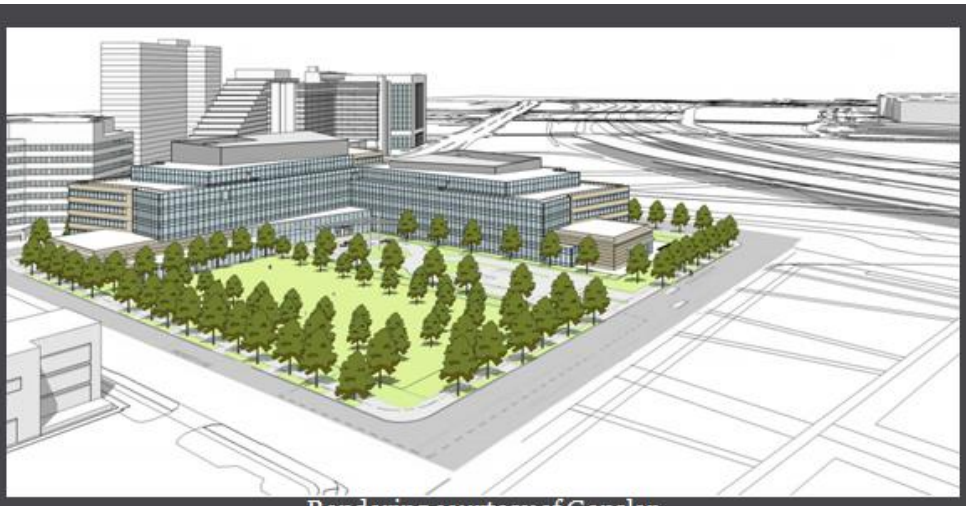

Rendering courtesy of Gensler

Memorial Vista

A North Virginia Office Building

Thesis Proposal - Revised

William J. Gamble | 5th Year – Construction Option | January 17th, 2013

Executive Summary

The following thesis proposal is written about Memorial Vista, an office building for an undisclosed aviation tenant in northern Virginia. The analyses that will be researched and conducted in the spring of 2014 will be a short interval production schedule (SIPS) on the façade of the building, prefabrication of the glazing of the building, and the implementation of an automated parking garage in lieu of the traditional underground garage. The goal of all three of these analyses is to reduce the overall duration of the project schedule.

Analysis 1 – SIPS Scheduling Applied to the Building's Façade
Memorial Vista has a façade that is made up of glazing, precast concrete panels, and metal paneling. All of these elements are bolted or welded directly to the concrete structure upon installation. For this analysis, the façade will be looked at to produce the most efficient installation of the materials that make up the façade. By implementing SIPS, the schedule should be significantly reduced in its overall time of enclosing the building, which in turn would reduce the duration of the entire project schedule.

Analysis 2 – Prefabrication and Study of Photovoltaic Windows
For this analysis, the installation of the windows will be studied even further. This building is made up of 65,558 square feet of glazing, where the possibility of prefabrication of the glass could be done to allow for a quicker installation time. Instead of hanging one window at a time, multiple window systems could be manufactured and then lifted into place to quickly attach to the structure. This could potentially shorten the schedule of the project and bring the team closer to their goal of turning the project over on time. To add to the value of the study of the construction of the installation of the glazing, the glass will be substituted with photovoltaic glass in order to lessen the load that the building produces.

Analysis 3 – Implementation of an Automated Parking Garage
The final analysis looks at the parking garage that was designed. The owner asked that the contractor dig to the lowest foundation level across the entire 4.7 acre site looking for contaminated soil. This is extremely time intensive, where if an alternative could be performed without excavating, both the schedule could be reduced and the owner could save on the excavation costs. To reduce the schedule time of erecting an underground parking garage, an alternative design will be looked at. The idea of implementing an automated parking garage will reduce the depth of excavation both horizontally and vertically. In the end, the goal of reducing the schedule would be potentially reached and the analysis would be considered successful.

The above analyses all have the possibility of achieving the goal of reducing the overall schedule length to turn the project over on time. Through research, planning, and calculations done in the spring of next year, it will be seen if these topics will be successful and applicable to Memorial Vista.

Table of Contents

Project Overview

Memorial Vista is unique in the fact that it is a $78.5 million office building in northern Virginia that will house a leading aviation tenant in the near future as the main east coast office. The office building itself is split into two wings; those being the North and South, to form a 'V' shaped building as seen below in figure 1. The South wing is six stories above grade, where the North is only five stories. This is due to air restrictions in the area, where the North wing falls into a more stringent restriction of building heights. The building not only took into account its surroundings in the design phase, but also looked to reduce waste and emissions by pursuing LEED gold with a target of 60 total points.

The price is rather on the higher end for an average office building that is 322,725 gross square feet due to both the owner's desires in how the building will appear, the unique high end finishes that the building will be accompanied with upon completion, and the large security and data package that a building in this location is accompanied with. The owner made it clear that the main concerns throughout the construction of Memorial Vista were both the schedule and the quality, but also strived to make the building safer and secure upon completion.

