Emory University
Psychology Building

Atlanta, Georgia

Technical Assignment #3

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Executive Summary

This technical assignment attempts to address the problems that have arisen during construction of the new Emory Psychology Building. Interviews were conducted with members of the construction management staff as well as Emory's building construction representative to discover the challenges that the project has faced. Fortunately for Emory and the construction management team, there have been few major issues thus far.

Although there have been few issues during construction of the building, the potential for problems has always existed. Troubles that typically haunt construction projects, like unforeseen conditions, were avoided on this building. Careful planning and good fortune attributed to avoiding those problems and making this project a success. One difficulty that the contractor did have during construction was with the assembly of punched out windows in masonry walls. The windows presented a challenge; but their issues were resolved with minor impacts to the project as a whole. Designer changes have also presented challenges, but like the windows, have had little or no negative effect on the cost or schedule of the project.

Since there have been so few problems on this project, there has not been a lot of need to accelerate the schedule. The building is actually projected to finish over a month ahead of schedule. Critical path activities are listed and analyzed to determine where the extra time has come from. The analysis shows that where the preconstruction team had anticipated risk and delays, there were not any. The extra time that they had built into the schedule for risk was unused and left more than enough time to finish at the end of the project. So much time was saved early in the construction that the production was actually slowed down purposely to save money on labor costs.

Emory and Holder collaborated to perform a value analysis of the Psychology building before construction started. The analysis focused on how well the proposed materials and systems served the university's needs. Cost was considered, but not necessarily the driving factor. Some cost was actually added to the building to improve the building's systems efficiency. Emory's building experience gave them a realistic idea of what type of building they would receive for the budget given. For that reason, and the fact that there were no added costs during construction, there was very little cut from the original scope of work.

Many things went well on this project, but there were also some areas for improvement. Some building features affected the speed and ease of construction and in some cases, how well the building will perform after it is completed. An additional analysis would likely determine if these features simply appear to be problems, or if they actually had an affect on the building. The main areas for improvement are listed; and the reasons why they were selected as potential problems are explained

The last section of this technical assignment provides ideas for additional construction management technical analyses. Each of the analysis could potentially save money or time during the construction period of the project. In some cases the suggested analyses attempt to resolve problems that were identified in other sections. Other cases look at areas where there wasn't necessarily a problem, but there may have been an opportunity to save time or money.

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3.1 Constructability Challenges

Like all construction projects, the Psychology Building has faced numerous challenges during construction. Fortunately, there have been no major schedule delays or cost increases on this project. That fact is a combination of having only minor problems and careful planning by the project team. Although there were no major schedule or cost increases, unforeseen conditions, the punched out windows, and late design changes have all had impacts on this project.

3.1.1 Unforeseen Conditions

Emory's current campus has been around since 1915. Since that time the campus has been growing in the amount of buildings and infrastructure that it contains. Unfortunately, not all of that construction has been well documented with as-built drawings and locations of underground piping. For that reason, Holder had to be very careful when coordinating all of the underground work for the Psychology Building. Any collisions would cause the new utilities to have to be re-routed and could potentially cause a delay to the schedule of three to four days. The image below shows the layout of conduit for new underground utility feeds.

Figure 1 Underground utility building feeds.

3.1.2 Solution Attempts

A building model with clash detection helped to coordinate the foundation system and underground utilities, but since some existing piping locations were unknown, the building model could not detect any of those collisions. The only option for Holder was to use the drawings that they had, and hope that they did not hit anything while laying the new utility piping. That hope causes a lot of stress since the project could be delayed at any point and there is really nothing that the contractor can do about it. Fortunately, they had enough accurate drawings that they only had two collisions.

3.1.3 Punched Window Construction

Although a curtain wall would be assumed to cause the most concerns involved with glazing, the punched out windows in the masonry walls ended up being more difficult to build. Problems with coordination, waterproofing, construction details, and manufacturer error caused this potentially simple part of the building to be more of a bother than necessary.

3.1.4 Punched Window Layout

When working with punched openings, the layout is the first major issue that can arise. If the layout is wrong, then the whole opening has to be reconfigured. Next, the rough opening has to be correct. After that, the blocking must all be installed correctly to coordinate with the rough opening size. All of these things have to go right before the window is even installed. Increased field supervision was required to help make sure that these processes were completed correctly.

After coordination of the blocking and layout for the opening, making sure that the opening will be watertight must be considered. Emory is especially conscious of waterproofing problems and even hires their own waterproofing consultant to assist in preventing leaks in the building skin. For this project, the same water proofing consultant was hired by the architect during design to ensure that the building will stay dry.

