Steel City High-Rise

Thesis Proposal

Senior Thesis

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Project Location: Pittsburgh, PA

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Executive Summary

This proposal will analyze the various issues that have arose throughout the construction of the Steel City High-Rise in Pittsburgh, Pennsylvania. This $100 million structure is comprised of retail space, office space, a parking garage, and hotel amenities, all within the heart of downtown Pittsburgh. Each portion of this building is very different in design, some more complicated than others. The project delivery is extremely unique and resulted in some interesting analyses opportunities. This report will go into further detail of the potential resolution of issues regarding the fabrication of structural steel, unique structural elements, collocation, and the vertical MEP systems of the building.

Analyses Summaries

Analysis 1: Fabrication of Structural Steel Members

A huge issue throughout the construction of Steel City High-Rise was the fabrication of structural steel members lagging the erection crew. With the winter months being unpredictable in western Pennsylvania, Turner Construction Company was looking for opportunities to fast-track the beginning of the project to either complete the project ahead of schedule or to provide a cushion if inclement winter weather were to delay the steel erection. In theory and partially in practice the plan was wise and running smoothly up until it was time for steel to begin. The foundations, site work and utilities, and masonry ended up finishing over a month ahead of schedule; however, the steel fabrication process was too far behind for the structural erection to be able to capitalize on the schedule acceleration.

Analysis 2: Unique Structural Elements

Another area that served as a complication and potential issue pertained to the diverse members throughout the structure. With the exception of the office portion (the top six floors), typical, repetitious bays did not exist in the building. With 18 stories and 3,300 significant steel members, having a large number of unique members can slow down both the design process as well as the fabrication, detailing, and erection of the members as well.

Analysis 3: Collocation

The on-site offices for the Steel City High-Rise are located in a building that is adjacent to the site footprint. The offices house all of the project team that is currently working, with the exception of the structural engineer and the architect. The architect attends biweekly OAC meetings and the structural engineer phones into subcontractor and OAC meetings sporadically approximately 2 times a month. The construction industry is largely interest in the benefits, consequences, and reality of implementing collocation to a project to see if it actually does benefit the team and project as a whole.

Analysis 4: Vertical MEP

The majority of the MEP for this project is within the hotel portion of the building, it is nearly all running vertically. The reason for this is because all of the floor plans for each level of the hotel are identical, so the bathrooms and areas requiring MEP are stacked upon each other. This is an extremely efficient way to construct the MEP systems; however, the work is currently scheduled to occur after the structure is completed and is set to be installed one floor at a time.

Project Background

The Steel City High-Rise is a brand new, ground-up building that will be the newest addition to the prominent Pittsburgh Skyline. This new building offers easy access to hundreds of restaurants, various forms of entertainment (music, athletics, site-seeing, and social settings), the Cultural District, and assorted forms of public transportation including the recently expanded North Shore Connector. The high-rise itself is a mixed-use space that offers 128,000 square feet of office space, 14,000 square feet of retail space, nearly 200 hotel rooms, and over 300 parking spaces.

In addition to the Steel City High-Rise offering new opportunities and attractions to the city of Pittsburgh, it has also been designed with the intent to preserve the city and environment as much as possible. The project is on track to achieve a LEED Silver rating with the intent that 50% of the building's power will be generated from a renewable source and a goal to increase the energy performance improvement is set in place. Additionally, the building is implementing the new Healthy High Performance Cleaning program to reduce the carbon footprint by 75.69 tons.

The project delivery method for this project is unique in that the original construction manager left the project very early on, so a new contract was developed for Turner Construction Company to join the project. Turner Construction serves as one of the prime contractors for the project and holds a Guaranteed Maximum Price contract with the owner. Another prime contractor present on the project, Scalise Industries, is contracted for a Design-Build of all of the mechanical, electrical, and plumbing scope of the building.

The total cost of the Steel City High-Rise is expected to be $100 million, while the cost of construction will round in at $67,000,000. That $67,000,000 is further broken down between the two prime contractors' packages. Turner Construction Company has estimated their contracted work to be $57,000,000, while Scalise Industries has priced the MEP scope at $10,000,000. Aside from the ownership of the contracted work, the prime contractors were also given a 2% equity of the building giving them partial ownership at the time of the project's completion in late 2015.