The general contractor brought on board was James G. Davis Construction through a CM at risk with a guaranteed maximum price contract. The core and shell of the building resulted in a schedule that began in April of 2011 when excavation of the site began to the substantial final completion date in October of 2013. Upon the completion of the core and shell, a bid will be accepted in mid-January of 2014 for the interior phase of the construction process before the tenant actually occupies the space.

Figure 1 – Rendering of Memorial Vista courtesy of Gensler

Analysis I – SIPS Scheduling Applied to the Building's Façade

Problem Identification

The site that Memorial Vista is to be a part of was once a plot of land in northern Virginia that was accompanied by a two story motel (designated as orange in figure 2 on the next page) and six industrial warehouses (designated as yellow in figure 2 on the next page). The major concern with this information is the fact that contaminated soil is a possibility. The red outline in figure 2 is the site perimeter for the future site. I can be seen that this perimeter encloses a road that is highlighted green, which must eventually be removed after the existing structures are demolished due to the fact that the location of the original road will be the location of the future building's Northern wing.

The Davis team and Excavation contractor assembled site utility plans from previous years in the location and also chose to perform spot checks in various locations with a backhoe to see if the utility drawings were accurate. After numerous spot checks were performed around the site it was apparent that the drawings had utilities miss marked and in some instances, the utilities were not marked on the drawings at all. Since a majority of the utilities were either out of place or not shown in the drawings, the relocation of the utilities under the existing road shown in green within figure 2 were estimated based off of previous projects that Davis performed in the area. Figure 3 shows just some of the utilities that run underground of the future Memorial Vista site, where it becomes obvious that the utility relocation process would take some time to begin with.

Figure 2 – Original Site Courtesy of Google Maps

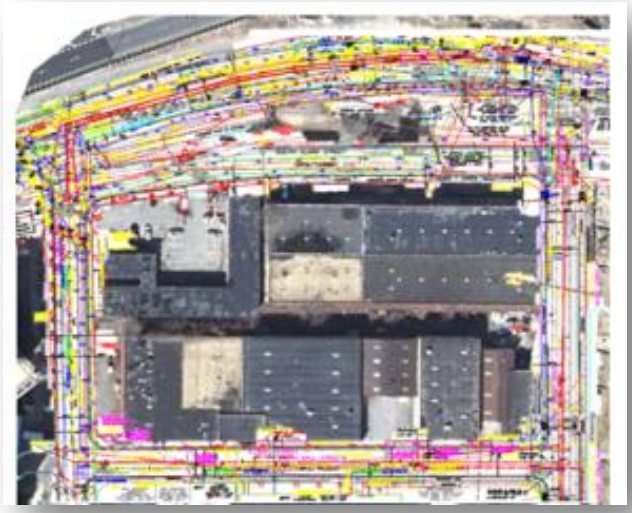

Figure 3 – Original Site with Existing Utility Overlay Courtesy of Davis and Google Maps

As the relocation process took place, activities were taking place fairly close to the predicted schedule until it was discovered that a large sewer main ran below the road that needed to be removed from the site. After looking at the surrounding utilities, it was determined that there was no redundancy in the system and that these were significant pipes for the County. In other words, the local pumping station had no backup or redundancy. The result would be that the team had to remove the gravity and forced main on the site and swap the path for new lines installed in the street on a bordering road. As a result, the team had to perform a complicated tie-in and swap process that cost more money than budgeted and pushed the schedule back immensely. To perform this tie-in to a new system of pipes that would bring the sanitary sewer line around the property of the building instead of through it, a line stop was needed. This caused some delays due to the fact that a line stop has an extremely long lead time and there are only a handful of crews in the country that perform the job. In the end, the cost was not a major problem due to the fact that the owner had money to spare, but the schedule impact was a greater problem due to the fact the interior fit-out of the building could not take place until the core and shell was completed.

Background Research Performed

Since the issue with the sewer main relocation was due to the fact that the schedule was extended past its original projected date by around six months, a short interval production schedule (SIPS) will be performed on the façade of the building. This SIPS analysis would focus on the schedule of the building after the concrete super structure is completed. The concrete superstructure would be adjusted from the six pouring sequences per wing to the three pours per wing to allow the project to start on the façade at around 4 months behind schedule.

When a SIPS breakdown is applied to a project, the schedule of that topic that is undergoing the SIPS process must be extremely detailed when compared to the original schedule of events. The process assigns durations for each activity and the crew size that will be needed to perform that task. The building must be also broken down into zones to allow for linear construction to take place as crews work to complete the building in the most efficient manner possible in order to decrease the project schedule. This method can be used, and is so efficient because the activities are sequenced not just by day, but they can get as specific as the hour or minute that the task at place must be performed.

A SIPS schedule focusing on the building's façade will be an interesting topic to look at due to the fact that the project is off track from its original projected schedule that the owner agreed upon. The SIPS process could be done to see when each piece of the façade of the building needs to be attached to the structure in order to get the project finished in time for its original projected substantial completion date of mid-April 2013. SIPS would be possible due to the fact that a majority of the façade comes in individual pieces and is attached directly to the concrete structure. The façade is made up of seven different types of glazing, precast concrete panels,

and metal paneling, all of which could be sequenced to quickly and efficiently be attached to allow for the schedule delay to be minimized from that of the original proposal. By decreasing the delay in the schedule through the study of short interval production scheduling of the façade, the original problem of the delay in the schedule due to the relocation of the sewer main can be hopefully be significantly reduced.

