AE 481W

Technical Assignment 3: Alternative Methods Analysis

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Construction Management

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Bakery Square – Building 1

11/21/2008

EXECUTIVE SUMMARY

Major constructability challenges at Bakery Square Building 1 include the mezzanine structural steel redesign, site utility coordination, and document control. Tools such as MicroStation and Constructware were used in conjunction with strong teamwork and communication skills to overcome these challenges.

MEP work, elevator installation, building enclosure, and structure construction are all activities on the critical path for this project. Weather and trucking are important factors to consider because they pose the biggest risk of delay at Bakery Square. Early installation of the elevator system is a key area of focus for schedule acceleration. It is possible to shorten the project by two months with only adding approximately $5,000 to the budget. Working night shifts are also considered to be a potential schedule accelerator and would cost only the loss of a half hour worth of pay each shift.

Value engineering ideas proposed by P.J. Dick range from simple standardization of brick sizes and gaining approval for a substitute waterproofing membrane to the complete redesign of the rotunda. Changing to standard size and color bricks would eliminate $40,000 of unnecessary cost and according to the owner, provide a better aesthetic look. A hot-applied waterproofing membrane would cost $13,000 more, but it is a product with 10 times the quality of the specified brand and enables construction to continue through winter. Redesign of the rotunda is projected to reduce cost, improve installation time, and require less coordination while still maintaining architectural style and approval of the owners.

Site congestion, the use of irregular formwork, specification for inconsistent and uncommon structural steel members, irregular benchmarks, and misplacement of the mechanical systems are all problematic features and areas that must be further analyzed. Correcting these problems will help to reduce costs, increase productivity, reduce schedule time, and improve quality.

Possible areas for activity analysis would include on site congestion problems, the irregular formwork used for the pile caps, standardization of the mezzanine level structural steel, and the relocation of the mechanical systems used to condition the retail space. Feasibility and logistics studies, cost comparisons, as well as structural and mechanical analyses will be used to address these problems.

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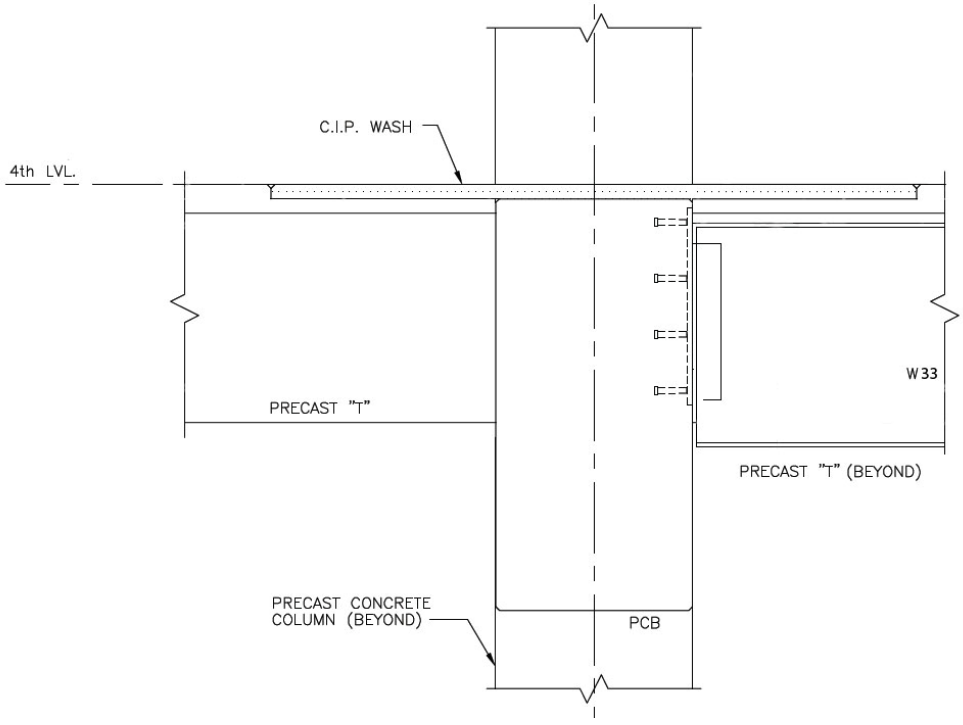
CONSTRUCTABILITY CHALLENGES

There are several issues that pose challenges to the constructability of Building 1 at Bakery Square. Eric Pascucci and Justin Jones, P.J. Dick's Project Manager and Project Engineer at Bakery Square Building 1, discussed a few of these key issues that caused problems during the construction process.

