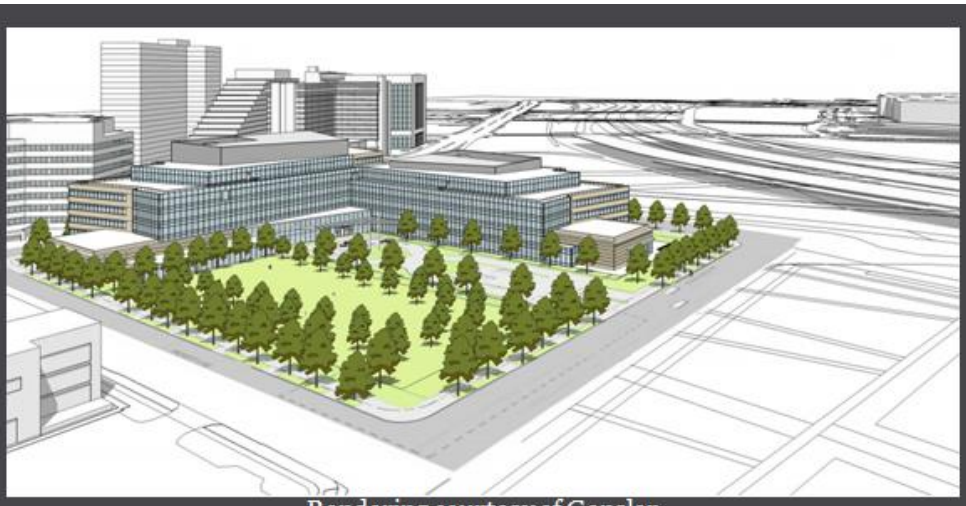

Rendering courtesy of Gensler

Memorial Vista

A North Virginia Office Building

Technical Assignment III

William J. Gamble | 5th Year – Construction Option | November 15th, 2013

Executive Summary

The following technical report it written about Memorial Vista, an office building for an undisclosed aviation tenant in northern Virginia. This report analyzes the schedule acceleration scenarios that the team encountered, items that were value engineered in the early phases of the project, and then the critical industry issues and feedback from an industry member that attended the Partnership for Achieving Construction Excellence (PACE) Roundtable event.

This report will first break down the critical path that Memorial Vista had to follow in order to turn the project over on the projected completion date. The first factor that was on the critical path is the permitting of the building and the equipment and systems that were to go in it. Following the permitting of the building and all the items surrounding it is the site utility relocations. These are critical due to the fact that relocations need to take place for excavation of the new buildings foundation and this process takes a substantial amount of time. Following the relocations is the concrete structure, and then the roofing and the façade to completely enclose the structure to become water tight. The last item that is on the critical path is the elevators within the building. These elevators are influential on the building's critical path due to the fact that there are fourteen of them and the installation process takes such a large amount of time.

After the critical path is established, the report will share how the Davis team was able to accelerate the schedule as needed to accomplish their goals of turning the building over on time. One of the initial problems was that during the site utility relocations, it was found that a sanitary sewer relocation and bypass must be performed. This process was not originally in the schedule because it was not known at the time what was below grade at the project site, but it quickly became apparent that the schedule needed to be adjusted to account for such an event. To get back on schedule, the concrete erection plan was transitioned from pouring the North wing first to doing the South wing first. This is due to the fact that the sewer main was located in the North wing, and was preventing any foundation work from being done in that area. To accelerate the pours, the team also consolidated the number of pours from six to three. This and other schedule acceleration scenarios will be further discussed in the report.

As the schedule was accelerated during the construction process to save time and money, value engineering was performed in the design phase to achieve the same goals as accelerating the schedule. A few of the items that were approved to be value engineered in the project to achieve the same job at a lower than budgeted price were changing the traffic coating in the garage levels to silane sealer to save around $440,000, changing the multipurpose space from pavers to colored concrete to save $37,000, eliminating the inner slab heat system in the Lobby space to save $25,000, and also change the thickness of the stone flooring in this space from 3 centimeters to only two centimeters to save $55,000. This and other value engineered items will be discussed in the report.

Not all of the value engineered material was approved. The report also includes items that were proposed by Davis to be value engineered but were not approved for various reasons. Some of the items that were proposed but rejected were changing the lobby structural glass fin walls to high span walls due to the cost reduction, changing the roof planters on the terraces from stone to cast-in-place concrete but the owner denied the idea to keep the quality of the building higher than average, and then the team also proposed changing the toilet partitions from the stainless steel that the drawings called for to a cheaper painted partition. Most of the ideas that were denied were due to the fact that the quality of the space was not kept, but all ideas were looked at to find what would best suite Memorial Vista.

The second part of the report reflects on the PACE Roundtable event. The critical industry issues sum up the sessions that William Gamble was able to be a part of. The two sessions that are included in the report deal with both safety and the prevention through design, and then the criteria and drivers for effective multi-trade prefabrication and modularization. The report will go into full detail of the sessions and how they can be applied to Memorial Vista.

The last part of the report is the feedback from the industry members from the Roundtable event. This session was a meeting with Bill Moyer from James G. Davis Construction, where he shared potential thesis topics that could be further studied due to the fact that they could possibly apply to Memorial Vista. Some of the ideas that were shared by Bill were to look further into having a checklist for safety in the design phases so designers could form a building that could be constructed in a safer manner. The next idea was to find a way to discover what utilities are below grade prior to the actual excavation process. This could save time later in the schedule due to the fact that team would know what exactly is below grade and could account for this in the schedule. Bill also stated it may be a good idea to look at the foundation of the North building due to the fact that the excavation of the site found that the precast piles would be ruled redundant. A potential idea would be to redesign a shallow foundation in lieu of the deep foundation called for and form a cost analysis. One of the last ideas that was shared by Bill was to study the sequencing of the project. Memorial Vista was scheduled in a way that the interior fit-out would not be bid out and started until the core and shell was to be finished. An area of study could be to linearly schedule the interior of the building in with the core and shell to see how much quicker and cheaper the building could be turned over. Further information will be discussed in depth in the report.

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Schedule Acceleration Scenarios

Memorial Vista is unique in the fact that it is an office building in northern Virginia that will house a leading aviation tenant in the near future as the main east coast office. It also must be stated that this report is only the core and shell phase of the project. Upon the completion of the core and shell, a bid will be accepted in mid-January for the interior phase of the construction process before the tenant actually occupies the space. To reach the goal of completing the project in the allotted time frame, a critical path was determined and set for the project. This path allowed the team to check how their sequencing came together and if their pace would be on track with the projected completion date. To adjust the project and the schedule various factors such as manpower, work hours, and delivery times could be manipulated to allow the project to remain on track.