Potential Solutions

If the SIPS analysis of the building's façade is done correctly, after the super-structure is constructed, the following could be potential solutions:

- The schedule could be reduced from the estimated four months and the team could then be closer to accomplishing their goal of turning over the building's core and shell to the interior fit-out contractor closer to the original estimated completion date of mid-April in 2013. If the schedule is reduced from four months, there could be associated costs that may be reduced. The costs of this project were not a major influence on the job, but it may be interesting to compare how much savings would be done if the schedule is completed earlier after the water main relocation adjustment was done. In the end, the analysis could prove that the SIPS study of the façade could be influential by reducing both costs and the duration of the schedule.
- The middle ground of the two possibilities is that time would be saved in some areas, but lost elsewhere, which would deem the SIPS process impractical in the end. In other words, no value would be either added or lost to the overall project.
- The analysis could also be concluded that no real value is added to the project at all and that the façade is already efficiently assembled without the use of SIPS. In the end, it would be concluded that the SIPS analysis not only doesn't produce savings, but would not be feasible. This could possible be due to the fact that the process doesn't save time in the schedule, and the analysis was not able to reach the goal it began with.

Methodology

To properly complete this analysis, the following steps must be completed below. A visual representation of the steps can be found in figure 4 on the following page.

1. Research must be completed on the SIPS analysis of similar buildings with similar façades. (i.e. Case Studies)
2. Research any information on typical crew sizes for the installation of a façade similar to Memorial Vista in a similar geographic location. When doing this, the productivity rates of the work must also be noted to ensure that the SIPS analysis of Memorial Vista is reasonable in the end.
3. Study the make-up of the façade and the sequencing that Davis construction proposed. This will help determine the zones that the work will need to be broken down into. It is also critical to see how Davis fastened the façade to the structure and what equipment

they used to do the job to prevent an analysis from becoming out of the realm of modern workers.

4. Develop a sequence of work with respect to the project schedule and the durations that need to take place with each task along with the crew sizes needed. This step includes making a detailed schedule to show the critical path of the façade installation process.
5. Explore any cost savings or losses associated with the time that the SIPS analysis is able to sway the schedule. This will be done by looking at equipment and labor costs that would be saved over the installation of the façade.
6. Develop a recommendation of whether or not implementing SIPS would successfully achieve the original goal of reducing the schedule or not.

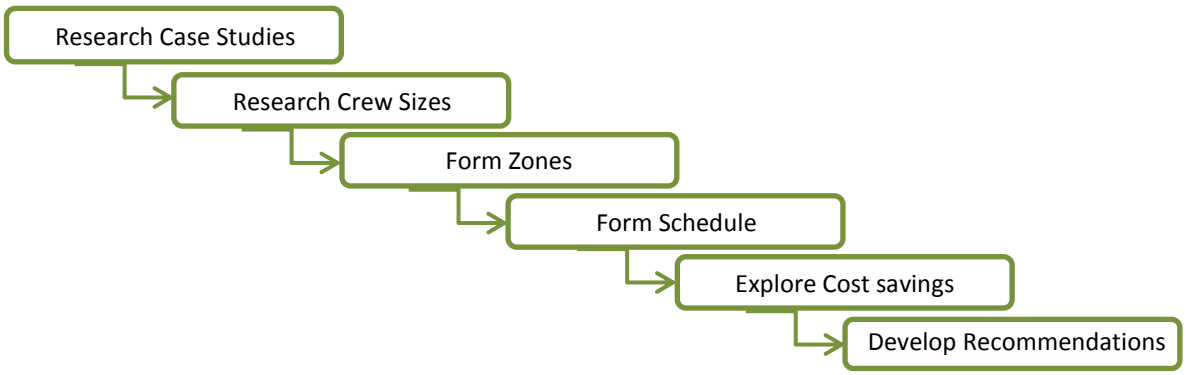

Figure 4 – Steps to Performing Analysis I on Memorial Vista's Façade

Expected Outcome

It is believed that if a SIPS analysis is implemented after the superstructure has been completed, that the study of the façade can be done to reduce the schedule by some time. It is probably unlikely to reduce the schedule fully to get back on track without the use of over time, but both options will be looked at. The cost saving should also increase if time is decreased due to the fact that these are inversely related to one another based on the fact that the longer the workers and equipment is on the site performing the job, the more money is paid to do so. This theory does not take into account the cost of overtime, which if done could significantly increase the cost. After the analysis is completed, the crews and tasks that make up the activities will be outlined in extreme detail, which allows for the completion date of the project to be more predictable. If the schedule were to be decreased in time, the overall problem would have been addressed and hopefully reduces the impact of the sewer main relocation.

