University of Maryland, Baltimore
New Administration Building
Baltimore, MD

Keith Meacham
Construction Management

Technical Assignment 3
Dr. John Messner

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New Administrations Building
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Project Team

Owner: University of Maryland, Baltimore
Architect: Design Collective, Inc.
Civil Engineer: Site Resources, Inc.
MEP and Lighting Engineer: BKM & Associates
Structural Engineer: ReStl Designers, Inc.
Design/Build Contractor - CM: Barton Malow Company

Project Information and Architectural Features

80,000 SF of Office and General Use Space
6 Floors Above Grade
Construction Cost: $29,500,000+
Project Duration: March 29th, 2007 - October 22nd 2008
Facade: Brick and Aluminum Storefront
878 SF Glazed Aluminum Curtain Wall
Brick Pavers in Lieu of Concrete Sidewalks

Structural System

Augercast piles tied into pile caps
-Caps tie into columns and grade beams
-Piles are 18" in diameter and 4000psi
Two shear walls on the North end
9" post-tensioned concrete (5000psi) elevated slabs

Mechanical and Electrical Systems

One 90,000 CFM Rooftop AHU
Eight AC Units (600 - 2500 CFM)
VAV terminal units (single duct)
Diesel Generator System: rated 200kW, 3φ, 4 wire, 208/120V

Executive Summary

This Technical Assignment analyzes the New Administration Building owned by the University of Maryland, Baltimore (referred to as UMB). Areas of focus consist of a constructability challenges, schedule acceleration scenarios, value engineering topics, problem identification, and technical analysis method.

The UMB is a campus located in Baltimore and this New Administration Building continues their efforts to have the highest quality facilities. This 6 story, above grade, building will contain the University's executive offices and conference rooms.

The building is 80,000 SF and the structure is cast in place concrete with post tension cables running in each direction. Construction started in March of 2007 and is scheduled to be complete by October of 2008. The total project cost is $29,600,000. Barton Malow Company (referred to as BMC) was awarded the Design/Build contract with a Guaranteed Maximum price.

Design/Build is very fast paced and can benefit all those involved if executed correctly. Schedules must be constantly updated to represent the updated design. It is very easy to fall behind early, so some concerns are staying ahead, sticking with schedule and the budget. Much of the difficulties of Design/Build can be remedied with open lines of communication between the owner, architect, CM and subcontractor.

Within constructability challenges there is discussion of what types of unique or problematic challenges were experienced during construction. Proper preconstruction and the fact the building is somewhat typical reduces the amount of challenges seen on a project.

Challenges and problems can lead to scenarios where activities need to accelerate to stay on schedule. There are multiple different kinds of acceleration. All jobs have money just for acceleration needs and have areas identified on the schedule where acceleration techniques can be enacted.

Value engineering takes place in preconstruction and discovers areas that can be changed to benefit the driving factors of the project (schedule, cot, etc.). This can be a difficult process because changes cannot detract for the goals of the owner.

After investigation of the topics above problems identified are explained in detail. These problems segway into research topics for possibly improving aspects of construction methods.

Finally the document ends with an explanation of four construction management techniques that could potentially improve the project. These four analyses will inspire research for the upcoming proposal.

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Much of what is described below overlaps. Something that accelerates the schedule may also be something that was value engineered in preconstruction. Ideas present in value engineering many times increase constructability of the building. Overlapping represents the fact that many topics discussed could be found in all three categories; constructability challenges, schedule acceleration scenarios, and value engineering topics.

1. Constructability Challenges

The University of Maryland, Baltimore Administration Building in many ways is a typical office building, but like all buildings there are unique differences. These differences give way to issues in constructability. Major issues involved were an ambitious schedule, post tensioning, and brick façade.

1.1 Schedule

The schedule for the Admin. Building was very aggressive and so was the owner. This 6 story building had to be completed in 24 months. It was very fast paced but the nature of Design/Build requires the design to remain flexible. The owner expects to be involved in design decisions and changes and the schedule leaves very little room for delay as a result of these changes.

