

Pennsylvania State University Burrowes Building: Technical Report II

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Courtesy of BLT Architects

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Executive Summary

This report was developed to analyze a specific building system such as support of excavation, mechanical system, electrical system, façade, etc... In the report below an analysis was performed on the support of excavation for the two knuckle structures that connect the wings to the core buildings. The excavation consisted of digging down to the foundation to allow for underpinning to be installed. The existing foundation was demolished and a new foundation was to be poured for the new knuckles. Micro piles were driven down 32' and then needle beams were installed on top of the piles. This allowed the structure to be supported while new footings were formed and poured to help prevent the core building from buckling. This work being performed on Penn State's campus caused a logistical nightmare for the Construction Manager PJ Dick. Safety was also a big concern throughout this process because there is no storage area for spoils. Dump trucks would make trips through campus during the work day to carry them offsite. The excavation was a very high risk event because there was a risk of one of the existing buildings coming down from removing the existing footings to replace them. This is why the micro piles and needle beams were installed to prevent this. This event took longer than expected on the schedule for the fact that there was unforeseen difficulties in the technicality of the excavation. PJ Dick's field superintendent noted that this activity added about 2 weeks to the excavation which pushed the knuckles to become the driving force for the schedule. The cost was increased well over the estimated cost for the excavation and this could've potentially be prevented if soil test had been performed around the knuckles to determine if there was bedrock down that far.

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Production Plan

Means and Methods

The system chosen to analyze for this report was the support of excavation for the knuckles of the Burrowes Building. This process began with the demolition and abatement of the existing knuckle structures. The north knuckle was the first structure to be demolished down to the foundation. The existing footer was then underpinned and demoed. The existing structure of the core building was supported by installing 13 sets of micro piles and 13 needle beams to transfer the weight of the structure. This allowed for the foundation footing to be formed and re-poured allowing it to support the larger load of the new structure. This process was repeated for the south knuckle as well. There was a major risk of hurting the structural integrity of the existing structures while the foundations were underpinned. There was crucial coordination by PJ Dick to ensure that this task was completed in a safe and effective manner. The major equipment used for this task included: 330 excavator, bobcat mini excavator, micro pile driver, and tamper.

Production Schedule

In the appendix on page 9 is a detailed manpower schedule that details the work performed from abatement to foundation completion for both the south and north knuckle. There was a labor curve created to show the amount of manpower at any given time throughout the schedule. Throughout this activity there is as many as 6 laborers performing a task and as low as 2 concrete finishers on a task. This activity is scheduled to take about 9 months to complete. The site for this project is too small to allow for both knuckles to be completed simultaneously. If this were possible it would significantly save time and money for the overall project costs.

Detailed Costs

The detailed cost estimate for this technical report was performed using Timberline. The estimate can be found in the appendix on page 10 where it breaks down all of the materials, labor, and equipment need to complete this system.

Site Plans and Logistics

One of the major changes between the original site logistics plan from technical report I and this one is that the temporary bathrooms needed to be moved in order to accommodate for the increased site traffic from dump trucks taking spoils offsite. The refined task oriented site plan can be seen below in the appendix on page 11.

Production Analysis

Production

The schedule is efficient for the size of the site and the minimum work space available to perform the work. The schedule would be more efficient if the black oak tree could be removed on the northeast side to allow for better access to the knuckle for excavation. The schedule would also be better if dump trucks could come in and out on the mall side to avoid the one way in and out. The number of crews able to work on one of the knuckles during the work day was limited because the space was very small and tight especially with a large excavator in the area removing dirt. This activity was performed at a great time of the year for the fact that it was after winter. This means that there wouldn't be any risk of running into frozen soil which could make excavating difficult. The superintendent when asked said "that besides the unforeseen issues of the difficulty of supporting a whole existing building to replace a footing, I wouldn't have changed the way we completed this activity." The amount of manpower used for each of the tasks suited the conditions that were presented to the project team.

Cost Analysis

After performing the Timberline cost estimate and comparing it with the actual and square foot estimate costs you can see that the numbers are within 10% of the actual cost. The Timberline was more accurate than the square foot estimate with only a 5.7% difference.

| Comparison of Timberline Estimate vs. Actual Estimate | | | |
|---|-----------------|------------------------|--------------|
| | Cost | Difference From Actual | % Difference |
| Timberline | \$ 1,241,258.00 | \$ 64,700.00 | 5.50% |
| Square Foot Estimate | \$ 1,286,226.00 | \$ 109,668.00 | 9.32% |
| Actual Estimate | \$ 1,176,558.00 | - | - |

Figure 1: Timberline Cost Estimate Comparison

The reasons for these differences is the fact that the square foot estimate is very generic and does not go into a lot of specific details for a system. Timberline allows you to include specific tasks and includes labor, equipment, and materials. The activities used in this estimate were chosen based on the schedule and information provided by the superintendent interviewed. The assumptions used to perform the timberline estimate include:

- Piles were driven using a drilling machine.
- Excavating amounts were determined from interview with superintendent.
- Concrete is included in underpinning line item.
- Actual Cost was given by Project Manager

Logistical Analysis

This project is being performed in the heart of the Penn State University campus. This means that site utilization is crucial to having an efficient and effective site. There is no room to store any kind of spoils from excavation and very little space for material laydown. One alternative method considered would be to excavate both knuckles at the same time to cut down on schedule time, but based on limited space this would be impractical and inefficient. Another method considered would be to block off one side of the mall near the library to allow for dump trucks to make trips in and out with a more direct path to a major road such as Atherton or College Avenue. An alternate considered by the project team was to remove some of the trees located very close to the building. It was determined after a Penn State arborist was called on site that the trees were heritage trees and needed to be left unharmed. Removing the one tree point out in the site logistics plan would've allowed for easier access for excavation, better crane access for forming and pouring the elevator shaft, erecting steel, and placing materials on the different floor levels.