Analysis II – Prefabrication & Study of Photovoltaic Windows

Problem Identification

The main problem for the construction of this building, as stated in Analysis I, is the under estimated length of the utility relocations. This resulted in an extended project duration. Based on the unforeseen conditions, the project was extended around another six months than originally projected. To help get the construction of Memorial Vista back on schedule the team at Davis looked at every aspect of the future activities in the schedule to see what would be combined or done more efficiently.

One thing that could have been focused on was the use of prefabrication of elements to quicken the installation process. Since the building is simply a core and shell method that is to be turned over to another team to perform the interior fit-out, the most logical items to prefabricate would be the elements of the façade, specifically the glazing. This structure is erected with seven different types of glass all of which are mounted to the structure of the building in small sections where each pain or unit is fastened with the help or a crane or hoist. The installation process then flows across the building on each floor and progresses up the structure. This is heavily time intensive and could be expedited through the use of prefabrication. If the window units were to be attached to the structure in a way that more than one is attached at a time, this could hasten the schedule. If the window units were pre-manufactured, the sealant between each window has the potential to be a tighter seal than those done in the field allowing for the quality control of the item to increase.

Background Research Performed

If Memorial Vista would have the glazing of the building be constructed in a modular fashion, the schedule could be potentially shortened after the sewer main relocation created a 6 month extension to the original schedule. Case studies would have to be researched to find the average number of panes that can be prefabricated and shipped to the site, and the total weight that the window system could weigh would also have to be found. In order to figure out how much time could be saved in the schedule, a sequencing plan could be made along with a schedule of the installation process.

Memorial Vista is accompanied with 65,558 square feet of glazing around the entire building's façade, with the addition of precast concrete panels and metal panels. This being said, the façade offers both physical and psychological benefits to the future employees that occupy the building. The views and abundant sunlight allow the building to be a healthier, more desirable space, but in the end, the glazing has low thermal resistance when compared to other building envelopes. Taking this into account, keeping the tenants of the building within their thermal

comfort zone costs an extraordinary amount of money throughout the year, based on the seasons. These prefabricated window systems could then be designed with photovoltaic glass to reduce the cooling loads of the building in the summer and heating loads in the winter. This is done by allowing the visual light to enter the building and illuminate the space like an ordinary window, but the inferred sunlight would be harnessed in the photovoltaic cells within the window. By installing photovoltaic windows modularly, the carbon footprint of the building could be reduced and could potentially add LEED points to the construction process.

Potential Solutions

If the prefabrication of the glazing of the building is to be completed and substituted for photovoltaic glass, the following could be potential solutions:

- After the prefabrication of the glazing takes place, the schedule is reduced significantly, which results in the project being turned over earlier. The photovoltaic windows could also potentially add value to the building by being installed in locations where sunlight hits the building directly, and therefore generates an electric load to reduce the cost to maintain the building.
- The prefabrication of the building could also take just as long as the original design due to the fact that the prefabrication time takes longer, or even due to the fact the attachment and installation of the larger glazing unit could take more time. If this is the result, the prefabrication may not be a suitable way to shorten the length of the schedule.
- The other result if that prefabrication takes longer than the original glazing that was to be fastened to the building. This could be due to the time it would take to manufacture or the installation and equipment that would be needed to install the prefabricated windows. The photovoltaic windows could also be deemed useless if the energy they produce is minimal and the payoff time for the windows would be longer than the life of the building.

Methodology

To properly complete this analysis, the following steps must be completed below. A visual representation of the steps can be found in figure 5 on the following page.

1. Research must be completed on the implementation of prefabrication of the building's glazing and compare the façade to other similar instances. (i.e. Case Studies)
2. Perform research on prefabrication of windows and locations in which they can be manufactured to see logistics of how and when the prefabricated windows can get to the site and when they would need to be ordered and delivered by.

3. Design a flow diagram of how work will proceed around the building, along with a schedule to determine if the prefabrication of the glazing would be useful in shortening the overall duration of the project.
4. Research the difference in installing photovoltaic windows, as opposed to traditional windows that make up the current building's façade.
5. Research the benefits and setbacks to installing photovoltaic windows.
6. Perform a solar study of the building and its geographic location to find where the photovoltaic windows could best be placed for optimum returns.
7. Find the electricity generated through the use of the photovoltaic windows.
8. Develop a recommendation of whether or not implementing the prefabrication and photovoltaic windows would successfully achieve the original goal of reducing the schedule and the building's carbon footprint or not.