Steel Mezzanine Level

One of the most challenging features of Building 1 is the steel mezzanine level that must be erected inside the shell of the fitness center. Original design intentions for the mezzanine cited that the mezzanine level would be attached to the already erected structure through the use of a post and hanger system. However, after detailing was completed by the precast subcontractor, this system was determined to be insufficient for the appropriate design loads and was redesigned.

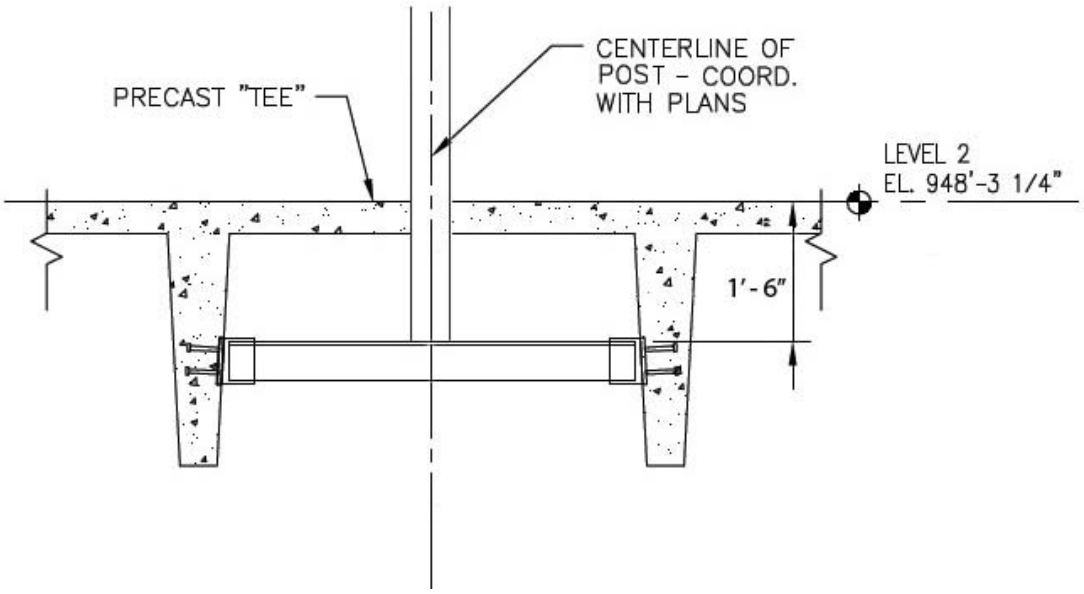
Coupling of the steel and precast systems became further complicated due to the redesign of the structure. Because of the large loads and long spans, substantially larger beams, weighing as much as 354 pounds per foot, were required. Therefore the beams would not be able to be supported by the post and hanger system and must be erected along with the precast structure.



- Figure 1 - Steel to Precast Connection

All of the precast erection must be completed by the original deadline of December 31, so scheduling and sequencing the erection of the steel to coincide with the precast concrete assembly is a key concern. Weekend shifts have been proposed as a solution for erecting the steel within the precast schedule. This would allow for the extra time required to lift these large beams without affecting the rest of the sequence.

Posts will still be used in design, but precautions must be taken to ensure that they combine properly with the precast system. Precast concrete tees are not able to support point loads applied to their surface, so holes must be coordinated during the precast member's fabrication. This will allow the post to go through the precast tee and rest on a beam that is fastened to the vertical portions of the tees such as in the figure below.

