Technical Assignment #3

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The Washington County Regional Medical Center

11116 Medical Campus Road
Hagerstown, MD 21742

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Project Information

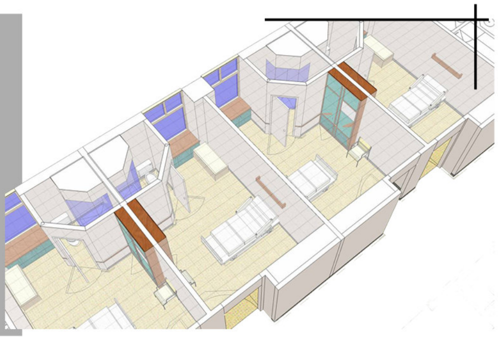
Size	500,000 sq. ft.
Height	5 levels
Project Cost	$150 million
Construction Dates	March 2008 - December 2010
Delivery Method	CM @ Risk

Project Team

Owner	Washington County Health Systems
Architect	Matthei & Colin Associates
CM	Gilbane Building Company
MEP Engineers	Leach Wallace Associates, Inc.
Structural Engineers	Abatangelo-Hason, Ltd.

Architectural Design

- Various facade types; brick, arch. precast, and glass
- Ballasted single ply roof membrane on rigid insulation
- (275) single bed rooms with private bathrooms
- (53) emergency treatment rooms
- (2) truma and 2 cardiac rooms



MEP Systems

- (5) AHU's totaling a maximum of 450,000 cfm.
- Central Utility Plant - (2) chillers & (2) cooling towers
- Electrical service feeds (3) substations each at 4,000 amps, 480Y/277, 13.2kV, 3 phase 4 wires.
- (2) emergency generators at 2,000 amps, 480Y/277
- Flourescent ceiling mounted light fixtyres typical

Structural System

- (150) deep foundation caissons under bed towers
- Spread footing foundation and grade beams under the other portions of building footprint
- Structural steel frame with 3-1/4" LWT concrete slab on 20 guage composite deck for the floors

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Executive Summary

The Washington County Regional Medical Center is a complex healthcare facility that presents many construction challenges. Project start-up and close-out typically are the areas that cause the most challenges. Since the medical center is still in the early phases of construction, many of the constructability issues encountered are derived from the early stages of the project. Project start-up must be effectively managed so that the schedule and cost of the project maintain critical milestones and the project budget.

There three main constructability issues outlined in this report and they are the drilled pier deep foundation system, a specific foundation wall, and unsuitable soils. The drilled piers, or caissons, must be able to set on adequate bearing rock. The problem was that the caissons were not the appropriate system for the underground conditions. The rock slopes steeply across the job and much of the surface of the rock is fractured. This complicates the drilling process and harms the schedule because the caissons must now continue through some rock until the entire caisson bears on sufficient rock. The foundation wall is a much more technical problem. The wall must retain a large amount of soils which it was not designed to do. However, the wall has already been erected as intended and this is where the constructability issues come into play. A solution to remedy the situation has been devised and must now be carried out in an efficient manner. The third constructability issue is the poor on site soils. They have caused excavation problems, but now they are affecting the concrete slabs on grade. The soil cannot hold the weight of the slabs or the loads placed on the slabs. The soils must now be over excavated and filled with a suitable material to allow placement of the slabs.

The schedule for The Washington County Regional Medical Center is not unlike many other project schedules in that it is very tight and hitting substantial completion on time is crucial. Acceleration scenarios are present, and identified and can be utilized if the project falls behind for any reason. Effects of the schedule acceleration must be closely monitored and followed so that future trades' work is not compromised.

Value engineering is a process each project goes through to see if value can be added or kept through the project by adding or changing materials, methods, and equipment. Outlined in this report are just a few of the many value engineering ideas that have been proposed for this project along with their value to the project and the owner. It also presents some ideas that were not implemented, but can be if the owner chooses to do so.

The information provided up to this point has been obtained through project personnel interviews. The remainder of the report discusses problem identification and a technical analysis of these problems. There are six problems outlined, deep foundation system design and construction, foundation wall design and construction, masonry work, steel and mechanical conflicts, medical equipment procurement, and installation of mechanical equipment on the third floor mechanical room. Each topic presents its own challenges; however, with research and design and construction analysis, a solution can be defined.

