parties

- Need more engineer involvement
  - Engineers should be on construction site more often
  - Intern with construction company for more experience

- Methods and process for manufacturers in providing new technology to the construction industry
  - What can a manufacturer do to promote new technology
  - Who takes the risk in new construction technology

- Loading situations during construction
  - Knowing how much loads are on the structure when constructed
  - Proper bracing and construction techniques must be used

B.2.2 Analysis of Discussion

The discussion during this session I felt had the greatest impact on my particular building project. The industry members had a lot to talk about and how they deal with real construction issues on a daily basis. One of the issues that I was surprised on was the focus on keeping construction simple. If the project can be simplified or value engineered and hold up to the owner's expectations and needs then all parties involved will benefit. Going for the newer technology is not always best for a building project. The industry members seem to really focus on coordination issues and constructing buildings as efficiently as possible. For instance, one topic of interest was that new admixtures and high strength concrete is not necessarily the best way to go on a project. It was recommended by industry members if feasible to go with larger columns and readily available concrete in the area. In the end a construction manager has a responsibility to gage on what is best for the owner and the constructability of a project.

Another issue that applies directly to my project is the coordination between engineers. On my project, there was an issue with the stud and structural engineer on details with the metal stud wall framing. Each engineer did some of the details and both assumed that the other will be responsible for the majority of the details. This ended up in a big coordination problem when it came time for construction and delays resulted because of it.

Another topic of interest is new technology and how do manufacturers go about presenting it in the construction industry. New technology is not always the best answer and can create more problems then good. On my project a new innovative Hambros joist system was installed to save time and money but the opposite resulted. Heavy members have to be positioned on the metal stud framing and sometimes by hand and created time delays. Some new technologies are not always best for a project and manufacturers must know when there product should be utilized.

One of the key contacts that I found was Oncore Construction. Oncore gave me some feedback during the break session about my particular building project. Oncore gave me some ideas about how to redesign the foundation system for my project that could have been beneficial to the owner of the project in time and cost savings.

B.3 Session 2: BIM Implementation Challenges - *Weaving BIM and Project Delivery*

B.3.1 Summary of Discussion

Some of the issues that were discussed during this session are as followed:

- Challenges companies face with BIM
  - Confusions with technology and implementation
  - Industry member projects that currently use BIM
- Future of BIM technology
  - Where and when do you apply BIM
  - Industry members utilizing technology and possible outcomes
- Advantages and Disadvantages of BIM
  - Paybacks v. extra work
  - Who is going to build models and take risk in usage
- Who leads the charge to implement BIM
  - CM / GC must force the issue to the design industry
  - How to use BIM throughout the entire project

B.3.2 Analysis of Discussion

The discussions during this session mainly focused on the implementation of BIM and some of the issues that is facing the industry today. I was surprised that some industry members already have there own division of BIM and use it on a daily basis. Other industry members did not have much to with BIM or are just starting to implement its usage. The general notion of industry members was that BIM is useful in complicated construction and finding conflicts in the schedule. But the usage up to this point is limited due to the difficulty of programming and finding people who can run these programs. It was pretty much unanimous that the future of BIM between all industry members looks to be very prevalent in the construction industry.

BIM technology was not applied to my thesis project but application of BIM could help out with some areas of the schedule. For my project, BIM would be best utilized under the finishing trades. With the project being a condominium, time is very critical to the success of a project. The project has phased occupancy while construction is still underway. Careful coordination and thought must be done to minimize conflicts with future home owners. BIM would help minimize the risk and show any conflicts between home owners and construction workers.

Some of the key contacts with industry members were Holder Construction and Clark Construction. Both of these companies have there own division of BIM and utilize the technology everyday.

B.4 Session 3: Building Owners Respect - *Building Owners Respect*

B.4.1 Summary of Discussion

Some of the issues that were discussed during this session are as followed:

- How to earn respect from owners
  - Set fundamental guidelines and establish a proper communication line of information
  - Knowledge and history of the owner
  - Presenting clearly the budget, marketing, schedule, and quality of the project
  - Being honest with the owner

- Indicators of respect from owners
  - Common ways of gaining and loosing respect
  - Surveys and scorecards

- Ideas for Research on how to gain owners respect
  - Knowing the benefits and limitations of partnering meetings with other project team members?
  - How important is respect on a project between owners, general contractors, and construction managers?
  - How do we measure respect in a project and customer relations?
  - What is in performance based specifications on a project?
  - How dose a construction company properly distribute company personal for repeat business and hard bids?

