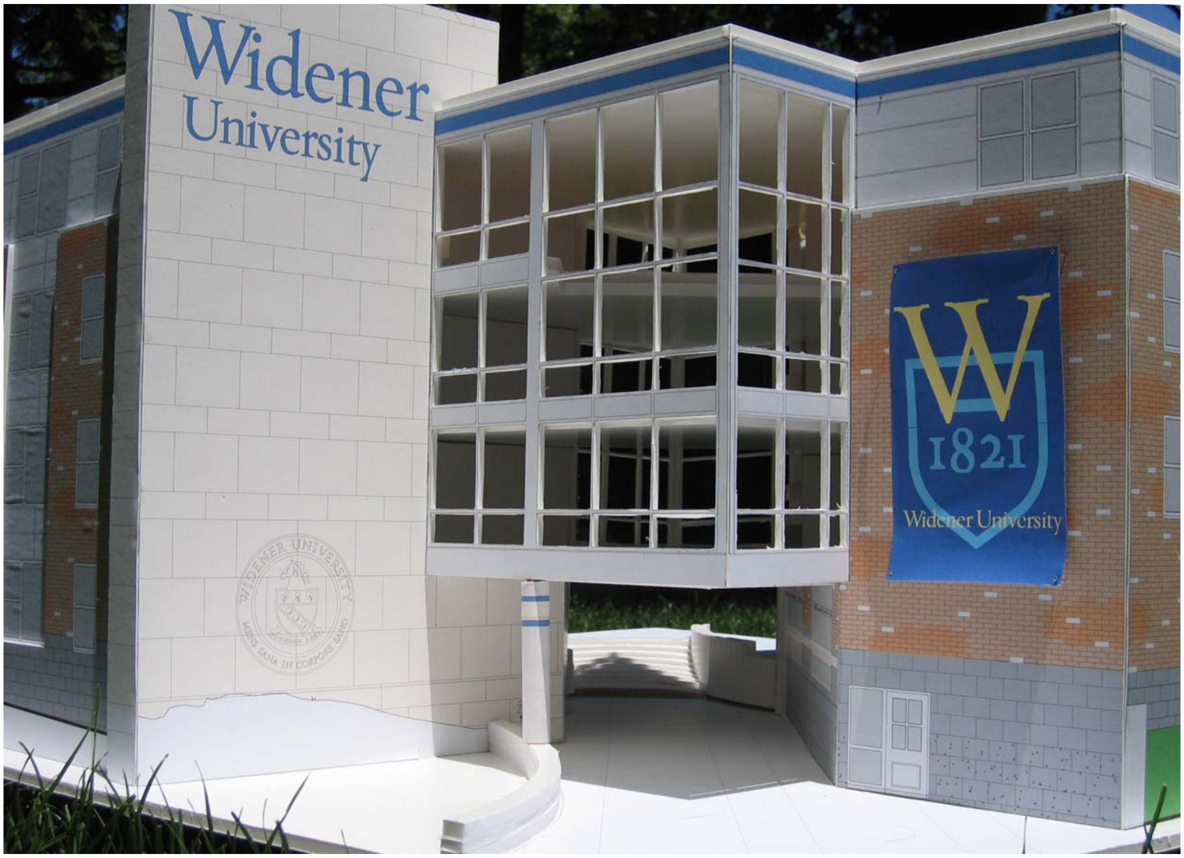
WIDENER UNIVERSITY

METROPOLITAN HALL



KEVIN ENGEL
Construction Management
Thesis 2005-2006

Advisor:
Dr. Messner

Construction Manager:
HSC Builders and Construction Management

Widener University
Metropolitan Hall
Chester, PA

Kevin Engel
Construction Management

General Info:
- Size: approx. 92,000 s.f, 4 Levels
- Owner: Widener University
- CM: HSC Builders & Construction Managers
- Design Architect: Cue to Kearney
- Executive Architect: Wallace, Roberts, & Todd, LLC.
- Civil Engineers: Catania Engineering Associates
- Structural Engineers: O'Donnell & Naccarato
- Mechanical, Electrical, and Fire Protection

Construction:
- Construction Schedule: July 2005 – August 2006
- Estimated Cost: $18 million
- Project delivery method: Design-build, with a Guaranteed Maximum Price.

Structural:
- Floors & Roof: 8" Hollow Core Plank
- Load Bearing Walls: 8" CMU
- Lateral Load supported by grouted CMU shear walls
- Shallow Footings 5'W x 14"H

Electrical:
- Fed from Moll Hall
- Enters building at 13.2kV
- Transformer reduces to 208Y/120V source for building
- Distributed by switchgear immediately following transformer
- Emergency power for life safety systems powered by 1000kW generator at 208/120V

Mechanical:
- Air enters and exits through rooftop heat recovery units
- Air then travels to geothermal heat pumps located in mechanical closets
- The air is then ducted to bedrooms and the hallway
- After flowing through the living spaces, the air is returned to the roof through the bathroom exhaust system

Fire Protection:
- Building is fully sprinklered
- System capable of providing .10 GPM per s.f. to the most remote 1500 s.f. area
- 100 GPM reserved for hose streams
- Sprinkler heads release at 165 degrees Fahrenheit.
- Annunciator panel located in the vestibule at the main entrance to the building
- System meets requirements of NFPA 13.

Special Issues:
- Geothermal heat pumps used for mechanical system required 72-500 ft. deep wells.
- LEED™ Certified Building
- Precast plank floors leave very little flexibility

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Abstract

The project used for this thesis is Widener University's Metropolitan Hall. Construction began on the building in July 2005 and is expected to be completed in time for students to move in for the fall semester of 2006. The project site is at the corner of 17'th and Melrose Ave. in Chester, Pennsylvania, an within the boundaries of Philadelphia.

The first analysis looks at the benefit of constructability reviews. This was an attempt to quantify the benefits obtained by conducting third party reviews of construction drawings. Overall this analysis was successful in that it found that on the typical project of $15 million, it is usually worth the $30, 000 cost and two weeks required for a thorough plan check because it will most likely save about $100,000.

The next section of this thesis is a change to the plumbing system in order to gain LEED™ points for water use reduction. This water use reduction was achieved by changing the water fixtures from the university's standard fixtures to more recently created models which require less water to achieve approximately the same result.

The last analysis, shortening the project schedule, is broken into two parts. The first part compares the options for the structural system, while the second part involves the creation of a SIPS schedule in order to organize the finishing trades into a more efficient work pattern. The structural analysis found that by using 6" tilt-up wall panels, in place of the CMU walls the project could save as much as 194 days, and is less expensive. The SIPS schedule only reduced the total duration by 3 days but it gives the opportunity to increase the rate of work without greatly increasing congestion.

Project Overview

1. Project Team

This project is being completed under a design-build arrangement between Widener University and HSC Builders and Construction Managers. Widener informed HSC that they wanted a high quality, LEED™ rated residence hall and were willing to spend up to $18 million for it.

In order to get several design ideas for the building, HSC conducted a design competition between four reputable architects. The resulting schematics were presented to representatives from Widener, who chose the design submitted by CuetoKearney Design LLC. HSC then hired the partnership of CuetoKearney and Wallace, Roberts, and Todd, LLC to complete the design for the building. The architects then brought Catania Engineering Associates, O'Donnell & Naccarato, and Alderson Engineering into the project as consulting engineers. HSC broke the construction of the project into trades and bid out each trade.

2. Construction Schedule

After 3 months of drilling the wells for the geothermal heat pumps, the building finally broke ground at the end of July 2005. The project is expected to be completed by August of 2006 so that it can be occupied by students in September for the fall semester. It is critical that the building be finished on time because students have been assigned to the building. This is reflected in the contract by charging liquidated damages if the project would be late. The full construction schedule for the building as well as a layout plan is included in Appendix D.

3. Construction Cost

The cost of the building is set by the guaranteed maximum price of the design-build contract between HSC and Widener. This $18 million maximum price limit is broken down into $14.5 million for the building and $3.5 million for the site work. The building size is approximately 92,000 square feet. This gives a cost of $157.61 per square foot for the building or $195.65 per square foot for the entire project.

The information on actual costs of individual systems was not available, so RS Means estimating data was used to get an idea of what the costs should be for the mechanical, electrical system, and structural system. The mechanical cost for a residence hall in the upper quarter of quality is $27.80 per square foot. Adjusted for the area of this building this becomes $31.58 per square foot, or $2.76 million for this project. The electrical cost for a building in the upper quarter of expenses is $14.20 per s.f. Adjusted for the size of this building the result is a cost of $16.13 per s.f. or $1.41 million. If the quality of the building were to be reduced to median quality, the costs would be brought down to $1.93 million for the mechanical system and $1.25 million for the electrical system. Using detailed estimating procedures, the structural cost of this building should be approximately $1.85 million. For calculations of structural costs, see APPENDIX D.

4. Building Architecture

The 92,000 square foot building, located on the corner of 17th and Melrose Avenue in Chester, PA has an L shape that allows it to make the most of its corner location. To keep the building from becoming an obstacle to pedestrian traffic, an open air walkway runs through the building at the corner of the L. The exterior is to have a mostly brick facade with some glass curtain wall and a large limestone signage wall to carry the university name at the corner. The roof structure is 8" hollow pre-cast plank which is covered by rigid insulation sloped to roof drains. The insulation is protected by a fully adhered single ply roofing membrane. The interior is made up of repeating apartment style dorms. Generally the apartments contain three large double rooms, a living area, a kitchen and two full bathrooms.

The building was required to meet IBC 2003 codes as part of the Statewide Building Code (Uniform Construction Code) adopted by Pennsylvania in April of 2004. The building is being constructed in an R-2 residential zoning district, which limits it to a height of 45 feet. This was difficult to achieve with four floors and ruled out using a steel framed building.

Previously this site had been an open area, a field hockey field, so there were no historical requirements. However, as part of a university campus it was assumed from the beginning that the building would blend in with and compliment the buildings around it.

5. Structural System

The structural system is 8” hollow core pre-cast plank flooring with spans ranging from 23 to 30 feet. The planks rest on the exterior walls and one of the hallway walls at the center of the building. The load bearing walls supporting the planks are 8” concrete masonry units. The CMU walls are grouted solid from the foundation through the first floor and in the shear walls. From the second floor up to the roof the walls are hollow, only needing reinforcement at the end of the walls. The walls then rest on shallow footings, typically 3’6” W x 12”H under the outside walls and 5’W x 14”H under the inside wall. The shear walls rest on huge 6’6”W x 36”H footings. The only exceptions to this system are the clubhouse building, which uses steel to support some areas because of openings in the ceiling, and the open walkway, which also uses steel to support the pre-cast concrete due to the longer spans involved.

6. Electrical System

Power will come from a feed connected at an existing transformer at nearby Moll Hall. The feeder will run underground in a 4” conduit at 13.2 kV. This will be carried by 3 #2/0, Type 133% EPR conductors with the capability of handling 15 kV. It will be reduced to a 208/120V, 3 phase, 4 wire power supply by a transformer at the entrance to the building; inside the mechanical room. This power will then be distributed by a switchboard to a fire pump, jockey pump, TVSS, and other distribution switchboards that will send power to the individual panelboards. The emergency system will be a generator capable of producing 1000kW at 125kVA. This power will be distributed in the form of 3 phase, 60 Hz, 208/120V power to the life safety systems panel and the elevator.

7. Lighting Design

All lighting for the building is fluorescent. This allows most of their lights to be under 40 Watts. There are 14 different lighting manufacturers used for the building but most of the lights are typical. In public areas, where there is a suspended ceiling, 2 x 2 or 2 x 4 Columbia fixtures are used. In the apartments themselves most of the light is provided by 6” compact fluorescent downlights. For this use, fixtures manufactured by either Lightolier or Prescolite are used. In the bedroom, where more general rather than focused light is needed, Cooper indirect wall lights are specified.

8. Mechanical System

The air intake and discharge for the building is on the roof in the form of 4 Greenheck ERV-521H heat recovery units. The units send the air to geothermal heat pumps located in the mechanical closet of each apartment unit. The heat pumps are part of a loop that receives water from 72 – 500 foot deep wells located in the rear of the building. From the heat pumps the air is ducted into the bedrooms and hallway of the building. Then the air travels through the living areas and is returned through the bathroom exhaust system into a vertical chase that takes it back to the rooftop heat recovery units and out of the building.

9. Fire Protection System

The fire protection system consists of a main fire pump and a jockey pump to provide water to the building. The building is to be fully covered by a sprinkler system with the ability to provide .10 GPM per square foot over the most remote 1,500 square foot area with 100 GPM reserved for hose streams. Sprinkler heads are to be released at a temperature of 165 degrees Fahrenheit. There is also to be a dry fire protection system covering the roof of the building.

The annunciator panel is located in the vestibule at the main entrance to the building. The entire system must meet the requirements of NFPA 13.

10. Inter-Floor Transportation

There will only be one elevator for the building. This elevator is to be a Schindler 2500 lb. hydraulic elevator. This will be located at the corner of the elbow of the building so that it is directly across from the main entrance to the building and approximately the same distance from each of the wings. The elevator is much larger than would be required simply for handicap accessibility so that it can accommodate freight tasks and students moving into and out of the building every year.

Analysis I

"Measuring the Benefit of Constructability Reviews"

1.1 Executive Summary

Initially the goal was to quantify the benefits of constructability reviews during the design process. However, after discussing this topic with several people it was found to be impossible, because when a mistake is found while in the design development and early construction document phase, it is simply corrected. Documentation of the possible effects of the mistake if left uncorrected is not maintained. This led the research to taking a look at reviews of the plans at a later phase, just prior to being released for bids. It was found that although it is commonly accepted knowledge that at this point the design is final and there is very little ability to change the cost of the building, there is still an opportunity to save a substantial amount of money by reducing change orders caused by errors in the construction documents. On average, for a $15,000,000 project it is possible to save over $100,000 of change orders, avoid nearly half of the RFI paperwork, and avoid claims almost entirely.

1.2 Overview

As part of the annual PACE Roundtable held last fall there was quite a bit of conversation related to the increase in change orders caused by incorrect or inadequate design documents. It is believed that the designers, architects and engineers, are being given less time than they were in the past to create plans for more complex projects. This causes them to feel rushed and increases the number of errors they do not see or have time to correct. Because every error on the part of a designer has the potential to become a change order during construction, these mistakes can cause an unexpected increase in the cost of the project. This is especially true on hard bid projects such as government work.

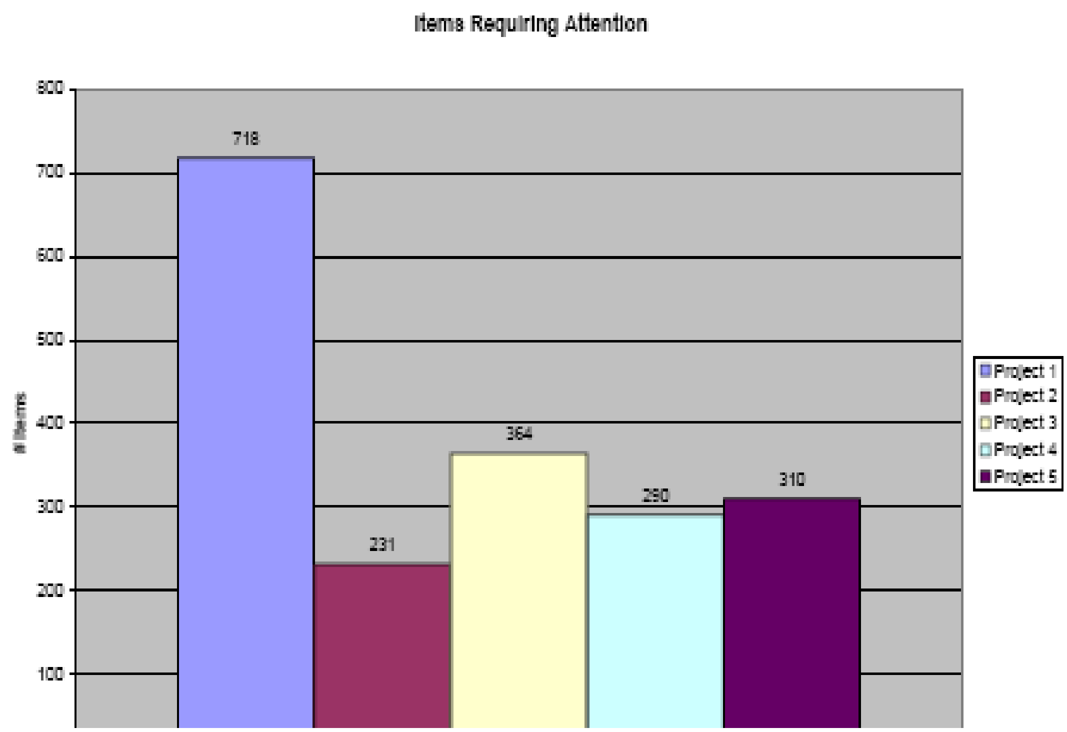
In order to avoid the unexpected price increase some construction managers and consultants are offering a design check service. By having a third party review the construction documents, mistakes can be fixed before the project is bid, or corrected by an addendum during the bidding process. To measure the benefits of conducting the review, data was obtained from one of the leading companies in this field, The Foreman Group. They began providing a design check service two years ago and recently began tracking the effect of their efforts.