Figure 1 (Left): Rendering of offices provided by Arquitectonica

Figure 2 (Middle): Rendering of Northeast facade provided by Arquitectonica

Figure 3 (Right): Rendering of lobby provided by Arquitectonica

Analysis 1: Fabrication of Structural Steel Members

Problem Identification

A long-term hurdle that occurred throughout much of the construction of Steel City High-Rise was the fabrication of structural steel members lagging the erection crew. Unfortunately, the winter conditions of western Pennsylvania are often unpredictable and rarely ideal for a steel erection crew. The Steel City High-Rise is scheduled to have much of the steel erection occurring through the entire winter season from Fall 2014-Spring 2015. Because it is impossible to forecast how much inclement weather could delay the project, the team aimed to fast-track the project from the very start.

The team explored several opportunities and found that accelerating the foundations work would accelerate the project up to two months ahead of schedule. This situation was ideal because the intention was to then start the steel erection two months ahead of schedule and to ultimately have a two month cushion that would allow for weather delays, while still completing the project on time, if not ahead of schedule. Unfortunately, a building with such a large magnitude of structural steel, the detailing, submitting, and fabrication of these members is a long process that greatly lags the amount of time that it takes an erection crew to place the members.

Background Research Performed

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Preliminary research was done to evaluate the potential influences that can slow the fabrication process for the structural members of this project in particular and then for general construction projects that may affect the industry as a whole.

One of these factors was the fact that the submittal process for the erection drawings was extremely tedious and time consuming for the details to be reviewed and approved for fabrication. As various sequences were submitted and approved, the fabrication process began. With approximately 2,880 tons of structural steel going into this building, the fabrication process could only move so fast. The steel fabricator, Amthor Steel, was working diligently to fabricate the steel as swiftly as possible. In fact, they dedicated two of their shops solely to the steel at Steel City High-Rise in order to accelerate their pace.

Unfortunately, even with the two shops devoting their time to the steel fabrication, the erection team was working at a rate that was faster than the production and delivery of sequences. This was an issue that was not solely a result of the erection drawings taking longer than the team had anticipated, but rather a lack of communication as members of the design team were changing. Throughout the design of the structure there were major changes to the design team for the architectural design and the MEP engineers. The change of hand hindered some of the communication on the project, but this was an unforeseen circumstance.

While the change in designers and directives was something unpredictable, an analysis of the steel members could be evaluated. A discussion with the fabricators regarding what members took the longest to fabricate will reveal whether or not having more repetition in the member sizes could have helped speed up the fabrication process. Additionally, the details and connections of the members will be explored too in order to evaluate whether or not those specifics may have hindered the fabrication schedule and flow. The structure is also sequenced in a manner that has 7-10 sequences per floor; however, each sequence typically spans three floors. This means that the steel cannot be delivered to site until one sequence for all three floors is fabricated, rather than fabricating all sequences on a single, given floor.

This analysis will investigate the fabrication process itself to see what elements took the longest and how the process can be accelerated without sacrificing the quality of the project. The analysis will explore how the fabrication flow works as an isolated schedule, rather than including the time that it takes to get the final approved erection and detail drawings for fabrication.

Problem Solution

Following this analysis the potential solutions that could occur are as follows:

- Consistent details for connections to allow for a smooth, repetitious fabrication process.
- Rework the sequencing to each floor, rather than sections per every three floor.
- Reduce cambered beams and consider replacing them with larger members.
- Scheduling more frequent deliveries to open more space in the fabrication shops.

Methodology

In order to complete this analysis the following deliverables must be completed:

- Research most efficient connection types during the fabrication process.
- Evaluate the fabrication shops and their capacity to store and output the fabricated members.
- Evaluate the fluidity and process behind the sequencing of the structure during the fabrication process.
- Develop site plan to determine how much steel can be delivered and stored at a time within the tight footprint.
- Calculate the cost of welded connections versus bolted connections.
- Research how much fabrication time can be saved by minimizing the different types of connections throughout the building.
- Research the cost, performance, and schedule for switching from cambered members to larger members.

Expected Outcome

Eliminating the cambered members and number of bolted connections will reduce the time for fabrication; however, it could result in an increase in the material cost of the structural system. An analysis of the material cost versus the schedule reduction savings will need to be evaluated to see the full impact on the cost of the project.

Analysis 2: Unique Structural Elements

Problem Identification

In addition to the fabrication process causing delays and concern on the project, the diversity of the members throughout the structural floor plan has also raised concerns. Excluding floors 13-18 for the office space, there are no typical bays or significant areas of repetitious members. The building tops out with over 3,300 substantial structural steel members, with very little uniformity between them. The lack of replication per sequence and per floor can significantly slow and delay the steel process in its entirety from the design to the fabrication and finally the erection. Developing a standard bay or form of repetition in the structural could reduce the cost and time of the structural system.