For this project specifically, it was determined that the critical path for the project began with the permitting process. The permits that were looked at and speculated to be most critical were the sheeting and shoring permits, due to the large amount of work that is done on the site and the safety factor that a process like this brings with it. The next component of the schedule on the critical path was the site utility relocations. As seen in previous reports I and II, the existing utilities below grade on this site are extensive. All around the perimeter and also on the road that originally went through the site contained utilities that were either not labeled, not in use anymore, or were still being used but were intertwined with the actual utilities that neighboring buildings use to remain operational. Some test holes were originally dug to spot check what was below grade, but none were able to fully tell what was below until the work was actually being done. The next critical path item was the concrete for Memorial Vista. Being in Washington D.C., the structure is composed of two-way cast in place concrete slabs with the addition of drop panels at the columns above grade. This allows for shorter floor to floor heights and allows the building to reach five stories in one wing of the building, and six in the other. The concrete is a critical path item due to the fact if it were to be delayed, the interior MEP fit-out and façade would also be delayed and the project would no longer be able to be completed on time without any adjustments in the future portion of the schedule. The next portion of the schedule considered to be on the critical path was the roofing and the Façade. With the installation of this shell, the building would be considered water tight and partitions and other systems would be able to be installed. The final element on the critical path would be the elevators that went into the building. Memorial Vista is different than an average five to six story office building with around 320 thousand gross square feet, due to the fact that the space contains fourteen elevators. The installation of these elevators is very extensive based on the fact that there is a wide range of credentials that must be met prior to the installation phase and after they are installed. The elevators begin installation after the concrete structure is completed, and they are one of the last things to be completed and inspected before the building occupancy can be issued. Figure 1 on the next page visually shows the critical path for Memorial Vista.

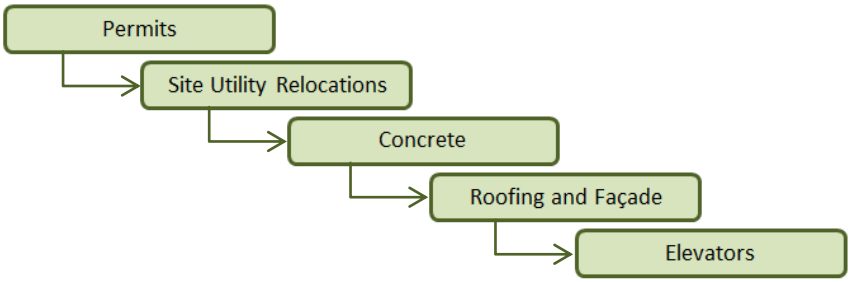


Figure 1 – Memorial Vista's Critical Path Layout

This critical path is unique to this project, due to the owner, type of building and contract, regional location, surrounding buildings, and unforeseen conditions that forced the schedule to morph and better fit the project. Along with the critical path, the risks associated with this project are equally as unique. The biggest risk early on in the project was the scheduling of the project's durations when dealing with permitting. These permits vary significantly due to the factors and characteristics the building possesses that differentiate Memorial Vista from other surrounding buildings. Being that the building needed to be permitted for numerous facets, and the fact that the county approved the drawings, these durations were set in the schedule more as guidelines and would have to be adjusted based on the actual times it took to permit the entire building.

One event that did take longer than the scheduled time was the site utility relocations. Since no real documentation of the utilities for this site was compiled or correct from previous installations, the time frame for relocations was more of an approximation. As a result, there were numerous unforeseen conflicts which required lengthy redesign time. This time to redesign then halted other activities that were to follow the utility relocation and began to bump the project completion date back. One of the main concerns was a sanitary sewer that had not been marked in the drawings and needed to be relocated to continue excavation for the building's foundation. The sequence for removing the gravity and forced main on the site and swapping in the new lines installed below the adjacent street was not entirely flushed out, and as a result, there were some delays to account for planning. It also turned out that there was no redundancy in the sanitary sewer system, and that these were significant pipes for the county. In other words, there was no backup or redundancy for the sewer system nearby so the sewer line had to be shut off and be completely relocated. As such, the team needed to do a complicated tie-in and swap process that cost a large amount of money that was not foreseen in the original conditions. All in all, the sewer main caused numerous delays due to the material (called a line stop) taking a prolonged time to manufacture and then be delivered to the site. Further lengthening the process of the sanitary sewer relocation was the fact that there are only a handful of crews in the country that can tie in the sewer lines and preform the relocation.

Since the relocation and tie-in took so long and was not originally fully counted for in the schedule, the first impacted item was the concrete structure. This is due to the fact that it was next on the critical path of the project to reach the projected completion date. To prevent the

completion date from being extended, the team revised the manner in which the building was being constructed on the job. The concrete sequencing was looked at and it was decided that it would be more beneficial to begin working on the South wing of the building first, instead of the North. The original plan was to start the concrete substructure and superstructure on the North wing due to the fact that this wing was comprised of concrete piles that would take longer in the foundation sequence. The sequencing of the concrete structure was reversed to have the South wing being constructed first due to the fact that the North wing was being impacted by the sanitary sewer relocation, where the South wing was not. To further shorten the durations on the concrete structure in the schedule, the team also consolidated the concrete pours of the floor from six down to only three per wing. This can be seen in figure 2 on the next page, where a webcam on the job is able to distinguish the three pours on one of the early floors being poured. By combining the slab pours from six to three, the team was able to recover most of the time lost from the sanitary sewer relocations.