The University of Maryland, Baltimore does not construct plain box buildings. It was imperative that, in addition to meeting the schedule and coming in under budget, a building with unique architectural features be delivered. As with any job there are last minute changes but this is seen even more on this particular project. This is a result of the owner's current office being right next to the future office. This means that every day the owner was walking buy and could potentially make changes. Issues such as these are worked with instead of overcome. An aggressive schedule is met with an aggressive team and the right subcontractors, with the same attitude. These in conjunction with communication between all parties of construction through the entire duration of the project is the only way to come out on the right side of challenges.

1.2 Post Tensioning

Post tensioning can be very difficult. Tendon bundles run long lengths in each direction. Careful penetration layouts must occur because core drilling after pours is a risky procedure. X-rays of the slabs must be taken for core drilling so the tendons are not cut and blown. If this happens they retract and lose much of their strength. A structural engineer must re-design that area so it can be reinforced and maintain structural integrity. Hiring someone to x-ray and repair blown tendons is very expensive which makes boxing out penetrations crucial. Conflicts can also occur with different contractors (concrete and MEP) working in the same area and the first slab was a race to get everything laid out properly before the pour. Recalling that the floor slabs were split into two sections, North and South, BMC had penetrations laid out directly after forming and ahead of the rebar crew. Layouts took only a day and normally were scheduled on pour dates of the previous slab. With most of the concrete crews focused on the pour, layouts could be done on the next half with little interference and congestion. Lastly, having prelim meetings with the MEP contractor responsible for penetration layouts to clarify representations on the drawings also took place.

Having long bundles, stretching multiple bays makes changes, for post tensioning, equally as difficult. Things changing such as penetration or file room locations calls for structural re-design, which can have a ripple effect on surrounding areas. These re-designs could potentially impact the schedule and also warrant a visit from the structural engineer to ensure the as-built matches the change. This was overcome by identifying changes as early as possible and making sure re-designs were complete and detailed so to not impact the schedule. In the figure below 2 typical bays are shown. Each heavy red line is several bundles consisting of up to 3 PT strands. In addition there are also layers of rebar mixed above and below the bundles.

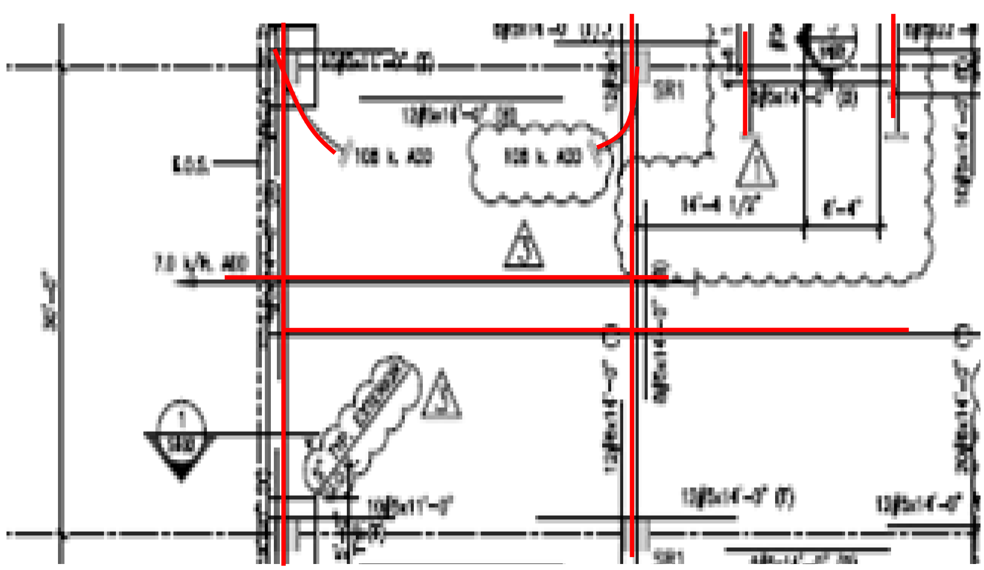

Figure 1
2 Typical 30' bays.