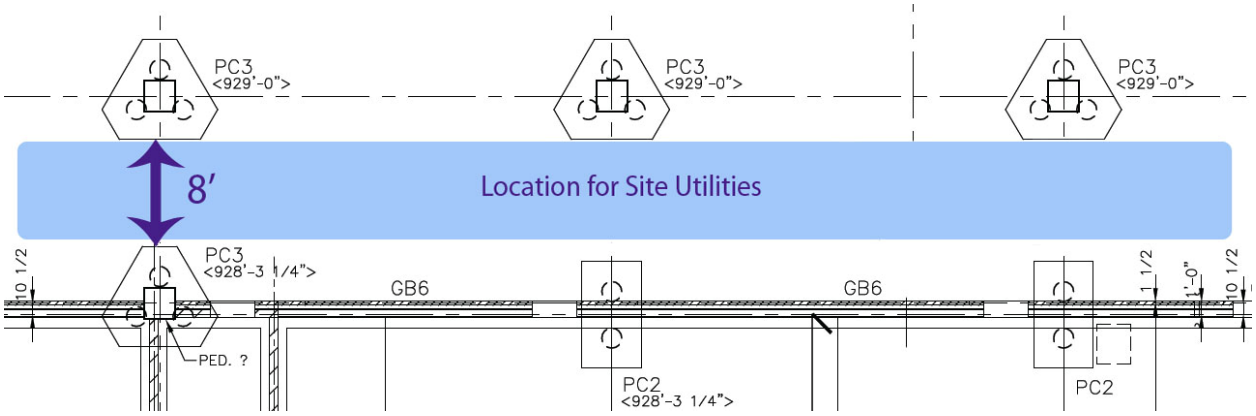


- Figure 2 - Post to Precast Tee Connection

Close coordination with the precast subcontractor helped to overcome all challenges that arose due to the redesign of the mezzanine level. The Manitowoc 999 crane that has already been in use for the precast concrete will be used to place the large steel members in place. One area of uncertainty that still exists is whether the 2nd floor must be shored in order to erect the remaining steel with a forklift. P.J. Dick is currently reviewing that information and will proceed as needed.

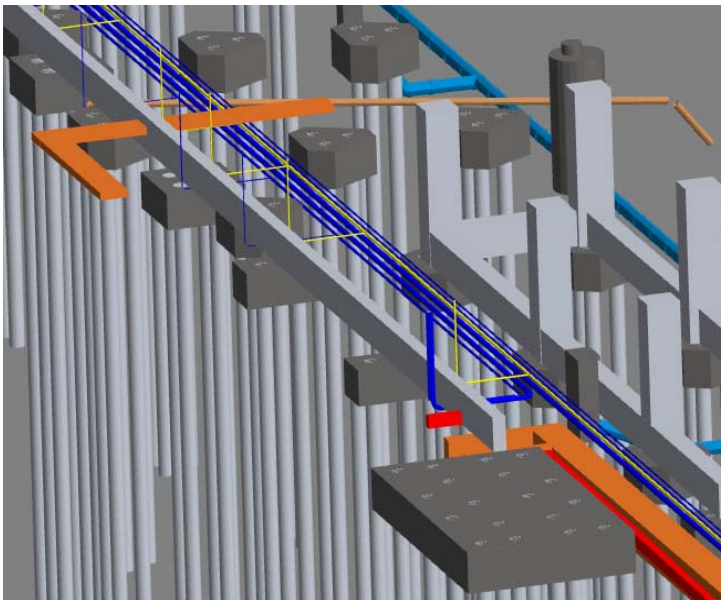
Site Utility Coordination

Another very challenging feature of Building 1 is the coordination of the site utilities because of the number of projects at the Bakery Square site. Astorino's design intentions were to run all of the utility lines directly beneath Building 1 in an area not wider than 14 feet. This included gas lines, electrical duct banks, water lines, and a storm line that reaches 15 feet deep in more than one location. To make it worse, all of these lines run between the foundations for Building 1. Once the pile caps are taken into consideration access will be as narrow as eight feet for the excavation and installation of the entire facility's utilities.