The data examined included some background of 13 projects they have provided design checks for, and the full report created for five of the projects. All projects involve multiple prime contractors with hard bids. At the request of The Foreman Group, no project names will be released in order to protect client information. Instead the projects will simply be referred to generically as Project 1, Project 2, etc. Data derived directly from the reports can be found in Appendix A.

1.3 Method of Plan Checks

The method used by Foreman to conduct the plan checks is to take the plans when they are considered 100% complete and have a team of five to ten people fill out a check list containing approximately 500 items. The list is broken down into several categories covering general, site, architectural, structural, HVAC, electrical, and interiors. There are usually many other questions and conflicts that are project specific or confusing that are caught by the team members and added to the end of the check list.

Chart 1. Items Requiring Follow-Up Action



The usual team members include a site superintendent who is between projects, an architect, a project manager, and structural, electrical, and mechanical engineers. Because these are professionals who usually are working in their fields, rather than always consulting, they are up to date on current developments in the industry and all have significant experience. One of the benefits of having a company with both design and construction management experience conduct the plan checks is that if the team would like the advice of a specialist in an area with which they are not familiar, they usually have one in the office.

The effectiveness of this method becomes clear when looking at the five reports provided by Foreman. As shown on Chart 1, the minimum number of items requiring further action was 231, and on Project 1, 718 items were identified that the reviewers believed should be corrected or clarified. The possible effect of these errors was estimated and is shown on Chart 2. It was estimated that the possible change order cost for the items found on Project 1 was $550,000. Because of the varying total project costs, the cost of the possible change orders found is represented on Chart 3 as a percentage of the entire project cost. This shows that because Project 1 was a much larger project, having the most possible change orders would result in a smaller percentage cost increase for the project. On Project 5 the amount of the change orders saved could potentially have increased the value of the project by 20.5% (see Chart 3). This is twice the typical 10% contingency applied to most projects and could have led to problems in financing the completion of the project even if there were no other problems during construction.

Chart 2. Estimated Value ($) of Potential Change Orders Found

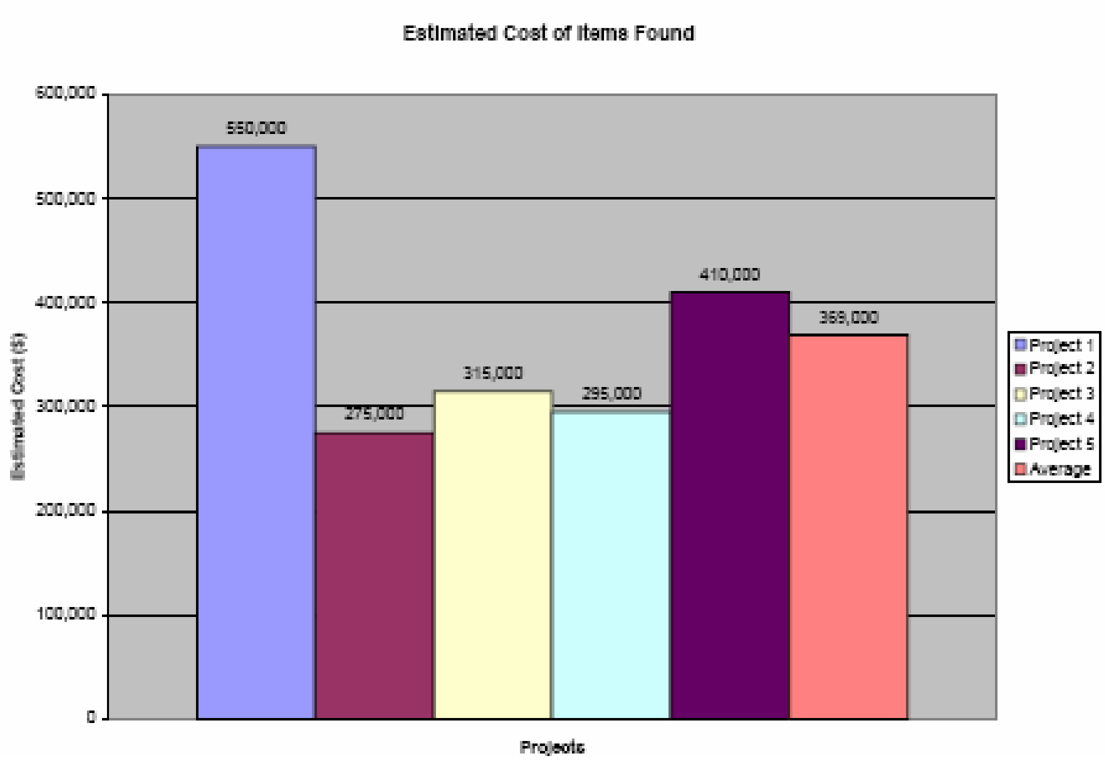
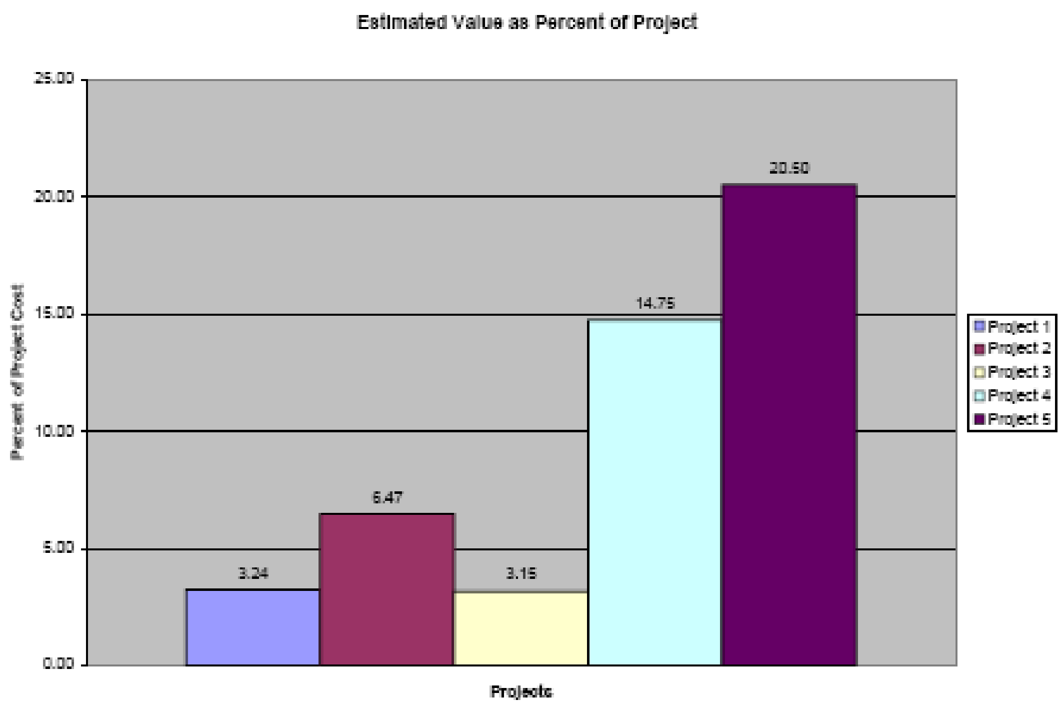


Chart 3. Estimated Value (% Project) of Change Orders Saved



1.4 Change Order Comparison

Change orders can come from several different sources. They can be caused by an owner changing their mind, a contractor preference for a different method, or errors in the construction documents. Because the designer does not have control of the first two causes, we will only consider errors in the construction documents, or A/E related change orders. Of the 13 projects used for plan check data, the total cost of A/E related change orders was $247,578 while the total value of the projects was $148.3 million. This gives a change order percentage of .16%. For projects in Foreman's database that did not use plan checks, A/E related change orders cost an average of .85% of the project cost. This means that for their typical project of $15 million there would typically be $24,000 of A/E change orders for projects that used plan checks compared to $127,000 for projects that did not use plan checks. This is a savings of $103,000 for the project.

As an added benefit, the clearer plans with fewer conflicts that reduce change orders also reduce RFI's. The same 13 projects had a total of 1634 RFI's, an average of about 11 per million dollars of projects. This can be compared to approximately 20 per million for projects that did not institute a plan check. This halving of RFI's will not only reduce paperwork during construction, but also avoids giving the contractor an excuse for filing a claim due to loss of productivity because of the paperwork.

1.5 Common Trends

After looking at the five complete reports, it was discovered that there were eight items that required action on all five projects. This can be seen from Charts 4 and 5 which show the number of projects each checklist item was found to require action on. These eight items are numbered below with specific comments following the bullets.

1. Reflected ceiling plans match architectural floor plans. All MEP fixture locations are coordinated with ceiling.
    - The Reflected Ceiling Plans did not coordinate lighting fixture requirements with the mechanical and plumbing needs. Another reason this item needed action was that room numbers or walls were shown incorrectly.
2. All material choices listed in the finish schedule are consistent with the materials identified on the plans and specs.
    - The finish schedule was either incomplete, missing, or in conflict with the specifications.
3. The size, location and type of foundations are clearly defined on the plans. Foundation plans include drains and tie-ins.
    - The common errors were not including foundation drains in the plans or not showing the depth of the foundation on the plans.
4. Structural drawings are clear and do not confuse bidders with respect to scope issues.
    - The structural drawings did not clearly show the scope of structural work. There were items missing from any scope of work and items that were

covered under more than one scope. Items not covered will be change orders. Items covered twice will be in both bids.

5. HVAC routing of duct and pipe does not conflict with architectural plans.
    - All of the projects had conflicts between mechanical or electrical work and the ceiling.
6. Architectural and Electrical drawings appear to be coordinated.
    - Electrical and Architectural drawings were in conflict due to missing fixtures, equipment, and specialties. They also had inadequate clearances for electrical items.
7. Specifications- Contractors scopes are clearly defined.
    - The specifications were missing work scopes, contained improperly defined scopes, or missed items.
8. Roof Drains shown and correct.
    - The Roof Plans did not show gutters and downspouts. Some did not show any roof drains or had them in locations that conflicted with architectural or plumbing drawings. Also, several Roof Plans showed roof types that differed from the specifications or other plans.

By studying the types of things that are missed on most drawings, it points to areas where a construction manager should be especially attentive. Focusing on these areas will almost always yield results in the form of future cost savings due to reduced conflict or confusion in the field.

Chart 4. Number of Projects Requiring Action for Each Item (first half)

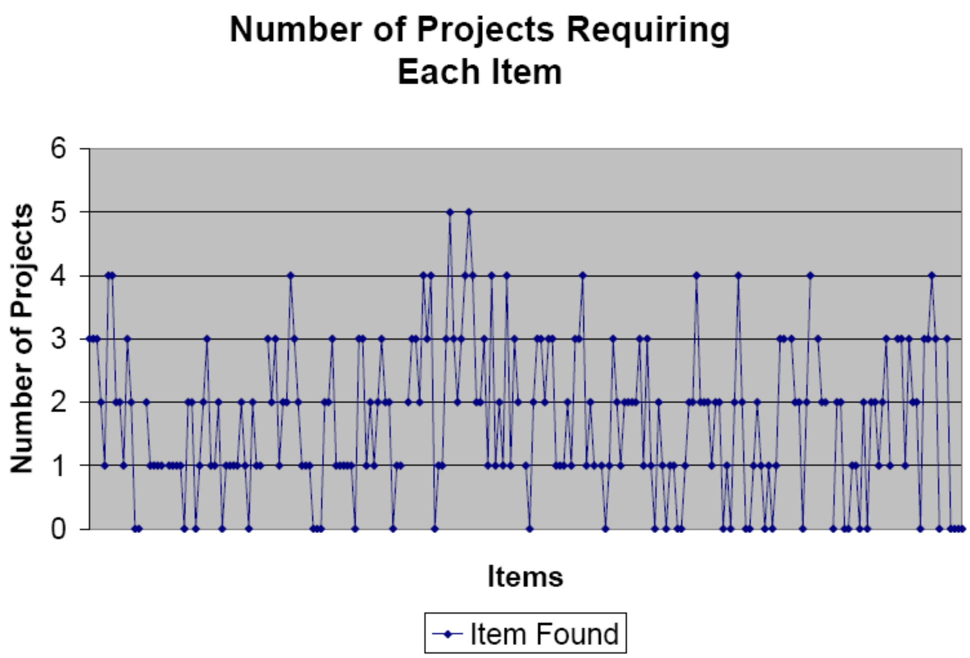
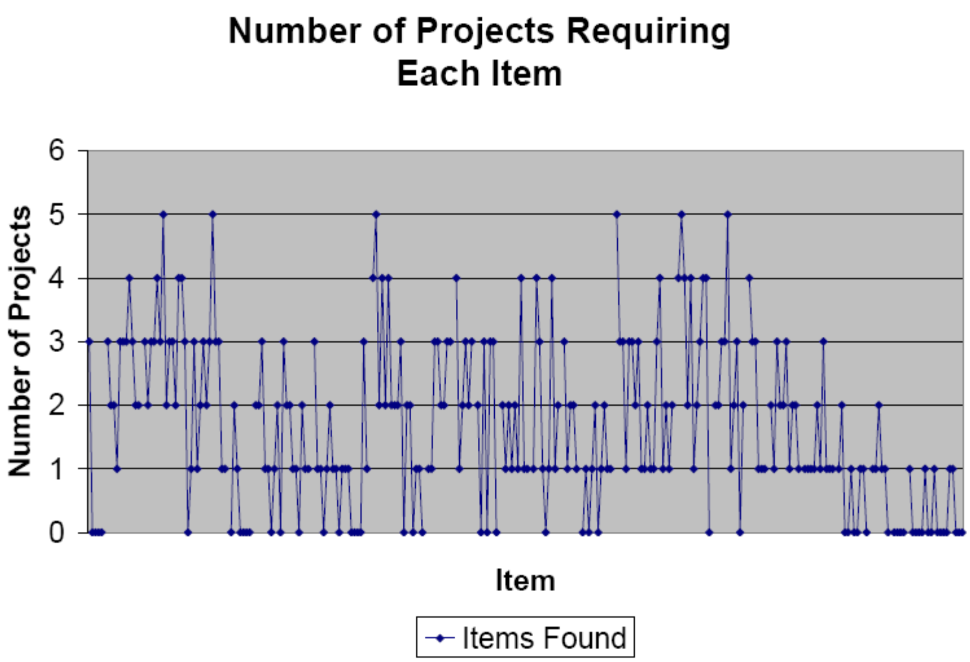


Chart 5. Number of Projects Requiring Action for Each Item (second half)



1.6 Challenges

It seems like it would be fairly easy to convince the owner that it is a good idea to have the plans checked before they go out to bid, especially when there is a guarantee that the amount saved will exceed the fee for the service. Although the fee is usually about $30,000 for a $15 million project, because it is typical to find over $100,000 of corrections this is money well spent. It may also be noted that in the projects studied, which include 260 prime contracts, there was only one claim filed. Because most owners should be interested in having a smooth, successful, construction project, this fact may appeal to them.

It is sometimes more difficult to convince the designer that it is a good idea. They may feel intimidated or resentful when told that their design is going to be reviewed by another architect. This is a natural reaction by most people when they feel somebody is going to be looking over their shoulder.

The best way to avoid this feeling of animosity is to educate the architect as to the goal of the review. It is not to pick apart their design; it is to act as a peer reviewer. Just as a writer does not send their book directly to the printer, but to an editor first, an architect is much better served by having a fresh set of eyes look at the plans. They may also be reminded that in a time where owners are increasingly filing claims against designers for errors and omissions, and it is becoming easier for a contractor to file claims directly against an architect, it may also be a smart financial move to get another opinion before sending their drawings out for bids.