3.1.5 Punched Window Details

One reason that the windows were such a challenge is that the detail drawings provided for the window construction were not as accurate as they could have been. The areas around the window that required caulking were not clearly identified in the drawings. The details of the window were not fully worked out until the windows were actually being installed. Eventually, the consultants and the Holder's field supervision corrected the problems, but since details were changed, the windows were more difficult and time consuming than originally expected.

Figure 2 View of punched out windows from the southwest.

Since there were so many windows of the same type, or very close to the same type, a checklist of what processes needed to be completed and in what order would have been very helpful for the windows. The amount of repetitive windows can be seen in the image above. Although a checklist wasn't developed on this project, it was certainly a lesson learned by Holder.

3.1.6 Window Manufacturer Issues and Testing

The waterproofing consultant required that a mock up be built of the punched out windows as well as testing on the actual building's windows. About 10% of the windows were tested at random. For the test, about a foot of the wall around the window had to be left out for the testing equipment. After the tests, the framers had to come back and finish the wall.

The tests revealed that there were leaks in the windows that were caused by the manufacturer. The manufacturer did not seal the windows properly at their factory. A wet seal was required at the factory to seal the glass to the metal. Poor quality control by the manufacturer caused there to be pin-hole leaks in the seal, which needed to be fixed. As a result of this, the manufacturer had to send out two representatives to the job site to reseal all of the windows. It took approximately 3-4 weeks for them to re-caulk every single piece of glass to the surrounding metal. During this time, the project team had to coordinate around the extra work to make sure that all of the windows were sealed. The building could not be completely dried in until the windows were all sealed, so the manufactures were given the highest priority.

Fortunately, the manufacturer error had little effect on the schedule. Their workers had to be coordinated around, and were somewhat in the way, but they did not cause a delay in the project. Also, they stood by their product and took full financial responsibility for their error. Although there were some flaws, the project team was relieved that the tests were done early and there were no leaks that could have damaged finishes or added extra cost. If the leaks were not discovered until later in the project, or after completion, there could have been major issues. Overall, this issue was a challenge during construction, but it was resolved successfully.

3.1.7 Design Changes

As with many projects, late design changes have been a challenge for the Psychology Building construction team. The main area for redesign has been on the second floor. The second floor is the main entry point of the building and has the most public spaces, so Emory wants to be sure that they have the best design possible. Since the project has been tracked on, or even under budget for the majority of construction, they decided to upgrade the finishes and redesign some of the second floor interior spaces.

3.1.8 Design Change Demolition

Anytime there are design changes during construction, there are going to be cost implications, schedule implications, and the need for additional coordination. On the Psychology Building, some of the design changes came after framing and some MEP rough in was already completed on the second floor. All of the work that had been completed before the redesign had to be demolished to make way for a new design. Since the changes were so late, the owner paid for the extra work.

Other areas of the building area were also subject to changes after their initial construction. In some areas the architect wanted outlets or switches moved on finished walls. These seem like minor changes, but they are very tedious and can add up to large costs. Every time an outlet has to move, the drywall has to be refinished and repainted. A new hole has to be cut out for the new outlet, and the electrician may tear part of the wall out to access the wiring. The whole wall may then need to be repaired. After awhile, the material cost and labor cost for these changes really adds up. Also, the work that these people are doing is taking time from completing the work that they are scheduled to do.

3.1.9 Design Change Sequencing Impacts

The owner and architect were having a hard time finishing the design of the second floor finishes (shown below), so Holder decided to skip that floor for its interior work sequence. Instead of moving up through the building by floor as a typical project would, the sequence was the first floor, third through fifth floors, and back to the second floor. This solution allowed time for the architect and owner to decide on finishes, as well as prevent any future demolition on the second floor. The change resulted in a minimal change in schedule since the work was almost the same, but in a different order. As an added bonus, the terrazzo flooring design never changed, and the flooring contractors were able to work on the second floor all alone, with no other work going on. This was especially helpful since terrazzo installation is typically a very sloppy process which requires some curing time where people cannot access the areas anyway.

Figure 3 View of second floor lobby before finish upgrades.

3.1.10 Design Change Slab Penetration Impacts

Another thing impacted by the second floor design changes was penetrations through the floor slabs. When the design changed, particularly on the north end of the building where the classrooms are, penetrations through the slab had to be moved. This caused the original holes to have to be refilled in most cases, and a core driller had to come on site to make the new holes. Both processes cost money, and the area around the core drilling has to be clear since it is dangerous and makes a mess. Anything finished or stored around the area must be protected.

