# TECHNICAL ASSIGNMENT 3

Alternative Methods Analysis – November 21, 2008

# BRIDGESIDE BUILDING II

Pittsburgh, PA


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# EXECUTIVE SUMMARY

This technical assignment takes a look at some of the constructability issues faced on the Bridgeside II project and their resolutions. Also the various schedule acceleration methods and the value engineering topics incorporated on this project. This report then explains some of the problems on the Bridgeside II project and possible analysis topics for further research.

The top constructability issues include the deep foundation system, the sunshade brackets, and site coordination. Bridgeside II is constructed on the site of an old steel mill and there were foundations and debris left in the ground that obstructed the H-Piles. Therefore each pile had to be pre-drilled. The sunshade brackets created a constructability issue because they had to be installed in two steps and the brackets were designed incorrectly. Site coordination was an issue because three different contractors were working in a relatively small space. The road contractor placed a fence 5 feet off the east side of Bridgeside II that shut down construction on that side of the building for 2 to 3 months. Also the delivery routes had to be reconfigured.

The critical path for Bridgeside II is the building exterior. When schedule acceleration was necessary, 10 hour shifts were worked and a Saturday shift was added. Most of the schedule acceleration occurred after the east side of the building was delayed. If additional acceleration is needed then the glass and glazing crews will work overtime which will add $7,000 to the construction costs. The majority of the value engineering on this project was owner driven scope reductions. However, the one true value engineering idea reduced the amount of hot water tanks and added a loop to serve each of the floors. This reduced costs and future maintenance.

Problems on the Bridgeside II project include the number of metal panel types, the exterior stud design, installing the deep foundations, and sizing the MEP systems. Each of these areas could be changed to create schedule and cost reductions. Some of the listed problems will be solved or redesigned in future technical analyses. Possible ideas for future research include a LEED analysis, a redesign of the deep foundations, reducing the number of metal panel types, and exploring the difficulties of designing a shell lab and office space.

# CONSTRUCTABILITY CHALLENGES

## Steel Foundation Piles

The site of Bridgeside II was once the home of the J&L Steel Mill. Once the mill was demolished the site was filled with man-placed fill ranging from 20 to 40 feet deep. A geotechnical report determined that the fill was variable in composition and not suitable to support the building loads. In order to support the building the geotechnical engineer decided to use steel H-piles driven 45 to 55 feet into the ground until bedrock was reached. Micro piles and drilled caissons were also determined to be viable options but the project team chose the H-Piles. The main constructability issue for this process was encountered when trying to drive the piles. Concrete footers and steel debris remaining from the steel mill were buried underground after the mill was demolished. The debris prevented the piles from being driven to the correct depth. In response to this issue the project team used two different crews to install the piles. The first crew used a rotary hydraulic drill to pre-drill each of the pile holes. The second crew then drove the piles into place. Some of the obstructions had to be removed but most of them were able to be drilled through. The pre-drilling process was much slower than the pile driving, therefore in order to prevent schedule delays the pre-drilling crews worked overtime and Saturday shifts.

Another issue with the H-piles was the presence of groundwater. When the borings were taken, water was noticed ranging between 24 and 45 feet below the surface. Occasionally the water reached as high as 13 feet below the surface. No excavation was required but a monitoring well was still constructed to keep track of the water levels. This was necessary because Bridgeside II sits adjacent to the Monongahela River. Figure 1 shows a detail of the monitoring well.