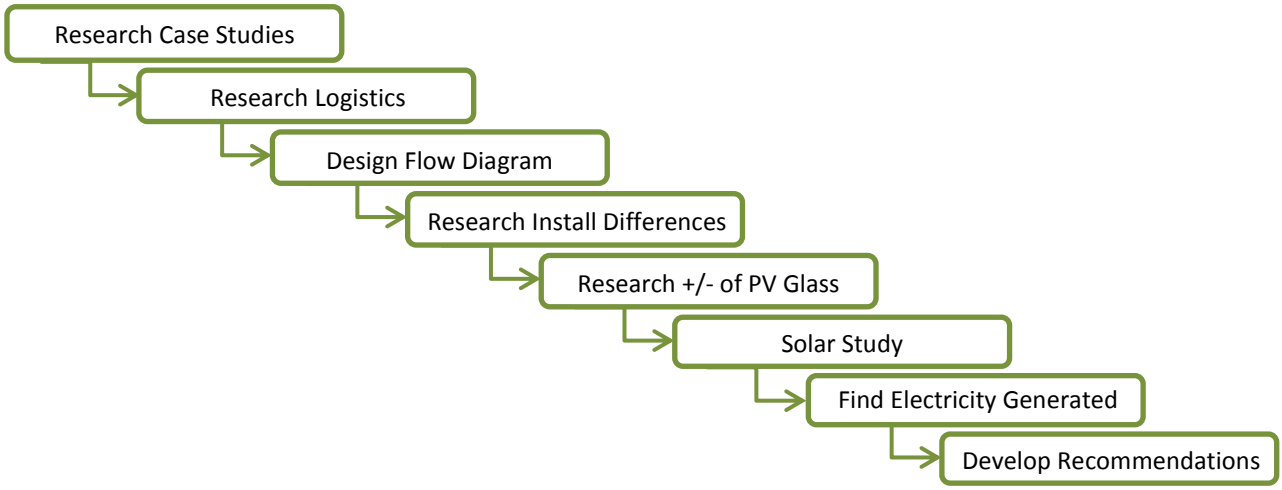

Figure 5 – Steps to Performing Analysis II on Memorial Vista's Prefabrication of Glazing and the Implementation of PV Windows

Expected Outcome

Once the study of prefabrication has been performed, it is believed that the schedule will be reduced due to the fact multiple pieces of the glazing would be hung at once. If this is true, in theory, the time it takes to install the prefabricated glazing should be significantly less, but research needs to be performed to see where time is saved and or lost. It is also expected that the photovoltaic windows will work best on the south façade of the building due to the fact this is where most of the sun light hits a building year round in the northern hemisphere. After significant modeling and data collection has been completed, the information should prove that the photovoltaic glass has the potential to save the owner a significant amount in the overall cost of running the building. If these assumptions are correct, the analysis will have helped solve the initial problem successfully.

Critical Industry Issue Analysis

The 22nd Annual PACE Roundtable was held this year for the fifth year Architectural Engineering students at the Pennsylvania State University. This event was put together to provide insight on current industry issues and topics for students to study. After hearing numerous industry members discuss leading issues and design implementations currently being used, it was obvious that prefabrication is an intelligent option for reducing the overall duration of the schedule. Since the line stop was necessary to relocate the sewer main on site, the schedule for Memorial Vista had to be severely altered and was extended to be around six months longer in schedule than originally projected. If the prefabrication discussion from the PACE event could be taken and applied to a system of the building to decrease the duration of the schedule, than the team could be closer to achieving their goal of getting back on their original schedule. In the end, the goal of this research is to outline the feasibility of prefabricating the glazing of the building, all while studying the solar patterns of the location to see if the implementation of photovoltaic windows could reduce the cost of the building load for the owner.

To see if this goal could be achieved, interviews could be conducted in order to collect information on the logistics of changing the original design to a modular design with photovoltaic windows. One can reference Appendix B to view potential interview questions for an industry member.

Another factor to complete the proper analysis of the prefabrication and implementation of the photovoltaic windows is the resources needed to do so. These can be found listed below:

- PACE Members specializing in prefabrication
- AE Faculty Members – In order to get ideas for prefabrication improvements
- Case Studies
- Davis Construction Team Members
- Onyx Solar Assistance Team Members (sales representatives)

Analysis III – Implementation of an Automated Parking Garage

Problem Identification

The utility relocation process was a severely influential stage early on in the project and heavily changed the original schedule and sequencing of the job to attempt to make up time on the job. Although these setbacks were a result to unforeseen conditions, the time must be made up as much as possible to hand over the job as close to the original time as possible. Items and sequencing processes on the schedule were studied and performed in the most efficient manor but the schedule remained around three to four months behind the original schedule.

One of the main reasons that the schedule could not be fully shortened was due to the fact that the entire site of 4.7 acres needed to be dug to the lowest footer depth in search of contaminated soil. The original twenty-five test bores over the 204,966 square feet of the lot showed some minor contamination in the soil, so the land was assumed to be contaminated as a whole. This site can be seen in figure 6 below, where it is important to note that since the entire site was to be excavated there was no one area that could be an assembly point, staging area, or location for job trailers. These specific areas crucial for a job site were to be sequenced and changed based on the work taking place and the schedule of future events on the project. During excavation, if the soil was found to be contaminated, the proper techniques were to be used to dispose of the toxic soil. As the excavation process was undergone, it was found that the soil was not contaminated in a majority of the lot. In the locations where the soil was contaminated, the soil was quickly and efficiently removed and disposed of.

In the end, the 4.7 acre site was dug to a depth of around 29.17 feet equating to a volume of just over 221,000 cubic yards looking for contaminated soils. If the site did not have to be dug this deep or there was something that could be done to eliminate contaminated soil, the schedule would have a better possibility of getting back on its original path.

