Fort Pickett Regional Training Institute Phase II
Blackstone, VA

Technical Assignment 3

Figure 1: Site Aerial - Courtesy of Barton Malow

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Executive Summary

Phase II of the Fort Pickett Regional Training Institute project is composed of the construction of three billeting buildings that total 120,000 SF for the Virginia Army National Guard. The buildings are being constructed in order to replace the current housing being utilized by soldiers that was constructed during WWII. The $28M design-build contract was awarded to Barton Malow, the Construction Manager on-site, and is expected to finish construction on January 13, 2012. The project is well under construction and is currently in the midst of many of the design and planning considerations that were undertaken prior to construction. Although the types of construction being utilized on the project are relatively simple, no construction project ever goes as planned. For this reason, Barton Malow investigated key constructability challenges, conducted a thorough analysis of value engineering alternatives, and used a number of schedule acceleration techniques. Using these techniques, as well as information gathered from the PACE Roundtable, this report investigates the strategies that can be implemented to minimize problematic areas on the project.

After speaking with the Project Manager on the project, it was possible to gain a better understanding of the constructability challenges faced by the construction management team. Although the project was provided with favorable circumstances, the project featured innovative building practices, such as precast hollow-core planks, SIPS, and a complex curtain wall. These issues were mitigated through previous experience from Phase I, as well as careful planning. The project team was also able to capitalize on a number of schedule acceleration techniques, specifically creating a schedule buffer through allotting overtime to the sitework and concrete trades, implementing clash detection of the MEP systems, and phasing construction between the buildings appropriately. To add further value to the project, value engineering topics were examined, so that both the management team and Owner benefited from their use. Using the information compiled, as well as ideas discussed at the PACE Roundtable, it was possible to compile a number of problematic areas that could use further planning or redesign. After analyzing the areas of concern, it was then possible to manufacture a number of possible beneficial project implementations, such as prefabricating the rooms, prefabricating CMU panels for the façade, developing short interval production schedules, utilizing material tracking software, and manufacturing virtual mockups.

By minimizing their high risk areas, introducing schedule acceleration techniques, and using favorable value engineering alternatives, Barton Malow was able to excel at Fort Pickett. Their strategies in combination with a number of the stated critical industry issues at PACE provided a number of areas to investigate further for improvement. This report serves as a foundation for developing a higher quality end product for both Barton Malow and the Virginia Army National Guard.

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Constructability Challenges

The Fort Pickett Regional Training Institute project consisted of a number of constructability challenges, specifically with the innovative building practices utilized. Unlike most projects, Barton Malow was provided with favorable site conditions, a cooperative Owner, and was not significantly impacted by neighboring occupied structures. There were no unforeseen conditions within the site excavation phase, particularly due to the shallow foundations. The site allowed more than adequate space for storage, deliveries, and logistics. The construction area was isolated from neighboring structures, so that a site fence at the very least separated usable buildings and construction. In addition, since this was a phased project, a number of the building practices were repeated for Phase II. Overall, the project faced only a few setbacks, but where there did exist adversity was in the new construction practices implemented, specifically the construction of precast hollow-core planks, CMU curtain wall, and structurally insulated panel system (SIPS).

Precast Hollow-core Planks

The most challenging construction practice implemented was the precast hollow-core plank floor system. The three billeting buildings were designed to use precast hollow-core planks for the second story flooring system with a two inch topping slab, a system considered innovative in comparison to the traditional metal decking and cast-in-place concrete system. The use of this system was believed to increase the cost of construction through materials, but significantly cut into the project schedule. Since the precast members were manufactured off-site, new concerns arose, such as deliveries, storage, and quality control.

Prior to erecting the planks, it was critical that the first floor load bearing walls were constructed and inspected properly. The planks were then laid down along the length of the building, so that the cranes could minimize pick times, as well as reduce confusion of what planks to lift. A crane was located on each side of the building, where it ran the length of the building using the same repetitive process. As seen in Fig. 2 to the right, the hollow-core planks were set with 75 ton and 100 ton cranes that were also used to set the trusses for each building.

Figure 2: Setting Hollow-core Planks – Courtesy of Barton Malow

In order to ensure structural stability during construction, the load bearing walls on the first floor were temporarily braced, which can be seen in Fig. 3 below. The walls were also bridged together with fasteners located 5' from the top of the stud wall, which can be seen in Fig 4 below. In order to place the planks properly, splice plates were welded onto the top of the load bearing walls to act as guides and additional security.