Field Supervisor Interview

Schedule Acceleration Scenarios

This activity is driving the schedule because the schedule was designed to be pushed by the completion of the knuckles. This means that this activity is a critical path item. The biggest risks to the project completion date would be issues such as: not being able to match new masonry to existing masonry, one of the existing buildings structurally failing during excavation, Penn State changes to the building, and clashing of new utilities in such a small space. There are a few ways that could be explored to potentially speed up this system. Removing the large black oak heritage tree on the east side of the north knuckle would allow better access to excavate down at more of a slope than what was used and could potentially eliminate shoring. Another way to speed up the system would have been to allow access for dump trucks up the mall near the library to allow for easier access in and out of the site instead of the one way in or out road used. To achieve the removal of the heritage tree would require a meeting with the Penn State Arborist and the Committee for the trees to explain why it should be removed and they make the ultimate decision. To gain mall access for trucks to remove spoils, Penn State OPP would've needed to discuss it in house and with the Board of Trustees to make a decision whether or not it endangers the student's wellbeing. These methods may actually result in a cost and time savings for the project because it would allow for more trucks to get in and out which would lessen the time it took to complete the activity.

Constructability and Logistical Challenges

The biggest constructability concern was supporting the existing structure while its foundation was underpinned. This can be seen in the figure where the needle beams were located. The knuckles are located in between the two wing buildings and the core building.

This caused the process of this activity to be very difficult because it was such a small space to operate large equipment in. It was also very difficult to have multiple contractors performing work in the space at one time. This caused a major safety concern and prompted a logistical schedule from PJ Dick to coordinate the work effectively and safely. After speaking with the project

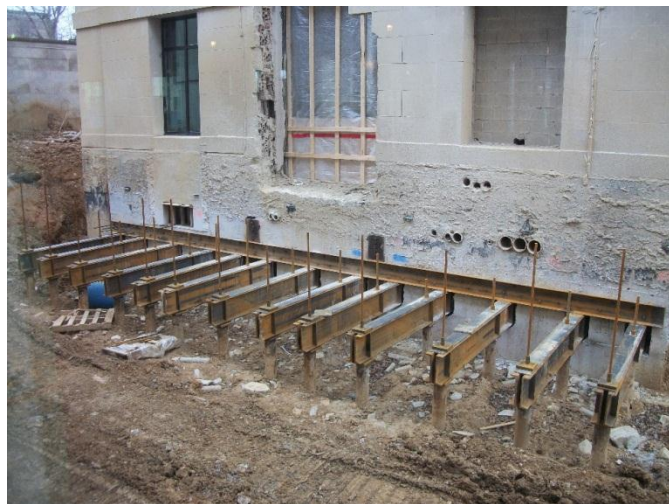


Figure 2: Micro-piles with Needle Beams @ South Knuckle

superintendent, he wouldn't have changed the materials used or the equipment. If it was up to

him he would've changed the access to the site to allow for easier traffic in and out of the site. This would've potentially cut down on schedule time for this activity.

APPENDIX

Field Superintendent Interview

1. What were some major constructability concerns when performing the support of excavation of the knuckles?
 - How to hold up the end of the Core building because of undermining the footer. This was achieved with 13 sets of micro piles and 13 needle beams.
 - Water run-off was also a major concern when excavating, so shoring was needed on the North Knuckle to protect against this.
2. Site logistics involved for this activity?
 - Access was very limited since it was located in the center of campus
 - Only one access road in and out
 - Major student pedestrian traffic during construction hours
 - Safety with using major excavating equipment and dump trucks in such a small area
3. Means & Methods?
 - Excavation was done with a 330 excavator and a small mini excavator for the areas the 330's bucket couldn't reach.
 - Micro piles and needle beams were used to support the core building while the foundation was underpinned.
 - Holes were drilled for the piles, then rods were threaded and the piles were grouted in place. The piles were then cut off and the slab on grade was poured on top.
4. Were there any ways that production could've been improved through better site use or other methods?
 - If the mall near the library on the Northwest side could've been used to access excavation because there was a large black oak tree on the Northeast side that couldn't be removed since it was a heritage tree. This caused us to have to use shoring because of having to dig down so far at such a small slope.
5. How did this activity relate to the critical path of the schedule?
 - The knuckles connect the 1930's Core building to the 1960's Wing buildings. The knuckles were basically the life line of the building. They allowed you to circulate between the different buildings.
 - The knuckles are what push the schedule. If the knuckles fall behind, the schedule falls behind.
6. What risks were involved that could've affected final completion?
 - Collapsing one of the existing buildings
 - Coordinating utilities through such a small space and connecting a new structure with the existing structures.

- Hurting the structural integrity of the buildings.
7. What could've been implemented to speed up the task besides manpower?
 - Removing the heritage trees that were in the way.
 - Limiting student access on the mall side near the library to allow for dump trucks to get in and out quicker.
 - A place to stockpile spoils.
 8. How did the project team overcome the challenges and issues of this task?
 - Coordination and major pre-planning of the activity and coordinating what contractors were performing work at certain times with the limited space.