B.4.2 Analysis of Discussion

Building respect with an owner is a very important concept for a general contractor or construction manager. In order to be successful in the construction industry knowing what an owner wants and expects is critical to the success of a project.

One of the discussions that surprised me was how open industry members were to how to make an owner satisfied. A lot of times these industry members are battling each other for a construction project and have the time to discuss there techniques of success to everyone else in the room. Some of the issues of interest for my thesis project are the

relationship between the contractor and owner. Understanding what the owner wants and needs are very big to a construction project.

For my project the needs are for the project team to complete a condominium that excels in quality and time of completion. This puts pressure on the team to perform at its best and overcome challenges. It is also important to understand what the building will be used for. The main key points for the owner are to begin phase occupancy and sell off the building as soon as possible. So in order to fulfill the owner's wants and needs the project team has setup a two phased occupancy in order to get homeowners moved into the condominiums as soon as possible.

Some of the key contacts for this session come from the Pentagon Renovation Project. On the Pentagon renovation project there are many requirements that the owner request from the project team. It is up to the project team to understand what the owner wants and implement a successful strategy for success.

C. Critical Issues Research

C.1 Introduction to Critical Issue

A critical issue that is to be pursued further in research is the decisions that industry members make in providing and utilizing new products. Who makes the decision to use a new product and when? What process of action can manufactures and suppliers do to promote new products? Who takes the responsibilities and risks? Can a process and procedure be created and implemented to help aid the construction industry? These questions are going to be researched and analyzed in the construction industry in hope of providing real solutions to real world problems.

It is a common notion that the construction industry is slow to adopting new products. As part of this research, we ask the question why? Why does it take the industry so long to adopt new products? In other industries products are adopted very quickly and efficiently but the construction industry tends to be very slow and hesitant.

The theme of the report as to building respect in the industry goes much farther. "Building for the Future" and gaining respect with other industry members in communicating efficiently is a step towards a better working environment for all. Building respect will lead to building a brighter future for not only students but for everyone who works in and out of the construction industry.

One example that is to be further researched as to why the construction industry is hesitant to the adoption and utilization of new products is the Hambros Joist Composite Deck System. The Hambros Joist Composite Deck System is an innovative product to the construction industry. On a micro level, the Hambros Joist Composite Deck System on the Wellington Condominiums Project will be analyzed in a separate investigation by asking the question: 'Was the Hambros Joist Composite Deck System a correct decision to be utilized on the Wellington Condominiums Project? Also where would this product be best utilized and the rational process for selecting this product?' As part of the main research and analysis, this product and others will be compared and looked at on a global scale. The research goal is to define common problems that industry members are having in the adoption and utilization of new products. Issues such as: unions, local conditions, laws, regulations and codes, availability of product information, product logistics, and unfamiliarity with products are some of the common issues as to why products are not readily adopted. It is in the hope of this research to solve some common issues that could be readily fixed and help alleviate common problems that the construction industry is having in the adoption and utilization of new products.

C.2 Main Research and Analysis

C.2.1 Problem Identification

What are the decisions that industry members make in providing and utilizing new products? Who makes the decision to use a new product and when? What process of action can manufactures and suppliers do to promote new products? Who takes the responsibilities and risks? Can a process and procedure be created and implemented to help aid the construction industry?

As being from the manufacturing industry side for many years and now crossing over into the construction industry, it has always been of great interest to understand why the construction industry is slow in adopting and utilizing new products. With connections between industries, better research and understanding of how the supply chain management system works is of great business and economic interest.

C.2.2 Proposed Solution

Many case studies have been researched through the implementation of new products in the construction industry. One product is the Hambros Joist Composite Deck System and its use in the construction industry. Much research has been done about products but very little as to improving the process of getting new and innovative solutions into the hands of the construction industry. Setting a path and a step by step procedure as to how to present and initiate new products in the construction industry is a key stepping stone towards improving the adaptation and utilization of new products. Also if a set path for manufacturers and suppliers are established better supply chain management and

communication lines can be established. As the industries move towards more team work initiatives, the greater the need for set processes and communication lines. The sooner products can be presented to the construction industry members, the better they can make decisions and solve problems.