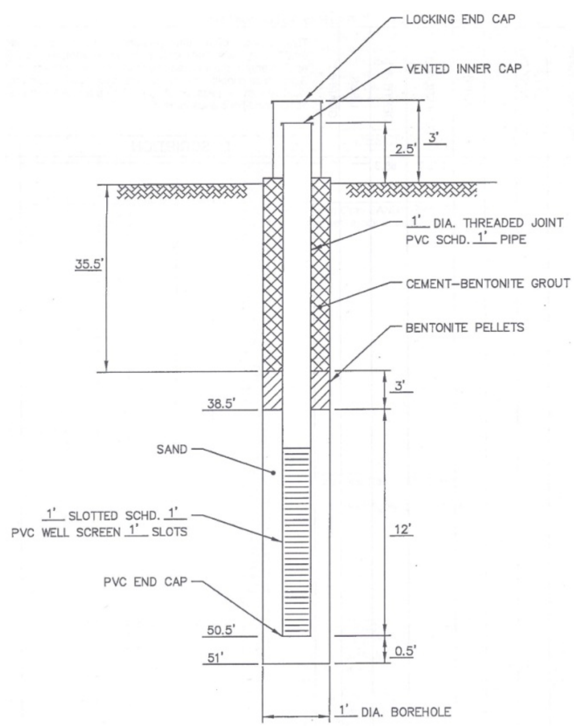


**Figure 1 – Monitoring Well Detail**

## Sunshade Brackets

Another constructability issue was the installation of brackets to support the sunshades. There were two issues that had to be solved during the design of the brackets. The first issue was that the steel tolerances were greater than the sunshades could handle. When the floor slab moved it could potentially bend or break the sunshades. The second issue was that the brackets had to be installed prior to the storefront window walls without interfering with the windows. The first issue was solved by incorporating a slotted connection into the angle that attaches to the slab. This allowed the slab to move without pulling on the sunshades. Figure 2 shows an elevation of the slotted connection. The second issue was solved by using a 2-piece design. The first piece is a steel angle that is fastened to the edge of the slab prior to the storefront windows. Then after the windows are installed the second piece is bolted to the steel angle. The second component is a steel u-shaped piece that supports the sunshades.

After the first piece was installed another constructability issue was discovered. The steel angle was too short and could not reach past the aluminum still on each of the windows. To correct this, a piece of the angle was cut off and a new angle was welded on. The new angle was long enough to extend past the sill and attached to the u-shaped piece. Figure 3 shows the final design of the sunshade brackets.

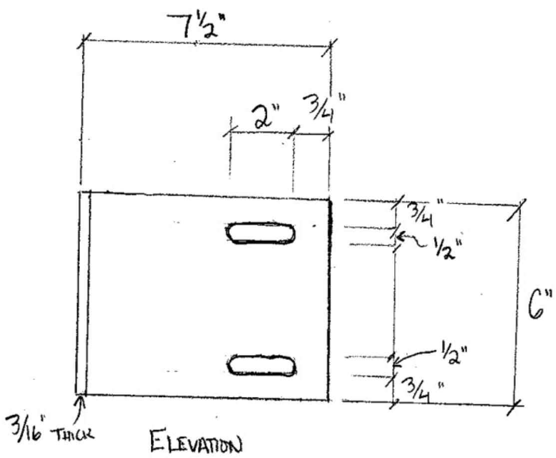


**Figure 2 – Angle Elevation**

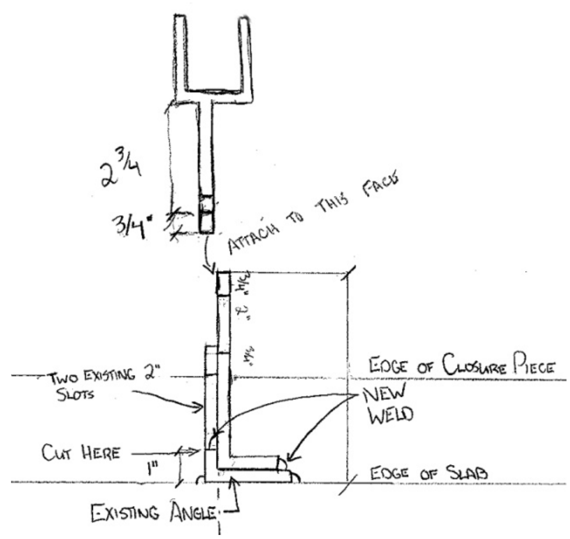


**Figure 3 – Sunshade Bracket Design**

## Site Coordination

A major constructability issue was site coordination. At the same time Bridgeside II was being constructed URA, who owns the Technology Center, was constructing a parking garage and relocating Technology Drive. Turner Construction had to coordinate layout space, delivery routes, and storage locations with the other two contractors. When the new Technology Drive was being constructed, the road contractor placed a fence 5 feet off the east side of Bridgeside II. URA had agreed to supply at least 15 feet of space between Bridgeside II and the fence. However, when they contracted Allison Park Construction to relocate the Technology Drive they did not apply the agreement into the contract. The fence shut down construction on the east side of the building for 2 to 3 months which affected the critical path of the schedule. This also interrupted access to other areas of the building and delivery routes. To overcome this issue Turner Construction created a site entrance near the trailers on the south side of the site. This provided access to the riverside of the building and a delivery route to get materials to the North end of Bridgeside II. Once the road was completed and the fence taken down, certain trades worked 10 hour shifts and added a Saturday shift. This accelerated the schedule but the completion date was still pushed back 2-3 weeks. This also added an additional cost to the project to pay for the overtime hours and the additional time Turner Construction spent on site. Figure 4 shows a site plan with the fence location and the modified delivery route.