Figure 3: Temporary Bracing – Courtesy of Barton Malow

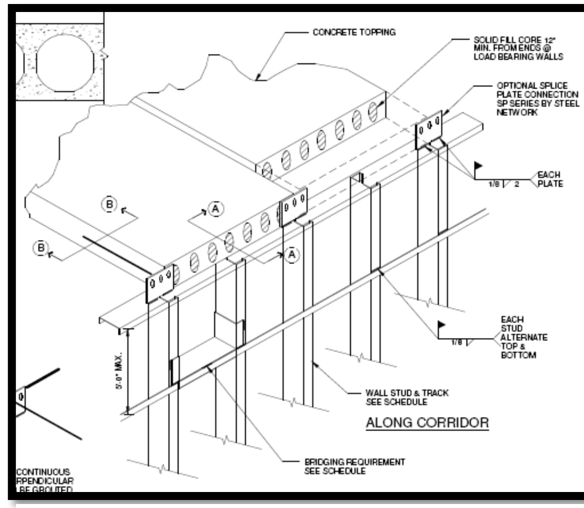

Figure 4: Stud Wall Detail – Courtesy of Barton Malow

After the hollow-core planks were set properly, it was then critical to secure them into place using reinforcing grout, and a topping slab. Continuous reinforcing in the form of #5 rebar was installed along all joints where it was then grouted, a task that can be seen in Fig. 5 below. In addition, each core in the precast members was grouted 12" from the ends to further the strength of the connection. Once the planks were properly grouted, it was then time to pour the topping slab. The topping slab was designed to enhance the structural integrity of the structural system, as well as provide continuity in the floor by removing aesthetically unpleasing joints. Since hollow-core planks were used in Phase I of the project, the construction management and design teams were able to learn from their past experience. In Phase I, the project team decided to proceed with the second floor load bearing walls upon completion of grouting the planks and then poured the topping slabs once the walls were completed. After running into a number of constructability issues regarding formwork and accessibility, the project team decided to pour the topping slab prior to erecting the

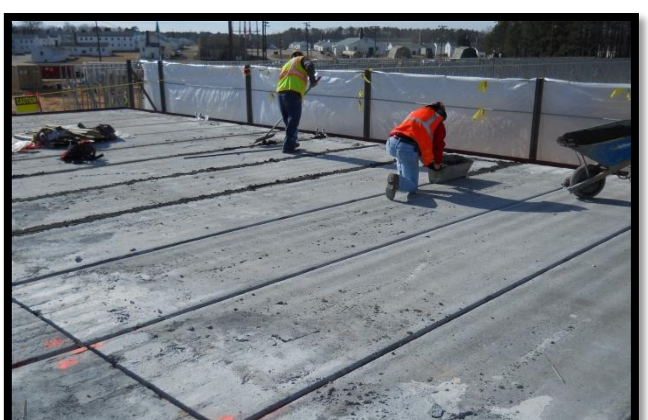

Figure 5: Grouting – Courtesy of Barton Malow

second floor's load bearing walls. In addition to changing the sequencing, Barton Malow introduced a key design feature to help with the concrete placement. As seen in Figure 6, 1/4" bent plates were added around the perimeter of the slab footprint that acted as formwork for the concrete pour. The bent plates provided a stop for the concrete and allowed the concrete to completely cover the precast hollow-core plank members. The 2" slab was reinforced with welded wire fabric, which further accelerated the schedule in opposition to using rebar. Upon proper finishing and curing of the topping slab, the second floor's load bearing walls were able to be erected, resulting in the completion of the second floor.