When given the report after a plan check has been conducted, architects will participate to varying degrees based on their understanding of the process, temperament, and ability. Some are naturally more cooperative than others and are more likely to make the changes recommended (See Charts 6 and 8). Others seem to be openly hostile to the process, but will still find some obvious errors that they will grudgingly fix. This seemed to be the case on Project 4. As shown in Charts 7 and 8, only 14.48% of the items found on this project were fixed leaving 248 items still unclear or incorrect. Some of these items seem to be major issues such as missing elevations, ADA requirements not met, and no lighting fixtures included on reflected ceiling plan. However, the architect still fixed 42 items would likely have been cited as reasons for a change order. In cases where the items are not fixed, the owner will have documentation that the architect refused to exercise due care in creating the construction documents and knew that the errors could cause problems. This may be beneficial if the items cause a major change order later in the project.

Chart 6. Number of Items Fixed on Each Project

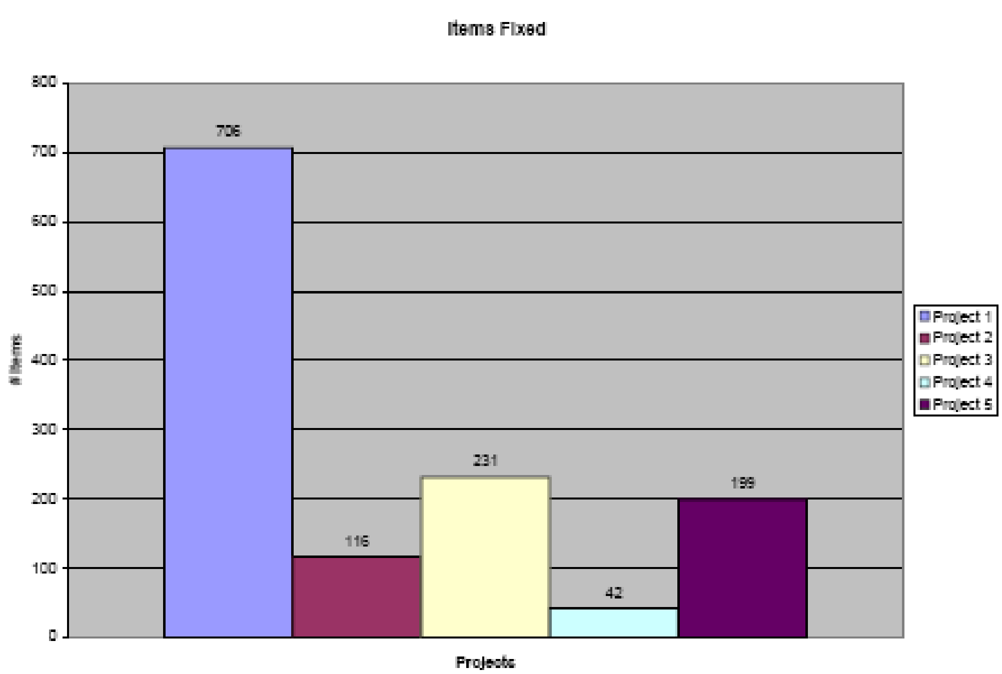


Chart 7. Number of Items Not Fixed on Each Project

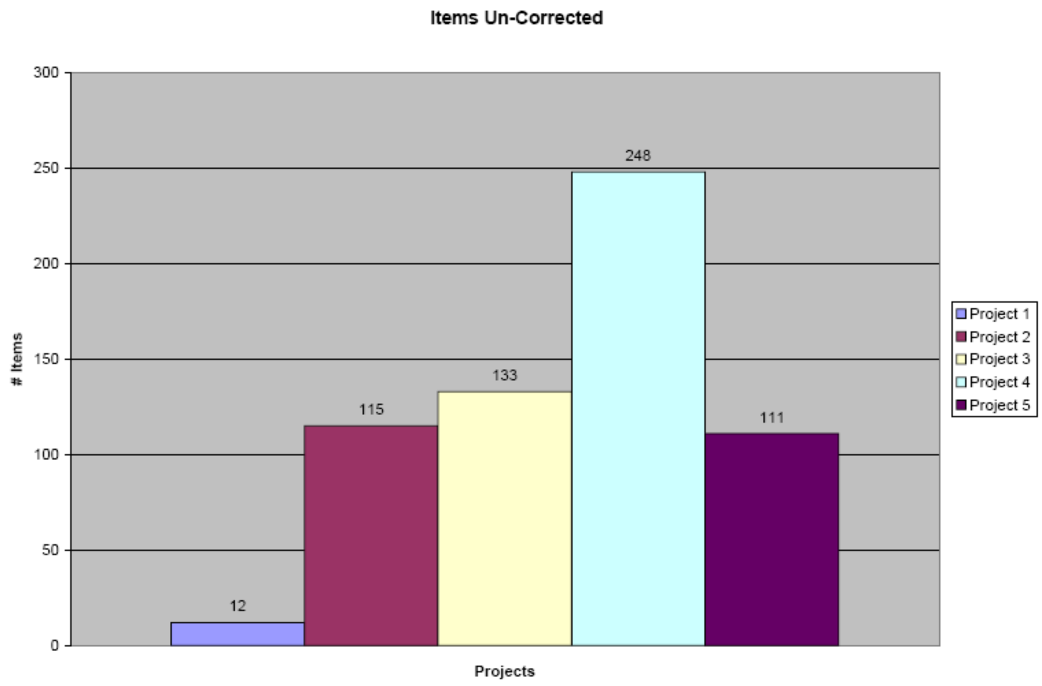
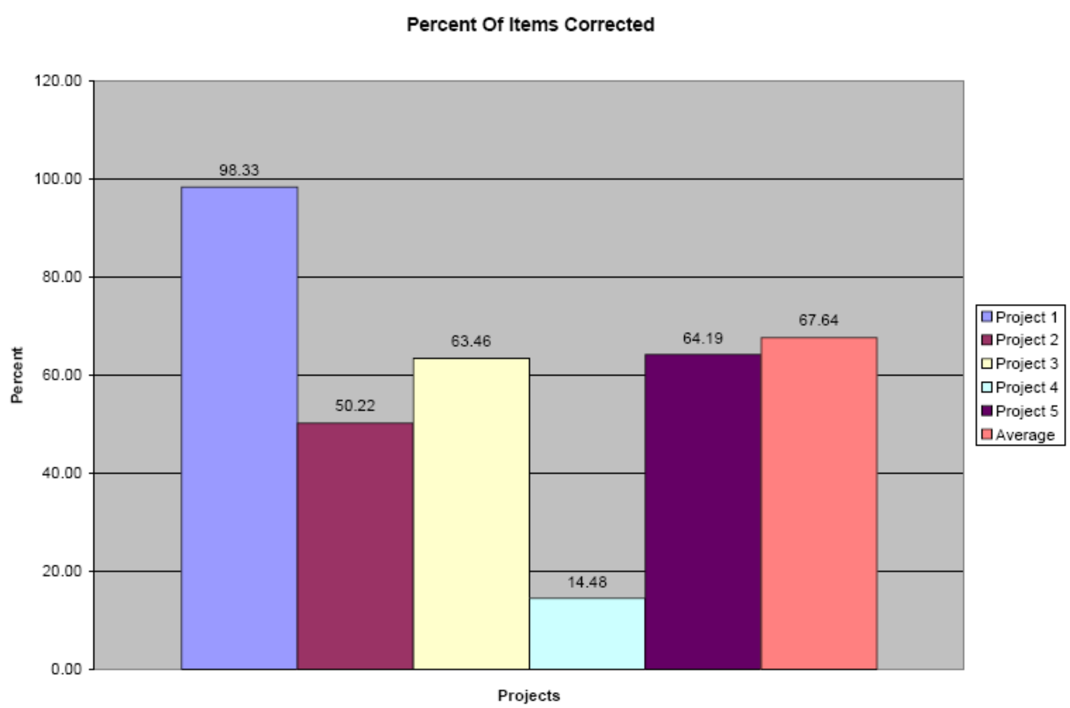


Chart 8. Percent of Items Fixed



1.7 Recommendation

After reviewing the data, the benefits of reduced change order quantity and cost, fewer RFI's, and smoother running projects are clear. There is also an obvious need for educating designers about the process in order to ensure their cooperation. The common errors should also be discussed within the design and construction communities so they can be caught either by the architect before releasing the drawings or by the CM during the bidding process.

Analysis II

“Gaining Plumbing LEED™ Points”

2.1 Executive Summary

At the beginning of the design process, it was originally assumed that the building would gain two of the required twenty six points required for LEED™ certification by being water efficient. However, during the design of the building, the decision was made to use the University's standard plumbing fixtures. This kept the building from gaining these two points and forced some value engineering decisions to be necessary elsewhere in order to make up for the missing points.

In order to display a breadth of knowledge in the field of Architectural Engineering, a design of the plumbing system for Widener University's Metropolitan Hall was created that would allow it to meet its original goal of increasing sustainability as represented by gaining both LEED™ points available for water conservation. After a study of the requirements to meet this goal, the design was created and shown to reduce water consumption by slightly more than the 30% required to meet the goal.

The more expensive fixtures needed to gain the LEED™ points will cost an extra $12,445.76, but will reduce water use by 6,030 gallons per day. This reduction in water use will save over $6,500 per year in utility costs at current Philadelphia water and sewer rates, paying the price increase off in less than 2 years.

2.2 Introduction

In order to show a breadth across the Architectural Engineering Curriculum a design of the plumbing system was created with the goal of attaining both of the water reduction points in the LEED™ rating system. In actuality the building was unable to achieve these points because the University was only willing to use their standard fixtures. If they could have been convinced to use more efficient fixtures they would have spent more up front, but would have saved enough in the first two years of building occupancy to make up for the extra cost.

2.3 LEED™ Requirements

The LEED™ Green Building Rating System for New Construction gives one point for achieving a 20% reduction in water usage, and another point if a 30% water reduction is achieved. The baseline for comparison is the Energy Policy Act of 1992 which gives the requirements shown in Table 1. Calculations for new buildings are to include only the following fixtures: water closets, urinals, lavatory faucets, showers, and kitchen sinks. The utility sinks in the building are not included. This is most likely because they are used for tasks like filling mop buckets where it does not matter how quickly water comes out of the faucet, the same amount of water is going to be used.

Table 1: Fixture Flow Requirement

Ratings of Energy Policy Act of 1992

Fixture	Flow Req.
Water Closets	1.6 gpf
Urinals	1.0 gpf
Showerheads	2.5 gpm
Faucets	2.5 gpm
Replacement Aerators	2.5 gpm
Metering Faucets	0.25 gal/CY

Adopted from Sloan Valve Company at: **http://archrecord.construction.com/resources/conteduc/archives/0505sloan-5.asp**

2.4 Design Changes

To begin the redesign, the original fixtures were analyzed to see which ones were using the most water. As a result of this study, the water closet and the shower jumped out as the most effective place to reduce water consumption. Studying product catalogs from several companies showed that the water closet could easily be reduced from 1.6 gpf to 1.0 gpf by using a pressure assisted design. This is the change that will be most noticeable to the owner and users because it is a completely different product than the one chosen in the original design.

To reduce water use by the showers, a flow controller (Figure 1) was added before the shower head. The flow control is a simple piece that screws onto the shower neck just before the shower head. It is threaded on both ends so the shower head simply screws into it rather than directly onto the neck.

This will reduce water consumption from 2.5 gpm to 1.5 gpm. Although some people will notice that there is less water coming out of the shower head, most people will not be able to notice the difference.

Figure 1. 1.5 gpm Flow Control[1]

These two changes were still slightly short of the required 30% water reduction, so the lavatory sink was also changed to reduce water flow from 2.3 gpm to 2.0 gpm. The appearance of the new fixture was very similar to the appearance of the one originally chosen (Figure 2). With this change water use was cut to 13,950 gal/day, down from 19,980 gal/day for the original design (APPENDIX B). This is 69.82% of the original design, a savings of 30.18% from the original design and a 31.6% reduction from the requirements of the Energy Policy Act of 1992.

Figure 2. New Lavatory Faucet[2] vs. Originally Designed Faucet[3]

1. Source: http://www.nrgsavers.com/prodwater.htm#
2. Source: http://www.plumbingsupply.com/kingstonbathroomfaucets.html
3. Source: http://www.deltafaucet.com/media/Product_Tech_Docs/Spec_Sheets/DSP-L-500_Rev_A_5947.pdf

As part of the redesign, an attempt was made to avoid changing the appearance of the fixtures. The final design only broke this limitation once. This was because the water closet in the original design was a very institutional style, wall mounted, tankless toilet. In the redesign a more residential styled, floor mounted toilet with a pressurized tank was used (Figure 3). Besides the improvement in aesthetics, this change was necessary to reduce water use by using a pressure assisted toilet.

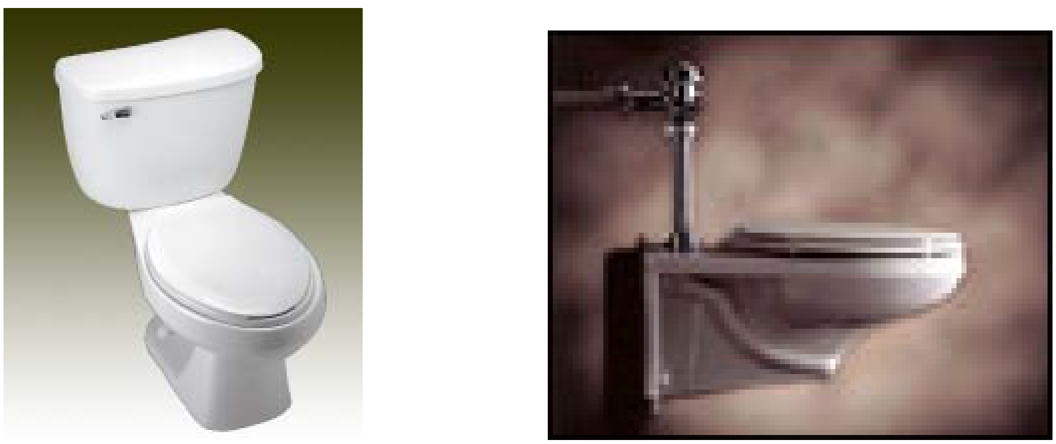


Figure 3. Pressure Assist Water Closet[1] vs. Wall Mounted Water Closet[2]

1 From http://www.mansfieldplumbing.com/psummary.asp?PROD=147-153
2 From http://www.americanstandard-us.com/pdfs/as/specsheet/SpecSheet_174.pdf

2.5 Cost/Schedule Comparison

Because better performing fixtures usually cost more, a comparison was made between the cost of the original design and the cost of the re-designed fixtures. As shown by Tables 2 and 3, the extra cost of the fixtures is $12,445.76. While this may seem like a big price increase, this cost is spread out over 355 total fixtures in the building, reducing water consumption by 6,030 gallons per day. Using standard Philadelphia area water and sewage rates (Appendix B) this results in a savings of $6,544.36 per year. The fixtures have a pay back period of 1.90 years.

Table 2. Original Design Cost			
Quantity	Item	Cost (ea. $)	Cost Total
103	Water Closet	249.00	25647.00
103	Lavatory	115.15	11860.45
101	Shower Head	130.55	13185.55
48	Kitchen Sink	89.25	4284.00
			$54,977.00

Table 3. Redesign Fixture Cost			
Quantity	Item	Cost (ea. $)	Cost Total
103	Water Closet	414.50	42693.50
103	Lavatory	66.07	6805.21
101	Shower Head	135.05	13640.05
48	Kitchen Sink	89.25	4284.00
			$67,422.76

Table 4. Pay Back Period

Original	Re-design	Saved	
19980	13950	6030	gal/day
599400	418500	180900	gal/month
5394600	3766500	1628100	gal/yr (9 mo. Occ.)
721.2032	503.5428	217.6604	Mcf
21856.72	15312.36	6544.36	Utility bill ($/yr)

1.90 Year Pay Back period

(12,445.76 / 6,544.36)

The construction schedule will not be affected by the change in fixtures because although one extra piece will need to be installed for the shower heads, the tank type water closet chosen in the redesign will take much less time to install (RS Means 2006). From looking at the master schedule for the project it does not appear as if the plumbing is on the critical path of the project, meaning that a small delay in the plumbing rough in or plumbing fixture installation will not hold up the project.