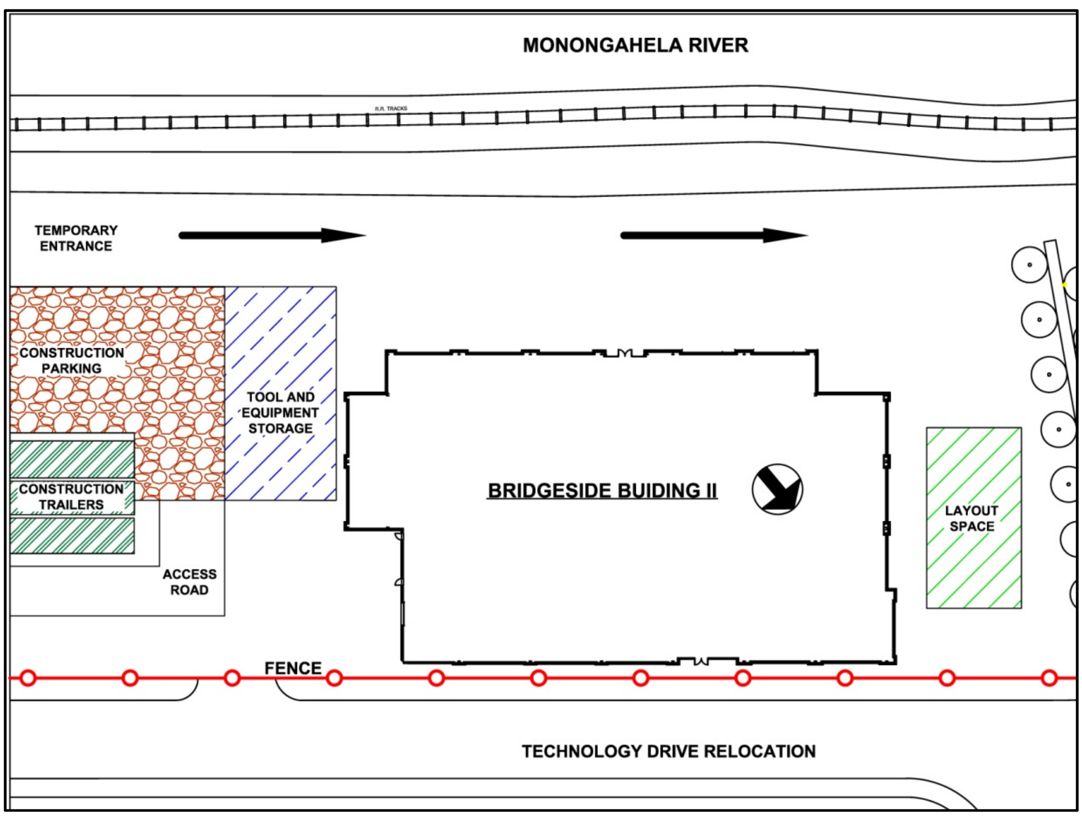


**Figure 4 – Modified Site Plan**

# SCHEDULE ACCELERATION SCENARIOS

The critical path for the Bridgeside II project is primarily based around the building exterior. The exterior has required the most coordination and also has had the most constructability issues. The construction of the exterior metal studs and the many types of metal panels has required a lot of attention. The critical path includes the following phases; foundations, structural steel, exterior metal studs, metal panels, glazing, roofing, and interior. Any delays to the critical path provide the greatest risk for getting the project completed on time. Most of the risk involves the building exterior because there is very little float allowed in the schedule for the metal studs and metal panels. The reason for the difficulty with the building exterior is because there is a lot of coordination between trades. Rather than extending from slab to slab, the metal studs are continuous on the outside of the building edge. Therefore, the studs had to be coordinated with the structural steel. There couldn't be any steel that would prevent a continuous run of metal studs and the studs had to be tied into the steel deck. The metal stud installation was followed closely by the metal panel installation, which required additional coordination. Any delays to the metal studs resulted in delays to the metal panels. Coordination was also required for the many different types of metal panels. There were four different types of panels and they were fabricated by two different manufacturers.