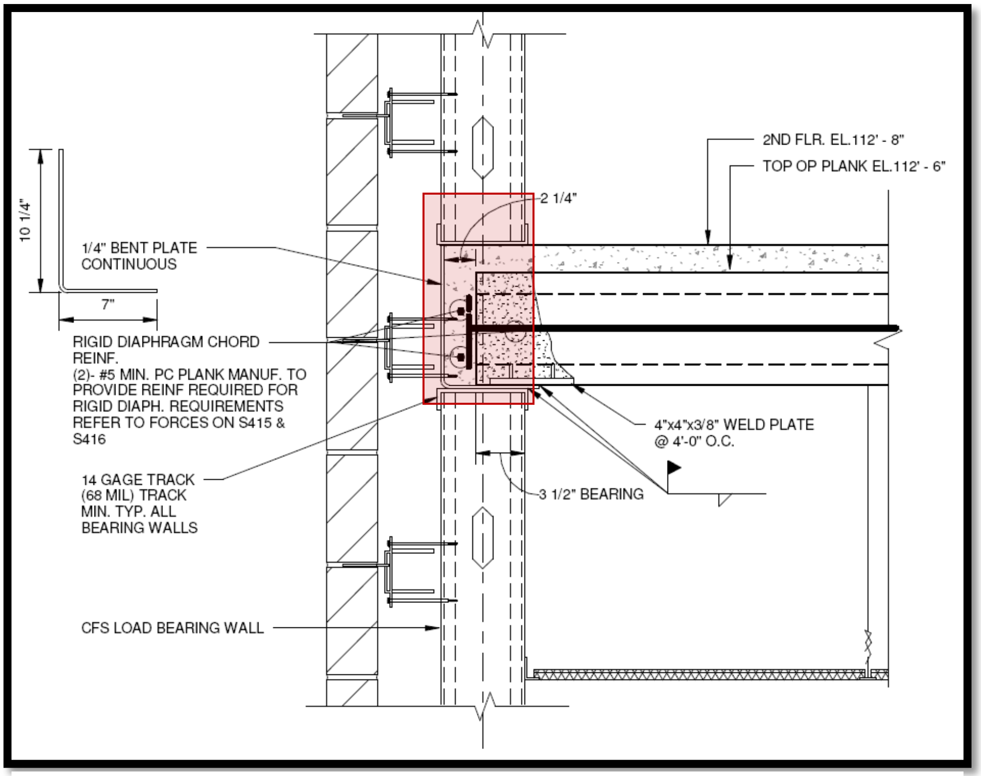

Figure 6: Slab Perimeter Detail – Courtesy of Barton Malow

Masonry Veneer

Due to the accessibility limitations and intricate block design, the masonry veneer posed as a significant constructability hurdle for the project team. The exterior façade work conflicted with the work of a number of other key trades and building components, particularly the exterior doors and stairs. In addition, the exterior block veneer was designed to include a number of different blocks, textures, colors, mortars, and patterns, which made the coordination and planning incredibly difficult.

The largest problem with the CMU veneer was accessibility to the building, especially the second floor. The buildings were designed to host an exterior stair case at each end of the three buildings, a design that differed from typical designs and created a number of coordination problems. In addition, only a limited amount of exterior doors were utilized to heighten the security of the buildings, which only exacerbated the buildings' accessibility problems. Exterior doors can be seen in Fig. 7, where the red signifies the door placements around the buildings with doors located on both floors at the ends of the buildings.

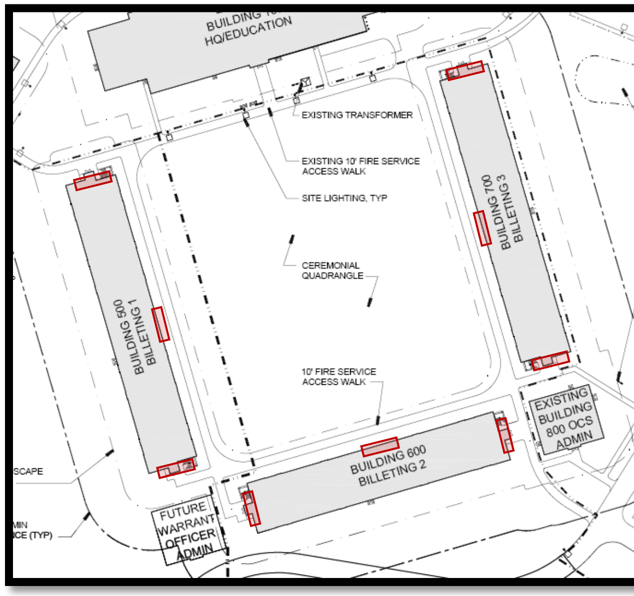

Figure 7: Door Layouts – Developed by Kendall Mahan

Construction of the façades started on the ends of the buildings, so that at least one stairwell could be constructed immediately to give access to the second floor. Once the first flight of stairs was completed, work began immediately on the second floor, and the masonry work continued across the rest of the exterior of the buildings. Shown in Fig. 8 below, the jack scaffolding had the capability of spanning a significant portion of the perimeter at one time, which was incredibly beneficial to the productivity of the work. Where issues arose was in the block placement of the second end of the buildings. According to OSHA regulations, there must be two usable exits in every construction area, a regulation that posed an enormous barrier for the project team when work began on the second end of the building. In order to correct this problem, Barton Malow constructed temporary steps and ladders to windows on the sides of the buildings. Not only did the construction of the second end of the building hinder the safety of the workers, but it impacted the efficiency of the trades. Up until this point in construction, the end windows had not been set to allow access for machinery to deliver materials and tools, as well as discard waste and remove tools. Since, the southern-most window of each end of the buildings served as the primary access window, due to its close