3.1.11 Long Lead Item Design Change Impacts

Other design changes that have affected the project are for long lead items. The architects decided late into construction that they would like to change the elevation of some eucalyptus panels on the second floor. Once again, this seems like a small change, but it is more difficult than it appears. The panels are pre-ordered in advanced because there is a 13-14 week lead time to get them manufactured and on site. The change puts the contractor in a bind since the panels that they ordered weeks ago are now useless, and the installation of new ones is delayed by as much as 14 weeks. There were also some fabric wrapped panels and other artistic panels that have been redesigned. These also have a long lead time and have been an issue, but the eucalyptus panels have had the most impact.

3.2 Schedule Acceleration Scenarios

3.2.1 Critical Path

The critical path of the Psychology Building Construction Schedule was/is as follows:

- Underground utility re-routing and installation
- Deep foundations (caissons)
- Cast-in-place concrete
- Steel
- Building exterior and enclosure
- Permanent power hook up
- Interior MEP work
- Finishes

The completion of each of these phases had, or will have a direct impact on when the building will be complete. Fortunately, the activities of the critical path have gone very well and have not impacted the schedule negatively. The foundations and cast-in-place concrete actually finished well ahead of their scheduled dates. The finishes were being tracked as being complete well ahead of the scheduled date and actually were slowed down to save money.

3.2.2 Risks to the Schedule

Although the schedule wasn't delayed, some activities still posed a lot of risk to complete the project on schedule. The preparation of the project team combined with a little luck helped to mitigate that risk and make the project a success.

3.2.3 Caissons

Due to the possibility of unforeseen conditions, the deep foundation system was the largest risk this project's schedule. A detailed soils report was necessary to help reduce the risk of drilling into rock for deep foundations. The soils report was done using hydrovac testing. Hydrovac tests find out different rock depths to ensure the drills do not hit rock when digging for the caissons. Drilling through rock is very time consuming and expensive. Holder carefully examined the soils report on this project in order to catch any potential problems before construction began. Their diligence paid off and the drills did not find any unexpected rock during excavation.

A large amount of focus was also put on the coordination of the caissons themselves. There were three separate contractors involved in their construction. There was one contractor to provide the rebar, one to tie the cages, and another to drill the holes, place the rebar in the holes, and place the concrete. Each delivery had to be carefully timed and tracked by Holder because if one contractor fell behind, the others were unlikely to make up the slack without additional costs. Careful planning prevented any delays involved with the caisson construction.

3.2.4 Formwork

The formwork wasn't really a large area of risk in the beginning of the project, and wasn't even looked to as a place to accelerate the schedule. The formwork contractors took that upon themselves. The formwork, which drives the cast-in-place concrete schedule, finished three weeks ahead of schedule. This was another area that went extremely well and bought extra time for the rest of the project.

3.2.5 Weatherproofing

Building dry in is extremely important since other things like sheet rock or insulation need to be replaced if they get wet and grow mold. The windows ended up being a concern to the schedule for reasons stated in section 3.1.2 of this report. Even with some issues, the building enclosure was completed on schedule and did not delay any other aspects of construction.

3.2.6 MEP Equipment

The ordering of MEP equipment is very important to a construction project. If the AHU's don't arrive to the site on time to drive out the humidity in the building, the finishes can be vulnerable to damage. It is much better to have the MEP equipment waiting on site to be installed for a couple of weeks than it is for the equipment to be a few weeks late. For this reason, Holder was reviewing a complete set of submittals for AHUS, loop switches and generators when construction started in October of 2007. Then they were able to release everything for ordering by January or early February of 2008. The equipment was not needed until August or September, but onsite and ready to be installed by May or June.

3.2.7 Curtain Wall

A glazed curtain wall for any building presents schedule challenges because of the complexity. The curtain wall for this building was looked at as a schedule risk and steps were taken to reduce the risk during planning. The largest impact of planning was the method in which the wall was constructed. Instead of framing the curtain wall in place, which is typically done, the curtain wall was framed horizontally, and then tilted up into place. The curtain wall contractor framed all of the mullions, gaskets and everything else except for the glass on large sawhorses on the ground, then tilted the frame up and anchored it to the structure. By building it that way, all of the tools and materials are readily accessible to the workers rather than being up on a lift and having to go up and down to get tools during construction. Each section was full height, at about 40' and had about a 20' width. Having the tower crane on site allowed this method to work and the whole process saved a considerable amount of time.