A. Constructability Challenges

A.1 Constructability Challenges Overview

Since The Washington County Regional Medical Center is still in the early stages of the construction process, many of the constructability challenges stem from project start-up. However, it is not uncommon to have construction issues during project start-up because start-up and close-out are typically the toughest areas of a project to complete. The top three constructability challenges that are being presented are derived from communication with the project staff through multiple person interviews. They represent views from different positions and allow for a complete, well rounded analysis of each topic.

A.2 Drilled Pier Deep Foundation System

As discussed in the previous two technical assignments, the medical center has three bed towers that are supported by a deep foundation system. The system chosen for the project was caissons. There are 150 caissons divided among the three bed towers. The depth varies from approximately six feet to about fifty feet; nevertheless, all of the caissons must reach an adequate rock surface with bearing pressure of 80,000 pounds per square foot.

The main issue with the caissons is the ability to reach sufficient bearing rock. This issue is not directly related to the caisson operation. The subsurface conditions show the rock sloping on the site at about a forty-five degree angle with areas sloping even more severely. The rock on site, when encountered, was also fractured at the surface. When the geotechnical report was performed to show the depth of adequate bearing rock, a two inch probe was used. The caissons vary in diameter, but the smallest size is thirty-six inches. When the caisson drilling apparatus was used to drill the caissons and it reached the depth at which the geotechnical report determined suitable bearing rock, only a portion of the diameter of the drill was on the rock. Consequently, satisfactory bearing pressure could not be reached. Please see Figure 1 for a diagrammatic view of the situation. The caisson contractor had to drill through the rock until the whole caisson was bearing on rock. As mentioned previously, the rock was at a steep angle which meant some of the caissons had to be drilled twenty more feet. This posed numerous issues related to the schedule and cost of the caisson operation and how it would greatly impact the remaining activities.

Figure 1: Caisson Diagram

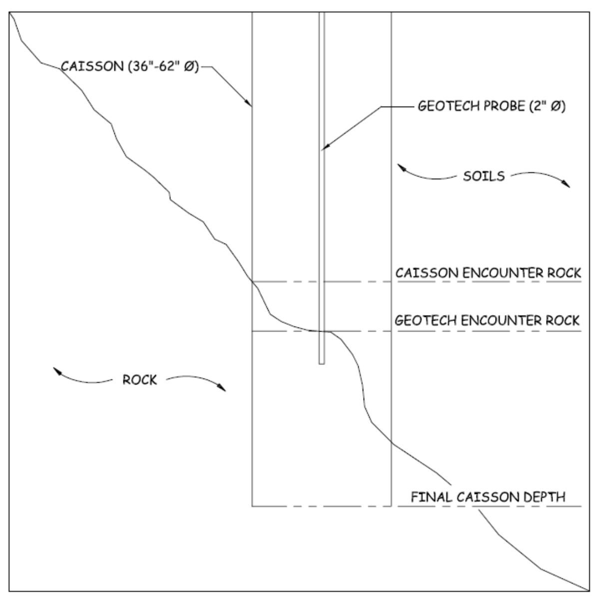

Figure 1 is for diagrammatic purposes only and was drawn by the author, not to scale.

The project team overcame this issue by adding more manpower and extra equipment. Since the site is fairly large and open and the project is in early stages of construction, space for extra equipment and men was not an issue. The original plan for the caisson operation included two drilling rigs and two crews working eight hour days. Since this delay in schedule, the plan now consists of six drilling rigs and six crews working ten hour days and every other Saturday.

A.3 Foundation Wall

The medical center's grade is sloped from plan east to plan west. The use of the site and the design has the first level on the west part of the building on grade, but the first level does not cover the entire building footprint. The second level includes the east part of the building where it too sits on grade while the second level on the west end of the building is elevated one story. For clarification, please see Figure 2 and note the floor designations on the bottom left of the section, 1st Floor, and on the top right of the section, 2nd Floor. The foundation wall is the east most wall of the level one footprint on the plans. It also supports the slab on grade for the east part of the building.