- Figure 3 - Site Utilities Location Beneath Building #1

In order to make sure that the installation of the utilities was successful, P.J. Dick modeled the underground utilities and the foundations in Bentley MicroStation. By modeling the utilities, P.J. Dick was able to foresee problems that might arise due to the congestion around these items. A screenshot from the 3D PDF that was produced for the site utilities at Bakery Square can be seen to the right. P.J. Dick also plans to use the model for monitoring the subcontractors' work.



- Figure 4 - 3D Model of Site Utilities

Critical changes pertaining to the site utilities were influenced directly by the creation and use of the 3D model. One of the waterlines and the electrical duct banks were moved to the front of the building because of interference with another waterline. By moving these items, direct access in now gained to both water lines, which is important because when additional lines tap into the water mains there will be less congestion in the area. Another benefit that comes from moving these utilities is the extra space gained for the excavation and installation of the storm and sewer systems.

P.J. Dick also analyzed site accessibility, sequencing, and maneuverability in order to justify moving other utilities located across the site. A storm water basin and electrical manhole were both moved in order to improve site safety and access. Both were located in the middle of the site and directly in the path for truck deliveries. The installation of these items would have extremely slowed onsite production for a number of days. Instead, P.J. Dick worked with Astorino in order to situate these items in different locations.

Document Control

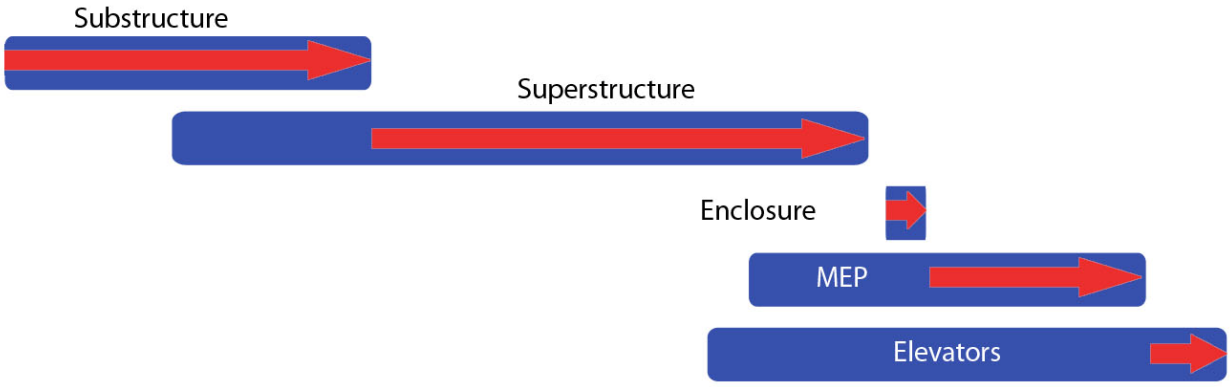
The last area of conflict, document control, is common throughout the construction industry but should not be overlooked. Justin Jones is concerned about the constant stream of drawing updates, RFIs, and changes that occur on a day to day basis. If a change or question is missed it can affect everything down the line.

P.J. Dick uses a couple of techniques in order to maintain fluid knowledge of the building and project as a whole. Constantly updating As-Built drawings and construction documents are the first steps when it comes to monitoring the project. Justin Jones spends his first moments in the morning to update his drawing set with any new RFIs, emails, or drawing packages that may arrive. He points out that it is important to have a copy of all versions of a drawing for future reference.

Constructware is another tool used by P.J. Dick to help track everything that is going in or coming out of Bakery Square. Autodesk's Constructware is a piece of software that provides a project management platform enabling efficient transfer of information, processes, and ideas. This online tool gives the entire project team instant access to up-to-date information anywhere with an internet connection. A central point of information is important for a successful project, and an easily accessible database, such as Constructware, only improves the production and accuracy of the project team.

SCHEDULE ACCELERATION SCENARIOS

Construction of the structure, enclosing the building, MEP discipline construction, and elevator installation all fall on the critical path of the schedule for Building 1.