C.2.3 Research Steps

The procedure to investigating the decisions that industry members make in providing and utilizing new products are as followed:

1. Research on the current published problems that the construction industry is having with particular products? Investigate common supply chain management procedures and the processes for the selection and utilization of new products in the construction industry.
2. Analyze some recurring problems that the construction industry is having at this current time. Come up with some initial solutions and procedures to helping alleviate some common problems.
3. With all this information, create and refine surveys and interview questions for all members in the supply chain system of the construction industry as to gain perspective to the difficulties outlined in introducing and utilizing new products. What are some of the benefits and problems that the construction industry is having with the adopting and utilization of new products? (Unions, Regulations, Codes, Local conditions, etc.)
5. Collect enough surveys and interviews that outline 10 products that are of concern to the construction industry. Out of those 10 products, group them to similar issues of conflict. Select one area of greatest concern to the construction industry and analyze a process and procedure for improvement.

The sources of outside information that will be required to fulfill these research steps are as followed:

1. Information from supply chain managers in the manufacturing and construction industry through research and surveys.
2. Connections with owners and design professionals (in particular the Wellington Condominiums Project) on there input of a process of utilizing new products.
3. Research documents in the areas of engineering technologies and diffusion.

C.2.4 Expected Outcomes

The expected outcomes are to create a logical and systematic approach as to how the construction industry can improve the supply chain management of utilizing new products. The implementation of this process can be immediately utilized by any company and can be a way in improving the flow of ideas and communication between

both industries. This process and procedure is the key to opening the door between industries and in hope of benefiting all parties involved.

I feel that all parties of the construction and manufacturing industry would benefit and have interest in the process and procedure of introducing and utilizing new products in the construction industry. Having a process that all industry members can follow may lead to having a more productive and respectful working environment.

C.3 Data Collection Tool

A survey is created to gain an in depth knowledge as to what the industry members feel of why implementation and adoption of new products are very slow. Other questions as to how other companies proceed in introducing and utilizing new products in the construction industry will be asked and examined for improvement. This survey will be handed out to a range of people in many construction related areas as to gain a large perspective of the whole construction industry. Interviews will be conducted to ask similar questions outlined in the survey. The data collection survey is presented below for an initial possibly as to what questions could be asked.

See the Following Attached Page for Sample Survey

SAMPLE SURVEY

Architectural Engineering Thesis Research

What decisions do industry members make in providing and utilizing new products?

Target Audience: Manufactering and Construction Industry Members, Owners, and Design Professionals.
Research Goal: To develop a systematic process for which construction industry members can follow when introducing and utilizing new products to the construction industry.

Please rate the following statements on a scale of 1 to 5, with 1 being strongly disagree and 5 being strongly agree. Additional Comments are provided and highly recommended for further in depth analysis.

		Strongly Disagree				Strongly Agree
1.	The construction industry is slow and has difficulties in adopting and utilizing new products.	1	2	3	4	5

Comments on why the construction industry *is/is not* slow and has difficulties in adopting new products:

2.	There is a clear and direct process for new products to become available in the construction industry. Clear communication exists between the manufacturing and construction industry.	1	2	3	4	5

Comments on there *is/is not* a clear and direct process for new products to be communicated efficiently between industries:

3.	There are minimal problems encountered with new products.	1	2	3	4	5

Comments on there *is/is not* minimal problems encountered with new products. If problems exist with new products please name the product and what the problem is:

4.	There are many ways for which new products are to become available to the construction industry.	1	2	3	4	5

Comments on there *are/are not* many ways for new products to become available:

5.	Team work in the supply chain is more prevalent now than before. If a problem dose arises with a new product, the problem can be easily fixed.	1	2	3	4	5

Comments on team work *is/is not* more prevalent now than before and if a problem dose occur with a product then it can be easily fixed:

6.	Manufacturers and Suppliers are willing to take on the responsibilities and risks of promoting new products to the construction industry.	1	2	3	4	5

Comments on manufacturers and suppliers *willing/not willing* to take responsibilities and risks:

D. Revised Problem Identification

D.1 Introduction

Several problematic features of Wellington Condominiums project were identified that could be pursued through a detailed analysis of technical building systems and construction methods. The following breakdowns of indicated problems are listed as followed:

D.2 Problem Identification Analysis

D.2.1 Mechanical System

i. **Problem:** There are no mechanical rooms to the condominiums but many mechanical closets. On the garage level there are two mechanical closets centrally located in the garage. The other mechanical closets are located in each condo and supply air for that particular condo. The system is an all air system and distributes the air through insulated metal ductworks.

ii. **Recommendation:** Decrease the amount of mechanical closets possibly by using different methods of heat and cool air distribution or having a centralized mechanical system. If the amount of ductwork and mechanical closet space can be reduced, more usable space is available to future home owners.