Figure 2: Foundation Wall Section

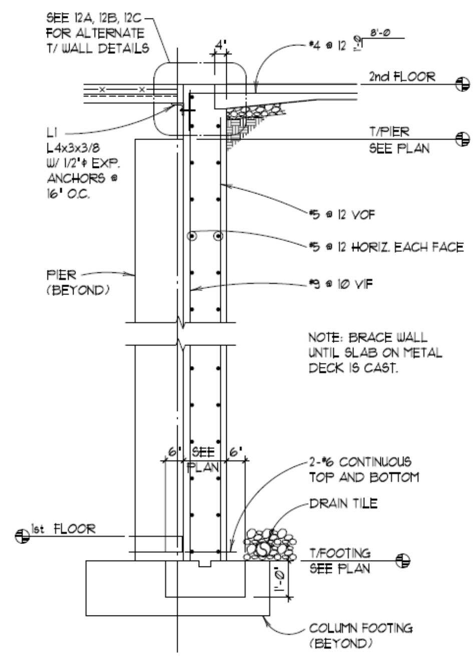

Figure 2 is an actual section, not to scale, of the foundation wall courtesy of the design team

The issue with this wall is it was designed solely for the purpose of a bearing foundation wall. The wall is unable to resist lateral pressure from the soil when backfilled. The wall was constructed prior to this knowledge and now presents the issue of how to hold back the soil. The wall must be able to retain the soils and support the loads that are bearing on it. This challenge presents a very high cost issue.

The project team contemplated different solutions many of which originally contained bracing. However, it was determined that permanent bracing of the wall, because of its length and height, was going to cost an unreasonable amount of money. The final solution to the challenge was to use a vermiculite flowable fill material between the soil and the foundation wall. This is a very low stress concrete ranging from about 100 pounds per square inch to 1000 pounds per square inch. This material will hold back the soils and exert no extra pressure on the foundation wall.

A.4 Unsuitable Soils

Technical Assignment #1 discussed the always present soils issue at the site. This risk was able to be mitigated in the early stages of excavation and construction with a few small remedies that were covered by contract allowances.

The constructability challenge with the soil becomes apparent when the compaction for the slabs on grade could not be achieved. The entire building footprint has a slab on grade. The compaction of the soils was not able to produce an adequate bearing surface for these slabs. The fear of the slabs cracking and failing leads to cost and schedule impacts of this constructability challenge.

This issue was not as hard to resolve mentally, but required a lot of time and money to remedy. The solution consisted of over excavating the soil and replacing it with a granular material that was able to be compacted easily and could support the slabs. The slabs could then be placed without fear of failure.

B. Schedule Acceleration Scenarios

B.1 Critical Path and Biggest Schedule Risks

The critical path for this project is not unlike most projects and project start-up is crucial to keeping the critical activities on time. One of the biggest risks to the schedule is the caisson operation. Like many deep foundation systems, the caissons are on the critical path. As discussed in Section A.1 of this report, the caissons also pose a big challenge. The schedule issues that come with this activity must be closely analyzed to produce an outcome that does not affect the total project schedule.

The steel is also on the critical path and may be the biggest factor to project completion. The team will need to find a way to keep the steel erection on schedule. This may be a hard task because of the caisson operation, but potential solutions are presented in a later section of this report.

Another big schedule risk, which may be overlooked and can not be controlled, is weather. The Hagerstown area had one of the wettest summers on record in 2008. This did not help the foundation work progress and it used all of the allowable weather days in the schedule. Getting these days back is not realistic, but creating a new buffer for future weather delays is imperative. Also, as a side note, the contract excuses weather as an acceptable delay and does not contain a "no damages for delay clause." Both of these factors will aide in recovery of money, but all project participants want the project to be completed on time and within budget.

B.2 Key Areas of Schedule Acceleration

This report has continually stated the impact of project start-up to the success of the project. Within its importance also lays the best opportunity to accelerate the schedule. The excavation and foundation stages of the project are typically when the project has the least amount of staff and equipment on site. This allows for three things: more manpower, longer hours, and additional equipment if needed. Costs are reduced for overtime pay when fewer workers are on site and adding people does not create safety concerns with respect to work areas. These concepts can also carry over to the early steel erection to allow the schedule to get back on track. Equipment may also be crucial to activity completion. With an open site early, more equipment will not hinder work spaces either.