3.2.8 Interior Construction

Since the curtain wall, caissons, underground utilities, cast-in-place concrete, and generally all of the construction went on or well ahead of schedule, the finishes schedule has been relaxed significantly. Basically, the remaining critical path activities like interior MEP work, framing, and drywall have reduced the amount of workers on site since the project is well ahead of schedule. For example, during the start of interiors, there were about 50 framers and drywall installers on site, and about 30 electricians. At that pace, the building was projected to finish about two months ahead of schedule. By reducing the numbers to about 15 framers and drywall installers and 12-15 electricians, labor costs are greatly reduced and the building will still be about one to one and a half months ahead of schedule.

3.2.9 Schedule Conclusions

Fortunately for Holder, they were very successful in the beginning of the project and were not rushed for time later in construction. Oddly enough, the only thing that they didn't plan for was that everything would go so well. Usually at least one facet of construction will go poorly and other aspects will keep the project schedule balanced. In the Psychology buildings case, everything went according to plan and the schedule was relaxed at the end.

Smart planning helped the schedule for this building, but they were ahead of schedule for several reasons. One is that they were involved in the bordering Eagle Row road construction and underground utility re-alignment right before the Psychology Building project started. The trailer compound was already in place and the employees were familiar with the site. Also, the site fence went up early and the site was taken over earlier than usually is allowed. This really allowed the project team to jump right into construction instead of a typically slower start. The mobilization and learning curve of getting to know the area was eliminated. That alone can take a couple of weeks off the schedule right off the bat. Also, Holder has done several projects at Emory in the past and they know the University well.

3.3 Value Engineering

As stated by Stuart Adler, Emory's representative on the Psychology project, a value analysis was performed rather than value engineering. The value analysis focused on maximizing the value of the products and materials going into the building. Cost implications were included in the analysis, but were not the driving factor. Emory and Holder were the primary parties performing the analysis.

3.3.1 Areas of Focus

Since Emory will continue to own and operate the building after construction, they were concerned about building costs while looking at the value analysis. Spending more money on construction was not an issue if the money would be made up in the future. For instance, Emory opted to add insulation to some of the building piping which increased the initial cost, but had a payback period of only two years due to an efficiency increase. Since Emory plans to occupy the building for much longer than two years, and probably more like fifty years or more, the change was made.

3.3.2 Added Cost

During the analysis, Emory actually decided to put more money into the project on two separate occasions. The original mechanical penthouse exterior wall was supposed to be constructed using metal panels, but it was changed to stucco to match the rest of the building. Emory felt that they were willing to spend the extra money for a finished product that would please them more. The same was true of the lobby on the second floor. At one point during the analysis, Emory decided that they would spend an additional $50,000 in the lobby to upgrade the finishes. They wanted the lobby to be a signature part of the building and felt that the extra money would allow them to get the quality that they desired.

3.3.3 Reduced Cost

The only example of something that was cut from the value analysis was the site walls. Originally the site walls were intended to be granite. After viewing renderings, Emory decided that while the granite site walls were aesthetically pleasing, they did not really add enough to the project to match their cost and ultimate value. They were replaced by a less expensive stone that made more sense for their purpose and for this project.

3.3.4 Assessment

There are several factors to consider when looking at the almost negligible amounts of value engineering that resulted in cost reductions on this project. A main factor is that Emory is an experienced owner and knew what to ask of the architect with the budget that they had. Another is that Emory is privately funded, and does not face cost issues commonly associated with publicly funded projects. For that reason Emory did not have to view the value analysis as one product’s cost compared to another product’s cost, but rather a product’s cost compared to the quality that they desired. Lastly, this project has had so few problems, that no cost issues have arisen since construction. Since nothing has gone over budget or hurt the schedule, Emory has not had to make decisions to reallocate funds.

3.4 Problem Identification

As a whole, the Psychology Building has gone very, very well. The project is well within the allotted schedule and is tracking to be on or under budget. However, there are some things that could have been constructed faster or, with a little more time, could have been planned or designed more efficiently. These items are:

- Ceiling heights
- Multiple Air Handling Units
- Lack of prefabrication
- Poor window insulation

3.4.1 Ceiling Heights

As in most buildings, the architect wants to maximize the space between the floor and ceiling. Unfortunately, this leaves little space for structural systems, piping, electrical conduit, and ductwork. All of these items are squeezed between the dropped ceiling tile and the bottom of the above floor and beams. An increase in that space of only six inches would make a huge difference during construction to eliminate clashes and help workers with access to their work areas.