2.6 Recommendation

The best thing to do at this point is try to convince the owner that although they may be attached to their standard fixtures, it is possible for them to save a substantial amount of money in future utility bills if they are willing to spend the extra money to install more water efficient fixtures in their building. It will also give them points toward obtaining a LEED™ rating for their building.

Analysis III

“Project Acceleration”

3.1 Executive Summary

The objective of the third analysis was to reduce the schedule and display a breadth of knowledge in the structural field by changing the structural walls from CMU to another system, while also looking at how more detailed planning using a SIPS schedule can speed up a project.

The original thought for the structural part was that pre-cast concrete walls would be the best method, however this had to be eliminated as an alternative after talking to a precast manufacturer who said that they always use 8" panels for buildings under five stories. This would not have given the opportunity to meet the structural breadth requirements and had to be eliminated from the possible options. After studying several different options, it was found that the best structural system for this building uses a 6" tilt-up concrete panel.

The SIPS scheduling part of this analysis involved seven finishing trades which had previously only been planned by floor. The logic for this analysis is that more detailed scheduling would improve the work flow and shorten the duration necessary for the entire building. After creating the schedule it was found that the increased flow would not necessarily speed up the schedule, but would allow the fewest people to be needed on site and would also make it a lot easier to increase the rate of work. This is because the smallest crews possible were used in the SIPS scheduling, but if more people were necessary, there would be less overlapping of work areas because everybody would be assigned to their own area.

3.2 Structural Wall Design

Overview:

The structure for the building is CMU walls with precast plank floors. The logic behind this system is that it allows a shorter floor to floor height while maintaining its cost competitiveness by using masonry walls. In order to display breadth in the structural area, it was decided to look at alternative options for the structural system which could reduce the time required to construct the building without creating a substantial price increase.

Floor Comparison:

The first step was to look at the choices for alternative structural systems. The first comparison was floor systems. The options for floors are precast concrete plank, post tensioned cast in place concrete, and steel beam and girder framing with deck and 4 inch slab. Because of the 45 foot maximum height requirement of the building, and the need to maintain four floors, structural steel was quickly eliminated from the list of possible solutions. The logic behind this was that a W14 steel beam under a 4 inch concrete slab would add 10 inches per floor to the total height of the building, raising it 3’4” and breaking the zoning law. This left precast plank and post tensioned floor systems to be compared.

Using R.S. Means 2000 to price the options, a cast in place, post-tensioned, elevated flat slab, with four uses of forms, with 125 pounds of superimposed load and a span of 30 feet will cost $259.60 per cubic yard and will be completed at a rate of 50.99 c.y. per day. This results in a cost of $1,326,844 for a 6” slab over 92,000 s.f. In comparison an 8” thick precast hollow core plank, delivered and erected will cost 6.50

per square foot plus 1.14 per s.f. for topping. This gives a total cost to the project of 702,880. The precast can be erected at a rate of 5,600 s.f. per day, so it will take 16.5 days to erect. Due to the $623,964 difference in cost before any factors where taken into account and the extra 3.5 days required for a post tensioned slab, the decision was made to keep the precast plank floor.

Wall Comparison:

The next decision to be made is the wall type. The options for walls were the existing CMU walls, steel columns with block infill, precast concrete walls, and tilt-up walls. See Table 1 for the daily output and cost of each of these systems. As the table shows, the fastest method is to use tilt-up panels, reducing the duration from 252 days to 58 days. Comparing costs, before factors are applied the tilt-up panels will reduce costs from $320033 to $291526, a savings of $28507. At this point all of the costs would be subject to the same location and inflation factors, so adding them would not change the outcome that a tilt-up panel is the least expensive choice. Because this is an estimate from a manual and not from actual subcontractor pricing, the level of accuracy achieved by the factors is not necessary.

In order to be sure nothing was missed in the cost for tilt-up construction, the cost breakdown was checked and found to include preparation of pouring surface, erect and strip forms, concrete in place, steel trowel finish and curing, reinforcing, inserts and misc. items, and panel erection and alignment.

Table 1 Structural Wall Comparison					
Wall Type	Daily output	Unit Cost	Unit	Duration (days)	Total Cost ($)
CMU	365	5.95	s.f.	252	320033
Steel Column	600	21.50	l.f.(column)	4	4300
CMU Wall	375	5.70	s.f.	245	524400
Steel Girders	912	42.50	l.f.	1.1	43818
Steel Total				250.9	572518
Precast Concrete	768	13.45	s.f.	120	723435
Tilt-Up	1600	5.42	s.f.	58	291526

Structural calculation:

Now that the structural system to be sized was defined as tilt-up walls with precast plank floor, the structural sizing of the system was carried out. The first thing to check was whether the proposed 6" panel could support the vertical building loads after it is placed. An assumption was made at this point that #3 rebar at 12" o.c. would meet the needs for bending while the panel is being lifted into place, while two #3 rebar would be needed 1-1/2 inches from the top of the cantilevered sections around the window cutouts. The loads on the building were kept the same as for the CMU wall design. These loads are taken directly from the structural plans and shown as Table 2. The maximum plank span is thirty feet so this length will be used in all calculations.

Roof Load (fourth floor walls):

Total Dead = 70 psf

Total Live Load = 30 psf

1.2D + 1.6L = 1.2(70) + 1.6(30) = 132 psf

132 x 30/2 = 1980 plf

Table 2. Design Load Schedule				
Component \ Area	1st Floor	Typical Floor	Lobby	Roof
Collateral		4	4	4
Partitions		10		
4" Concrete	50			
5" Concrete				
8" Hollow P/C		55	55	35
3/4" Gyp. Top		6	6	
Roofs & Insul.				11
Total Dead Load	50	75	65	70
Total Live Load	100	40	100	30
Total Load	150	115	165	100

Third Floor Walls:

Fourth Floor panels + Transferred Load = 960 + 1980 = 2940 plf

Dead Load = 75 x 1.2 = 90 psf x 30/2 = 1350 plf

Live Load = 40 x 1.6 = 64 psf x 30/2 = 960 plf

Total Load = 2940 + 1350 + 960 = 5250 plf

Second Floor Walls:

Third Floor Walls + Transferred Load = 960 + 5250 = 6210 plf

Dead Load = 75 x 1.2 x 30/2 = 1350 plf

Live Load = 40 x 1.6 x 30/2 = 960 plf

Total Load = 6210 + 1350 + 960 = 8520 plf

First Floor Walls:

Second Floor Walls + Transferred Load = 960 + 8520 = 9480

Dead Load = 75 x 1.2 x 30/2 = 1350 plf

Live Load = 40 x 1.6 x 30/2 = 960 plf

Total Load = 9480 + 1350 + 960 = 11790 plf

Panel Axial Strength:

$P_o = .85\, f'_c\, A_c + A_s f_y = .85(4)(12x6 -.11) + .11(60) = 251$ Kips

251>11.8 → OK

The next step in designing the panel is to find the optimum lifting points. The worst position for a panel is in the horizontal position because after the panel begins to rotate the axial load of its own weight will reduce the area in tension, the same as post tensioning or a beam column. This means that if the panel can resist bending when it is horizontal, it can resist bending at any point during the rotation. Because the panel was being designed as a four point lift, the quarters of the panel were found by splitting the panel at its axis of symmetry and finding the centroid of the remaining half panel in the x and y directions, then the lifting hook was placed in the middle of the quarter. The typical panel is represented as Figure 1. The calculation of these points is shown below.

y = [(5’6”)(10’8”)(5’4”) + (1’)(3’6”)(10’2”) + (2’8”)(3’6”)(1’4”)] /

[(5’6”)(10’8”) + (1’)(3’6”) + (2’8”)(3’6”)]

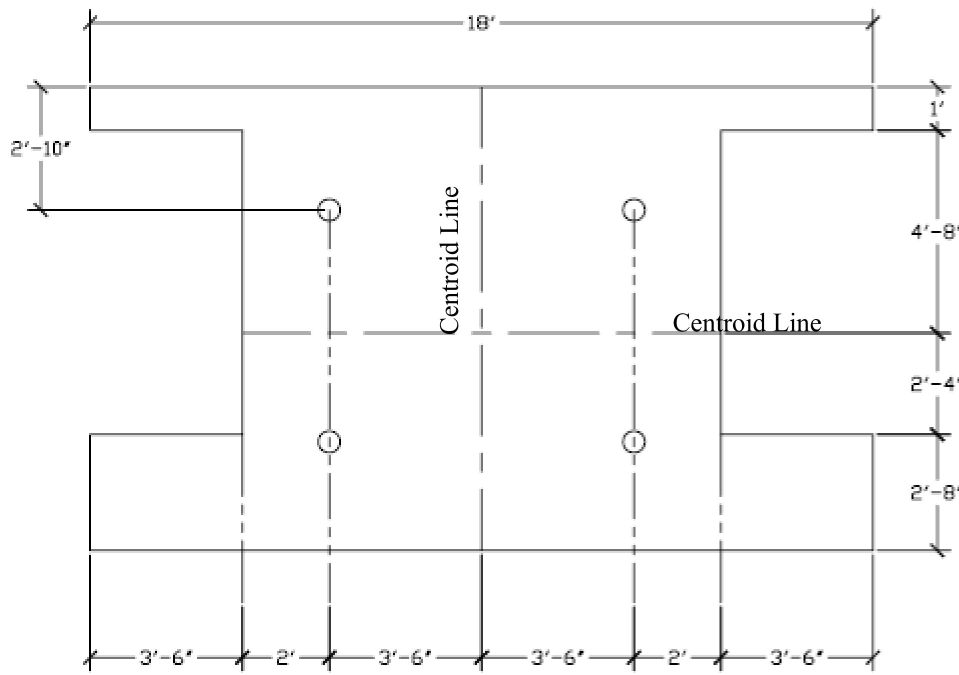
= 360.8 / 71.63 = 5.04’, approximately 5’

x = [(5’6”)(10’8”)(5’6”/2)+(1’)(3’6”)(5’6”+3’6”/2)+(2’8”)(3’6”)(5’6”+3’6”/2)] /

[(5’6”)(10’8”) + (1’)(3’6”) + (2’8”)(3’6”)]

= 254.43 / 71.63 = 3.55’, approximately 3’6”

Figure 1 Typical Panel.



After finding the lifting points, the weight on each lifting point was calculated by finding the weight of the entire panel and dividing it by four. To make sure the load is balanced evenly, the weight of each quarter, as defined by the approximate centroid lines was also found. This calculation is shown below.

W = 2 [(5'6")(10'8") + (1')(3'6") + (2'8")(3'6")](6")(150 pcf) = 10728 pounds

10728 / 4 = 2682 pounds for each lifting point

By Centroids:

Lower Quarters = [(5'6")(5') + (2'8")(3'6")] (6")(150) = 2763.4 pounds

Upper Quarters = [(5'6)(5'8") + (1')(3'6")] (6")(150) = 2601.4 pounds

As you can see, the lifting points for the lower quarters appear to hold slightly more weight than the upper quarters. This is due to the rounding of the exact centroid locations. To be conservative, the higher 2,763.4 pounds will be used in checking the shear at the lifting points to ensure they do not tear out of the panel. This is similar to punching shear of a concrete slab around columns and was calculated as follows.

$\Phi V = .75(f'_c)^{1/2}(4)(A_c)$

A_c = perimeter x depth

Depth = 6"

Assuming shear failure at 45 degree angle, perimeter = 2(pi)(r) = 2(3.14)(6) = 37.7 inches

$A_c = 6 \times 37.7 = 226.2 \text{ in}^2$

$\Phi V = .75(4000)^{1/2}(4)(226.2) = 42{,}918$ pounds

42,918 > 2763.4 → OK

The next load calculated was the moment due to the weight of the panel. This was calculated as a simply supported beam between the lifting points and a cantilevered beam from the lifting points out to the edge of the panel. The moment calculations are:

Middle: $wl^2/8 = (150/2)(7)^2 / 8 = 460$ ft. lb.

Ends: longer = $wl^2/ 2 = (150/2)(5'6")^2 / 2 = 1134$ ft. lb.

Shorter = $wl^2/ 2 = (150/2)(2)^2 / 2 = 150$ ft. lb.

Calculating the moment capacity as a 1 foot wide flat slab with a #3 60 ksi rebar spaced ever 12 inches, 1-1/2 inches from the bottom (exterior) of the panel gives the following results.

Reinforcement = .11 in^2 per foot

D = 6-1.5-3/16 = 4.31 in

a = [(.11)(60)] / [(.85)(4)(12) = .162

c = .162 / .85 = .190 < .375(d_t) = 1.62 → Φ = .9

ΦM_n = .9[(.11)(60)(4.31 - .162/2)] = 25.11 in. kips.

25.11 / 12 = 2.09 ft. kips.

2090 ft. lbs. > 1134 ft. lbs. → OK

The last thing checked was whether the cantilevered sections on the end of the panel would support their own weight when the panel is in place.

For the 1' x 3'6" section over the window:

Moment = wl^2/ 2 = (150/2)(3'6")^2 / 2 = 459 ft. lb.

Capacity =

Reinforcement = 2 x .11 in^2 = .22 in^2

D = 12-1.5-3/16 = 10.31 in

a = [(.22)(60)] / [(.85)(4)(12) = .324

c = .324 / .85 = .381 < .375(d_t) = 3.87 → Φ = .9

ΦM_n = .9[(.22)(60)(10.31 - .324/2)] = 120.56 in. kips.

120.56 / 12 = 10,049 ft. lbs. > 459 ft. lbs. → OK

For the 2'8" x 3'6" section under the window:

Moment = wl^2/ 2 = (200)(3'6")^2 / 2 = 12259 ft. lb.

Capacity =

Reinforcement = 2 x .11 in^2 = .22 in^2

D = 32-1.5-3/16 = 30.3 in

a = [(.22)(60)] / [(.85)(4)(12) = .324

c = .324 / .85 = .381 < .375(d_t) = 11.36 → Φ = .9

$\Phi M_n = .9[(.22)(60)(30.3 - .324/2)] = 397$ in. kips.

397 / 12 = 33,200 ft. lbs. > 1225 ft. lbs. → OK

Recommendation:

From the calculations shown above, a 6” tilt-up panel, with a #3, 60 ksi reinforcing bar placed in a grid every foot, at 1-1/2 inches from the top of the panel, and two of the same rebars placed 1-1/2 inches from the top of the cantilevered ends, around the windows, will support the panel while it is being lifted into place as well as while it is supporting the building loads.

The cost and schedule estimates show that using tilt-up wall panels should be both faster, and less expensive than the current design of CMU walls. Because of this it is recommended that the tilt-up panels be used.

SIPS Scheduling

Overview:

Short Interval Production Scheduling (SIPS) is a fairly new tool developed by Hensel Phelps Construction Company and first documented by Alvin Burkhart as part of the 1989 Construction Congress. The goal of the schedule is to plan activities to a much higher level of detail than is allowed by the typical Critical Path Method schedule in order to allow better coordination among trades and a smoother flow of work. By creating a "Parade of Trades"[1] for the work flow a reduction in the need for built in buffers is achieved. This creates a shorter overall project duration; which also reduces costs.

In this project a SIPS schedule was created for the finishing trades. The trades had previously been simply scheduled by floor; however, it was believed that the typical apartment floor plan of the residence hall would make it possible to achieve a better flow of work by scheduling the trades to the detail of a SIPS schedule.

Trade Identification:

For the purposes of this research, finishing trades were defined as interior trades which must be completed after drywalling and taping is complete. On this project this definition included seven activities in the apartments. Once these activities were identified the interrelationships were studied and the most effective order was decided to be: wall painting, ceiling, electrical trim and lights, casework, plumbing fixtures, doors and hardware, then flooring.

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[1] Tommelein, I.D., Riley, D., and Howell, G.A. (1998). "Parade Game: Impact of Work Flow Variability on Succeeding Trade Performance." *Proc. Sixth Annual Conference of the International Group for Lean Construction*, IGLC-6, 13-15 August held in Guaruja, Brazil, 14 pp.

Trade Durations:

After determining the trades to be included in the finish scheduling, the amount of time necessary to complete work in a typical area was needed. For this, the productivity rates from R.S. Means were used. The rates found are shown in Table 3. After taking off the amount of work for each trade in the typical Unit A apartment arrangement the durations shown in Table 4 were found.