At this point in the project there have only been two significant delays to the schedule. The first delay occurred when the sunshade clips were improperly designed. The clips were not designed long enough to reach past the aluminum sills. However, by the time this was noticed they were already installed. The schedule was delayed about a week for the new clips to be manufactured, the old clips cut off, and the new clips welded on. The second delay occurred when the road contractor, Allison Park Construction, set up a fence 5 feet off the east side of the building. URA had originally agreed to allow Turner Construction 15 feet of clearance but did not apply this stipulation to Allison Park's contract. Work on the east side of Bridgeside II was shut down for 2-3 months while Technology Drive was constructed and all the deliveries had to be rerouted. Some of the lost time was made up by working overtime and adding a Saturday shift. However, the project completion date was still pushed back a couple weeks. Currently the project is scheduled to be completed by Christmas.

Two areas that have potential for schedule acceleration are the deep foundations and glass and glazing. The schedule was accelerated while the steel piles were being installed to keep the pre-drilling crew ahead of the pile driving crew. The pre-drilling crews worked overtime and picked up a Saturday shift. Occasionally night work was performed if they were falling behind. This cost additional money for all of the overtime hours and for the additional Turner Construction staff who were on site. However, some money was saved because the cranes were taken off site sooner than expected. If additional schedule acceleration is needed then the glass and glazing would be accelerated. To accomplish this, the glazing crews would work 10 hour days rather than 8 and would work a Saturday shift. This would create an additional 18 crew hours per week and would cost an additional $7,000.

## VALUE ENGINEERING TOPICS

There were three value engineering items that were simply scope reductions in order to reduce costs. These items detracted from the initial goals of the owner; however, they were owner driven. The first item removed was the window davits. The davits were being installed to hold window washing equipment. Each davit was attached to the steel beneath it and required 2 angles and a steel post. By removing the davits a total of $18,000 was saved. The next value engineering item was the removal of one of the rooftop air handling units. Since Bridgeside II is a shell office and lab building the loads on the air handling equipment is unknown. To save some money the Ferchill Group decided to remove one of the four rooftop units. The roof curb was still constructed so that when the building is fully leased the unit can be installed fairly easily. The final scope reduction item was the removal of one of the boilers. Similarly to the air handling unit one of the seven boilers was removed from the penthouse until the building loads require it. This item was another scope reduction to lower the construction cost.

The last value engineering item for Bridgeside II was a true value engineering idea because it saved money and added value to the project. In the original design there was a hot water tank on every floor to serve the bathrooms. The hot water tanks were value engineered out of the project and replaced with 1 large tank located in the penthouse. Then a loop was constructed that serves the entire building. This value engineering item saved a total of $7,000. Since there are fewer tanks the electrician will have less work because there are fewer items to power up. Also 1 tank is easier to maintain than 5.

During the design phase two value engineering items were considered that would add cost to the project but would reduce life-cycle costs. The first item was a heat recovery loop. The heat recovery loop was estimated to cost $400 to $500 thousand. Allen and Shariff, the MEP engineer, performed a life-cycle cost analysis and determined that the system would take a significant amount of time to pay off. Therefore the heat recovery loop was not utilized. The second item was a white EPDM roof that would reflect more light than a typical black EPDM membrane. This value engineering item was also not implemented.

## PROBLEM IDENTIFICATION

### Exterior Metal Studs

Rather than extending from slab to slab, the exterior metal studs were installed in continuous runs and fastened to the slab edges. The studs were installed in 30 foot pieces and required metal tracks at the seams. The studs were constructed in this manner to accommodate the installation of the metal panels. However, this construction method created coordination issues with the steel and metal panel contractors and it took longer to build than a typical slab to slab detail. The metal stud contractors were required to work on multiple floors at a time and carry materials between floors. An easier method would have been to construct one floor at a time.

## Metal Panels

The exterior façade was constructed with 4 different metal panels and cast stone on the lower level. This created a lot of coordination issues during construction and procurement. The panels include soffit panels, insulated metal panels, ribbed profile panels, and composite panels that had a separate manufacturer than the previous panels. It would have been easier to coordinate if 1 or 2 types of panels were utilized. Also since the panels were on the critical path a simpler installation could create a schedule reduction.

## Foundation Piles

Due to the existing conditions, piles were required to be driven 45 to 55 feet until bedrock was reached. The existing man-placed fill was not suitable to support the loads of Bridgeside II. The problem was faced when the piles were obstructed by existing foundations and debris remaining from the steel mill. Since the piles could not be driven through the debris, each hole had to be pre-drilled and some of the obstructions had to be dug out of the site. This delayed the schedule and created additional costs. Alternate foundation types or drilling methods could be explored.