Figure 6 – Site to be Excavated courtesy of Davis and Google Maps

Background Research Performed

Since the utility relocation process was scheduled to be completed early on in the project and took so long to complete a line stop, a redesign of the building could have been performed to help save time and get the project turned over to the owner on time. A redesign that would have been influential for both problems would be the design of an automated parking garage. Before this could be done, the site would have to be studied further to see how contaminated the soil is and what can be done to mitigate the contamination. If a simple procedure could be done in substitute for excavating and removing all of the soil, a large chunk of time in the schedule could be saved.

Once the soil contamination was completed the parking garage could be constructed. After some research was conducted, it was found that the average automated parking garage can be as small as sixty percent of the volume of a conventional parking garage. Not only is the overall area smaller, but the depth is also significantly reduced of each level. This can be seen in both figures 7 and 8 below, where the vehicles are parked closer together both horizontally and vertically. This would allow the new garage to quickly reach the original number of 556 parking spaces. In the end, this increases the revenue producing square footage of the garage, reduces the material needed for construction, and could potentially shorten the length of the construction of the garage due to the decreased depth that needs to be dug to construct the structure.

If the soil contamination is able to be easily mitigated from the site and the automated parking garage is put in place at sixty percent of the area and half of the depth, the schedule will be significantly reduced to allow for the completion date to be even closer to the original projected completion date. This would then allow Davis to turn the project over to the interior fit out team, which allows the owner to get tenants in the building.

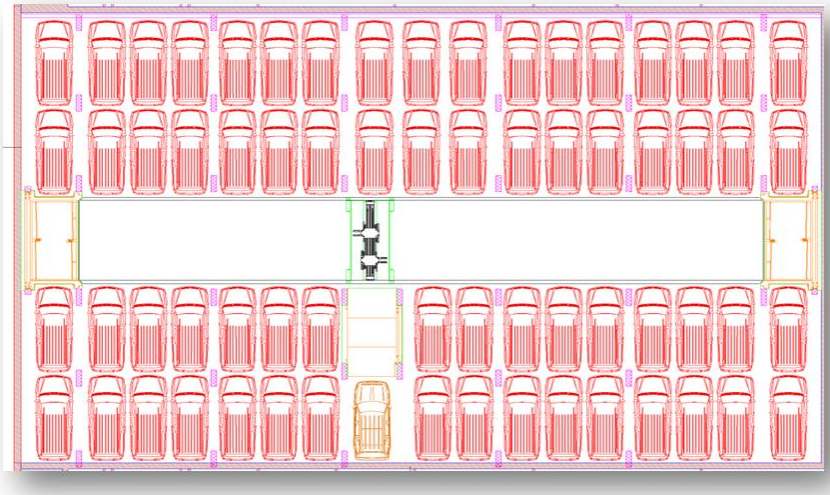

Figure 7 – Horizontal Layout courtesy of Parking Development Solutions, LLC and Davis

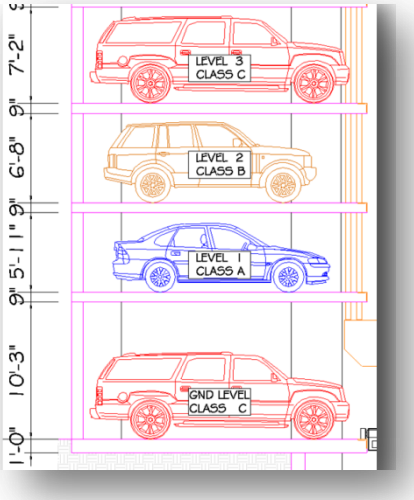

Figure 8 – Vertical Layout courtesy of Parking Development Solutions, LLC and Davis

Potential Solutions

If the analysis of the soil contamination is done with the addition of an automated parking garage in exchange for the traditional one designed, the following could be potential solutions:

- If the soil contamination is able to be fixed through an easier method than excavating the site, and as a result - time will be saved. This would not be determined until extensive research was to be completed to determine the most effective way to eliminate the soil's toxins in the shortest amount of scheduled time. By implementing the automated parking garage, the schedule could also be reduced. This would further help the team in their goal of getting back on schedule after the unforeseen consequences of the sewer main relocation.
- The soil mitigation and implementation of the parking garage could also result in being no more effective than the original design, where not time would be saved in the schedule.
- The analysis could also conclude that the mitigation of the soil takes longer than simply excavating the whole site looking for the contaminated soil as it appears and then removing it from the site. This may be found right away, or worse off, the soil could be tested after completion to be found that the soil is still contaminated. This could result in heavy costs to fix. The automated parking garage could also result in a severely increased cost to the buildings construction cost that takes the life off the building in energy savings costs. The other factor that could take place is that the garage could also result in being the same size as the existing garage, or even worse – it could be bigger.

*Note that the outcome could also be a combination of the three outcomes above, where pieces could lead to a shortened schedule and others either don't affect the schedule to do so negatively by adding more time than originally anticipated.

Methodology

To properly complete this analysis, the following steps must be completed below. A visual representation of the steps can be found in figure 9 on the following page.