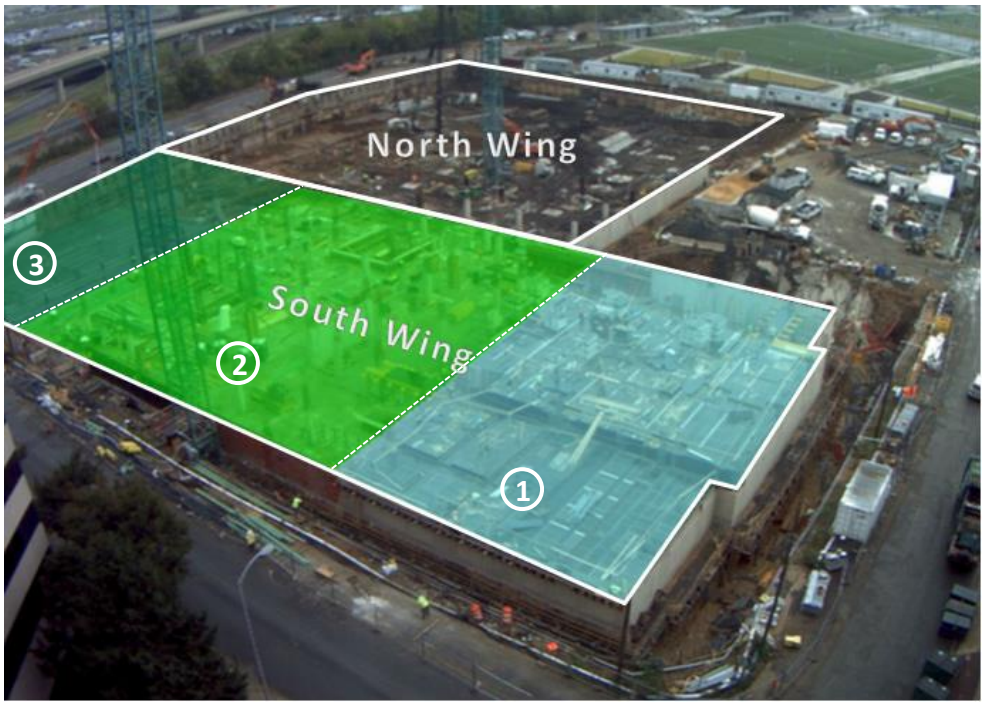


Figure 2 – Concrete Floor Sequencing Pours (Courtesy of Davis webcam)

Value Engineering Implementations

James G. Davis Construction (Davis) was brought on this project when the construction drawings were 90% competed. The team's task was to look at the buildings structure, layout, and materials and propose potential value engineering alternates to those given in the original specifications and drawings. The team came up with a list of close to eighty value engineered items, where thirty-two of them would be implemented in the project to have a savings of just over three million dollars. Numerous ideas were proposed ranging from deleting the traffic coating in the garage levels to revising the garage lighting from LED to florescent fixtures. These items were all done to reduce the cost of construction but there were also a few things the team though of that may not have necessarily deduct initial construction cost, but would eventually reduce the cost of the building in the life span of the structure. One example is the installation of occupancy sensors in the garage level. These occupancy sensors would have an upfront cost, but would save the owner money on the electric bill in the future.

One of the first items the team chose to focus on was the traffic coating in the garage levels P1 and P2. This coating was projected to be around $455,000 for the entire garage, and Davis looked to lower this cost but supply a similar look and composition. The solution was to apply a silane sealer that would provide a waterproof and protective layer on the concrete that would save around $440,000. This is a similar substance, giving the garage floor a similar finish and quality for a significantly cheaper price.

Davis also looked at the flooring in the multipurpose space. This space had a call-out that stated the floor was to be comprised of pavers, but Davis proposed an alternative of colored concrete. This colored concrete would be much easier to produce, due to the fact a dye would simply be added to the slab as it is poured, and then the floor would be broom finished. By eliminating the pavers, the team was able to save the owner a total of just over $37,000.

Within the slabs of the Lobby space, the drawings also called for inner slab heat through the use of electric current. This would have cut down on the heating bill but would have raised the cost of the electric bill each month during the winter months. The team decided that this could be eliminated fully from the building and it would save almost $25,000. The owner agreed and this item was deleted.

Remaining in the Lobby space, the drawings also called for stone flooring that was three centimeters thick and it must be shipped all the way from Jerusalem. This being an already high-end and expensive finish that the owner desired, Davis looked to somehow make the stone cheaper but keeping the look the owner wanted. The solution was to change the thickness of the stone from three centimeters to two centimeters. This minor change saved $55,000 and there is no difference to the naked eye that enters the Lobby space. Keeping the aesthetic appeal of the Lobby space as originally planned, but preforming these value engineering tasks allows the owner to keep the quality that is desired for the building, all while saving money.

One of the other implementations that Davis found in the value engineering process that the owner and architect agreed on and was approved was changing the Betonite water proofing at the vertical foundation walls to sheet water proofing. This was found to be easier to install, with fewer chances of human error and resulted in costing $78,000 less. In the end, the same job would be performed and the water would be retarded from getting in the building, but the sheet water proofing cost a significant amount less.

The following is a table (table 1) expressing a few of the value engineered items that were passed for Memorial Vista.

Table 1 – A few of the Accepted Value Engineering Items for Memorial Vista

Accepted Value Engineering Items						
VE #	Add or Deduct	Item Description	Individual Value	Total Alternate	Included in GMP	Comments
6		**Delete Traffic Coating & Replace w/ Sealer - Except Air Shafts and Vault**				
	DEDUCT	Painting - Precision (Add silane sealer at P1 level)(Delta of DAVIS Est. and Precision) Waterproofing - *James Myers* (Delete traffic coating) DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	
3a		**Replace Pavers at Multi-Purpose Area with Colored Concrete**				
	DEDUCT	Site Concrete - GT DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	Broom finished color concrete.
10a		**Delete All Slab Heat (Lobby Portion)**				
	DEDUCT	Electrical - PerLectric DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	
29		**Occupancy Sensors at Garage Levels**				
	ADD	Electrical - PerLectric DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	Alternate provides occupancy sensors at all garage lighting except lobbies
53		**Delete Mini-Blinds on Typical Floors**				
	DEDUCT	Window Treatments - Accent DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	Mullion extrusions will still include blind pocket for tenant work
25a		**Sheet Waterproofing ILO Bentonite at Vertical Foundation Walls**				
	DEDUCT	Waterproofing - *James Myers* DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	
56g		**Change Stone Flooring in Lobby to Alternate Thickness - 2cm ILO 3cm**				
	DEDUCT	Stone - Bratti (Thickness Change Only) DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	YES	

Since around eighty ideas were originally formulated as possible value engineering items for Memorial Vista, there were some ides that were deemed unlikely to work or were turned down by the owner or architect. Reasons for turning down some of the value engineering ideas could be that the exclusion or replacement of a specific material goes against the integrity of the building and its aesthetic features, or that it went against the fondness of the quality that the building's future tenant expects.

The team originally looked at the glazing and façade of the building and found relatively few items that could be potentially value engineered due to the fact that the structure is fairly simple and fastened directly to the concrete structure. One thing that was found was that the Lobby had a façade composed of structural glass fin walls. The team proposed an alternative solution of being simple high span storefront, but the idea was turned down due to the fact that the quality of the building would have been compromised and the aesthetic appeal would have been altered from that of what the owner desired.

This same reason for turning down the alternative of the high span glass storefront was the reason for the owner and architect turning down the value engineered idea to revise the toilet partitions from stainless steel to pained toilet partitions. If the owner would have accepted the painted toilet partitions in lieu of the stainless steel partitions, than the owner could have saved upwards of $42,000 but the owner felt that the quality of the building and its materials and components were more important than the final cost of the building. After all, the tenant will call this space home after the completion of the building and must be pleased with the office space that they will run their business out of.