Specific trades that could be affected by these schedule acceleration areas are:

- Deep foundation work[1]
- Other foundation systems[1]
- Steel erection

B.3 Costs and Techniques of Schedule Acceleration

The main technique of schedule acceleration used at Washington County Regional Medical Center was, as implied above, to add manpower and work longer hours. However, these two techniques alone will not bring the schedule to where it needs to be. Another technique to help alleviate schedule concerns was to re-sequence the building's steel erection. See Appendix A for a comparison of the old sequence to the proposed sequence. It shows two different scenarios of adjustment of the sequence to allow the deep foundation caissons to finish. This will allow the steel erection to start on time and maintain their schedule. The steel erection crew will also start with an increase in manpower and will work longer hours to make up time. Keeping the steel erection on schedule is crucial to the overall project success. If re-sequencing the steel allows the caisson contractor to finish and the foundation problems to be resolved prior to the steel making it to those areas, then the techniques will prove to be valuable.

The obvious costs of the schedule acceleration techniques used are the overtime pay for all the employees that a directive as been given. They must also be able to pay for the extra manpower and equipment usage. Re-sequencing the steel does not provide an explicit cost impact yet. However, as mentioned in the previous technical assignments, the largest picks for the steel were in the bed towers. These were to be completed first so a smaller, less expensive crane could finish the erection. The new sequence may create problems with the large crane's on site time.

[1] A different contract for the deep foundation work and the other foundation work (spread footings, foundation walls, and grade beams) allows for different crew balances and acceleration areas

C. Value Engineering Topics

C.1 Value Engineering Ideas Implemented

The following table, Table 1, shows three of the biggest value engineering ideas that were implemented on the project and their direct savings to the project.

Table 1: Value Engineering Ideas Summary

VALUE ENGINEERING IDEAS	
Idea	Direct Cost Savings
Use fiberglass insulation on interior walls instead of mineral wool	$106,000.00
Change HP/MP duct to allow for TDC joints	$95,000.00
Reduce dimming requirements from 1% to 5% in certain areas	$70,000.00

C.2 Impacts of Value Engineering Ideas

The first value engineering (VE) idea, using fiberglass insulation on interior walls instead of mineral wool insulation board, has subtle impacts. The inherent nature of the mineral wool insulation board makes in fire resistant. The fiberglass insulation that is replacing this is not fire resistant and extra measures to meet flame spread and fire ratings for the interior partitions will have to be considered. This idea does not really affect the owner's goals for the project. However, mineral wool insulation is a sustainable product that, when compared to fiberglass insulation, can reduce energy and life cycle costs.

The second VE idea is to change the high pressure and medium pressure duct to allow for TDC joints. This idea will help expedite the mechanical duct installation on site. This system will allow for a quicker connection of the duct rather than cutting and installing the flanges in the field. This particular idea, since it relates to accelerating the construction process, correlates well the owner's goal of opening the hospital on time. It should also help with leakage problems and allow for a smoother commissioning process.

The third VE idea is reducing the dimming requirements from on percent to five percent in the entire facility except radiology rooms, operating rooms, and classrooms. This idea reduces costs because of less stringent specifications. The equipment will not have to be as technical or complicated. The idea aligns with the owners goals for the project because the dimming requirements were held for the most important rooms in the building including the operating rooms. This will help the medical center become a top notch operating and trauma center in the region.

C.3 Value Engineering Ideas Not Implemented

There were several VE ideas that were considered, and may still be considered, but not implemented into the project yet. The major VE idea that could potentially save the project a lot of money, yet maintain the standards and specifications, is allowing a different Air Handling Unit (AHU) manufacturer to produce the AHU's. Considering the project specifications and controls, researching and comparing components shows that an alternative AHU manufacturer could produce adequate units and save the project about $300,000. Another potential VE item that could save the project a substantial amount of money and not detract value would be to use CPVC pipes and fittings in lieu of schedule ten black pipe with schedule forty pipe fittings. This could save another $135,000. These ideas are not just cost cutting implementations, rather ideas to either add value or maintain the same value and save money at the same time.