Table 3. Productivity Rates

Hours/Unit	Unit	Activity
0.006	s.f.	Paint Walls
0.011	s.f.	Paint Ceiling
0.50	ea.	Elec. Trim & Light Fixt.
0.40	l.f.	Casework
1.6	ea.	Plumbing Fixt.
1.14	ea.	Doors / Hardware
0.016	s.f.	Flooring

Table 4. Durations for 1 Crew

crew size	Preferred Order	Durations	# Crews Needed	Resulting Duration
1	Paint Walls	2 days	2	1
1	Paint Ceiling	2.25 days	2	1.125
1	Elec. Trim & Light Fixt.	2 days	2	1
2	Casework	1 day	1	1
1	Plumbing Fixt.	2 days	2	1
1	Doors / Hardware	1 day	1	1
1	Flooring	2.5 days	2*	1.25

At this point it is realized that not all unit types will result in exactly the same amount of work. In order to create the proper flow, it will be necessary for the subcontractors to accept that on some days they may have to work late in order to finish their unit, but on other days they will get to go home early or be sent to other jobs.

Creating the SIPS Schedule:

In order to balance the durations, the fastest trades were examined first. These were casework and doors/hardware. Because doors/hardware is a one person activity, slowing it down can only be accomplished by having the carpenter stop working. This would not be beneficial to the project. Next the slower activities were looked at and found that by adding another person to wall painting, ceiling painting, plumbing fixtures, and flooring each trade could finish a typical unit in one day. The slowest activity, flooring, would need 1.25 days, but because this activity is the last one through the space, they will be able to catch up on Saturday or by working ten hour days. The final schedule is shown in APPENDIX C.

4D Model:

To display the flow of work through the building, a 4D model was created. 4D models are created by merging a 3D model with a schedule. Software for this task is currently available in the form of Common Point or NavisWorks. For this project, the decision was made to work with NavisWorks because it seemed to be more user friendly.

The first step was to create the 3D model in AutoCAD. This was accomplished by drafting the basic geometries in 2D and extruding them to create blocks. In order to provide the necessary link to the schedule, the model was then exported to Autodesk VIZ which allowed saving it as a 3DS file which can be read by NavisWorks. Next the Microsoft Project schedule was linked to NavisWorks. Then different types of activities were set up and given individual colors as shown in Table 5 so it would be clear who was in each space. This was followed by attaching the necessary objects from the model to each activity and running a simulation to test everything.

Table 5. Activity Colors

Activity	Color
Paint Walls	Red
Paint Ceiling	Green
Elec. Trim & Light Fixt.	Yellow
Casework	Purple
Plumbing Fixt.	Blue
Doors / Hardware	Orange
Flooring	Brown
Finished Area	Green Tint

During simulating, several inconsistencies were found in the plan. They were fixed in the schedule and the model was updated to show the improved plan. The mistakes included missing activities and steps performed out of sequence. While these mistakes were fairly easy to spot in the model they had been overlooked several times in the schedule. This is the truly valuable part of a 4D model because it is easy to overlook a mistake when it is buried in several pages of a schedule than when the objects are obviously out of sequence in a model. For screenshots of the finished model, see APPENDIX C.

Schedule Comparison:

In the original plan for the building the total time for the finishing trades to complete a floor was 34 working days. In the schedule developed using SIPS methods, the work required 33 working days. While this only saves one working day, the bare minimum of crews are used in a much more orderly working pattern. Should it become necessary to accelerate the finishing trades to offset delays incurred on the project, it seems likely that the SIPS schedule could be accelerated with much less loss in productivity because the work could still follow the pattern created, possibly by simply linking adjacent areas and doubling the manpower to double the rate of work. In the original schedule where crews are only told what floor to be on, adding manpower is more likely to create losses in productivity due to congestion.

Recommendation:

Using SIPS scheduling is a good way to organize a project so that trades can flow in a more methodical pattern. In this project it yields the fewest number of people required to complete the finished trades. This would reduce the cost of the work and make it easier to shorten the total duration of this part of the project if it were necessary to do so. It is recommended that increased planning be put into parts of a project where there are several crews working in the same area or within close proximity to each other.

Conclusion

During the process of studying Widener University's Metropolitan Hall, a lot of valuable information has been obtained pertaining to constructability reviews, the LEED™ point system and how it relates to water used, the cost competitiveness and time savings of tilt-up concrete wall panels, and the improved project organization made possible by SIPS schedules.

During the research of constructability reviews, it was found that although it is common knowledge that the later you review a project, the less impact you have on its cost, it is still possible to save an average of $100,000 on a $15 million dollar project while cutting RFI's in half and virtually eliminating claims. While having designs reviewed before bidding can always be beneficial, this practice shows particular promise on hard bid jobs.

In the analysis of gaining LEED™ points for reduction of water usage it was found that it is possible to reduce water use by at least 30% by using fixtures that are designed to reduce the flow of water. These fixtures may cost more, but the savings in utility bills alone will be enough to pay for the fixtures in less than two years. If the energy savings from reducing the need to heat the water were included in the analysis, the pay back period would have been even shorter.

In the schedule reduction analysis it was found that a great deal of time could be saved while also saving money by changing the walls from load bearing CMU to tilt-up concrete panels. These panels would not change the look of the building at all because they would still be covered by the brick façade on the outside and the drywall on the inside. Also during the schedule reduction analysis, it was found that a SIPS schedule would allow the finish trades to be more organized, allowing the minimum of people to be needed, and making it easier to accelerate the project at the end if there should be any delays during construction

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APPENDIX A

Item # and Group	Project 1		Project 2		Project 3		Project 4		Project 5		# Projects Requiring This Item	# Projects Correcting This Item
Total Project Cost	17,000,000		4,250,000		10,000,000		2,000,000		2,000,000			
	Req. Action	Corrected	Req. Action	Corrected	Req. Action	Corrected	Req. Action	Corrected	Req. Action	Corrected		
General Review - Discipline Check												
1					1	1	1		1		3	1
2			1		1		1				3	0
3	1	1			1	1			1		3	2
4					1				1	1	2	1
5	1	1									1	1
6	1	1	1				1	1	1	1	4	3
7	1	1	1		1	1			1	1	4	3
8	1	1							1		2	1
9	1	1							1		2	1
10	1	1									1	1
11	1	1			1				1		3	1
12					1				1		2	0
13											0	0
14											0	0
General Review - Title Block												
1					1				1	1	2	1
2	1	1									1	1
3									1	1	1	1
4									1	1	1	1
5									1		1	0
General Review - Typ. Sheets												
1					1	1					1	1
2									1		1	0
3									1	1	1	1
4					1	1					1	1
5											0	0
6					1	1			1		2	1
7					1	1			1	1	2	2
8											0	0
9			1								1	0
10	1		1								2	0
11					1		1		1		3	0
12									1	1	1	1
13									1	1	1	1
14	1	1							1	1	2	2
15											0	0
16									1	1	1	1
17									1	1	1	1
18									1	1	1	1
19									1		1	0
20	1	1							1		2	1
21									1	1	1	1
22										1	0	1
23							1	1	1	1	2	2
24									1	1	1	1
25									1	1	1	1
Site and Civil Review												
1	1	1					1		1	1	3	2

2	1	1			1	1					2	2
3	1	1			1	1	1				3	2
4							1				1	0
5	1	1							1	1	2	2
6	1	1					1				2	1
7	1	1	1		1		1				4	1
8	1	1					1		1		3	1
9	1	1							1		2	1
10	1	1									1	1
11	1	1									1	1
12	1	1									1	1
13											0	0
14											0	0
15											0	0
16					1	1	1				2	1
17					1	1	1				2	1
18					1	1	1		1		3	1
19			1	1							1	1
20							1				1	0
21							1				1	0
22									1	1	1	1
23									1		1	0
24											0	0
25	1	1			1		1				3	1
26					1	1	1		1	1	3	2
27					1						1	0
28					1		1				2	0
29					1	1					1	1
30			1	1					1	1	2	2
31					1	1	1		1		3	1
32	1						1				2	0
33					1		1				2	0
34											0	0
35							1				1	0
36							1				1	0
Architectural Review												
1					1	1			1	1	2	2
2	1	1			1	1			1		3	2
3	1	1			1				1		3	1
4					1				1	1	2	1
5	1	1			1		1		1	1	4	2
6	1	1			1	1	1	1			3	3
7	1	1			1	1	1		1		4	2
8											0	0
9									1	1	1	1
10	1	1									1	1
11			1	1			1		1	1	3	2
12	**1**	**1**	**1**		**1**	**1**	**1**		**1**	**1**	**5**	**3**
13	1	1	1						1	1	3	2
14	1	1							1	1	2	2
15	1	1					1		1		3	1
16	1	1			1	1	1		1		4	2

17	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**5**	**5**
18	1	1			1	1	1		1	1	4	3
19					1	1			1	1	2	2
20					1	1			1	1	2	2
21	1	1			1	1			1	1	3	3
22									1	1	1	1
23			1		1	1	1		1		4	1
24	1	1									1	1
25	1	1							1	1	2	2
26									1		1	0
27	1	1			1	1	1		1	1	4	3
28									1	1	1	1
29	1	1	1	1	1	1					3	3
30					1	1			1	1	2	2
Architectural Review - Schedules												
1									1	1	1	1
2											0	0
3							1		1	1	2	1
4					1	1	1	1	1		3	2
5			1		1	1			1	1	3	2
6			1		1	1					2	1
7			1	1	1	1			1	1	3	3
8			1	1	1	1			1	1	3	3
9									1	1	1	1
10									1	1	1	1
11									1	1	1	1
12	1	1							1	1	2	2
13									1	1	1	1
14			1	1	1	1			1	1	3	3
15			1	1	1	1			1	1	3	3
16			1		1	1	1		1	1	4	2
17					1						1	0
18					1	1	1				2	1
19					1	1					1	1
Architectural Review - Floor Plans												
1					1	1					1	1
2											0	0
3			1								1	0
4					1	1	1		1		3	1
5					1	1			1	1	2	2
6					1	1					1	1
7	1	1			1	1					2	2
8					1	1			1	1	2	2
9					1	1			1		2	1
10					1	1			1	1	2	2
11					1		1		1	1	3	1
12					1						1	0
13	1	1			1		1				3	1
14					1						1	0
15											0	0
16					1	1			1		2	1
17									1		1	0

18											0	0
19					1						1	0
20									1	1	1	1
21											0	0
22											0	0
23									1	1	1	1
24							1		1		2	0
25					1	1			1	1	2	2
26	1	1			1	1	1		1	1	4	3
27					1	1	1				2	1
28					1	1			1		2	1
29					1	1	1				2	1
30									1		1	0
31					1	1			1	1	2	2
32							1	1	1	1	2	2
33											0	0
34	1	1									1	1
35											0	0
36			1	1			1				2	1
37	1	1	1		1		1				4	1
38					1	1			1		2	1
39											0	0
40											0	0
41									1	1	1	1
42							1		1		2	0
43							1				1	0
44											0	0
45							1				1	0
46											0	0
47							1				1	0
48					1		1		1		3	0
49	1	1			1		1				3	1
Architectural Review - Exterior Elevations												
1					1		1		1	1	3	1
2					1	1			1	1	2	2
3					1		1				2	0
4											0	0
5			1	1	1						2	1
6	1	1	1	1	1				1		4	2
Architectural Review - Wall Sections												
1					1	1	1	1	1	1	3	3
2					1				1	1	2	1
3							1		1	1	2	1
Architectural Review - Vertical Calculations												
1											0	0
2	1	1					1				2	1
3					1	1			1	1	2	2
4											0	0
5											0	0

6							1				1	0
7									1		1	0
8											0	0
9					1	1			1	1	2	2
10											0	0
11					1	1	1				2	1
12					1	1			1	1	2	2
13					1	1					1	1
14					1	1			1	1	2	2
15	1	1			1	1			1	1	3	3
16					1	1					1	1
Architectural Review - Enlarged Plans												
1			1				1		1		3	0
2			1				1		1		3	0
3									1	1	1	1
4			1		1				1		3	0
5	1	1			1						2	1
6					1		1				2	0
7											0	0
8					1	1	1		1		3	1
9					1	1	1		1		3	1
10	1				1	1	1		1		4	1
11					1	1	1		1		3	1
12											0	0
Architectural Review - Details												
1					1	1	1		1		3	1
2											0	0
3											0	0
4											0	0
5											0	0
Architectural Review - Reflected Ceiling Plans												
1			1		1	1			1	1	3	2
2			1	1					1	1	2	2
3	1	1							1	1	2	2
4									1	1	1	1
5					1		1		1	1	3	1
6					1		1		1	1	3	1
7					1		1		1	1	3	1
8			1	1	1		1		1	1	4	2
9			1		1				1	1	3	1
10	1	1							1	1	2	2
11					1	1			1	1	2	2
Structural Review												
1					1		1		1	1	3	1
2							1		1	1	2	1
3	1	1			1	1			1	1	3	3
4			1	1	1		1				3	1
5	1	1	1	1	1	1	1				4	3
6	1	1			1	1	1				3	2
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8	1	1			1	1					2	2
9			1	1	1				1	1	3	2
10					1	1	1		1	1	3	2
11					1	1			1	1	2	2
12	1	1	1	1	1	1	1				4	3
13	1	1	1		1	1	1				4	2
14	1	1	1		1						3	1
15											0	0
16	1	1									1	1
17	1	1	1				1				3	1
18									1		1	0
19							1		1	1	2	1
20	1	1			1	1			1	1	3	3
21	1	1	1								2	1
22	1	1			1	1			1	1	3	3
23	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**5**	**5**
24					1	1	1		1	1	3	2
25					1	1	1		1	1	3	2
26									1	1	1	1
27			1								1	0
Food Service Equipment												
1											0	0
2	1	1			1						2	1
3	1	1									1	1
4											0	0
5											0	0
6											0	0
7											0	0
Plumbing Review												
1	1	1					1				2	1
2	1	1					1	1			2	2
3	1	1	1				1				3	1
4	1	1									1	1
5							1	1			1	1
6											0	0
7							1				1	0
8			1	1			1				2	1
9											0	0
10	1	1	1				1				3	1
11	1	1							1		2	1
12	1	1			1						2	1
13							1				1	0
14					1						1	0
15											0	0
16	1	1							1		2	1
17	1	1									1	1
18							1				1	0
Fire Protection Review												
1	1	1					1		1	1	3	2
2					1						1	0
3									1	1	1	1
4											0	0

5					1						1	0
6			1						1		2	0
7	1										1	0
8			1	1							1	1
9											0	0
10									1		1	0
11									1		1	0
12									1		1	0
13											0	0
14											0	0
15											0	0
16											0	0
17	1	1	1						1		3	1
18			1								1	0
HVAC Review												
1	1	1			1		1		1		4	1
2	**1**	**1**	**1**		**1**		**1**		**1**		**5**	**1**
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4	1	1	1		1	1	1				4	2
5			1						1		2	0
6			1	1	1		1		1		4	1
7	1	1							1		2	1
8	1	1					1	1			2	2
9	1	1							1	1	2	2
10	1	1			1				1		3	1
11											0	0
12	1		1								2	0
13					1				1	1	2	1
14											0	0
15	1	1									1	1
16	1	1									1	1
17											0	0
Electrical Review - General												
1									1	1	1	1
2									1	1	1	1
3	1	1			1	1			1	1	3	3
4					1	1	1		1	1	3	2
5					1	1	1				2	1
6	1	1							1		2	1
7					1		1		1		3	0
8			1				1		1	1	3	1
Electrical Review - Site Documents												
1	1	1			1		1	1	1	1	4	3
2									1	1	1	1
3					1	1			1	1	2	2
4					1	1	1		1	1	3	2
5	1	1			1	1					2	2
6			1		1	1			1	1	3	2
Electrical Review - Lighting System Documents												
1	1	1			1	1					2	2

2											0	0
3					1	1	1		1		3	1
4											0	0
5	1	1			1	1			1		3	2
6					1		1		1		3	0
7											0	0
Electrical Review - Life Safety Systems												
1	1	1					1				2	1
2					1	1					1	1
3					1	1			1	1	2	2
4									1	1	1	1
5			1	1	1	1					2	2
6									1		1	0
7	1	1	1		1	1			1		4	2
8									1	1	1	1
9					1	1					1	1
Electrical Review - Power Systems												
1									1	1	1	1
2	1	1			1		1	1	1		4	2
3	1	1			1				1		3	1
4			1								1	0
5											0	0
6							1				1	0
7	1	1			1		1		1	1	4	2
8					1	1					1	1
9	1	1					1				2	1
Electrical Review - Low Voltage Systems												
1	1	1			1				1	1	3	2
2					1						1	0
3					1				1		2	0
4					1				1	1	2	1
5			1								1	0
Electrical Review - Specifications												
1											0	0
2							1	1			1	1
3											0	0
4					1						1	0
5	1						1				2	0
6											0	0
7									1	1	1	1
8			1				1	1			2	1
9					1						1	0
10					1	1					1	1
Electrical Review - Misc.												
1	**1**	**1**	**1**		**1**		**1**		**1**	**1**	**5**	**2**
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3	1	1			1	1			1		3	2
4	1	1									1	1
5	1	1			1		1				3	1