One minor value engineering item that the team found was to revise the roof planters that were to go on the balconies of the top floors on each wing from the original design of having masonry planters to potentially having cast-in-place concrete planters. By having cast-in-place concrete planters on the roof areas, the planters themselves could have been manufactured extremely easy and would have save just under $500. The owner stated this would not be the look the building was going for and that it would have been against the owner's goals of having a high quality work space. As a result, the cast-in-place concrete planters were denied and the masonry stone ones remained.

The Davis team also focused on the lighting fixtures that were to be going into the buildings garage. The drawings and architect called for the fixtures to be LED, but Davis found that a savings of $24,000 could be made if the owner switched to florescent fixtures. Again, the owner turned the idea down with the persuasion of the architect due to the fact that the LED fixtures would light the space in a cleaner way and therefore allow the building to have a higher quality look.

The table on the following page (table 2) expresses a few of the value engineered items that were denied for Memorial Vista for various reasons, some of which cannot be disclosed in this report based on the owner's wishes.

Table 2 – A few of the Discarded Value Engineering Items for Memorial Vista

Discarded Value Engineering Items						
VE #	Add or Deduct	Item Description	Individual Value	Total Alternate	Included in GMP	Comments
57		**Change Lobby Structural Glass Fin Walls to High Span Storefront**				
	DEDUCT	Interior Glass - Harmon DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	NO	
42		**Revise Roof Planter Detail - CIP Concrete ILO Masonry / Stone**				
	DEDUCT	Concrete - Facchina Masonry - Genco Stone - Bratti (BUDGET) DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	NO	
46		**Revise Toilet Partitions to Painted ILO Stainless Steel**				
	DEDUCT	Toilet Partitions - Material Distributors DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	NO	
63		**Revise Garage Lighting from LED to Fluorescent Fixtures**				
	DEDUCT	Electrical - PerLectric DAVIS Markups (5%)	Omitted for Confidentiality	Omitted for Confidentiality	NO	$46 premium per fixture - For Additional LED's required due to reduced light levels, add $149/each

In the end, value engineering was found to be a crucial part to the project, where the cost of the project was reduced, but the quality and the original characteristics of the building were able to remain. The value engineering process is most influenced by the owner of the building. Numerous ideas can be proposed, but only ideas that remain aligned with the owner's goals and intentions while lowering the cost of the construction process will be implemented. For Memorial Vista, the owner's focus was on the schedule and safety, but most importantly quality. The owner cared that the project was completed on time due to the fact that the interior fit-out of the building was not to be started until the core and shell of the building was completed. Safety is always a main factor due to the fact no owner wants an unsafe building that could either result in a project delay or increased project costs. Lastly, the owner of this building focused on quality due to the caliber of clients that will be occupying the space after it is completed. The occupants are leaders in the field of aviation, so the space must look sleek and remain a healthy and productive space for the employees to get their job done.

Critical Industry Issues

PACE Roundtable Overview

This next section along with the following section of the report are formulated with the help and information provided by the roundtable event put together with The Partnership for Achieving Construction Excellence (PACE). This event was held on November 6th and 7th, 2013. The event is an annual event held at the Pennsylvania State University where Architectural Engineering fifth year construction students and construction industry professionals have the opportunity to come together and discus current industry topics that seem to be thriving and upcoming. For this event, there were two breakout sessions, where both students and industry members alike had the choice between three topics to go discus and learn more about. The first breakout session was comprised of safety and prevention through design, information management for the workforce, and assembling effective cross functional teams. One of the three subject matters was chosen and discussed. This is also true for the second session, but the topic material changed to owner phasing decisions for cost effective retrofits, efficient delivery of facility management information, and criteria and drivers for effective multi-trade prefabrication and modularization. The following report is based off of the informative sessions that William Gamble was able to be a part of. The first session that he was able to accompany was the safety and prevention through design. The second session was the criteria and drivers for effective multi-trade prefabrication and modularization. The following will go into further detail of each session. Please reference Appendix A for the actual layout of the critical industry issues from the Roundtable event.

Breakout Session 1

The first session that William Gamble was able to attend was the discussion on safety and the prevention through design that can take place early on in a project to help eliminate safety problems in the future of the project not only as it's being constructed, but also as it is occupied by the tenant of the building. Numerous industry members accompanied this room to share what their company has been doing and what they have personally seen or heard in the field. The discussion was kicked off with the question of how aware the design community is when it comes to the impact they have on construction safety, and the response from Andy Rhodes from Southland Industries was that they are normally unaware of it and in most cases safety in the design phase is simply a "happy bi-product". It became clear that most industry members felt that safety is considered to be an expertise of the contractor in the construction phase and not so much so of the designers in the early stages. From the discussion it was established that safety is normally enforced from the owner, and then this knowledge and care for safety is passed down through the ranks of all workers within the project. These safety features must not be implemented strictly during the construction phase and forgotten about during the occupancy of the building, but rather transitioned to when the owner is occupying the

structure. An example discussed at the PACE event was having D-rings fastened directly to the concrete structure of a building so that there was always a tie off point during the construction of the façade of the building. These tie-off points would remain in the building if any work was to be done in the future; allowing safe procedures to take place during construction and any maintenance after the building is occupied.

One of the second ideas that the group discussed in the breakout was the fact that no contract in the market as of now really has any language in it that discusses and enforces safety and collaboration in the early design phases of a project. This contract language and enforcement would lead to higher front end costs to produce early planning, but this cost could easily be shown to save the owner money further down the line of the project. An example of how the design can be looked at is by using something like augmented reality to focus on the buildings features to make the space safer. One example would be to raise the window sills to 42" so that no railings would need to be put in place in the construction process, or allow access panels to be around five feet off of the floor so a ladder is unnecessary. One thing that was brought up was that on one of the SKANSKA projects, they worked with the design team to put in a fin pillar in the shaft of a building under construction. This fin pillar has an eye wash station on every floor and also a vacuum shaft that allowed the workers to hook a hose up to the shaft and vacuum the waste right out of the building. This eliminated the clutter of vacuums and allowed the site to be exponentially safer.

In the end, the session led to the fact that the United States has no real directions or guidelines that point the designers in the safest direction. If something like this was put into place, the building would be designed and constructed safer and cheaper in the long run. One way of ensuring safety would be implemented would be to have a safety checklist similar to the Leadership in Energy and Environmental Design (LEED) checklist that focuses on making buildings greener and have smaller carbon footprints. This safety checklist would focus on common design failures that are easily overlooked in the design phase. An example of this is having the VAV's only one foot above the ceiling tile instead of the random elevation of six feet. By having the VAV's located lower in the plenum space so they are easier to access and are therefore safer to install and maintain. In the end, points would be rewarded for following the checklist and a financial incentive could be rewarded similar to that of LEED, where a certain number of points would have to be reached. To further discuss design issues that are normally overlooked, one would be able to contact Andy Rhodes from Southland Industries. He is a design engineer at the mechanical contracting company and had numerous points on areas that are usually overlooked in the design phases of most projects.