D. Problem Identification

The following is a list of problems that face the project team at The Washington County Regional Medical Center:

- Deep Foundation System Design and Construction
- Foundation Wall Design and Construction
- Masonry Work
- Steel and Mechanical Systems Conflicts
- Medical Equipment Procurement
- Installation of Mechanical Equipment in Third Floor Mechanical Room

More detail, information, and technical analysis on these topics are provided in the next section of this report. This will show the theory behind identifying these as problems on the project.

E. Technical Analysis Methods

E.1 Deep Foundation System Design and Construction

The deep foundation system problems have already been explained and addressed in Section A of this document. With the previous information about the caissons in mind, research into alternate systems would produce a different outcome. The two main focuses for this topic would be schedule acceleration and cost. An analysis of alternate systems would have to be considered. Research into alternate systems would encompass initial analysis of minipiles, geopiers, and friction piles. Each of these systems, at first glance, may be a viable alternative to the caisson operation. A deeper investigation of an alternate system will have to be based on information provided about the rock formation at the site and be able to distribute the load to the earth as originally intended. All three ideas would generate a new set of construction issues that would have to be assessed on a case by case basis related to The Washington County Regional Medical Center.

E.2 Foundation Wall Design and Construction

The foundation wall design was another topic previously discussed in Section A of this report. Knowing the situation with which the wall was involved will allow appropriate research of a retaining type of structure that will also serve its duties as a bearing foundation wall. A much more technical approach can be taken to this problem based on a structural analysis. This analysis will consist of the forces created by both the soil and the building loads. However, the construction techniques would presumably not be affected much through this change. The wall would only vary slightly in size, but since no reinforcing bar was in the original footing, a new design may include substantially more reinforcing bar. The initial cost of the two different walls would not vary by much, but the redesign and implementation of the new wall would cost considerably less than the proposed fix to the current wall. The schedule would also not be halted to remedy the work.

E.3 Masonry Work

The masonry work on the job is restricted, for the most part, to the lower two floors of the medical center. Timing of the masonry work could pose a problem to the completion date of the project because of winter weather work. Architectural precast panels are already being used for the bed towers' façade. Adding architectural brick precast panels to the lower floors of the building to replace the masonry work would save on site work time. Research could be performed based upon field and shop duration calculations, cost, quality, and safety. Another concern, and point of analysis, would be to check the different loads a precast system would place on the building. New support systems will need to be researched and could possibly cause bigger steel sizes; although bigger steel sizes would cost more than the precast could save. Adding a thermal element to this precast wall system could open a new door to energy and material savings. The thermal properties of wall units can be better with less room than conventional building methods.

E.4 Steel and Mechanical Conflicts

There are many conflicts between two of the major building systems; steel and the mechanical distribution systems. These are mainly found in the lower levels of the building and towards the exterior of the medical center, but some changes in the lower level could force compounding mistakes throughout the building. Four dimensional modeling and clash detection software may alleviate these problems and could be researched and quantified. Information could be more readily available to the contractors and provide for a smoother flow between the architect and the contractor. This implementation could also facilitate a shorter schedule because these conflicts could be solved simply ahead of time and field work would not be hindered.

E.5 Medical Equipment Procurement

Medical equipment is always changing and advancing; therefore, many medical buildings do not select their equipment until the very end of construction. This creates a problem in both design and construction because the team is building for something that they know nothing about. This topic may not be able to be researched as easily, but is a constant problem in the healthcare market and is worthy of notation.

E.6 Installation of Mechanical Equipment in Third Floor Mechanical Room

One of the main mechanical rooms is located on the third floor of the South Bed Tower. The equipment installation will generate problems because of the height at which the equipment will need to be hoisted. The façade installation will also be ongoing and coordination between the exterior skin and the equipment installation will be crucial. There must be a way to install the equipment into the building without affecting the precast panel erection of the South Bed Tower. Constructability issues present the most challenging situation for the installation of this large equipment. An analysis of site and crane logistics will need to be considered as well as alternate methods to furnish the equipment.