6	1	1			1		1				3	1
7	1	1							1	1	2	2
8	1	1			1	1			1	1	3	3
9					1						1	0
10	1	1									1	1
11	1	1			1						2	1
12	1	1									1	1
13					1	1					1	1
14			1	1	1	1	1				3	2
15	1	1			1		1		1	1	4	2
16	1	1									1	1
17	1	1			1	1					2	2
18	1	1									1	1
19	1	1							1	1	2	2
Specification Review												
1	1	1	1				1		1	1	4	2
2	**1**	**1**	**1**		**1**	**1**	**1**		**1**	**1**	**5**	**3**
3	1	1	1	1			1		1	1	4	3
4	1	1					1	1			2	2
5			1		1	1	1		1	1	4	2
6									1		1	0
7					1	1			1	1	2	2
8			1		1	1			1		3	1
9			1		1	1	1		1	1	4	2
10			1		1	1	1		1	1	4	2
11											0	0
Roofing - Overall Roof Plan												
1							1		1		2	0
2							1		1	1	2	1
3			1	1	1				1	1	3	2
4					1	1	1		1		3	1
5	**1**	**1**	**1**		**1**		**1**		**1**		**5**	**1**
6							1				1	0
7					1		1				2	0
8					1	1	1		1		3	1
9											0	0
10					1		1				2	0
Roofing - Roof Details												
1			1		1		1		1		4	0
2			1		1	1			1	1	3	2
3			1				1		1	1	3	1
4			1								1	0
5			1								1	0
6			1								1	0
Interiors - Signage Schedule and Details												
1			1		1	1					2	1
2					1	1					1	1
3	1	1	1		1	1					3	2
4					1	1	1				2	1
5					1	1	1				2	1
6			1		1	1	1				3	1

7			1	1							1	1
8			1	1	1	1					2	2
9			1		1	1					2	1
10					1	1					1	1
Interiors - Casework Floor Plans												
1			1	1							1	1
2			1								1	0
3					1	1					1	1
4					1	1					1	1
5			1		1	1					2	1
6					1	1					1	1
7			1	1	1	1	1				3	2
8					1						1	0
9					1						1	0
10							1				1	0
Interiors - Enlarged Casework Plans												
1							1				1	0
2					1	1	1				2	1
3											0	0
4											0	0
5							1				1	0
6											0	0
7											0	0
8							1				1	0
9							1				1	0
10											0	0
Interiors - Graphics												
1							1				1	0
2							1				1	0
3	1	1					1				2	1
4							1				1	0
5							1				1	0
6											0	0
Interiors - Corridor Elevations												
1											0	0
2											0	0
3											0	0
4											0	0
Agency Approval Review												
1	1										1	0
2											0	0
3											0	0
4											0	0
5											0	0
6	1										1	0
7											0	0
8											0	0
9	1										1	0
10											0	0
11											0	0
12											0	0

13											0	0
14	1										1	0
15			1								1	0
16											0	0
17											0	0
18											0	0
Specific Items / Additional Notes												
Number of Project Specific Items Found/Corrected	581	579	140	85	154	96	134	26	92	60	1101	846
Total Items (Req. Attention / Corrected)	718	706	231	116	364	231	290	42	310	199	1913	1294
Number of Items Un-Corrected	12		115		133		248		111		619	
% Items Corrected	98.33		50.22		63.46		14.48		64.19		67.64	
Estimated Value of Items Found ($)	550,000		275,000		315,000		295,000		410,000		369,000	
Estimated Value as Percent of Project	3.24		6.47		3.15		14.75		20.50			
Cost of A/E Related Change Orders ($)	20,906		0		TBD		TBD		TBD			

APPENDIX B

Table 1. Current Fixture Water Use Calculations

Quantity	Use / Day	Item	Manufacturer	Model Number	Water Use	Daily Use (Gal/Day)	Cost (ea. $)	Cost Total
103	1500	Water Closet	American Standard	2257.103	1.6 gpf	2400	249.00	25647.00
103	2100	Lavatory	Delta	525	2.3 gpm	4830	115.15	11860.45
101	4500	Shower Head	Delta	1323WS	2.5 gpm	11250	130.55	13185.55
48	1500	Kitchen Sink	Delta	100	2.3 gpm	1500	89.25	4284.00
					Totals	19980		$54,977.00

Table 2. Redesigned Fixture Water Use Calculations

Quantity	Use / Day	Item	Manufacturer	Model Number	Water Use	Daily Use (Gal/Day)	Cost (ea. $)	Cost Total
103	1500	Water Closet	Mansfield Plumbing	147-153	1.0 gpf	1500	414.50	42693.50
103	2100	Lavatory	Kingston Brass	KB-541-B	2.0 gpm	4200	66.07	6805.21
101	4500	Shower Head	Existing w/ NRGSaver	NS377	1.5 gpm	6750	135.05	13640.05
48	1500	Kitchen Sink	Delta	100	2.3 gpm	1500	89.25	4284
					Totals	13950		$67,422.76

Table 3. Usage Assumptions

# People	Fixture	Assumption		
300	Water Closet	5 Flushes/day/person	1500	Flushes/day
300	Lavatory	7 uses/day/person (1 Min. Ea.)	2100	Minutes/day
300	Shower Head	15 Minutes/day/person	4500	Minutes/day
300	Kitchen Sink	5 gallons/day/person	1500	gal/day

Table 4. Water and Sewer Charge for Philadelphia

Quantity Charges			
Monthly Water Charge	Water Service Charge per Mcf	Monthly Water Usage	Wastewater Services Charge per Mcf
First 2 Mcf	$19.91	All billable water usage	$15.99
Next 98 Mcf	$15.77		
Next 1,900 Mcf	$14.03		
Next 2,000 Mcf	$10.50		

APPENDIX C

Structural Calculations:

CIP Detailed Estimate

Strip Footings	width	depth	conc. Cy/ft	steel wt/ft	Length(ft.)	material	Labor	Equip.	total	total w/O&P	Total Cost
F20.12	24"	12"	0.074	2.67	415	8.36	5.62	0.04	14.02	18.00	7470.00
F36.12	3'6"	12"	0.13	4.9	688	12.09	6.83	0.04	18.96	23.92	16456.96
F50.14	5'	14"		11.47	239	4.36	3.33	0.00	7.69	10.32	2466.48
			0.216		239	17.50	9.72	0.06	27.28	34.37	8215.10
F66.16	6'6"	16"		17.47	139	6.64	5.07	0.00	11.71	15.72	2185.08
			0.321		139	26.00	14.45	0.09	40.54	51.08	7100.18
F66.36	6'6"	36"		146.81	112	52.85	24.59	0.00	77.44	99.00	11088.00
			0.722		112	58.48	32.49	0.21	91.18	114.89	12867.32
											$67,849.12

Col Footings	size	depth	conc. Cy	steel wt	Number	material	Labor	Equip.	total	total w/O&P	Total Cost
F30	3'x3'	12"	0.333		1	26.97	14.99	0.10	42.05	53.41	53.41
				25.03	1	9.51	7.26		16.77	21.30	21.30
F40	4'x4'	12"	0.693		6	56.13	31.19	0.20	87.52	111.15	666.89
				41.72	6	15.85	12.10		27.95	35.50	213.00
F50	5'x5'	12"	0.926		8	75.01	41.67	0.27	116.94	148.52	1188.16
				62.58	8	23.78	18.15		41.93	53.25	425.99
F86	8'6"x8'6"	18"	4.01		5	324.81	180.45	1.16	506.42	643.16	3215.79
				347.48	5	132.04	100.77		232.81	295.67	1478.35
F100120	10'x12'	26"	9.63		3	780.03	433.35	2.79	1216.17	1544.54	4633.62
				816	3	293.76	136.68		430.44	546.66	1639.98
F5080	5'x8'	18"	2.22		1	179.82	99.90	0.64	280.36	356.06	356.06
				190.09	1	72.23	55.13		127.36	161.75	161.75
											$14,054.29

Piers	size	Total (ft.)	conc. Cy	steel wt		material	Labor	Equip.	total	total w/O&P	Total Cost
P1	20" x 20"	86.5	0.103			8.34	4.64	0.03	13.01	16.52	1428.98
		86.5		18.79		7.14	5.45		12.59	15.99	1383.00
P2	26" x 26"	11	0.174			14.09	7.83	0.05	21.97	27.91	306.98
		11		27.72		10.53	8.04		18.57	23.59	259.46
											$3,378.42

Slab on Grade	s.f.					material	Labor	Equip.	total	total w/O&P	Total Cost
5"	2176					1.31	0.67	0.01	1.99	2.43	5287.68
4"	18693					1.07	0.65	0.01	1.73	2.15	40189.95
6x6 W1.4xW1.4 W	208.69	c.s.f.				19.35	17.35	0	36.7	50	10434.50
											$55,912.13

CIP CONCRETE TOTAL $141,193.96

Grouting First Floor Walls

Exterior	11	640	7040	0.85	1.44	0.2	2.49	3.34	23513.60
Interior	11	810	8910	0.85	1.44	0.2	2.49	3.34	29759.40
								Total	$53,273.00

8" CMU

Exterior	10.33	1876	19379.08	2.48	3.55		6.03	8.15	157939.50
Exterior	10.67	938	10008.46	2.48	3.55		6.03	8.15	81568.95
Interior	10.33	1620	16734.6	1.63	3.45		5.08	7.05	117978.93
Interior	10.67	810	8642.7	1.63	3.45		5.08	7.05	60931.04
Exterior	11	640	7040	2.48	3.55		6.03	8.15	57376.00
Interior	11	810	8910	1.63	3.45		5.08	7.05	62815.50
								Total	$538,609.92

TOTAL MASONRY COST $591,882.92

Precast Plank			
Width(ft)	Length(ft)	# Pieces	S.F.
8	15	32	3840
8	18.67	32	4779.52
8	18	32	4608
8	12	4	384
8	14	4	448
8	11	4	352
8	23	48	8832
8	22	28	4928
8	33	40	10560
8	32	16	4096
8	15	16	1920
8	23.5	28	5264
8	30.5	28	6832
8	23	56	10304
8	30	56	13440
8	15.5	16	1984
8	21.5	16	2752
8	15.5	36	4464
8	14	8	896
8	19.5	8	1248
8	19	20	3040
8	19	21	3192
8	28	18	4032
8	11.25	9	810
		Total	103005.5

Precast Hollow Plank, 8" thickness						
mat	lab	equip	total	total w/O&P	Total S.F.	Total Cost
5.45	0.84	0.45	6.74	7.95	103005.5	$818,893.88

Columns									
	Number	Shape	# floors	mat	labor	equip	total	total w/O&P	Total Cost
C1	2	HSS 10x10x5/8	2	950	43	27.5	1020.5	1150	4600.00
	2	HSS 10x10x1/2	2	950	43	27.5	1020.5	1150	4600.00
C2	1	HSS 8x8x5/8	2	950	43	27.5	1020.5	1150	2300.00
	1	HSS 8x8x5/8	2	950	43	27.5	1020.5	1150	2300.00
C4	2	HSS 4x4x5/16	4	144	35.5	23	202.5	246	1968.00
C5	11	W10 x 60	4	65.5	2.1	1.35	68.95	77	3388.00
C7	2	HSS 6x6x5/16	5	236	38.5	24.5	299	370	3700.00
C8	4	W10 x 39	3	42	1.97	1.25	45.22	58	696.00
								Total	$23,552.00

Lintels									
	# Lintels	Shape	Pcs/Lintel	mat	labor	equip	total	total w/O&P	Total Cost
W8 x 31	4		1	30	3.76		36.17	42	168.00
L1	19	5x3	2	43	27		70	89	3382.00
L2	1	4x3	2	43	27		70	89	178.00
L2B	10	4x3	3	64.5	40.5		105	133.5	4005.00
L2C	5	4x3 & 6x3	3	64.5	40.5		105	133.5	2002.50
L3	7	6x3	2	78	47		125	158	2212.00
L3B	12	6x3	3	117	70.5		187.5	237	8532.00
L4	12	7x4	2	85.8	51.7		137.5	173.8	4171.20
								Total	$24,650.70

Structural Shapes								
	Length(ft.)		mat	labor	equip	total	total w/O&P	Total Cost
W8 x 24	24		23	3.76	2.41	29.17	34.5	828.00
W12 x 16	18		13.5	2.35	1.51	17.36	20.5	369.00
W12 X 19	102		21	2.35	1.51	24.86	29	2958.00
W12 X 22	38.5		21	2.35	1.51	24.86	29	1116.50
W12 x 30	30		33.5	2.56	1.64	37.7	43	1290.00
W12 x 45	16		48	2.76	1.77	52.53	59.5	952.00
W12 X 50	11		48	2.76	1.77	52.53	59.5	654.50
W14 X 22	29.33		25	2.09	1.34	28.43	32.5	953.23
W14 x 26	47		25	2.09	1.34	28.43	32.5	1527.50
W14 x 61	78		71	2.72	1.74	75.46	85	6630.00
W16 X 36	14.67		38.5	2.59	1.66	42.75	49	718.83
HSS 10X8X5/16	16		950	43	27.5	1020.5	1150	18400.00
							Total	$36,397.56

TOTAL STEEL COST $84,600.26

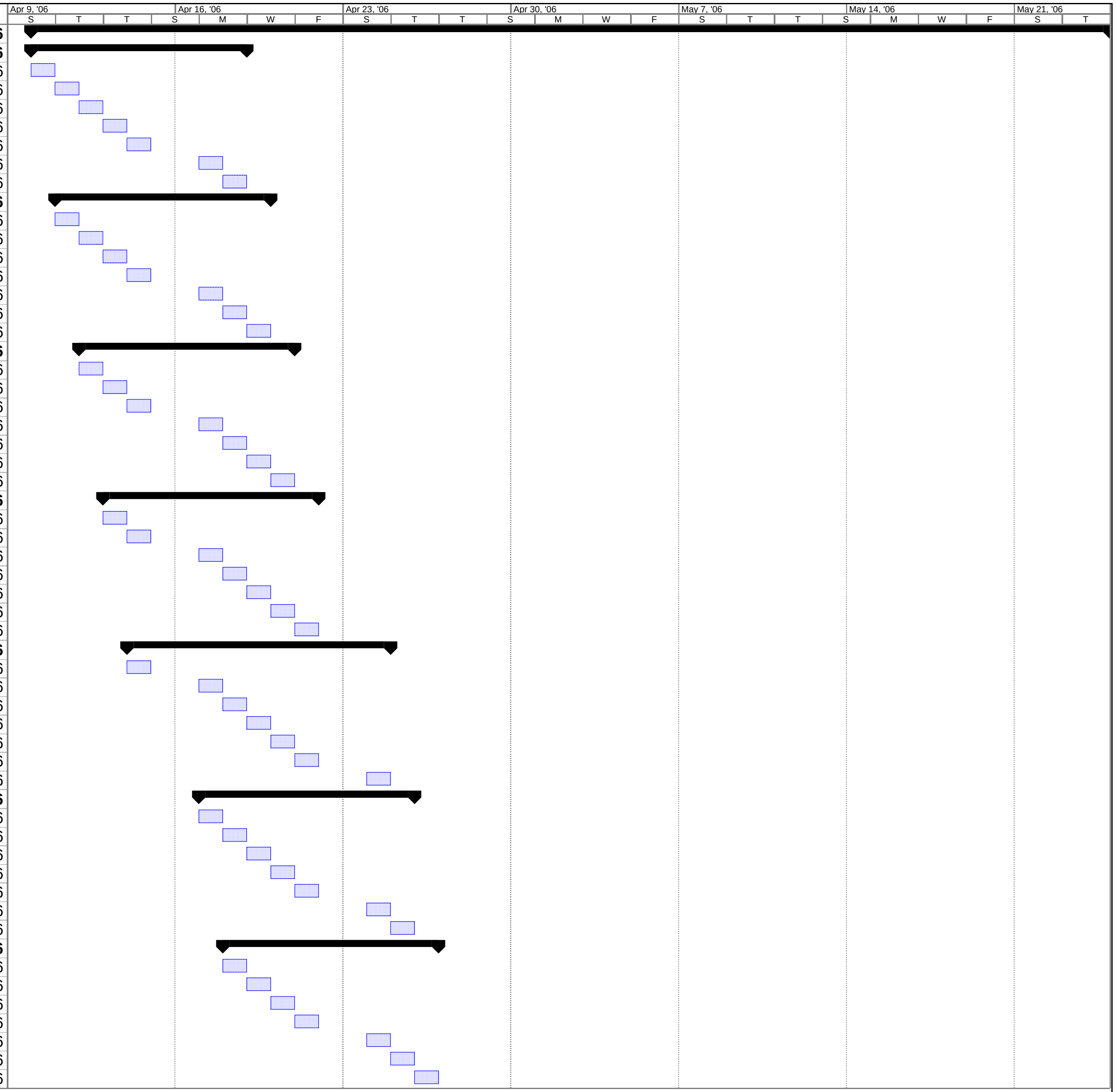
Structural Estimate Totals	
TOTAL CIP CONCRETE	$141,193.96
TOTAL MASONRY COST	$591,882.92
TOTAL PRECAST COST	$818,893.88
TOTAL STEEL COST	$84,600.26
Structural Total	$1,636,571.02