During this meeting of both students and industry members, it was surprising to learn that there was no safety design in the early stages of a project. Every company out there stresses how their companies greatest core value is safety and getting their employees home at the end of the day, yet no one has taken the safety portion back to the design phases. It is only enforced during the construction portion of the project. It was apparent that this will not be

true for much longer, and companies are striving to get safety to be a core component in a building's design and layout so that the building process as a whole can be as safe as possible.

This implementation of safety in the early phases could easily be applied to any project, especially Memorial Vista. If safety was to be looked at earlier, less time would be wasted on the site trying to ensure all procedures are being completed in the easiest and safest manner. Memorial visa could have performed an augmented reality session with safety personnel from within Davis, designers, code inspectors, and other critical players in the buildings layout process to discuss the layout of items to be safer in the construction and occupancy phases.

Breakout Session 2

The second session William Gamble was able to attend was the session on criteria and drivers for effective multi-trade prefabrication and modularization. This session provided material on the fairly new topic of modularization within buildings. Through the use of building information modeling (BIM), virtual models can be manufactured to allow prefabrication to take place. This prefabrication can take place both offsite and on, but multi-trade prefabrication is normally manufactured in an offsite location. These satellite facilities allow the prefabrication to be of a higher quality, preformed safer, removes some human error, and allows the fabrication process to be more efficient.

One of the first topics that arose in the discussion was the fact that prefabrication needs to be considered in the design phase, especially in the case of multi-trade prefabrication. This is due to the fact that a well-planned out design must be completed and looked at extensively to eliminate clashes and problems before being prefabricated. Once in the prefabrication process, the building must have repetition in the prefabricated modules in order to save money. The more repetition that can take place, the more money can be put back in the owner's pocket. This is included in the design phase due to the fact that if the designer can design repetitive modules within the building, they will be easier to manufacture in a prefabricated manner.

Another factor that must be looked at in the design phase is the logistical issues that arise with a prefabricated systems going into a building. In the case of the concrete structure at Memorial Vista, prefabrication could have been done to eliminate the massive amount of concrete trucks that needed to go in and out of the site to deliver the concrete. With the manufactured slabs, there would be one truck per piece, and within the slab would be the conduit and other systems that could be laid within the structure to save time and money. One negative to this delivery of the prefabricated systems would be that a large laydown area would need to be allocated, and if there was a delay in the delivery, a blip in the schedule could take place and push the completion date back from its forecasted date.

The second topic that was discussed was the actual cost of the prefabrication. Like stated before, for prefabrication to significantly decrease the cost of the construction process, there

must be repetition within the building and this must be translated all the way back to the design phase. This means that early involvement on a project is a necessity. One of the other hidden costs with prefabrication is that some material must be stored off site. With the storage of material off site is the actual cost of the space, the transportation costs, and then the insurance on the material in that storage space. The other cost that can easily be overlooked is the cost of inspections of the prefabricated multi-trade items. There are numerous inspections in the manufacturing plant that allow for higher quality items, but then more inspections take place in the field. It was surprising to find that in some instances, the same item can be inspected twice which is not only a waste of money, but also time. An industry member that one would be able to further contact to find out more about the impacts of multi-trade modularization would be Chuck Tomasco from Truland Systems.

This implementation of multi-trade prefabrication would have a hard time applying to Memorial Vista. This is because this office building is a core and shell building, where each wing of the building varies. The façade of the building is already simple in nature due to the fact that the curtain wall, precast panels, and metal cladding fasten directly to the concrete structure. The only thing that would have the potential of being modularized would be the MEP and fire suppression systems within the building. These systems would have had to be redesigned to be more repetitive and symmetrical. The current design for the mechanical system is composed of variable air volume units that are spread randomly throughout the building due to the fact that the interior of the building has not been established, and will go in the design phase after the completion of the core and shell. Some of the other systems may have the ability to be prefabricated, but these would have had to have been extensively modeled using building information modeling and would end up costing more upfront than the saving in the end from the prefabrication process. In the end, the team at Memorial Vista would have had to look at both the positives and negatives and weigh their options in whether or not multi-trade prefabrication could have been beneficial.

Feedback from Industry Roundtable

The last session of the day was a breakout session with an individual member from the industry to share their input on the student's individual thesis buildings. William Gamble was able to attend an interactive meeting with Bill Moyer from James G. Davis Construction. Since this project is a Davis project, William felt Bill Moyer would be able to have the most influential input based on the fact that he would know information on the building without having to go into too much detail about the project. To see the layout of the industry member feedback form from the PACE Roundtable event, please reference Appendix B.

The first thing that Bill recommended based off of the informative sessions that were presented earlier in the day, was to look further into creating a checklist for the designers of the building to form their building around. If this was done in the early stages of Memorial Vista, the team would create a safer site and would save money later in the job. This checklist must be similar to the LEED checklist and have a reward system and points to reach levels of safety. Various levels could lead to monetary incentives or tax reductions once in place. To further look into this, Andy Rhodes from Southland Industries could be contacted to find problems in the design phase and areas where points could potentially be rewarded.

Another thing that came up in discussion with Bill Moyer was the fact that the utilities below grade at this site were so extensive and ended up being such a large and influential part of the critical path that it may be a good idea to look into a way to find out what is below grade. This early forensics of what is below grade would be done before the construction process and before the relocation process takes place. If a better initial study of the underground utilities was performed, the schedule could have been adjusted early to account for such a mammoth amount of utilities to be relocated. To receive further instruction of how this forensics process of the underground utilities takes place, it was said that one could contact Naresh, an estimating consultant for Davis, and he would be able to discuss different ways to perform the utility relocations in a better manner. Another contact that one could reach out to would be Busy Ditch, a utility contractor. They would be able to provide the logistics and up and coming processes that could be applied to this site. The final step to this research topic would be to find a case study that has a similar issue of having a large amount of utilities underground, and what was done to prevent the schedule from slipping and avoiding issues.

One of the third possible research topics that was discussed was to look at the foundation of the building. This building requires precast concrete piles in the North wing of the building. With precast concrete piles, the lead time on these is quite long so the order was sent in prior to excavation. Once excavation did actually begin, it was found that the bearing capacity of the soil was greater than anticipated and the piles would actually be redundant if installed. Since they were already being manufactured and shipped to the site, the piles were put in place anyway. It was discussed that a good research topic may be to redesign the foundation and discover if there would be a large cost savings if the foundation was switched to a shallow foundation with column piers and footers. To perform these calculations, a study could be

performed in a few footing locations with the help of Walter Schneider and notes from CE 397A – a foundations class at Penn State.