- Figure 5 - Critical Path

Precast concrete erection, building enclosure, and elevator installation are the areas of most concern for scheduling activities at Building 1. Since the installation procedure and submittal process for the precast and elevator contractors are so difficult, it is necessary to keep these activities on schedule. The enclosure of the building must be considered as a critical process in the project because this is the defining point for when most of the interior work can be started.

Weather is by far the most problematic exposure that affects the schedule for Building 1. Rain, snow, and wind can halt the erection of the superstructure, which is by far the largest individual portion of the project. All time lost due to inclement weather must be accounted for with overtime hours in order for the project to finish on time.

Trucking is another important risk the must be considered when constructing the building because precast members are shipped over 150 miles to reach the site. Since the loads are over the weight, length, and width limits, the tractor trailers are only allowed to travel on the roads between the following time periods.

Permitted Movement Times
3 a.m. – 7:30 a.m.
9 a.m. – 4 p.m.
7 p.m. – sunset
9 a.m. – 4 p.m. Fort Pitt, Squirrel Hill, or Liberty Tunnels

- Table 1 - Permitted Load Schedule

Schedule acceleration is proposed to be done in two different ways. If the project falls behind schedule, interior operations and tasks, such as running conduit, that do not require enormously high task lighting could easily be done during night hours. More challenging activities could possibly be done at night if the project was failing to meet the schedule, but it would just be more costly and more difficult to coordinate safely. Crews would work 7.5 hours but get paid for 8, therefore cost would not be a huge issue.

Elevator installation is the other area that could be accelerated if need be. There are two elevator banks, each containing two cars, and it will take approximately 4 – 5 weeks for each elevator. If work began once the building began operating off of permanent power, the installation would be complete at the end of June. Justin Jones proposes to begin work in the first elevator bank before the permanent power is installed in order to cut time off of the schedule. The material and labor to run the temporary power to the elevators is estimated to cost about $5,000, but could reduce the project by as much as two months.

VALUE ENGINEERING TOPICS

Key ideas used for value engineering at Bakery Square Building 1 included specifying an alternate waterproofing membrane, eliminating single source specifications, redesigning the rotunda, and using standard brick sizes and colors. All of the above mentioned value engineering ideas were applied to this project and improved the project's cost, schedule, or quality.

A cold-applied waterproofing membrane was specified for enclosing the interior spaces below the parking garage, but P.J. Dick is in the process of approving a hot-applied membrane instead. The cold-applied membrane can only be applied while the temperature is above 40 degrees; unfortunately the schedule requires that waterproofing occur in the middle of January when the average high in Pittsburgh is only 37 degrees. To maintain the schedule P.J. Dick has proposed the use of a hot-applied membrane that can be applied as long as the temperature is above 0 degrees. The product is also rated to be 10 times better and can be installed with only a $13,000 increase in price, which will probably come out of contingency.

A mesh screen facade was specified for use on the building, but was required to be manufactured by Cambridge Architectural. Through talks with the owner and architect, P.J. Dick was able to open the specification to all qualified substitutes. This enabled competitive bidding to occur and reduce the cost of the system. Exact cost savings are unknown because the owner decided to eliminate this item from the scope of work.

P.J. Dick was aware that the design for the rotunda would be very expensive to construct, and by working with the architectural team, they were able to redesign the rotunda. An expensive roof and stud framing system was eliminated from the original design to make an overall less costly and better looking rotunda design. Less coordination will be needed with the new design and therefore decrease the cost even more.

Value engineering concepts can be as simple as changing the shape and the color of brick used for a project. Non-standard sized bricks with a non-standard color were specified for the walls in the elevator lobbies. By simply adjusting the bricks to a standard size and color similar to the types specified, $40,000 was saved and the owners were happier with the look.