D.2.2 Foundation Systems

iii. **Problem:** The subsoil conditions on the construction site as specified in the geotechnical report from Earth Engineering was not very good and that a good portion of the sub grade soils would have to be removed and replaced with structural fill. Another cause for alert to the project team in the geotechnical report was that the foundation floor grade was under the groundwater level. If the design was to stay as planned the whole bottom third of the foundation would be underwater. Another problem with continuing the original design is substantial excavations below the existing grade would have to be done to achieve the proper amount of required structural fill. This would result in having to rock excavate and use equipment like hydraulic hammering, splitting, or other rock removal techniques. Blasting was not recommended therefore a rock crusher and other equipment would have to be brought on to do the job. All these added expenses can be seen in the estimate to how much it costs the developer and owner. The total expenses just for poor subsurface conditions not including the dewatering and waterproofing systems was well over $160,000. This also delayed the construction and handover date for the project.

iv. **What actually occurred:** The geotechnical engineers offered two solutions to the problem in both raising the foundation up to where the Uwchlan Township zoning would specify or permanent dewatering systems and waterproofing would have to be instituted to the design. The architects and designers felt that it was best to proceed with installing permanent dewatering systems with waterproofing. The architects and designers also went with in the original design wall strip and single slab column footings.

v. **Recommendation:** The architects and designers want to keep the foundation where it is and not to alter the parking garage. Therefore sticking with a permanent dewatering system is something that should not be altered. On the other hand, the wall strip and single slab column footings are very large in size and thickness and require by the structural engineer 6,000 PSI strength concrete. If a matt slab foundation system could be utilized to reduce the depth and strength of the concrete it could do the following possibilities:

1. Save time and money by not having to excavate as deep in rock material.
2. If footing depth can be decreased possible savings in the dewatering system could happen.
3. Using a matt slab could reduce the strength needed for foundation concrete and also if designed correctly act as a slab on grade. This could potentially save time and cost to the project.

D.2.3 Façade in Winter Months

vi. **Problem:** With all the early delays on the project it has pushed construction of the building façade to the winter months of 2006. This creates logistical issues on how to construct the building façade and keep on schedule. Sometimes the winter months can be harsh in Pennsylvania therefore proper weather days accounted for cannot be overlooked. With that in mind, the scaffolding at this current time is through the use of a typical metal modular frame scaffolding system. This system is very easy to assemble and light to handle. This system if done in the winter would have to be protected from the winter elements and provide a proper work place for all construction workers. Decreased productivity will result if the scaffolding operation is not properly planned for in the winter months.

vii. **Recommendation:** One of the reasons why the façade can not start early is because all the condominium balconies when constructed require there own support when the concrete is gaining strength. These supports are its own scaffolding system which continues to build upon itself when another floor is constructed. No masonry construction can occur until all balconies have gained strength, which is one of the reasons why the building façade has been pushed to the winter months. Pre cast stone is used as architectural ornamentation throughout the condominiums façade. A crane

must be used to put these large cast stone pieces in place. This may require the masons to stop laying the brick while the cast stone is placed. With having to deal with winter conditions and potentially delayed work while numerous pieces of ornamentation are being placed; it is recommended that the whole façade be pre cast. If one system is already utilizing pre cast why not the entire building? This would eliminate the worries of scaffolding, crew productivities during the winter months, and logistical issues with having a proper work place, equipment, and material available.

D.2.4 Transfer Slab

viii. **Problem:** The most critical part of the schedule came when the 12" transfer slab was being constructed. This took by itself 75 days to complete and was very critical to the project being completed on time.

ix. **Recommendation:** See if the transfer slab can be constructed in a different way. A lot of resources in labor, equipment, and time were spent on constructing the transfer slab. The project team could look into the possibilities of using steel beams and joists to supporting the first floor. The rest of the floors use load bearing metal stud walls and composite deck systems; so why not use a similar system rather then the whole foundation utilizing concrete. Any approach that can save time and costs to the transfer slab construction is huge to the project.