Figure 2 shows the amount of reinforcement congestion near interior columns.

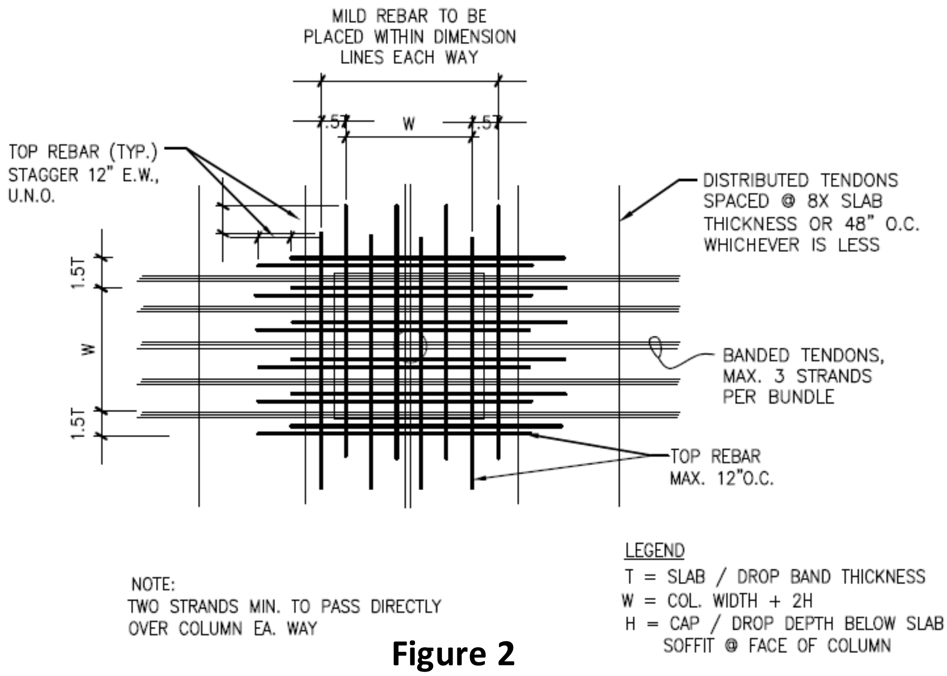

Figure 2
Reinforcing at interior column.

Figure 3 was taken on a North end pour and notice the congestion of PT strands laid East to West and North to South.

Figure 3
Reinforcing at interior column.

1.3 Brick Facade

Something that will be discussed in the value engineering section is the fact that the owner originally asked for cast stone accents around the windows. Eventually the owner agreed to use only brick but was intent on having attractive architectural features. Due to the tight schedule there was not enough time for the owner to meet with the architect and contractor to discuss conceptual changes, a common requirement for UMB. The job was moving and this would delay progress. The resultant design required a lot of interpretation by the mason. The drawings were lacking good window details and posed many questions. Construction could not stop and did not have sufficient time for ambiguities to be clarified. At this point mock-ups became very important to keep construction going. Luckily a high quality masonry contractor was awarded the job and did well visualizing and interpreting the drawings. The owner was pleased with the details and window accents, so no delays were experienced.

2. Schedule Acceleration Scenarios

Since the Administration building is confined to such an aggressive schedule it is seen that most activities are on the critical path. The different phases of construction more or less describe the critical path. Each phase has its own critical path but because of the fast paced schedule each phase as a hole leans on one another. If one phase lagged behind it would delay the entire building. It was imperative that foundations and superstructure finish on or before schedule because there was little wiggle room after and the progression of the building depends on these activities. Even more important was enclosure. Enclosure started without superstructure being completed but after the first floor was framed and sheathed the superstructure had to be done. This was necessary so sufficient room was available for scaffolding to be installed on three sides. Getting the building enclosed and water tight is always a major milestone on a schedule because it signifies the ability to begin finishes and the sooner finishes begin the sooner inspections can be done and areas can be turned over to the owner.