Figure 8: Scaffolding – Taken by Kendall Mahan

proximity to the storage and waste containers, work on these faces of the buildings created additional coordination and planning. Each interior trade had to coordinate with the masonry Subcontractor to plan the most optimal time to make material deliveries and waste removals.

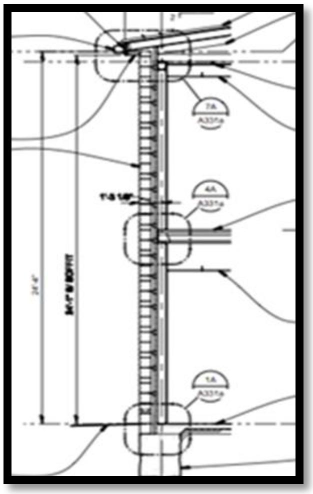

Figure 9: Exterior Wall Section – Courtesy of Barton Malow

The building of the veneer followed typical masonry wall construction with the construction of the exterior sheathing, vapor/air barrier, mortar nets, weep holes, masonry ties, and other miscellaneous items that preceded erection of the blocks. The base of the masonry veneer rested on the continuous footers that supported the exterior load bearing walls. As the block courses continued to be constructed, masonry ties held the veneer to the exterior sheathing and cold formed metal stud wall structure. To provide additional support, steel angles were used as ledges for block on the second floor exterior in order to further distribute the load on the metal stud walls. Although the construction was very similar to typical masonry veneers, the complexity of the construction came in the variation of block and mortar types.

In conjunction with the atypical design of the buildings, the façade featured a complex arrangement of block work. The façade consisted of precast concrete lintels, split face CMU, and smooth CMU, which can be seen in Fig. 10, as well as a variety of different colors, mortars, and course thicknesses associated with each material type. Incredible coordination was required to ensure that each course of the wall was constructed properly and even more planning was needed for material handling. Some block courses were comprised of only one block and color, which made the quick interchange of materials critical to meeting durations. For example, parts of the wall design called for three courses of split-face gray block with gray mortar, followed by one red course of block and mortar, and then back to the gray block and mortar, which can be observed in

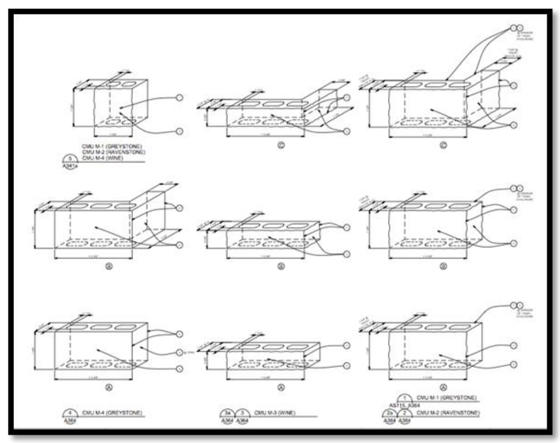

Figure 10: CMU Types – Courtesy of Barton Malow

Figure 11: Masonry Veneer – Taken by Kendall Mahan

Fig. 11. It created a condition of extreme planning, material preparation, and material storage. The mason held a heavy dependence on the laborers to provide the correct materials, so that their work flow was not interrupted. Another design setback with the veneer occurred with the top course of the block. The top course utilized split-face CMU, which created an uneven joint between the roofing soffit and the block, a condition that was considered to be aesthetically unappealing to the Architect. In order to correct this flaw, a design change switched the block from split-face CMU to smooth CMU.

SIPS

Another constructability issue came in the form of the SIPS, an implemented value engineering option, as well as a way to accelerate the project schedule. In opposition to using traditional metal roof decking, the design team believed it was in the best interest of the project to pursue the use of SIPS. Although the SIPS had an enormous upside, their use throughout the construction industry is still relatively new to construction and something that the Subcontractors and project team on-site had little experience with.