D.2.5 Access and Flow of Work at Elevated Floors

x. **Problem:** There are only two access ladders on the south side of the building for workers to gain access to the upper floor levels. Also only one dumpster on the south side of the project is utilized during construction. This creates heavy traffic on the south side of the project site and makes it unproductive for workers on the north side of the building.

xi. **Recommendation:** Add more access points and dumpsters around the job site. This will give workers more time to construct and increase productivity on the job site.

D.2.6 Communication between Engineers

xii. **Problem:** The structural engineer and stud engineer did not coordinate properly the details for the connection and placement of load bearing metal stud walls. Issues of metal studs in the middle of elevator shafts and connection of metal stud walls to floors were a common error on the project. This created added delays in the project schedule where time savings were to be expected.

xiii. **Recommendation:** Have more communication lines between engineers on a project. Force the engineers to come to the project site and coordination meetings to properly

scope who is responsible for what. By planning and coordinating ahead of time this can create a reduced schedule in design and construction.

D.2.7 Phasing of Project

xiv. **Problem:** The finishing trades are to construct the building in two phases named phase 1 and phase 2. The phases divide the building in half and begin construction starting in phase 1. Phase 1 construction continues up each floor until all floors are completed. Once phase 1 is completed, phase 2 can begin. The issue with dividing the building in half is that home owners will be living in phase 1 when phase 2 is under construction. The phasing of the project is being utilized to accelerate the schedule but may in fact delay the schedule. See Figure 1 below to illustrate the phasing sequence.

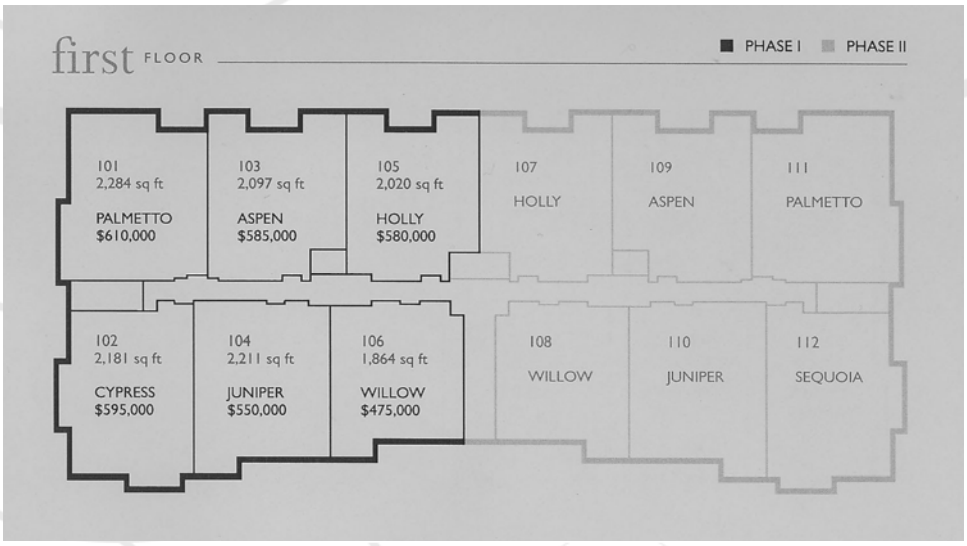

Figure 1: First Floor Phase 1 and 2 – Wellington Commercial Construction

xv. **Recommendation:** Workers must access the building one way or another and work to construct the building. Time must be put into closing off the south side of the building when phase 2 is under construction. Noise, dust, and increased traffic of labor, materials and equipment are issues that the project team must keep to a minimum when home owners are living in the building. To avoid conflicts with home owners and have a productive workplace, I would recommend that phase 1 and 2 be created into four phases. The four phases can represent each floor and can be constructed in order or in any way the project team seems fit. If the project team wants to have the first and forth floor constructed as soon as possible then arrange the phases as shown below:

Phase 1: 1St Floor
Phase 2: 4th Floor
Phase 3: 3rd/2nd Floor
Phase 4: 3rd/2nd Floor

This will do away with having to worry about home owners on the same floor and having to block off every floor when constructing. This will promote better living and working conditions for both parties and avoid conflicts that will arise. This will promote an accelerated schedule that the team is looking for but at a lesser risk of conflicts created.