Schedule acceleration scenarios were scarce because many issues were discussed during value engineering. In fact, electrical R/I was significantly ahead of schedule which minimized congestion throughout the building. Contracts were designed to ensure that the quickest methods of construction were used for certain assemblies, such as scaffolding three sides of the building so masonry is erected on each side simultaneously or covering windows with heavy duty board for better moisture protection which reduced problems with finishes.

2.1 Identified Acceleration Areas

Consistent with many projects, money was set aside in the contract for acceleration. Although there were areas identified within the schedule as possible acceleration, it was rarely used. One area identified was foundations and superstructure. A logical choice because, with fewer men on site during these phases of construction, it is much cheaper to have crews work extended hours and/or Saturdays.

Another area on the schedule with potential acceleration was R/I and finishes. This was a viable option due to the large and somewhat typical interior areas. Extra men could be brought in without interfering with trades already in progress. Considerable cost implications of extra men at this phase would apply. Because of the large spaces, it was possible to have ceiling mechanical R/I and vertical drywall go up at the same area and time. Significant time is saved anytime two trades can occupy the same space and work as if there is only one. Below demonstrates work occurring simultaneously.

Figure 4
Drywall and mechanical installation.

One of the few instances of acceleration was seen in some of the offices. The modular furniture locations were changed and so telephone and data hook-ups had to be moved as well. Extended hours was used for these electrical and drywall changes.

Many times money for acceleration is used because of inclement weather delays or problems with MEP coordination, but the weather had no impact on construction and coordination went smoothly. Also the target date for enclosure was met and finishes proceeded as planned.

3. Value Engineering Topics

Value engineering develops design alternatives that benefit the project either in schedule, quality, or cost without adversely affecting each other. The UMB Admin. Building was driven primarily by schedule and so most of the value engineering options that were explored and implemented save time on the schedule. Many of these options go along with the categories above. Some identify constructability problems and solve them before appearing in construction. The same goes for schedule acceleration.

3.1 Steel to Cast-in-Place, Post Tension Concrete

Initially the building was designed to be structural steel. Barton Malow decided that finishing on time with steel was virtually impossible due to the aggressiveness of the schedule. Steel requires design documents well in advance, because lead time for steel is so lengthy. Steel was chosen because the owner wanted large spans, conducive to flexible floor plans. BMC had to convince the owner that cast-in-place post-tension concrete was the right system to meet the demanding schedule but also achieve the same plan flexibility as steel. PT can achieve large open spans plus the lack of long lead time means no construction delays due to deliveries or minor changes. Also, MEP coordination was made much easier because floor to floor heights were increased drastically when compared to steel (Increased plenum space means more room for MEP).

3.2 Cast Stone Accents to All Brick

The building is brick façade with punch windows, metal wall panels, and a curtain wall. The original drawings call for cast stone accents around the windows. This was a design to ensure that the building was not a “bland box”. Each limestone piece is pre-fabricated which indicates lead times and schedule implications. In addition, each piece is installed individually and since there are 800 windows, the schedule would without a doubt extend. In fact, this change saved the owner $500,000 and 2 months off the schedule. This was done without sacrificing architectural details that make the building stand out. Bricks soldier courses wrapping around the building in various areas and each window sill took the place of the limestone. Below shows the soldiered brick courses around the windows.