3.4.2 Multiple Air Handling Units

The Psychology Building uses four AHUs to help condition and control the air flow of the building. The units range in size from 4,900 CFM to 55,280 CFM. The three smallest units combined are still not as large as the largest unit. Multiple units cause a lot of extra piping and less space in the mechanical penthouse. If the three smaller units were combined into one, it could potentially save space, equipment cost, installation costs, and future energy costs.

3.4.3 Lack of Prefabrication

There are two areas on this building where prefabrication might have increased production, the steel connections and some of the mechanical equipment. In each of these, field connections are time consuming and the working environment is not always ideal. Prefabricated connections are usually of better quality and can reduce the amount of work that needs to be done onsite.

3.4.4 Poor Window Insulation

The punched out windows are not necessarily poorly insulated, but there is a supply air vent above each one of them. If the window R-value were increased, the size of the AHUs may be able to be reduced because of the more efficient window types. A double paned or triple paned glass may be able to provide a more efficient window to allow for a mechanical system reduction.

3.5 Technical Analysis Methods

3.5.1 SIPS for Interior Construction

Short Interval Production Schedules (SIPS) help to streamline activities on a building construction project. They are usually used for the interior of a building. The basic idea of SIPS is that each contractor has a given amount of time in one area to complete their work, before moving on to the next area. Another contractor will follow with their work directly behind them. If they don't finish their work in the given amount of time, they are responsible for making up the work before the next contractor enters that space. SIPS work best for buildings with highly repetitive work and could be used on this building for the first, and third through fifth floors. The work that needs to be done on those floors is largely the same and could work well with SIPS. The floors could be further broken down into north and south areas, to make eight total sections.

3.5.2 SIPS Implementation

SIPS or any other type of scheduling wasn't necessary for this project because of how well the schedule was adhered to in the beginning of construction. However, if there were a problem, SIPS could have helped to make up time at the end of the project. Also, even if they are already ahead of schedule, finishing early can help reduce general conditions and other costs associated with construction.

To develop a SIPS schedule, the building and areas in it will have to be analyzed with the help of the subcontractors responsible for work in those areas. The subcontractors can give an idea of how much time it will take to complete their work. After all of their schedules are compiled, a rough SIPS can be made. The subcontractors will have to be involved again to review the schedule and ensure that they can complete the work on time. After their review and input, a final schedule can be made.

3.5.2 Prefabrication

As mentioned previously, some of the structural steel connections and mechanical connections probably could have been prefabricated to increase quality and reduce installation time on site. To find out if this is could be advantageous, difficult connections would have to be identified on the drawings by asking the Psychology Building project manager. Then steel fabricators and mechanical shops would have to be contacted to determine the time and cost of making the difficult connections before shipping the materials to site. That information would be compared to the actual time and cost of the connections made on site to see how the two methods compare, and if a cost and/or schedule savings is possible.

3.5.3 Development of a Punched Out Window Quality Control Checklist

As mentioned before, the punched out windows in the masonry walls ended up being one of the more difficult parts of the Psychology Building construction. Typically, these are not a problem, but the details were not fully developed and unclear in some areas. A checklist of the construction of the windows to determine the quality could have helped out tremendously. The checklist would be developed by and monitored by the construction manager. An initial draft could be created with the help of the waterproofing consultant for the project. Since the details were a problem in this situation, the checklist could involve a more in depth review of the window submittals also.

The checklist would help to eliminate confusion during the construction of the windows, and increase the overall quality of the final product. The checklist would have to be very detailed and include specific areas to caulk, and where not to caulk so that each window would be installed and sealed correctly. With the amount of windows on this building, saving even a few minutes per window could trim a few days off of the schedule. Also, the amount of time spent re-caulking or re-installing any part of the windows would be reduced.

3.5.4 Cost Analysis of Scaffolding for Building Facades

To complete the masonry backed stucco façade for the Psychology Building, Holder used scaffolds to cover three sides of the building for a long time during construction. This can be very expensive since the scaffold was rented by month plus costs associated with erecting and dismantling the scaffolding. By getting different prices and determining how much scaffold was needed, and for how long, a cost analysis could be completed based on the following areas for the scaffolding:

- Type of scaffolding
- Amount of scaffolding required
- Time required on site
- Buying vs. Renting scaffolding
- Ability to use the same scaffolding in different areas based on schedule