E. Technical Analysis Methods

E.1 Introduction

Detailed analyses of technical building systems and construction methods have been selected and are proposed for future investigation. The three main problematic areas on the Wellington Condominiums Project are detailed in the following sections below.

E.2 Technical Analysis 1 – *Foundation Redesign*

E.3.1 Problem Statement

With poor subsurface conditions prevalent, can the foundation system be redesigned to possibly reduce cost and time spent without interfering with architect or owner needs?

This problem was identified through the geotechnical reports, change orders, and project manager interviews. A lot of money, time, and energy were spent by the project team having to deal with poor subsurface conditions. An analysis communicating some potential solutions is one study of great interest to many on the Wellington Condominiums Project.

E.3.2 Proposed Solution

A possible solution to the Wellington Condominiums Project is for a structural redesign of the foundation system. The current foundation system makes use of single slab column footings and will be challenged through the redesign of a mat slab foundation. A mat slab foundation system is proposed and will be researched to do the following possibilities:

1. Save time and money by not having to excavate as deep in rock material.

2. If footing depth can be decreased possible savings in the dewatering system could happen.
3. Using a matt slab could reduce the strength needed for foundation concrete and also if designed correctly act as a slab on grade. This could potentially save time and cost to the project.

E.3.3 Research Steps

The procedure to investigating if a mat slab foundation system would be more viable than a traditional single slab column footing is as followed:

1. Learn in more detail and have available the single slab column footing's estimate, schedule, design documentation, specifications, and methods of construction.
2. Redesign the foundation system utilizing a mat slab foundation. Figure out how much material, cost, and time would be spent to construct.
3. Compare the two systems and create a matrix chart based on the owner requirements of which system overall is better for the project.
4. (Optional) The matrix chart could be given to other project team members to see what there opinion is on the system and see how everyone responses compare.

E.3.4 Expected Outcomes

The mat slab foundation system at first seems to be an ironic system to select rather than pouring single slab column footings. When looking at the following items: cost and time spent to rock excavate by rock hammering, putting in a extensive permanent dewatering system and support equipment, weeks of delays that would push back the façade construction to the winter months, and the structural engineer specifying the use of 6,000 PSI concrete for footings. Once you look at all those variables the cost and ease of simply pouring the entire slab may be a better alternative. Until the analysis is completed there is no fast way of determining whether this is a better alternative. Also the analysis can be swayed either way by the owner's input of the foundation system based on a matrix chart. This matrix chart could be given to different project team members and see if there are any differences in how people think on the value engineering analysis. It would be worthwhile to investigate this to see the current industry outlook and whether or not industry members have a building respect for one another.

As from the questions, it is clear that anyone on the project team would be interested in the research presented here. Architects would be interested in the analysis if any changes in the design or composition of the building were made. The engineer and contractor would be interested as to see if the footing requirements can be decreased and provide more value to the constructability of the project. The owner would be interested if the

alternative design could save time or even cost to the project without having to alter major building systems and components.

E.3 Technical Analysis 2 – *Façade Integration*

E.4.1 Problem Statement

With many early problems and delays on the project, is there a way to construct the building façade, in the winter months of 2006, in a more productive manner? Can this be done without ruining the architectural style and vision of the owner and architect design?

This was one of the first things that was looked at and asked to the project manager when analyzing the project schedule. The schedule at first was not this way but with early delays it has pushed back façade construction to the winter months.

E.4.2 Proposed Solution

At first glance the answer to this is 'Yes we can change the building façade!' But caution must be in place when wanting to change the architectural style of the building façade. The proposed solution would be to introduce a façade integration of exterior components. This will be done through the use of pre cast throughout the entire façade rather than on the first floor. The first floor mainly consists of pre cast that have to be situated with a crane. Following the construction of the pre cast, the rest of the floors utilize traditional brick masonry construction. One of the major reasons why exterior masonry construction can not start is the formwork in place for the cantilevered cast-in-place condominium balconies. These balconies require a great deal of time to pour and form. After the fourth floor balconies are poured, they must wait to be at strength before the scaffolding is removed.