The last topic that Bill Moyer discussed was looking at the sequencing of the project and the schedule that was underwent. For Memorial Vista, the core and shell is being completed now and then after this has been completed, the interior fit-out will be set out to bid and be completed. Since the core and shell needed to be finished before the interior fit-out is started, there would be a longer schedule and more cost associated with the project. Bill stated that it may be creative to look at ways of overlapping the two schedules and studying the difference in costs and project duration. To study this, one would have to get in contact with the team that was on site for the construction process. They would then be able to share critical information in how the project could be better sequenced and how to change the schedule to accelerate and adjust it to better suit the project. One would also have to contact the estimating department at Davis to find information on the actual construction costs of the project and try to obtain the information on the interior fit-out pricing. This would be a little more difficult to do, seeing that the interior fit-out is about to be bid on in the future and the information must not be extended to be public information.

Appendix A

Critical Industry Issues

The 22nd Annual PACE Roundtable
November 6th & 7th, 2013

Session 1

Topic: Safety – Prevention through Design

Research Ideas:

1.) Look into a contract that has language to include safety and collaboration within the contract
    i. Will have some front end cost, but need to show owner that the cost will be worth it in end.
    ii. Owner needs to be on board with safety.
    iii. Safety starts at top and is passed down chain.
    iv. Maybe look into augmented reality with 'safety coordinator' to walk the model and find things that can be fixed in the design phases to be safer.
        a. Example 2 – Make the window sills at 42" to eliminate the use of railings later in the construction process.
        b. Example 1 – have access panels only a few feet off of the ground to eliminate the building engineers from having to get a ladder to maintain the building.
        c. Example 3 – Have fin pillars in the shafts during construction that have eye wash stations and cleaning vacuum shafts.

2.) Group discussed the fact that there was no real guideline for designers to follow in the early design phases of a building.
    i. If put into place, building would be designed and constructed to be safer and cheaper.
    ii. Maybe form a checklist similar to LEED to enforce the safety in design.
        1. Checklist would focus on common design failures.
            a. Example – VAV's 1' above the ceiling tile instead of 6' to allow the maintenance and insulation to be completed in a safer manner.
        2. Financial Incentive to reaching pints on the checklist.

Session 2

Topic: Criteria and Drivers for Effective Multi-trade Prefabrication and Modularization

Research Ideas:

1.) Prefab needs to be considered in design phase.
    a. Prefab needs to have repetition to save money.
    b. Increased safety
    c. Logistical Issues with prefabrication.

i. Prefabrication (of concrete façade/ slabs) can reduce the number of deliveries (the number of concrete trucks).
ii. Need to have laydown/ Staging areas locally

2.) The cost associated with prefabrication.
i. A lot of early involvement
ii. Cost to store product off site
iii. Cost of inspections
1. Although less inspections on rite, there are stringent inspections while manufacturing.

Appendix B

Feedback from Industry Roundtable
The 22nd Annual PACE Roundtable
November 6th & 7th, 2013

Industry Member: Bill Moyer with James G. Davis Construction

Key Feedback: *Which research topic is most relevant to industry? What is the scope of the project?*

1.) Safety in the early design phase of Memorial Vista
    - Form a check list?
    - Form a reward system with ranking similar to LEED?
2.) Look into more examination of utilities below grade before construction begins.
    - Look at early forensics
    - Look at infrastructure contract.
3.) Look at the foundation of the building – it was discovered that the precast pile on the North wing of the building were redundant due to the soil bearing capacity.
4.) Look at the scheduling of the project.
    - This project required the core and shell of the building to be completely finished before the interior fit out was underwent.
    - Look to see how much extra time and money would be needed to have almost an interiors and a base build project instead of overlapping them.

Suggested Resources: *What industry contacts are needed? Is the information available?*

1.) Industry contact being Andy Rhodes – a design engineer with Southland Industries.
2.) Industry contact being Naresh – an estimating consultant with James G. Davis construction that would be able to discuss different ways to perform the utilities relocations better and be more prepared.
    Also would be able to get in contact with Busy ditch Inc. – A utility contractor that could also discuss alternatives to the utility relocation and discovery process.
    One may also want to find case studies with similar situations.
3.) Could contact Walt Schneider here at Penn State to assist in the calculations.
4.) One would contact the team that was on the site for the construction process for better sequencing in the schedule than originally planned, and then also talk to the estimating department within Davis Construction.
    It would also be influential to find case studies with a similar schedule constraint.

Analysis 1 – Applying SIPS scheduling

One of the first problems that the team on this job came across was the fact that there were more underground utilities than shown in the drawings and most of which were mislabeled or not even marked at all. As relocation of the utilities that ran through the site began, a large sewer main was discovered. It was determined that this was the primary sewer main for this area, with no redundancy elsewhere. Since these were significant pipes for the county, the team needed to perform a complicated tie-in and swap process to allow the systems to be relocated. This process was not accounted for in the schedule and took a large amount of time to perform. Because of the delay, the scheduled completion date had to be adjusted.

The team regained a month in the schedule by focusing on the cast-in-place concrete pours. The original plan was to have the pours be done in six stages per wing, but these were consolidated down to only three pours per wing. By combining the slab pours from six to three, the team was able to recover some of the time lost from the sanitary sewer relocations, but all the time had not been made up. The project date, based off of scheduling calculations was still projected to be two months after the original completion date that the owner agreed on. The owner ended up re-agreeing with the new schedule, even though the building was a core and shell and the interior construction was not to be bid out until the completion of the base build.

For this analysis, the sequencing of the façade will be looked at to see what could have been done each day to finish at the original projected day of August 9th, 2013. This would result in the project potentially being able to start the interior construction on time and then handing the building over to the owner earlier than what was actually done by the team. The fact that the utilities underground were found and caused a delay were completely out of the hands of the team, and they did take steps to gaining time back and getting the schedule back on track. On the other hand, if SIPS scheduling was performed it could have been seen exactly what would have needed to be done each day and how long each activity could take in order to complete the office building on time. With the SIPS schedule, sequencing would also have to be looked at, along with logistics to perform the job in the quickest and safest fashion.