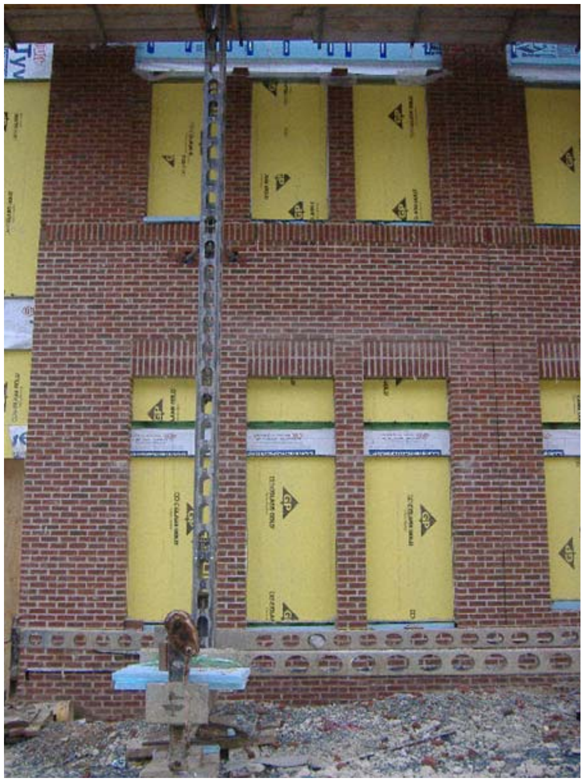

Figure 3
Brick window detail.

3.3 Scaffolding 3 Sides of Building

Having enclosures and masonry go smooth is key to façade construction. There is a lot of material and contractors must reach the entire length of the building, while moving vertically up. Achieving the second point with few breakdowns and set-ups can be difficult. To remedy this BMC made it mandatory for the masonry sub to have full length hydraulic scaffolds on 3 sides of the building, during the enclosure phase. The owner incurs a greater expense than hanging scaffolding from the roof but the facade is installed much faster and so construction can progress faster. This leads to a water tight building which allows interior finishes to begin much sooner. Figure 5a shows the scaffolding that was present during façade construction.

Figure 5a
Façade scaffolding.

Figure 5b
Façade Scaffolding.

To further moisture protection, temporary and dense window panels were installed in lieu of thin plastic that is commonly used in construction. These can be seen in figure 5b. BMC experienced far fewer moisture problems after the building was enclosed compared most projects. Moisture problems, many times, call for replacement of damaged or moldy finishes and can delay work.

3.4 Using Metal Stud and not CMU Back - Up

UMB commonly uses CMU back-up for the brick. Barton Malow strongly advised against this because once again this would drag out building enclosure. Metal wall studs can be framed from inside the building, thus requiring no lifts or scaffold. The ability to frame from within allows material to be stored on floors of the building and contractors to seamlessly progress through the building.

3.5 Changing Air Handling Unit

3 different air handling units were called out by the mechanical engineer to be placed on the roof. Also a penthouse was supposed to be constructed onsite. BMC estimators came up with two different options to improve this design. Option 1 was to have an AHU on every other floor inside the building, each servicing 2 floors. Option 2 was to combine all 3 AHU’s into 1 and install it on the roof. Option 2 was chosen. This AHU was delivered in 8 components and assembled onsite. Once assembled the AHU has a self contained penthouse which will make future maintenance easier. Also, having only 1 AHU reduces the penetrations through the roof. There was only 1 supply and return riser each. Figure 6 is one of the 8 preassembled components that were delivered and assembled on site.

Figure 6
1 of 8 AHU Components delivered on site.

4. Problem Identification

4.1 Schedule

As mentioned in constructability challenges, the schedule for the University of Maryland, Baltimore Administration Building is very demanding. No matter what size or type of building, a 24 month schedule is aggressive. Large amounts of preparation and planning go into successfully meeting as schedule such as this one. Any ways to make processes go smoother or faster make the schedule much more feasible.

4.2 Curtain Wall

Curtain walls are popular architectural features that truly give buildings an identity. They are great for letting in natural light and warming spaces during the day. But at night exists the opposite effect. Large amounts of heat at night can escape through curtain walls.

The U.S. Department of Energy recommends that windows have a U value of .35 Btu/sq. ft. x h x degF or less. The UMB Admin. Building specifications call for windows with a U value of no more than 0.66 Btu/sq. ft. x h x degF. This is almost twice the recommended value.

5. Technical Analysis Methods

Not enough problems arose on the UMB Admin building and because of this the technical analysis methods will be things that improve the project. Not necessarily fixing a problem that on the job.