This creates huge logistical issues and delays in constructing the façade. If the system components can be preassembled whether they are the balconies or façade, cost and time could be saved on the project.

E.4.3 Research Steps

1. Learn in more detail about the integration of façade components through the use of pre cast or preassemblies in fabrication shops.
2. See if there are feasible ways of constructing building facades in the winter months. Look at research papers if available through ASCE databases. Talk to industry pre casting companies on alternatives for the given situation.
3. If pre cast is the main alternative, a rendering should be created to show the owner that there are little if any differences to the architectural style and vision to the project.

4. Do a cost, schedule, and methods of construction comparison analysis of the building façade options.
5. (Optional) Do a matrix chart with all project participants to gain a sense of what is important to them on the project when it comes to façade composition and construction.

E.4.4 Expected Outcomes

The expected outcome for the façade analysis is very clear before doing the investigation. Pre cast could save you time and cost in labor and equipment. During the winter months this becomes greater due to the loss of expected productivity during this time period. With the addition of not being able to start constructing the building façade due to the scaffolding in place for the cast-in-place balconies; there is a great demand for alternative means and methods of construction. Pre cast is one way of solving this but further research should be conducted to see if there are other methods of constructing building facades during the winter months. The architectural style of the project would have to be rendered to see if the exterior has changed in dramatic or subtle ways. This is one of the first research steps because if the exterior façade changes architecturally, most likely the owner or architect is not going to approve of the changes. But if a rendering can show that minimal changes would occur and substantial cost and schedule savings would result then this could be a good alternative.

The owner, architect and contractor would have the greatest interest in the façade composition and construction. Each have there own reasons for how this should be done. A further option could be employed to research how an owner, architect, and contractor think about façade construction. The main theme of building trust and respect come about to how do project team members see each other. Does the owner respect and trust the contractor to constructing a façade that is of great style and vision? There are many more questions that can be answered from this and to determine how respect and trust is at the current time in the construction industry.

E.4 Technical Analysis 3 – *Phase Restructuring*

E.4.1 Problem Statement

As shown in Figure 1, when phase 2 is under construction, phase 1 will be occupied by home owners. Is their an alternative method that the finish trade's work flow will have less conflicts with home owners, increased productivity, and decreased schedule and cost?

This problem was identified when interviewed with the head saleswoman of Wellington Condominiums. During the interview the marketing and advertisement of the project was discussed in more detail.

E.4.2 Proposed Solution

Restructure the phasing of the finishes trades to promote a better working and living environment for both parties that inhabit the space. The less conflicts that can arise between construction workers and home owners the more productive, cost and schedule savings, and ease of work flow for the project team.

E.4.3 Research Steps

1. Learn in more detail why the project is phased this way and interview with the project team.
2. Come up with an alternative flow of trades and phases to the project to promote a safer and more productive environment for all parties.
3. Create a 4D model of the flow of trades during the finish sequencing to show of possible conflicts with the original phasing and alternative phasing.
4. Calculate the cost and schedule of the original and alternative phasing and compare.

E.4.4 Expected Outcomes

The expected outcomes will be if sequenced correctly, a decrease in cost and time spent on the project with less conflicts between home owners and construction workers. This would be of great interest to the owner because it will decrease the chance of complaints and help sell units much more quickly. The contractors if created a better work flow will increase productivity and finish the project ahead of schedule. Also the home owners will appreciate it much more if they do not have to deal with noise or dust pollution with there brand new luxury condominium. It might be a small fix but can go a long ways in the project being more successful.

F. Weight Matrix

F.1 Introduction

A weight matrix was created to show how effort will be distributed with the different analyses presented in the attached report. For a breakdown of each analysis presented see the weight matrix chart below.

F.2 Weight Matrix Chart

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Critical Issues Research	25%				25%
Analysis 1 Foundation Redesign		10%	15%		25%
Analysis 2 Façade Integration		10%	10%	5%	25%
Analysis 3 Phase Restructuring		10%	5%	10%	25%
Total	25%	30%	30%	15%	100%

F.3 Brief Analysis

From the graph, 25% of the time will be dedicated towards research. Value Engineering, Constructability Reviews, and Schedule Reduction are allotted respectively: 30%, 30%, and 15%. A bulk of the time spent will be in Value Engineering and Constructability Reviews of the topics presented.