Analysis 2 – Ultra-Ever Dry to Foundation

The waterproofing for the foundation of Memorial Vista was originally done with bentonite fabric that formed stringent backfill requirements. These backfill requirements take into the fact that the aggregate filling in against the foundation wall be ¾" or less, free of debris, sharp objects and stones. There is also extra care required when backfilling to prevent damage to the waterproofing system. On this job, the soil in the area was quite granular and the size of the rocks that were used for backfill was limited to ¾" or less. Because it was only a thin fabric on the wall that acted as a vapor barrier, many times the fabric ripped, and a repair had to be made. When the fabric would rip, all backfill operations would have to stop and the damaged

waterproofing would be repaired per the manufacturer's guidelines. When the repairs took place, this slowed down the schedule. As a result, numerous repairs had to be made and work was slowed down and began to fall behind schedule.

To solve this problem, a different product by the name of Ultra-Ever Dry could have been used. This product is a super hydrophobic coating that repels water, oil, and other liquids. This means that instead of being a vapor retarder, where some water vapor does make it through the barrier like the bentonite fabric, the Ultra-Ever Dry substance would prevent the flow of any water through the building if applied properly. Along with its qualities to repel liquids, it also has superior abrasive resistance to materials surrounding it. This is important because the spray would be easily applied in two coats to the foundation of the building in the same places that the bentonite fabric was applied, but would be done quicker, more efficient, and would allow for the backfill process to be done with ease. The original installation of the bentonite fabric calls for an adhesive to be applied to the wall and then the sheets to be pressed against the wall with an overlap of the edges being at least four inches. This allows for a lot of human error to take place. The Ultra-Ever Dry is applied in a base coat and a top coat, where the installation time can be significantly reduced with the use of an industrial heat gun. The backfill process could also be looked at. The soil being used to backfill would not have to be checked for sharp objects that could have damaged the previous water retardant, therefore allowing the process to be completed quicker. In the end, the Ultra-Ever Dry could result in being cheaper to install, and allow for a quickened schedule due to its easy install and tougher qualities.

Analysis 3 – Photovoltaic Windows

This building has an extremely large amount of glass accompanying the façade of the structure, with 65,558 square feet of glazing. This large amount of glazing will allow for beautiful views of northern Virginia and Washington D.C. skyline, but will also let in a lot of inferred light that will result in some unwanted heating in the summer. In the winter, heat will escape to the exterior environment though those same windows. In the end, the owner of the building will have to pay large amounts of money for the heating and cooling loads, specifically the cooling loads in the summer. Along with the cooling loads, a large amount of energy is used to create the desired air temperature to allow the occupants to be in their thermal comfort zone. This energy is pulled off of the grid that the building is tied into and results in increased costs to the owner during the life cycle of the building.

To compensate for these large loads, a solution was found to gather energy from the large amount of sunlight hitting the glazing. With the long summers and abundant solar energy a simple solution would be to accompany the glazing throughout the building with photovoltaic windows. These windows consist of a transparent film that one can see through like an average window, but within the film is heat trapping molecules. The molecules harness the energy from the inferred light that the sun provides and allows visible light to pass through. As the inferred light hits the solar cells, it excites them and creates voltage and current that in turn creates power. This power could be stored and used in the buildings load that the occupants put forth

or used for the cooling energy needed in the summer time. This process of using the energy that is supplied by the sun allows for the owner to save massive amounts of money off of their heating bills. The photovoltaic windows are also a creative alternative to photovoltaic solar panels that are traditionally big and bulky and must be located on the roof. With the film of solar cells in the window panes, the building continues to get assistance on the electric load needed all while eliminating the unappealing look of solar panels located somewhere on the property. The sequencing of the installation of these windows could also be potentially looked at to see if large portions could be prefabricated and delivers on site only to be lifter into place. In the end, the goal of the owner to have the highest quality product will be met, but the bonus is that money will be saved in the lifespan of the building.

Breadth 1

This solution of having photovoltaic windows accompanying Memorial Vista allows for the building to cut down on the energy use within the building. An area for further study could be the solar angles that the building will be hit by and the potential energy gains that could come with this throughout the year. These gains could then be put towards the reduction in the mechanical load cost of the lighting and electrical load cost.

Analysis 4 – Automated Parking Garage

The final problem that the team faced was numerous issues with the foundation. The owner of this site wanted the land to be excavated to the full area that it encompassed all the way to the lowest part of the foundation. This was done to check for contaminated soils that had been partially found in a few of the test bore samples that had been completed in the preliminary stages of the project. After the excavation process was under went, it was found that there was little to no soil contamination, and a large amount of money was put into digging such depths. In the end, the excavation crew went down to about 30 feet below grade to form and pour the foundation and erect the two story 556 car garage that sits below the superstructure.

The land that Memorial Vista sits upon was excavated to a total of around 155,000 cubic yards. This is an extremely costly and time intensive process that the team underwent. A possible solution that would alter the structure and architecture of the building would be to have an automated parking garage instead of the traditional underground garage. By having an automated parking garage, the owner would save massive amounts of money due to the fact a significantly less soil would have to be removed on site during the excavation process. The garage would also not have to be lit or conditioned with fresh 100% fresh air due to the fact no human being would be going down below grade. The tenant would drive up and select what type of car they have, exit the vehicle, and the machine would do the rest. This reduction of the mechanical system and lighting load would significantly decrease the cost per month to run during the lifespan of the building. The result of having a smaller foundation would be to have the schedule reduced, which would help on getting the project back on schedule from being off

due to the utility relocation process. The circulation of the garage and layout would have to be designed and the number of parking spots could be significantly increased.

Breadth 2

A breadth that could be looked at for changing the typical garage to an automated parking garage could be to study the structure of the new design and what would be typically needed to hold up a typical bay. Since more cars would be located closed to one another, and there is no longer a live load for humans and moving vehicles. The load calculations should result in different findings than that of those of the original garage and the structure would have to be resized. This typical bay could then be interpolated and the cost could be compared to the original design to see the difference. The lighting and mechanical loads of the existing garage could also be estimated and compared to the minimal loads of the automated design.