Location Factor 1.13

Structural Project Total = $1,849,325.25

SIPS SCHEDULE

ID		Task Name	Duration	Start	Finish
1		**Finishes**	**33 days**	**4/10/2006**	**5/24/2006**
2		**100-104 Clubhouse**	**7 days**	**4/10/2006**	**4/18/2006**
3		Paint Walls	1 day	4/10/2006	4/10/2006
4		Acoustical Ceiling	1 day	4/11/2006	4/11/2006
5		Elec. Trim & Light Fixt	1 day	4/12/2006	4/12/2006
6		Casework	1 day	4/13/2006	4/13/2006
7		Plumbing Fixt.	1 day	4/14/2006	4/14/2006
8		Doors / Hardware	1 day	4/17/2006	4/17/2006
9		Flooring	1 day	4/18/2006	4/18/2006
10		**110 Unit Type E**	**7 days**	**4/11/2006**	**4/19/2006**
11		Paint Walls	1 day	4/11/2006	4/11/2006
12		Paint Ceiling	1 day	4/12/2006	4/12/2006
13		Elec. Trim & Light Fixt	1 day	4/13/2006	4/13/2006
14		Casework	1 day	4/14/2006	4/14/2006
15		Plumbing Fixt.	1 day	4/17/2006	4/17/2006
16		Doors / Hardware	1 day	4/18/2006	4/18/2006
17		Flooring	1 day	4/19/2006	4/19/2006
18		**111 Unit Type A**	**7 days**	**4/12/2006**	**4/20/2006**
19		Paint Walls	1 day	4/12/2006	4/12/2006
20		Paint Ceiling	1 day	4/13/2006	4/13/2006
21		Elec. Trim & Light Fixt	1 day	4/14/2006	4/14/2006
22		Casework	1 day	4/17/2006	4/17/2006
23		Plumbing Fixt.	1 day	4/18/2006	4/18/2006
24		Doors / Hardware	1 day	4/19/2006	4/19/2006
25		Flooring	1 day	4/20/2006	4/20/2006
26		**112 Unit Type A**	**7 days**	**4/13/2006**	**4/21/2006**
27		Paint Walls	1 day	4/13/2006	4/13/2006
28		Paint Ceiling	1 day	4/14/2006	4/14/2006
29		Elec. Trim & Light Fixt	1 day	4/17/2006	4/17/2006
30		Casework	1 day	4/18/2006	4/18/2006
31		Plumbing Fixt.	1 day	4/19/2006	4/19/2006
32		Doors / Hardware	1 day	4/20/2006	4/20/2006
33		Flooring	1 day	4/21/2006	4/21/2006
34		**113 Unit Type A (KT)**	**7 days**	**4/14/2006**	**4/24/2006**
35		Paint Walls	1 day	4/14/2006	4/14/2006
36		Paint Ceiling	1 day	4/17/2006	4/17/2006
37		Elec. Trim & Light Fixt	1 day	4/18/2006	4/18/2006
38		Casework	1 day	4/19/2006	4/19/2006
39		Plumbing Fixt.	1 day	4/20/2006	4/20/2006
40		Doors / Hardware	1 day	4/21/2006	4/21/2006
41		Flooring	1 day	4/24/2006	4/24/2006
42		**114 Unit Type A (KT)**	**7 days**	**4/17/2006**	**4/25/2006**
43		Paint Walls	1 day	4/17/2006	4/17/2006
44		Paint Ceiling	1 day	4/18/2006	4/18/2006
45		Elec. Trim & Light Fixt	1 day	4/19/2006	4/19/2006
46		Casework	1 day	4/20/2006	4/20/2006
47		Plumbing Fixt.	1 day	4/21/2006	4/21/2006
48		Doors / Hardware	1 day	4/24/2006	4/24/2006
49		Flooring	1 day	4/25/2006	4/25/2006
50		**115 Unit Type C**	**7 days**	**4/18/2006**	**4/26/2006**
51		Paint Walls	1 day	4/18/2006	4/18/2006
52		Paint Ceiling	1 day	4/19/2006	4/19/2006
53		Elec. Trim & Light Fixt	1 day	4/20/2006	4/20/2006
54		Casework	1 day	4/21/2006	4/21/2006
55		Plumbing Fixt.	1 day	4/24/2006	4/24/2006
56		Doors / Hardware	1 day	4/25/2006	4/25/2006
57		Flooring	1 day	4/26/2006	4/26/2006



Project: SIPS Schedule
Date: 3/22/2006

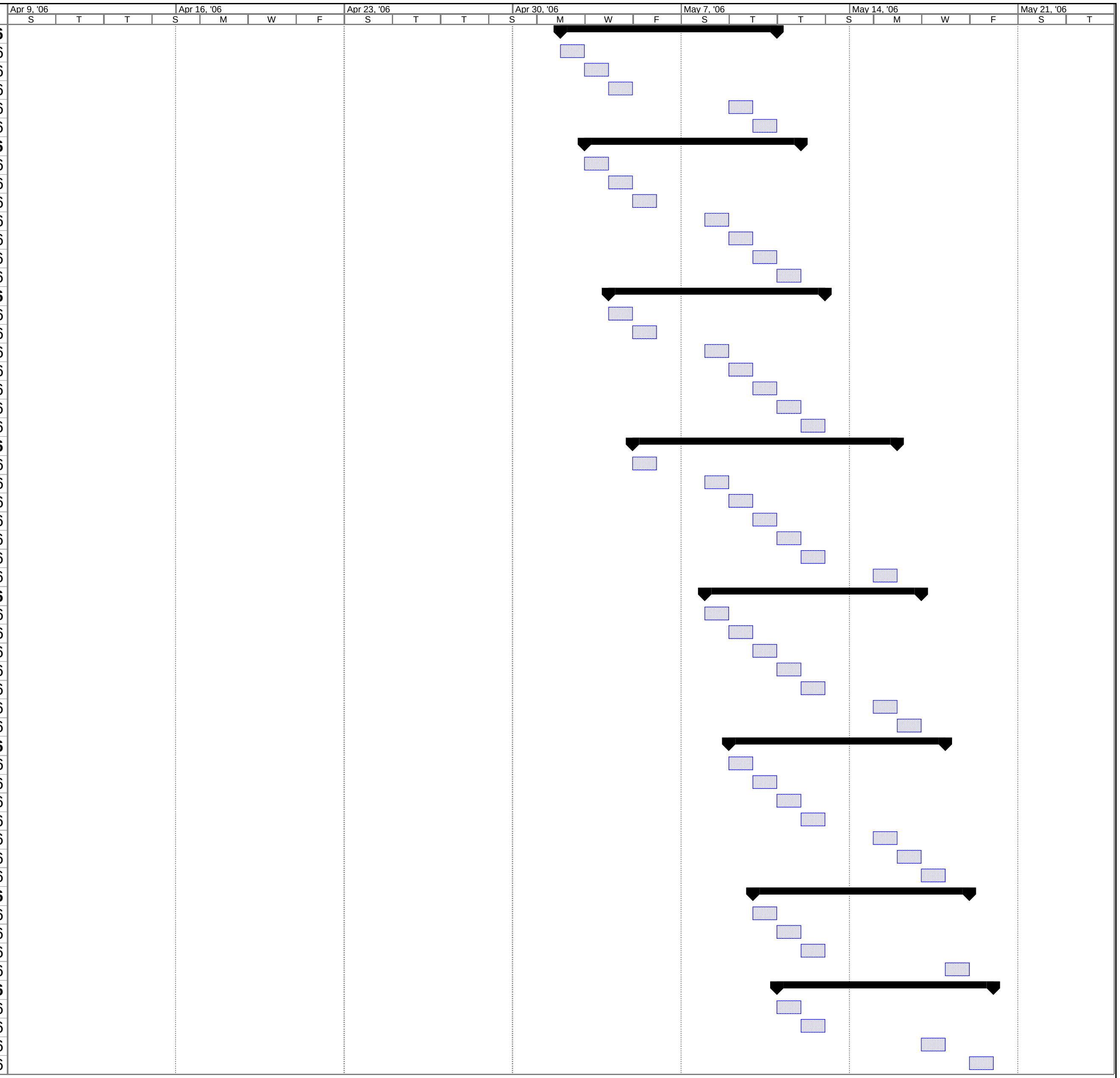
Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline

ID		Task Name	Duration	Start	Finish
58		**116 Unit Type A**	**7 days**	**4/19/2006**	**4/27/2006**
59		Paint Walls	1 day	4/19/2006	4/19/2006
60		Paint Ceiling	1 day	4/20/2006	4/20/2006
61		Elec. Trim & Light Fixt	1 day	4/21/2006	4/21/2006
62		Casework	1 day	4/24/2006	4/24/2006
63		Plumbing Fixt.	1 day	4/25/2006	4/25/2006
64		Doors / Hardware	1 day	4/26/2006	4/26/2006
65		Flooring	1 day	4/27/2006	4/27/2006
66		**117 Corridor**	**7 days**	**4/20/2006**	**4/28/2006**
67		Paint Walls	1 day	4/20/2006	4/20/2006
68		Acoustical Ceiling	1 day	4/21/2006	4/21/2006
69		Elec. Trim & Light Fixt	1 day	4/24/2006	4/24/2006
70		Flooring	1 day	4/28/2006	4/28/2006
71		**118-124 Closets**	**7 days**	**4/21/2006**	**5/1/2006**
72		Paint Walls	1 day	4/21/2006	4/21/2006
73		Paint Ceiling	1 day	4/24/2006	4/24/2006
74		Doors / Hardware	1 day	4/27/2006	4/27/2006
75		Flooring	1 day	5/1/2006	5/1/2006
76		**125 Corridor**	**7 days**	**4/24/2006**	**5/2/2006**
77		Paint Walls	1 day	4/24/2006	4/24/2006
78		Acoustical Ceiling	1 day	4/25/2006	4/25/2006
79		Elec. Trim & Light Fixt	1 day	4/26/2006	4/26/2006
80		Flooring	1 day	5/2/2006	5/2/2006
81		**125-131 Closets**	**7 days**	**4/25/2006**	**5/3/2006**
82		Paint Walls	1 day	4/25/2006	4/25/2006
83		Paint Ceiling	1 day	4/26/2006	4/26/2006
84		Doors / Hardware	1 day	4/28/2006	4/28/2006
85		Flooring	1 day	5/3/2006	5/3/2006
86		**135 Main Entry**	**7 days**	**4/26/2006**	**5/4/2006**
87		Paint Walls	1 day	4/26/2006	4/26/2006
88		Paint Ceiling	1 day	4/27/2006	4/27/2006
89		Elec. Trim & Light Fixt	1 day	4/28/2006	4/28/2006
90		Doors / Hardware	1 day	5/1/2006	5/1/2006
91		Flooring	1 day	5/4/2006	5/4/2006
92		**140 Lobby**	**7 days**	**4/27/2006**	**5/5/2006**
93		Paint Walls	1 day	4/27/2006	4/27/2006
94		Paint Ceiling	1 day	4/28/2006	4/28/2006
95		Elec. Trim & Light Fixt	1 day	5/1/2006	5/1/2006
96		Doors / Hardware	1 day	5/2/2006	5/2/2006
97		Flooring	1 day	5/5/2006	5/5/2006
98		**141 Laundry Room**	**7 days**	**4/28/2006**	**5/8/2006**
99		Paint Walls	1 day	4/28/2006	4/28/2006
100		Acoustical Ceiling	1 day	5/1/2006	5/1/2006
101		Elec. Trim & Light Fixt	1 day	5/2/2006	5/2/2006
102		Casework	1 day	5/3/2006	5/3/2006
103		Plumbing Fixt.	1 day	5/4/2006	5/4/2006
104		Doors / Hardware	1 day	5/5/2006	5/5/2006
105		Flooring	1 day	5/8/2006	5/8/2006
106		**142 Trash Room**	**7 days**	**5/1/2006**	**5/9/2006**
107		Paint Walls	1 day	5/1/2006	5/1/2006
108		Acoustical Ceiling	1 day	5/2/2006	5/2/2006
109		Elec. Trim & Light Fixt	1 day	5/3/2006	5/3/2006
110		Doors / Hardware	1 day	5/8/2006	5/8/2006
111		Flooring	1 day	5/9/2006	5/9/2006