Description	Improvements			
	Cost	Quality	Schedule	Owner's Goals
Waterproofing		✓	✓	✓
Mesh Façade	✓	✓		
Rotunda	✓	✓	✓	✓
Brickwork	✓			✓

- Table 2 - Areas of Applied Value Engineering

It is arguable that all of the value engineering ideas correlated with the goals of Walnut Capital. Cost may have been increased with the suggested waterproofing solution, but the schedule was accelerated and a better product was used. In order for the owner to receive compensation for their investments the building must be finished as soon as possible, and the hot-applied waterproofing aided in accomplishing that goal.

Value engineering for the mesh facade would have been successful had it not been deleted from the scope. Even with the cost reduction from multiple bidders, the owners did not wish to move ahead with this architectural feature.

As for the rotunda and brickwork value engineering, improvement were made in one or multiple areas as well as meeting the Walnut Capital's goals. The brickwork was more desirable to the owners and was less expensive. Redesign on the rotunda was an overall win that showed improvements across the board.

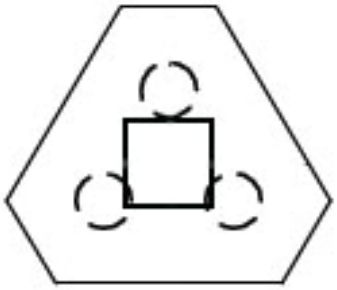
Justin Jones did not have any examples of value engineering ideas that got rejected.

PROBLEM IDENTIFICATION

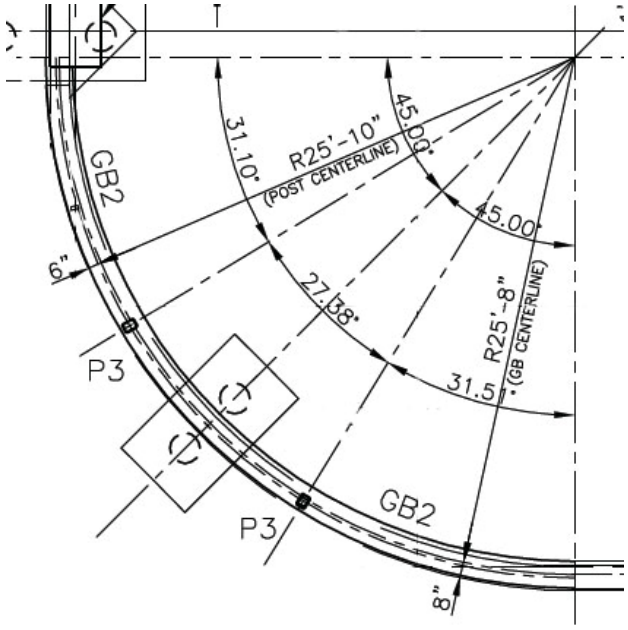
Construction of Building 1 is flowing smoothly thanks to well performing design and construction teams, but there are a few problematic features to this project, which will require further analysis. Key identified issues include a congested site, irregular formwork, irregular structural steel members, irregular grid layout, and poor placement of the mechanical systems. By reviewing these features through an all inclusive analysis ranging from construction practices to each of the building systems, a better option may become readily apparent.

Site congestion may not seem to be a big issue because of the large size of the site, but this large space is quickly consumed with equipment and materials when four large projects are ongoing at one time.

Irregular design specification can be adjusted in order to realize improvements in cost, schedule, and coordination. A triangular pile cap could be redesigned into a square formation in order to improve the time needed to form these items.