5.1 Short Interval Production Schedule

The schedule set forth by the owner of the UMB Administration building was achieved by BMC. This analysis will examine if performing SIPS on a part of this project will prove to be beneficial. SIPS are good for buildings with repetitious work; office buildings or hotels. The UMB Administration building is fairly repetitive during the rough in and finishes phase, and is worth exploring.

SIPS break areas on a floor plan into zones of equal sizes. One contractor is given a certain amount of time to complete all their work within a zone. Another contractor follows and does their work in that zone within the same amount. The contractors progress from one zone to the next and form what is called the "parade of trades."

Initial research will begin by consulting with a general contractor who is well versed in SIPS. Their advice will undoubtedly assist in determining how applicable SIPS are for this project. Then analysis of the floor plans will take place and based on this analysis zones will be developed for the schedule. With further research and discussions with subcontractors, durations will be determined for the amount of work involved in each zone. From there a sequence of trades will be developed and put in a SIPS matrix. Once developed, the results will be analyzed and schedule impacts will be determined. These results will show if SIPS is a viable option for the University of Maryland, Baltimore Administration Building.

5.2 Unlimited use Formwork

The concrete contractor on this project used unlimited use "Doka" formwork when erecting the columns. The elevated slabs were formed with multiple use, job-built plywood forms. This technical analysis will involve designing the elevated slabs to be formed using the unlimited use formwork and examine the schedule implications.

Much like SIPS research, consulting a GC who has had unlimited use formwork utilized for floor slabs will take place. Rough durations for daily output and crew sizes will be developed based on these discussions. Multiple sources of durations will yield the best numbers for analyses. Once the research is compiled it can be normalized and applied to the UMB Administration Building using formwork information from Technical

Assignment #2. After all the information and research is compiled it will be assessed and determined if unlimited formwork would have benefitted this project.

5.3 LEED

Leadership in Energy and Environmental Design is the standard developed by the USGBC to determine whether or not a building is energy efficient based on certain criteria. Having this building achieve a LEED rating was not investigated. As part of this technical analysis the possibility of achieving LEED certification will be entertained. The goal here is to determine how the cost and schedule would be affected, short and long term, by attempting LEED certification. Many times it is shown that impacts are minimal and the returns make the extra worthwhile.

Recycling is many times a good and relatively simple activity that can begin in demolition and continue all the way through construction. Utilizing different dumpsters for different materials onsite requires dedication from the subs and project managers. The importance must be stressed to everyone. In addition to diligent managing, extra dumpsters require more space on a site. Finding space for multiple dumpsters will prove difficult on an already tight, urban site.

Some of the focus will be directed toward the already mentioned curtain wall and also the other 800 windows where a lot of heat escapes to the environment. Glass with better U values is often heavier, so structural impacts need to be examined. Material research along with load calculations will need to be developed for many of the assemblies present within the UMB Admin. Building.

Alternate materials will receive some LEED points as well as tweaking some systems within the building. Generalized HVAC calculations can be done to determine the energy used inside the building and alternative distribution systems can be explored. Generalizations will have to be made because re-designing an entire building will take more time than available. Research will consist of internet, ENR magazines, and consulting with manufacturers and contractors to receive prices/performance numbers and durations respectively.

5.4 Material Cost

One of the topics mentioned at the 2008 PACE Roundtable was material cost. Companies expressed concern that prices were rising due to the economy crisis, high energy costs (effect manufacturing and shipping price), and escalation. Many times a contractor locks into a price early in design and then by the time construction is afoot the actual material price is much higher. Contractors at the Roundtable discussed that procurement of materials is always a gamble. It can lead to pricey change orders and bad blood between different parties.

This Technical Analysis will examine different possibilities for procurement, so the contractor can be sure not to lose money due to escalation and other factors listed above. Heavy research will go into looking through ENR cost data from past and present. Trends will need to be shown through graphical analysis. These trends will be used in attempts to predict costs. Researching how different companies, already, set up their contracts to try and avoid procurement problems in conjunction with the graphs will ideally lead to a logical and systematic way to contract the procurement of materials in advance.