Background Research Performed

The design process becomes significantly longer with such a large number of distinctive members as each of these members has to be evaluated in great detail when determining the connections, loads, and details which in turn can also lengthen the submittal process. The submittal process requires the designer to submit the erection drawings and details, and every minute detail is examined and either is marked for approval, revisions, or denied. The more details that there are to examine the longer the review process is and the opportunity for design error increases. The submittal process for the structural steel details and erection drawings began in early April of 2014 and were not completed and approved in full for construction until late August of 2014.

Discussions with the designer and the fabricator could provide insight into whether there was a real benefit to this design. An alternative approach could be standardizing typical bays throughout the structure to expedite the schedule in various ways including the design and detailing process, the fabrication process, and the erection process. An analysis will provide further insight as to what drove the existing design: cost, sequence, performance, etc. Further research will show which approach is more beneficial based upon the cost, performance, and duration of the steel structure beginning with the design phase and ending with the completed installation. This evaluation shows great potential for pursuing a structural breadth that would require the redesign and creation of a typical bay for the building, as well as a building enclosure analysis of how the structural system and enclosure are connected.

Problem Solution

Following this analysis the potential solutions that could occur are as follows:

- Reduce the number of exclusive members within a given area and maximize the number of opportunities to create similar bays or sequences throughout the structure.
- Acceleration of the schedule and potential for a SIPS schedule as a result of more consistent members.
- Reduce the number of distinct connections to have more uniformity during fabrication and during the erection process.

Methodology

In order to complete this analysis the following deliverables must be completed:

- Evaluate benefits and consequences of having the existing, inconsistent structural system with the designer and fabricator.
- Research the opportunities in schedule reduction, cost savings, and efficiency of standardization and SIPS scheduling.
- Research impact of submittal process for structures that have similar and repetitious floorplans or areas.
- Examine productivity of erection crews that are working on large varieties of members and connections within a day versus a select range.

Expected Outcome

Establishing a consistent bay or more typical members throughout the building will help reduce the design time, the submittal approval process duration, the fabrication process, and the schedule of the structure and potentially the project as a whole. Adding more consistency to the structure can open more opportunities for further value engineering on the project such as the aforementioned SIPS approach.

Analysis 3: Critical Industry Research: Collocation

Problem Identification

Collocation is a hot topic in the construction industry and it has been heavily debated as to whether or not there is real benefit to establishing collocation on a project and to what extent. At the Steel City High-Rise, collocation was partially established with all of the project team present in the field office, with the exception of the structural engineer and the architect. Arquitectonica sends their architect to the field office for biweekly Owner-Architect-Contractor meetings, whereas the structural engineer conference calls in on occasion. It appears that there is an added value to the collocation of the various parties and that the problematic areas tend to correlate with the respective parties that are not actively engaged in the collocation plan.

Background Research Performed

Many of the issues, miscommunications, and questions that have occurred throughout construction were resolved very quickly due to the collocation of the team. Nearly all of issues that have been difficult to handle in a timely manner have been matters that needed to be taken up with the architect and/or the structural engineer.

In order to see if this is merely coincidental or if it in fact is a result of those parties being the only two that are not participating in collocation, a survey will be sent out to industry leaders and PACE members. This survey will explain the situation and ask a series of questions related to the circumstances. After the data is collected, it will be compared to the experience at Steel City High-Rise to see if complete collocation would have been a better opportunity.

Problem Solution

Following this analysis the potential solutions that could occur are as follows:

- The design team will add representatives to be immersed in the collocated field office.
- More stringent requirements should be set for meetings and deadlines, particularly for the parties not involved in collocation.

Methodology

In order to complete this analysis the following deliverables must be completed:

- Industry Survey to ask questions such as:
  - What size project (small, medium, large) would largely benefit from collocation?
  - Is there a correlation between the project size and the success of collocation?
  - In your experience does collocation work better on new construction, renovations, or is it an equal opportunity for both?
  - What parties should be actively engaged in collocation? Subcontractors? Owner? Designers?
  - Do you see collocation as an added cost to the project or a preventative measure for avoiding incurred future costs?
  - Does it have a positive or negative impact on a company's operations as a whole outside the scope of this project?
  - Have you noticed the various members of the project team becoming more reliable, less reliable, or neutral?
  - Does collocation improve or hinder the maintenance and management of the project?
  - What are the additional and sizeable costs that can be a result of collocation?
  - How is the response time impacted by collocation for inquiries, RFIs, submittals, and conflict resolution?
  - Have you noticed an impact on productivity as a result of collocation?
  - Scaled questions:
    - How would you rank the impact of collocation on a project overall?
      - 1 (negative impact), 3 (neutral impact), 5 (significant improvement)
    - Would you recommend that collocation be implemented more often?
      - 1 (never), 3 (needs further testing), 5 (absolutely)

Expected Outcome

Collocation will correlate with more successful communication on projects. This will further support the theory that many of the issues regarding the submittals and disputes could be circumvented if collocation were widely and uniformly accepted. In this case, collocation should be required for all parties involved in the project. Exceptions will not be made for the design team without either bringing a representative to the field office permanently, or establishing a better system for responses and meeting expectations. If a party were unable to actively participate in collocation, they would have to agree to necessitated deadlines, communication expectations, and a predetermined frequency of in-person meetings, as well as conference calls.