Project: SIPS Schedule
Date: 3/22/2006

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

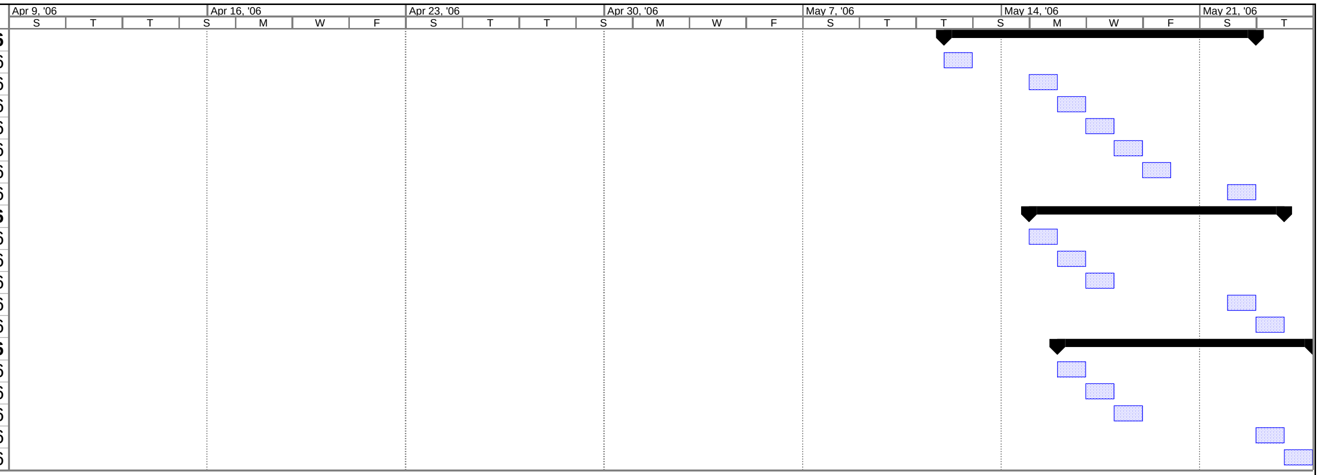
ID	Task Name	Duration	Start	Finish
112	**143 Elevator Room**	**7 days**	**5/2/2006**	**5/10/2006**
113	Paint Walls	1 day	5/2/2006	5/2/2006
114	Paint Ceiling	1 day	5/3/2006	5/3/2006
115	Elec. Trim & Light Fixt	1 day	5/4/2006	5/4/2006
116	Doors / Hardware	1 day	5/9/2006	5/9/2006
117	Flooring	1 day	5/10/2006	5/10/2006
118	**150 Unit Type G East**	**7 days**	**5/3/2006**	**5/11/2006**
119	Paint Walls	1 day	5/3/2006	5/3/2006
120	Paint Ceiling	1 day	5/4/2006	5/4/2006
121	Elec. Trim & Light Fixt	1 day	5/5/2006	5/5/2006
122	Casework	1 day	5/8/2006	5/8/2006
123	Plumbing Fixt.	1 day	5/9/2006	5/9/2006
124	Doors / Hardware	1 day	5/10/2006	5/10/2006
125	Flooring	1 day	5/11/2006	5/11/2006
126	**150 Unit Type G West**	**7 days**	**5/4/2006**	**5/12/2006**
127	Paint Walls	1 day	5/4/2006	5/4/2006
128	Paint Ceiling	1 day	5/5/2006	5/5/2006
129	Elec. Trim & Light Fixt	1 day	5/8/2006	5/8/2006
130	Casework	1 day	5/9/2006	5/9/2006
131	Plumbing Fixt.	1 day	5/10/2006	5/10/2006
132	Doors / Hardware	1 day	5/11/2006	5/11/2006
133	Flooring	1 day	5/12/2006	5/12/2006
134	**152 Grad. Assist. Unit**	**7 days**	**5/5/2006**	**5/15/2006**
135	Paint Walls	1 day	5/5/2006	5/5/2006
136	Paint Ceiling	1 day	5/8/2006	5/8/2006
137	Elec. Trim & Light Fixt	1 day	5/9/2006	5/9/2006
138	Casework	1 day	5/10/2006	5/10/2006
139	Plumbing Fixt.	1 day	5/11/2006	5/11/2006
140	Doors / Hardware	1 day	5/12/2006	5/12/2006
141	Flooring	1 day	5/15/2006	5/15/2006
142	**153 Unit Type A**	**7 days**	**5/8/2006**	**5/16/2006**
143	Paint Walls	1 day	5/8/2006	5/8/2006
144	Paint Ceiling	1 day	5/9/2006	5/9/2006
145	Elec. Trim & Light Fixt	1 day	5/10/2006	5/10/2006
146	Casework	1 day	5/11/2006	5/11/2006
147	Plumbing Fixt.	1 day	5/12/2006	5/12/2006
148	Doors / Hardware	1 day	5/15/2006	5/15/2006
149	Flooring	1 day	5/16/2006	5/16/2006
150	**154 Laundry Room**	**7 days**	**5/9/2006**	**5/17/2006**
151	Paint Walls	1 day	5/9/2006	5/9/2006
152	Acoustical Ceiling	1 day	5/10/2006	5/10/2006
153	Elec. Trim & Light Fixt	1 day	5/11/2006	5/11/2006
154	Casework	1 day	5/12/2006	5/12/2006
155	Plumbing Fixt.	1 day	5/15/2006	5/15/2006
156	Doors / Hardware	1 day	5/16/2006	5/16/2006
157	Flooring	1 day	5/17/2006	5/17/2006
158	**155 Corridor**	**7 days**	**5/10/2006**	**5/18/2006**
159	Paint Walls	1 day	5/10/2006	5/10/2006
160	Acoustical Ceiling	1 day	5/11/2006	5/11/2006
161	Elec. Trim & Light Fixt	1 day	5/12/2006	5/12/2006
162	Flooring	1 day	5/18/2006	5/18/2006
163	**157-159 Closets**	**7 days**	**5/11/2006**	**5/19/2006**
164	Paint Walls	1 day	5/11/2006	5/11/2006
165	Paint Ceiling	1 day	5/12/2006	5/12/2006
166	Doors / Hardware	1 day	5/17/2006	5/17/2006
167	Flooring	1 day	5/19/2006	5/19/2006



Project: SIPS Schedule
Date: 3/22/2006

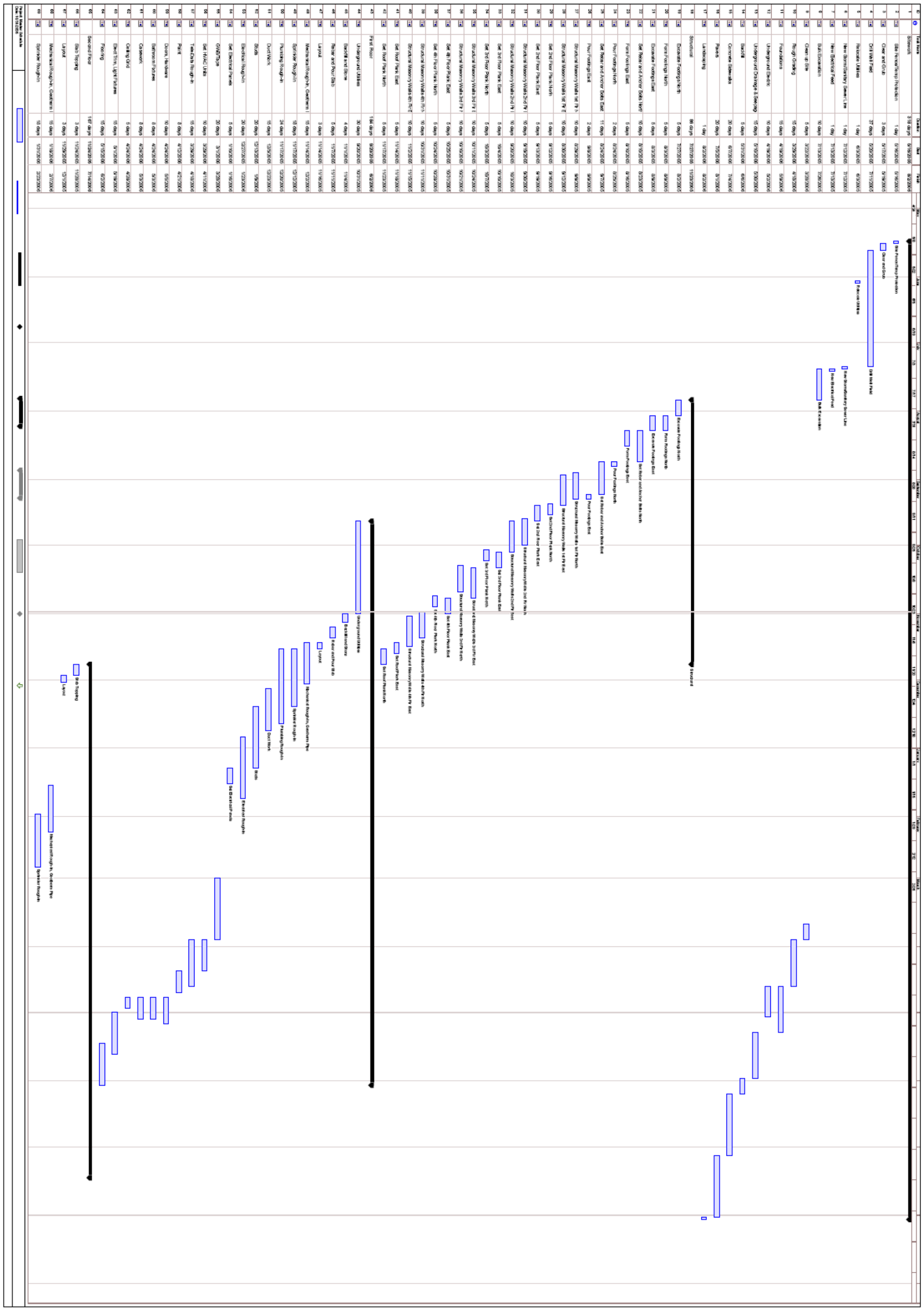
Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary | Deadline

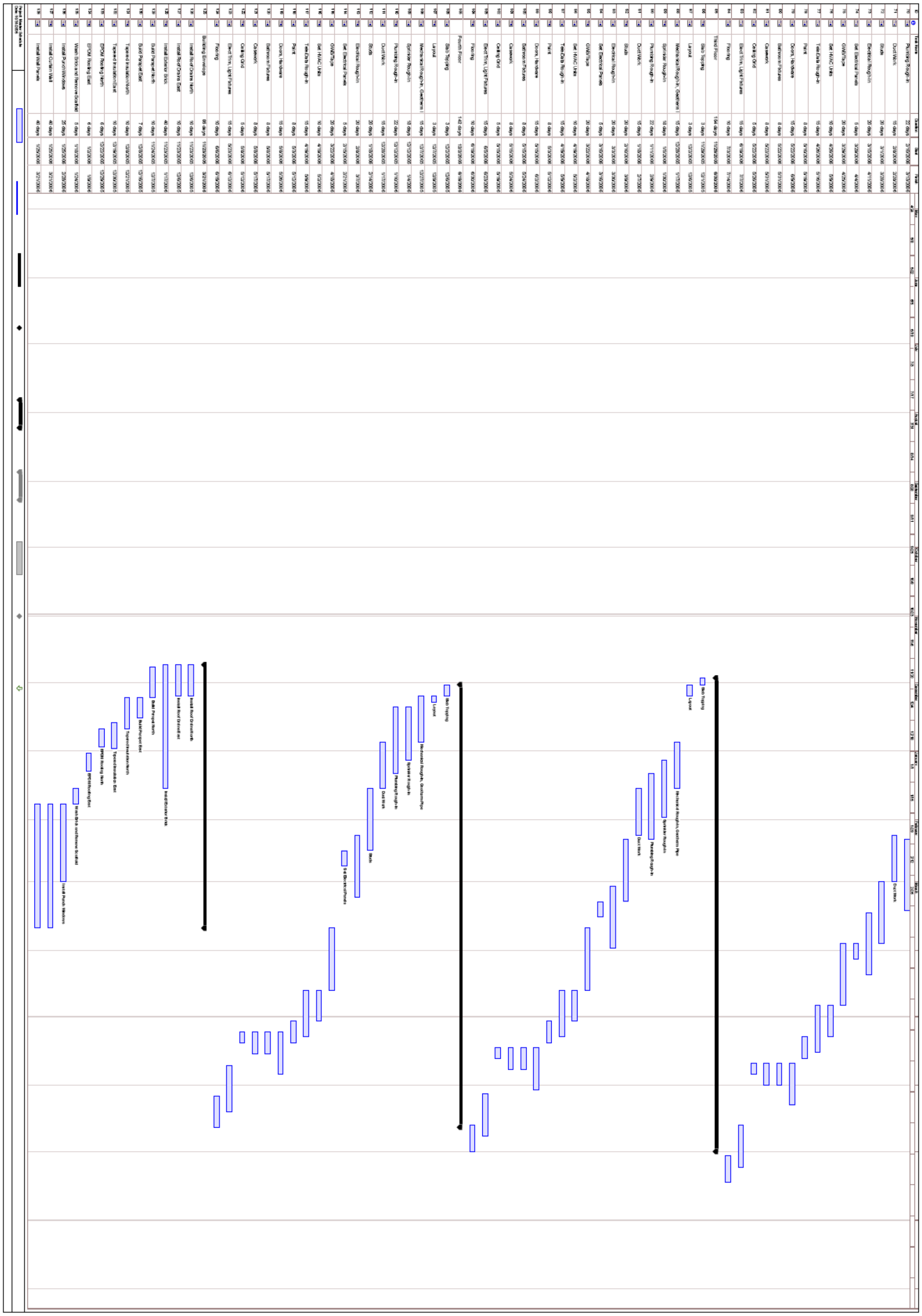
ID		Task Name	Duration	Start	Finish
168		**160 Unit Type B**	**7 days**	**5/12/2006**	**5/22/2006**
169		Paint Walls	1 day	5/12/2006	5/12/2006
170		Paint Ceiling	1 day	5/15/2006	5/15/2006
171		Elec. Trim & Light Fixt	1 day	5/16/2006	5/16/2006
172		Casework	1 day	5/17/2006	5/17/2006
173		Plumbing Fixt.	1 day	5/18/2006	5/18/2006
174		Doors / Hardware	1 day	5/19/2006	5/19/2006
175		Flooring	1 day	5/22/2006	5/22/2006
176		**165 Mechanical Room**	**7 days**	**5/15/2006**	**5/23/2006**
177		Paint Walls	1 day	5/15/2006	5/15/2006
178		Paint Ceiling	1 day	5/16/2006	5/16/2006
179		Elec. Trim & Light Fixt	1 day	5/17/2006	5/17/2006
180		Doors / Hardware	1 day	5/22/2006	5/22/2006
181		Flooring	1 day	5/23/2006	5/23/2006
182		**166 Electrical Room**	**7 days**	**5/16/2006**	**5/24/2006**
183		Paint Walls	1 day	5/16/2006	5/16/2006
184		Paint Ceiling	1 day	5/17/2006	5/17/2006
185		Elec. Trim & Light Fixt	1 day	5/18/2006	5/18/2006
186		Doors / Hardware	1 day	5/23/2006	5/23/2006
187		Flooring	1 day	5/24/2006	5/24/2006



APPENDIX D

Figure 1. Detailed Construction Schedule (per HSC Plan)





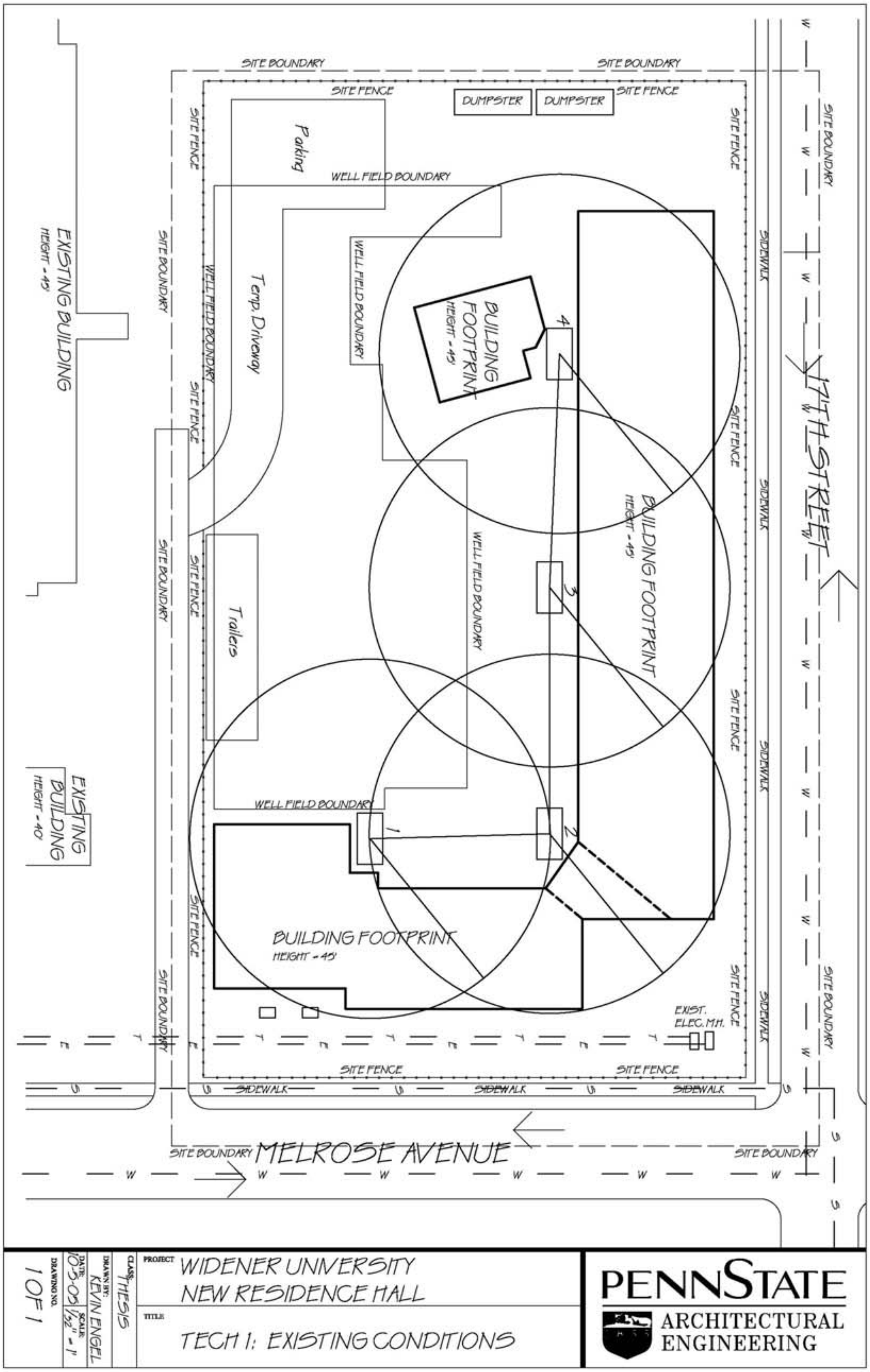


Figure 2. Existing conditions and construction methods site plan