SIPS are a composite material that consists of OSB sheathing that is filled with spray foam insulation. In order to meet the quality and standards proposed by the Architect, the Barton Malow project team visited the factory where the panels were constructed. Pictures of the panels manufactured for the Fort Pickett project and the manufacturing line can be seen below in Fig. 12 and Fig. 13. Again, thanks to Phase I of the project, Barton Malow had the opportunity to learn from past mistakes and changed the designs of the panels. The SIPS used in in the Phase I construction were 9' in length and were considered to be time consuming in the erection process. In order to increase efficiency, Phase II was designed with significantly larger 24' panels that minimized the amount of butt joints, fasteners, and panel lifts required to erect the roofing system.

Figure 12: SIPS – Courtesy of Barton Malow

Figure 13: Manufacturing Line – Courtesy of Barton Malow

Although the design size of the panels were altered to aid in the construction process, the work was still unprecedented for the responsible Subcontractor. In addition, the panels required an enormous amount of planning towards deliveries, storage, and erection. A picture of the panels set in place can be seen in Fig. 14 below.

Figure 14: SIPS Erection – Courtesy of Barton Malow

Schedule Acceleration Scenarios

The Fort Pickett Regional Training Institute is currently under construction and plans to meet the expected January 13, 2012 completion date. For this project, Barton Malow used an outside scheduling service to build the schedule, as well as continue to maintain it. Every week, the schedule is adjusted to meet the appropriate stage in construction and create new three week look-ahead schedules for the Construction Management team and Subcontractors. Since the construction is a Department of Defense project, the schedule is closely reviewed by the Army Corps of Engineers and their scheduling consultant to ensure that Barton Malow meets their expected turnover date. To this point, Barton Malow has successfully avoided all of the potential schedule setbacks while enacting a number of schedule acceleration techniques and is well on its way to handing over a quality product in the middle of January.

Critical Path

The critical path schedule associated with Phase II of the Regional Training Institute project followed a fairly traditional construction process with a few unique features, which can be observed in Fig. 15 below. The sitework phase consisted of mobilization, site establishment, and the installation of underground utilities. Within the site establishment activities, many of the items were required to be relocated, such as the truck wash station, temporary fencing, and storage trailers. Upon completion of the sitework, the next phase of construction was the foundations. The foundations included excavation, reinforcing, and pouring the strip footers, followed by excavating, reinforcing, pouring, and finishing the slab-on-grade. Once the foundations were completed, the superstructure could begin to be erected. Activities in the superstructure included constructing the first floor’s loadbearing stud walls, setting the hollow-core planks, pouring the topping slab on top of the planks, constructing the second floor’s loadbearing walls, and setting the roof trusses. Upon completion of the building’s superstructure, construction could begin on the building enclosures, which was composed of