1. Research must be done on buildings in the area with similar contaminated soil issues to figure out what steps were done to eliminate the soil and cost associated with it. (i.e. case studies)
2. Research alternatives for removing contaminated soil.
3. Choose best alternative that applies to Memorial Vista. All critical issues must be looked at when dealing with how the soil contamination is taken care of and the duration it takes to remove the toxins. Cost is not necessarily an issue due to the fact that the owner is willing to pay to have the soil removed, but any steps that can be done to save time would be extremely helpful in getting the project back on schedule.
4. Research automated parking garages and their applicability to the site (i.e. case studies)
5. Determine if benefits out way the negative issues with an automated parking garage for Memorial Vista.

6. If more benefits, than a parking garage shall be designed and implemented into the building. Here, the garage will need new circulation plans to show how the garage differs from the previous design.
7. Study the differences in cost to run the automated garage as compared to the previous traditional garage. The automated garage will have no human occupancy so there is no need for lighting of copious amounts of fresh air. This should be a potential topic for a breadth, all while showing cost savings.
8. Develop a recommendation of whether or not implementing the automated parking garage would successfully achieve the original goal of reducing the schedule or not.

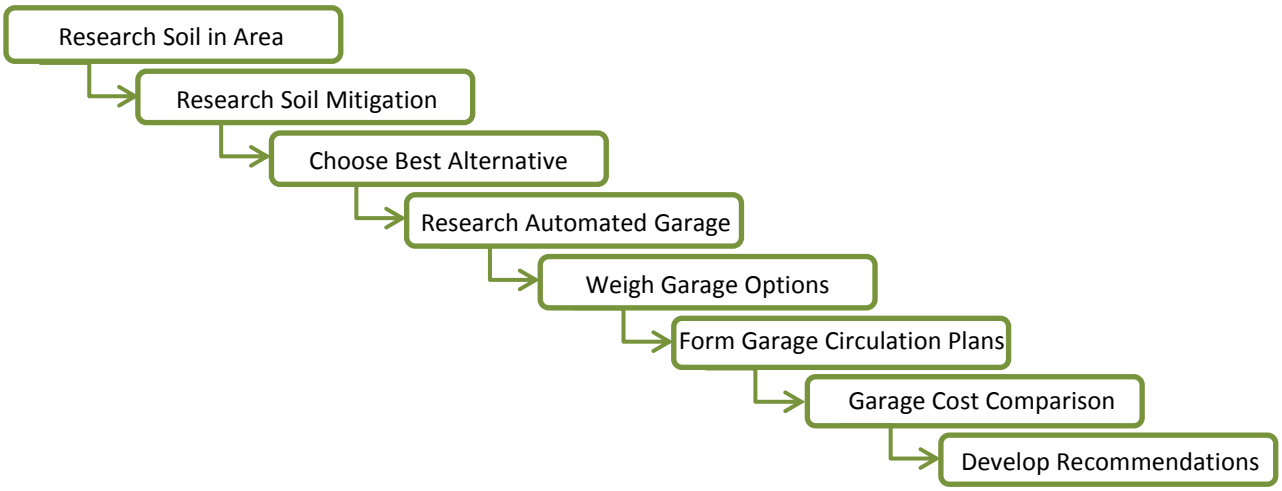

Figure 9 – Steps to Performing Analysis III on Memorial Vista's Parking Garage

Expected Outcome

After this analysis is completed, it is assumed that the outcome will be that the parking garage will be significantly reduced in size – both horizontally and vertically. If this is true, the schedule could be reduced but the major influence on the schedule is whether or not the soil can be mitigated without excavation. If there is some substance or method that removes the toxins without removing the soil, this would save enormous amounts of time and impact the schedule by getting the buildings sequencing back on schedule at an early phase in construction. In the end, the soil mitigation and parking garage redesign are projected to significantly save time in the schedule and bring the team closer to their original goal of substantial completion. This could also result in a lower insurance premium and less interest expenses for the owner due to the fact there will be no human beings in the parking garage and the garage should potentially be turned over faster than a traditional garage as previously designed for the project.

Analysis Weight Matrix

The following is a table that shows the focus that will be devoted to each analysis during the spring 2014 semester and how they apply to the core topics that the Architectural Engineering Department strives to cover. Table 1 below shows the analyses that will be studied and the breakdown of how they apply to the critical issues.

Table 1 – Analysis Weight Matrix

Analysis Weight Matrix					
Analysis Description	**Critical Research Issue**	**Value Engineering**	**Constructability Review**	**Schedule Reduction**	**Total**
SIPS Scheduling Applied To Façade	5%	0%	10%	10%	25%
Prefabrication and Study of PV Windows	15%	5%	5%	10%	35%
Implementing an Automated Parking Garage	10%	10%	5%	15%	40%
Total	30%	15%	20%	35%	100%

As seen in table 1, the largest focus will be put on the implementation of the automated parking garage in lieu of the traditional garage that was designed for the building. One reason for this is due to the fact that it is a complete redesign and there is little information gathered from classes taken in the Architectural Engineering major at the Pennsylvania State University, so research must be done individually. The other topics will also be studied in depth, but there is some previous knowledge that will be helpful in the study of these topics.