Analysis 4: Vertical MEP

Problem Identification

The mechanical, electrical, and plumbing systems for the structure are fairly simple for the anticipated completion, as they are either standardized for the hotel requirements or the reoccurring office spaces and many areas are to remain core and shell for future tenant fit-out. The majority of the MEP is housed within the hotel portion of the structure, where the floorplan layout is very similar and repetitive. Because of this, the MEP systems are stacked vertically in order to rise through all of the bathrooms and necessary spaces without taking up a lot of space. While this process is extremely efficient in terms of constructability, the work is not currently scheduled in a way that maximizes the schedule of the project as a whole.

Background Research Performed

Currently, the MEP systems are scheduled to be commence after the structural system has been erected in its entirety. The schedule reflects that the MEP systems will be installed one floor at a time following the topping out of the structure; however, it may be possible to achieve a more efficient schedule.

An alternate approach to be explored would be having the MEP installation climb with the structure. This would mean that as a level of the structure is completed and moving to the next level, the MEP would start on the floor below the newly started structural elements. This could allow the work to occur simultaneously and potentially save on schedule time and money.

Problem Solution

Following this analysis the potential solutions that could occur are as follows:

- Reschedule the MEP installation to follow the structure.

Methodology

In order to complete this analysis the following deliverables must be completed:

- Evaluation of the overhead working conditions and safety analysis
- Research of QA/QC requirements for MEP work prior to the building enclosure.

Expected Outcome

The mechanical, electrical, and plumbing system installations will progress along behind the structural work. There is great potential for a schedule reduction and cost savings associated with reducing the schedule and the labor for the work. This flow could hypothetically also serve as another opportunity for a SIPS analysis and schedule rework.

Analysis Weighting System

The following chart shows a breakdown of the four proposed analyses and how they will be weighted as a scoring system for the grading of the final proposal.

Analysis Description	% of Final Grade
Analysis 1: Fabrication of Structural Steel Members	20
Analysis 2: Unique Structural Elements	40
Analysis 3: Critical Industry Research: Collocation	25
Analysis 4: Vertical MEP	15

Conclusions

This proposal has outlined and identified potential areas of improvement that are available at the Steel City High-Rise. The areas of interest include opportunities for cost savings, schedule reductions, and an overall goal of increasing productivity without sacrificing quality or safety along the way. The analyses will be further developed and executed in the spring of 2015 and they include: evaluations of the fabrication of the structural steel, the unique structural members, collocation and how it relates to the construction industry, and the vertical MEP systems.

Reducing the variability throughout the structural members, details, and connections can benefit the project team as a whole, and allow for a smoother schedule with opportunities for a schedule acceleration. In addition to focusing on the schedule and constructability, the cohesiveness of the project team will be analyzed to ensure maximum productivity and conflict resolution.

Appendix A: Breadth Studies

Upon closer examination of the analyses, there are great potentials for breadth options to demonstrate knowledge areas outside of the realm of the construction based conflicts. When choosing breadth analyses, the following options may be explored outside of construction management: architectural, mechanical, lighting/electrical, acoustics, and structural. Below is a preview of the intended breadth options for the analysis of the Steel City High-Rise.

Structural Breadth

A structural breadth will be performed in order to evaluate whether or not having a typical bay system in the structure would prove to be beneficial to the structural system and to the project as a whole. Currently, it seems as though the varying structure could be increasing the cost, the fabrication and design process, the erection, and the project schedule as a whole. A bay will be designed that is intended to preserve the performance of the structure, while accelerating the design, fabrication, and erection of the steel. The material and labor costs, as well as the schedule reduction or escalation will be evaluated.

Architectural Breadth

An architectural breadth will be performed on the building enclosure in order to gauge how the structural system and enclosure are coordinated. This analysis will provide insight as to whether or not the schedule is aided or hindered by these connections and integration between the systems. This could potentially be impacting the fabrication of the steel members and will be evaluated from both a cost and scheduling standpoint.