Rendering courtesy of Gensler

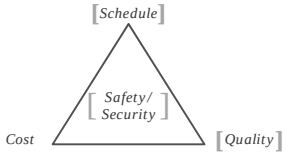
Memorial Vista

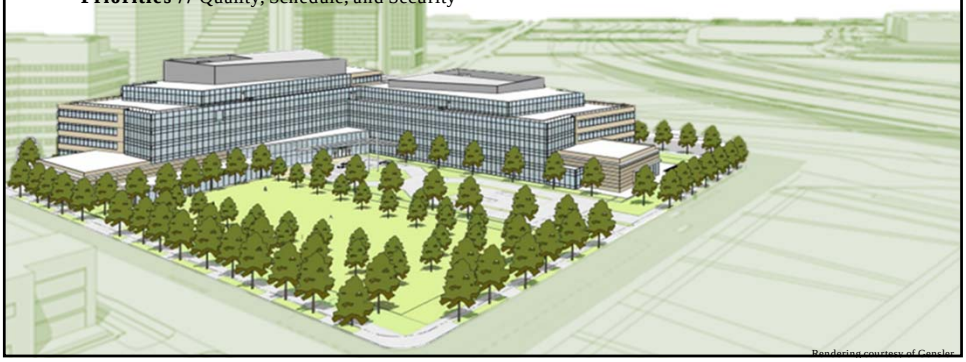
A North Virginia Office Building

William J. Gamble | 5th Year – Construction Option | Tech Assignment 3

Project Summary

Function // Office Building
Overall Project Cost // $78.5 Million
Dates of Construction // April 2011—October 2013
Size // 322,725 Gross S.F.
Building Height // 5 Stories above grade on North Wing
// 6 Stories above grade on South Wing
// 2 Underground levels (parking)
Sustainability // LEED Gold – targeted to hit 60 points
Structure // Cast in place plat plate slabs with drop panels at columns
Façade // 7 different types of glazing, precast concrete panels, & metal paneling
Priorities // Quality, Schedule, and Security





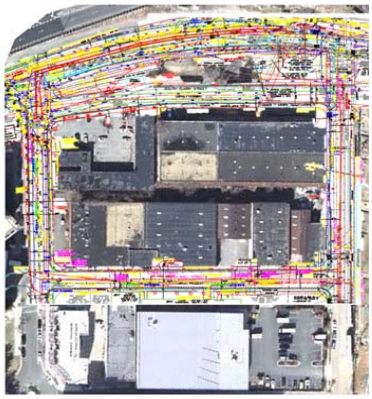
Rendering courtesy of Gensler

Analysis 1 – Applying SIPS Scheduling

Problem
- Underground utilities mismarked or not labeled
- Utilities needed to be relocated
- Sewer main ran directly through site with no redundancy
- Utility relocations took longer than planned in schedule

Solution
- Perform a SIPS analysis of the façade
- Clear up logistics of site to better perform sequencing

Areas of Analysis
- Schedule reduction



Original Site with the Existing Utility Overlay

Drawings courtesy of Google Maps & DAVIS

Analysis 2 – Ultra-Ever Dry to Foundation

Original Design
- Bentonite fabric with 4" overlaps

Problem
- Human error in installation
- Duration for backfill
- Easily damaged and work is stopped

Solution
- Ultra-Every Dry hydrophobic coating to foundation
- More efficient and has superior abrasive resistance
- Could allow for quicker schedule

Areas of Analysis
- Schedule acceleration
- Value engineering
- Eliminate some constructability concerns
- Research topic

MUD TEST: Untreated boot (R) and boot sprayed with Ultra-Ever Dry (L).

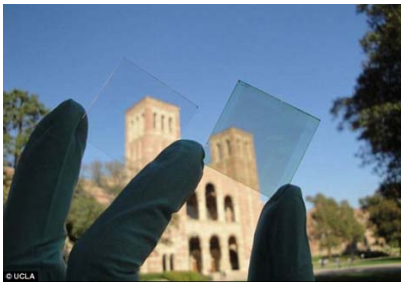
Picture courtesy of Google

Analysis 3 – Photovoltaic Windows

Problem
- 65,558 square feet of glazing
- Cost to condition air for occupants to reach thermal comfort zone

Solution
- Replacing traditional glazing with photovoltaic windows
- Energy harnessed from inferred light would be stored
- Reduce cost of building's loads during its lifespan
- Potentially prefabricate sections to reduce schedule

Areas of Analysis
- Value engineering
- Research topic
- Schedule reduction



Picture courtesy of Google

Breadth
- Potentially study the amount of energy this product would supply and see how much money could be saved.
- Could also study the solar angles to see what months and what locations would benefit most

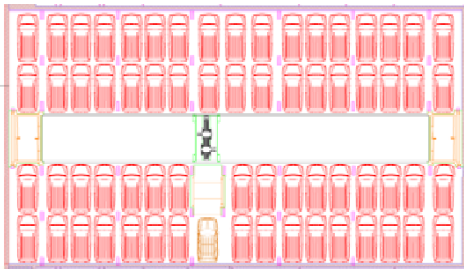
Analysis 4 – Automated Parking Garage

Original Design
- 2 story underground parking garage

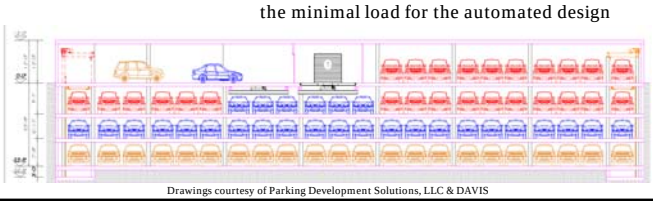
Problem
- Land was to be completely excavated (Contaminated soil)
- Large excavation footprint

Solution
- Automated parking garage
- Reduced footprint & depth
- Reduce mechanical & lighting load
- More cars per area

Areas of Analysis
- Schedule acceleration
- Value engineering
- Research Topic

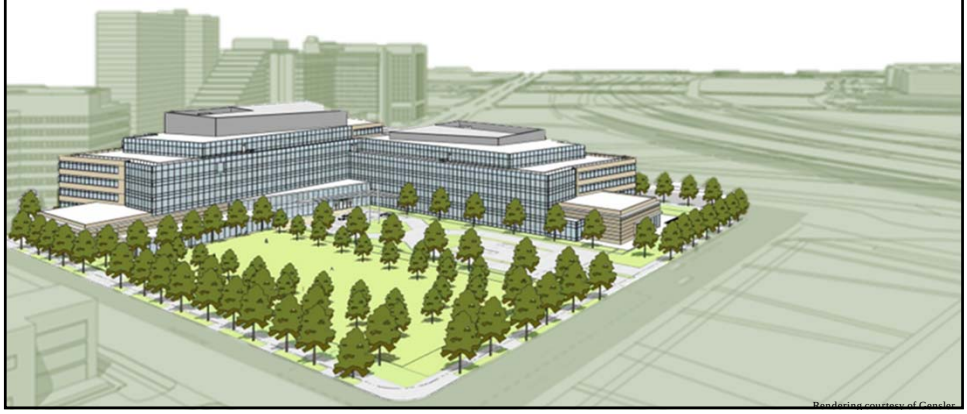


Breadth
- Study of structure to hold up typical bay
- Lighting and mechanical load of original garage could be analyzed and compared to the minimal load for the automated design



Drawings courtesy of Parking Development Solutions, LLC & DAVIS

Questions?



Rendering courtesy of Cengler