Finally, it is important to note that the heaviest critical issue being studied is the schedule reduction. This is the main focus and theme around the research to be completed all due to the fact that the early stages of the utility relocations led to a significant increase in the overall length of the schedule.

Conclusions

The length of the schedule was such a large concern for the team on this project due to the fact that the utility relocation process early on in the project took more time than what was projected. To make up for this, activities in the schedule were reorganized, but not all the time was completely gained back. In the end, the overall goal of the analyses is to get the project back on schedule after unforeseen conditions added significant time to the overall length of the project. Applying short interval production scheduling to the façade could potentially save time in the enclose process of the building and this would decrease the overall duration of the project schedule. Prefabrication of photovoltaic windows also has the possibility to decreases the length of the schedule, as does the implementation of an automated parking garage.

A short interval production schedule is known to decrease the length of schedules when needed, all while promoting increased worker productivity. This scheduling could be applied to the façade of the building to allow the components of the enclosure to be attached to the structure more rapidly, but the quality should remain the same. If the installation process and scheduling of activities of the enclosure of the building could be studied and performed in a quicker, more suitable manner, the project could become closer to being back on schedule. The next analysis to get the project back on schedule was the prefabrication and prefabrication of photovoltaic windows along with their frames. By installing these windows in a fashion where large lifts would be done to fasten the curtain wall to the structure, some of the human error that could result in the installation process could potentially be removed. This is due to the fact that fewer connections would be made on site, which would save time in the installation process. The final analysis proposed was to mitigate the contaminated soil and then construct an automated parking garage in lieu of a traditional underground parking garage. This would reduce the size of the area that would need to be excavated both horizontally and vertically. In the end, an automated parking garage would save both time and money for the owner. Through research of case studies and applicable information, these analyses will be applied to Memorial Vista to see if they are applicable in reaching the goal of reducing the overall schedule of the project.

Appendix A

Breadth Studies

One of the requirements for thesis is to have breadths in two areas outside of one's option. These breadths must stem off of the original analyses, where a topic must be researched that doesn't necessarily apply to the construction option. For the purpose of this thesis, the first breadth comes from analysis two, where the electrical output of the photovoltaic windows will be looked at along with a solar study for an electrical breadth. The second breadth comes from the third analysis, where the parking garage will undergo an architectural redesign due to the fact it is being altered to become an automated system instead of a typical underground garage.

Electrical Breadth

The first breadth to be looked at falls under the second analysis. Here, the glazing that accompanies the structure will be looked at. These windows are being altered to be made of photovoltaic glass, where visible light passes through the window unit, but inferred light is harnessed in cells within the window and converted to electricity. A solar study will have to be completed to find where the windows should be installed based on where the benefits from the photovoltaic system could produce the best output. The electricity that they generate would then be calculated for the whole year and show how much energy they produce to reduce the buildings energy load. The photovoltaic system will then be connected with the buildings power distribution system. In the end, the cost of the windows will be compared to the output they create and the time that the windows are able to pay for themselves will be found to show the owner the upfront cost may be worth it down the road when the building is in use.

Deliverables

- A model of the building to use in a solar study to see where the photovoltaic windows could be best implemented.
- Calculations on electric output.
- Calculations to see when photovoltaic windows will pay for themselves.

Architectural Breadth

The second breadth to be looked at falls under the third analysis. This analysis looks at mitigating the contaminated soil and constructing an automated parking garage in lieu of a traditional underground parking garage. For this breadth, the architectural layout will be studied. Since the parking garage designed will be removed and a new automated one will be substituted a model will be created to show the new design and circulation in and around the structure.

Deliverables

- A model of the new parking garage will be produced.
- Flow diagrams will be created.

- A description on how the automated garage still meets all the desires of the owner and how money could be saved due to the fact there would be no human occupancy.
    - Lower insurance costs
    - Lower mechanical load
    - Lower lighting load

Appendix B

Potential Interview Questions

(1) *Have you ever been on a team for a project that was able to implement* prefabrication*? If so, what type of project and where was it implemented?*

(2) *Was the project behind schedule when* prefabrication *was implemented or was it in the initial design plan?*

(3) *For both you and your construction team, what were the benefits and drawbacks to the* prefabrication *process when applied to your project?*

(4) *From your experiences, would you recommend* prefabricating *curtain wall and glazing systems? Have you ever* prefabricated *or dealt with photovoltaic glass?*

(5) *If a glass curtain wall was* prefabricated*, what was the connection process? Did it take less time to attach to the structure than the original frame-by-frame design?*

(6) *Are there particular projects or clientele that are better suited for* prefabrication *or can it be used across most projects in the reduction of the schedule and project durations?*

(7) *Would you be able to list a few items that would require stricter quality control? Are the connections or water proofing details any different than if the system was to be installed traditionally?*

(8) *Are there any special crews or equipment needed to perform the installation of the* prefabricated *glazing?*

Appendix C

Spring Semester Projected Schedule