- Figure 6 - Triangular Pile Cap

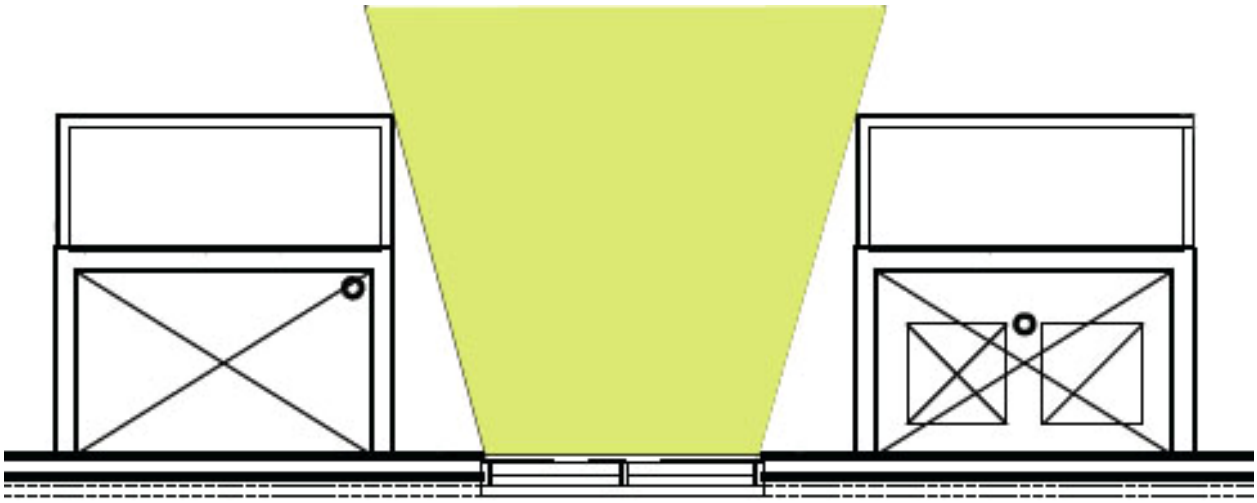


- Figure 7 - Layout discrepancies

Another possible area of conflict might be the layout seen to the left where the grade beam and posts are laid out on different lines. A single point of reference would simplify the construction and minimize coordination efforts.

Structural steel is another item that should be specified common member sizes when being designed. The member sizes for the mezzanine level are not common nor are they consistent across the floor. This could increase cost due to rare sizes, increase in duration because of mill production schedules, and a necessity in further coordination increase due to inconsistent member sizes

Multiple rooftop units are currently located on the south edge of the low roof above level 3, but a better option might be to locate them at the rear of the building. The large ducts pass through the fitness center to reach the retail space and occupy a lot of space and limit the views to direct sunlight. It may be more efficient to locate them closer to the retail space and eliminate losses in air flow.



- Figure 8 - Mechanical Shafts Blocking Sunlight

TECHNICAL ANALYSIS METHODS

One analysis that could be performed to improve the project would be to redesign the triangular pile caps used for Building 1. These pile caps are not designed to be constructed efficiently or productively. Therefore it could be argued that by using a square footing the reduction in labor costs due to more efficient forming methods would outweigh the cost of extra concrete.

Analysis for this project activity would follow a step five process. First productivity rates would have to be found and compared for both a triangular and square pile cap. From this information, the difference in cost between the two designs could be calculated. A material takeoff would need to be done in order to compare the cost of each version. Research would continue by analyzing the structural loads of the building and on the pile cap and ensuring that the new design would be able to withstand the required loads. Findings would be very straight forward with the use of a simple overall cost comparison.

Another possible area of analysis for the project would be to investigate the site congestion and propose a coordination plan that could be used to help manage the site more effectively. Comprehensive research would have to be done to compare the ongoing projects that are occurring on site at Bakery Square. Schedule, material staging, utility location, and site access comparisons would all have to be undertaken to understand the complex nature of the site. BIM could be used to create a 4D model that would show the ongoing change on site over the period of the project.

A third analysis topic could be an investigation into standardizing the structural steel used for the mezzanine level of the fitness center. An analysis of the building's structural system would be the first step in investigating this topic. Once that occurs the members could be redesigned with the idea of consistent and standard member size usages. Then a cost comparison could be completed by estimating the costs of both systems. A questionnaire for the erection team and foreman might be useful and could gain input from experienced personnel about the use of standard and consistent beam sizes.

A last analysis could be performed on the relocation of the mechanical system to a more efficient and aesthetically pleasing location. A study of the heating and cooling loads for the building would need to be completed first. From there code

compliance would be an issue and would have to be investigated. Lighting and energy studies could also be done to show any improvements that might have occurred due to moving the mechanical system. A cost comparison would also need to be created in order to compare pricing for both systems.