Appendix A: Sequencing Diagram Comparison

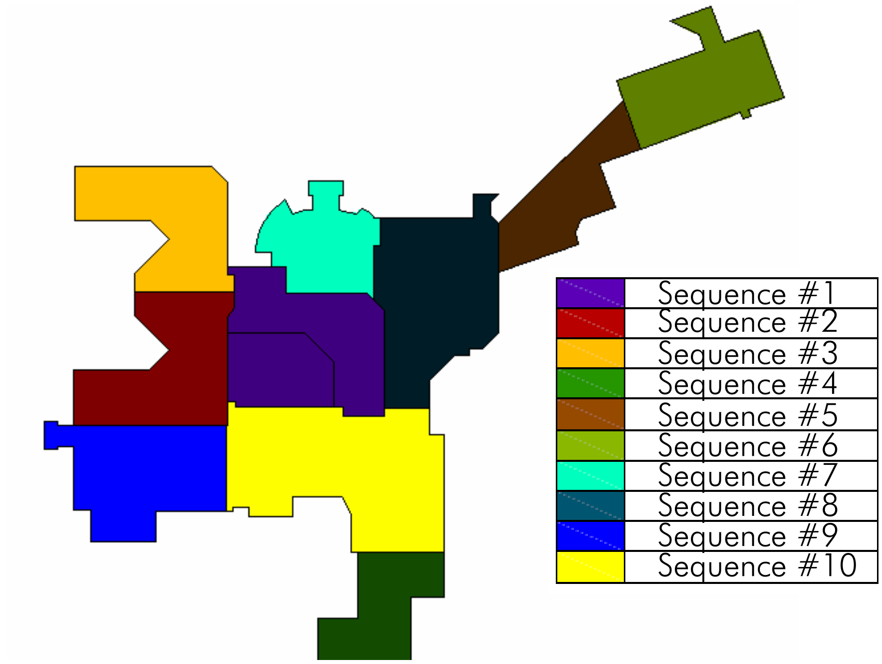

Figure A-1: Original Sequence

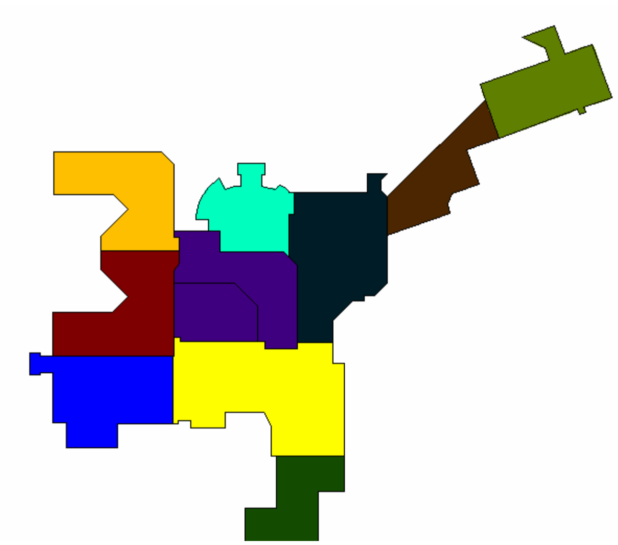

Figure A-2: Sequence Option 1

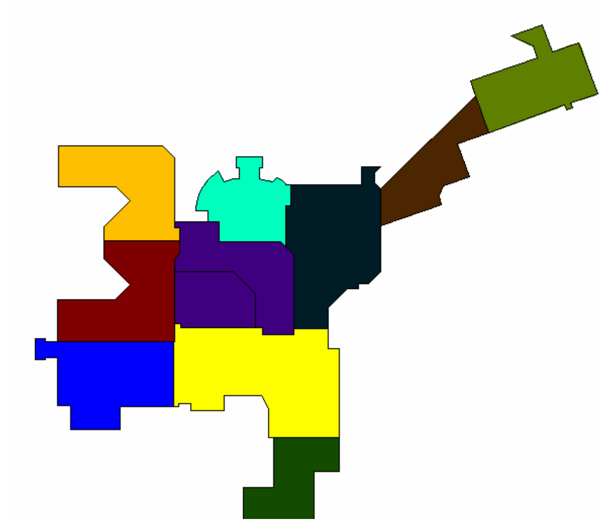

Figure A-3: Sequence Option 2

Sequence #1
Sequence #2
Sequence #3
Sequence #4
Sequence #5
Sequence #6
Sequence #7
Sequence #8
Sequence #9
Sequence #10

Sequence #1
Sequence #2
Sequence #3
Sequence #4
Sequence #5
Sequence #6
Sequence #7
Sequence #8
Sequence #9
Sequence #10