## Sunshade Brackets

The sunshade brackets caused a problem on site because they were initially designed wrong and they had to be installed in two phases. The initial design was incorrect because the angle was not long enough to reach past the window sill. Fixing the brackets created a 1 week delay. Then the brackets had to be installed in two phases because the entire bracket obstructed the storefront windows. A possible redesign for this process would be to prefabricate the storefront windows and the sunshades into one unit.

## Site Coordination

A major problem for the Bridgeside II project was site coordination. There are three different contractors on site and all the layout space, storage space, and delivery routes have to be coordinated. Miscommunication between the owner and the road contractor cause a 3 month delay to the east side of Bridgeside II. This created schedule and cost implications. More effort put into planning and schedule coordination could prevent delays to all three of the projects.

## MEP Design

Since Bridgeside II is a shell office and lab building, one of the problems during the design phase was sizing the mechanical and electrical equipment and placing the wet stacks. There are currently no tenants and the exact layout of each floor and how the space will be used is unknown. The MEP engineers were forced to size the equipment based off assumptions and previous projects. The systems also had to be sized slightly larger than similar buildings to protect against higher than expected loads. This problem could have schedule and cost implications because if the demand of the building was known then smaller or less amounts of equipment could have been designed.

# TECHNICAL ANALYSIS METHODS

### LEED Accreditation Analysis

The initial design for Bridgeside II incorporated several green features. However, the only green feature not removed from the design was the sunshades. LEED could be beneficial for this project because it would reduce the life-cycle costs for the owner and tenants. Also since the building is not leased, a LEED certification could interest potential tenants. For a LEED analysis I would start by incorporating the white EPDM roof and the heat recovery loop back into the design. I would then investigate other LEED points that could be earned on this project. The heat recovery loop is an expensive system but it would reduce operating costs and possibly allow for a size reduction of the mechanical equipment. A mechanical design analysis would need to be performed to implement the heat recovery loop and a cost analysis to determine how long it would take to pay back the initial investment. Additional analyses would be required to determine the cost and schedule implications of adding the LEED features.

### Metal Panel Analysis

For a value engineering analysis I might reduce the number of metal panels installed on the building exterior. Currently there are four types of metal panels being utilized as well as cast stone on the first level. Two different manufacturers are fabricating the panels and this has created coordination issues during construction and procurement. Installing only 2 of the 4 panel types would reduce fabrication costs and create a schedule reduction for construction and material lead time. This analysis would be performed by comparing the cost and schedule data gathered from the metal panel contractor and manufactures for different numbers of panel types. A possible way to illustrate the results would be to create a 4D model of the building exterior with 2 panel types and with 4 panel types.

### Foundation System Analysis

The first problem faced on the Bridgeside II project was installing the deep foundations. The foundations and debris existing on the site created obstructions and prevented the H-piles from being driven conventionally. Additional crews and equipment had to be utilized to pre-drill each pile location. Also the holes could only be drilled to 20 feet otherwise the piles would not meet the uplift and lateral force requirements. The additional crews, equipment, and overtime work all added cost to the project. The schedule was also delayed due to the extended drilling time and for digging out shallow obstructions. A possible analysis topic would be to select an alternative deep foundation system that could be installed in less time. An option is micro piles because they are smaller in diameter and can be driven at a greater speed. This would prevent the need for pre-drilling unless the obstruction is steel debris. Another option for this analysis would be to select an alternative drilling method. The rotary hydraulic drill was able to break through concrete with ease but had difficulties drilling through the steel debris. An auger is an option that might have fewer problems. The goal for this analysis is to create a schedule reduction. Alternative methods might increase the cost but if the building is completed at an earlier date then the owner will be able to lease the space sooner. A schedule analysis would be performed by gathering data for various deep foundation types and installation methods from the pile contractor and the geotechnical engineer.

## MEP Design Analysis

Bridgeside II is a shell office and lab building that currently has not been leased to any tenants. Therefore, the exact use of the building and the layout of the spaces have not been determined. This creates an issue when sizing the MEP equipment and placing receptacles and wet stacks. The MEP engineer bases his design off past projects and assumptions. Also the equipment is typically sized larger than necessary to prevent problems with larger than expected loads. Since the location of lab equipment and washing stations are not determined, receptacles and wet stacks are placed in excess. A possible analysis topic would be to examine the difficulties of designing a shell space and to determine the cost implications of overdesigning the equipment. I would also analyze the cost of designing the equipment too small and having to provide upgrades. I will perform this analysis by speaking with the MEP engineer and by comparing similar building demands. The items of interest would be the air handling unit sizes, the outside air requirements, feeder sizes, fume hoods, and the quantity of items such as receptacles and wet stacks.