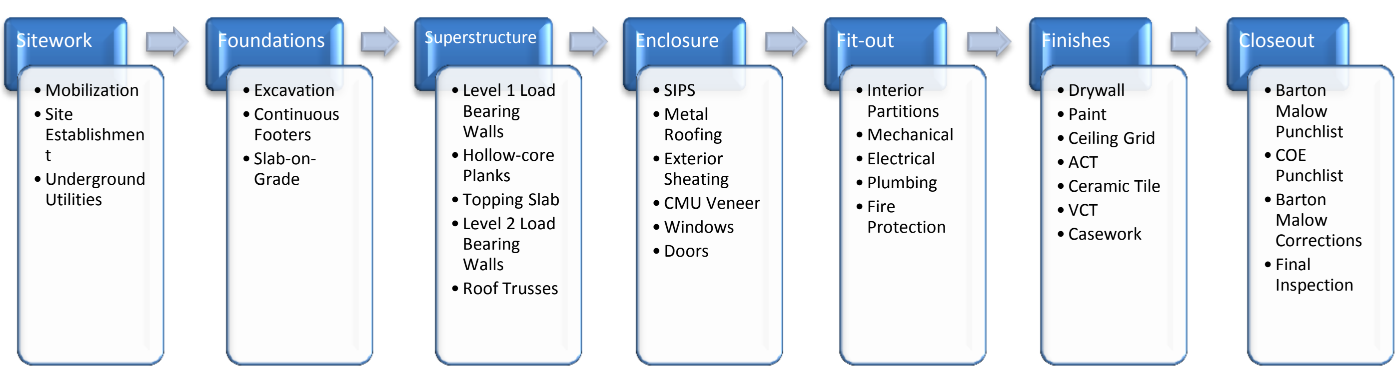

Figure 15: Critical Path – Developed by Kendall Mahan

setting the SIPS, finishing the roof, hanging exterior wall sheathing, erecting the CMU veneer, and setting the exterior windows and doors. Once the buildings were enclosed, fit-out could begin for the MEP systems. Once the fit-out phase was completed, finishes could begin, which included the following: drywall, patchwork, paint, installing ceiling grid, dropping ceiling tile, setting ceramic floor tile, installing VCT, and installing casework. The final step along the critical path was the closeout phase, which was made-up of Barton Malow's punch list, the COE's punch list, Barton Malow's back check/corrections, and the final inspection for turnover.

Risks to Meeting Construction Completion Date

The project's schedule has a number of potential risks, as well as a number of penalties for failing to meet the agreed completion date. The contract has liquidated damages built-in, in-case Barton Malow fails to complete the billeting buildings on time. The Virginia Army National Guard has the intention of moving into the facilities upon completion, where they can then move in their furniture. If the buildings are not completed on time, this step will be delayed, which will force the VAARNG to store their furniture elsewhere, and Barton Malow will be allotted the financial damages incurred. Possibly the most important risk that Barton Malow faces is the rating that the COE representatives award to the project team at the end of the project. With a currently weak building market, it is critical for Barton Malow to obtain a favorable rating, so that it can be used to help the company win further work with the government.

One of the largest risks on the projects is the setting of the precast hollow-core planks on the second floor of each building. If the hollow-core plank erection activity is delayed, the entire project will be delayed. The use of hollow-core planks is relatively new to the construction industry, so there is an expected learning curve for the workers. In addition, there are a number of components that have the potential to cause more delays within erecting the second floor. When using precast concrete elements, there is typically a long lead time associated, which must be considered during the design phase. The planks must be properly coordinated, delivered, and stored on-site or construction itself cannot begin. Once the materials are on-site, cranes must be present to erect the planks, as well as a great deal of planning for laydown areas. Once the planks are set, the floor must be reinforced, grouted, and completed by pouring the topping slab. The second floor is an absolute critical step along the project schedule and must be thoroughly investigated.

Another enormous risk on the project is the building enclosure, which is crucial for interior finishes to begin. Due to the design of the buildings' layouts, there is a relatively large amount of exterior surface area in comparison to the buildings' footprints. Interior work is completely restrained by the work of the exterior enclosure trades, which include the roofers and masonry Subcontractors. The roofers must put special emphasis on ensuring that the SIPS are ordered, delivered, and stored on site properly. Since the roofing activities are scheduled during the summer, special attention must be made towards weather delays for both rain and the sun. The summer months have been known to present days with dangerous temperatures and humidity levels that could derail the project's schedule. Although the façade features CMU block, opposed to a timely brick construction, the veneer still takes a considerable amount of time. Materials must be present, there must be coordination with the sitework Subcontractor, and weather must be taken into consideration.

Areas for Schedule Acceleration

In order to ensure that the project met the turnover date, Barton Malow implemented a number of schedule acceleration techniques that were able to build in buffers into the schedule. In addition, with a project overhead around $35,545 per week, the faster the work could be completed, the greater the fee the company could gain. The first area that the project team addressed was the sitework and concrete work. Typically, these trades are not pushed, since there work is performed early during construction, but Barton Malow found it advantageous to accelerate these trades. They measured the risk associated with not finishing the project on time, and the reward far outweighed the cost of accelerating these trades. As a result, Barton Malow paid the sitework and concrete trades' overtime, so that they could finish early, which pushed the schedule forward by an entire week. By moving these trades in and out as quickly as possible, it allowed the rest of the buildings' construction to proceed, where multiple new trades could begin work.

Another schedule acceleration technique that was implemented was the use of BIM for clash detection. Although the Owner decided not to use BIM, Barton Malow decided to proceed forward at their expense, since they believed that it would be advantageous to the project. The Subcontractors were bid out with the requirement of having to incorporate modeling techniques into their work. Once all of the systems were designed, all of the involved parties were brought together to perform the clash detection and coordinate efforts to correct the problems. Although the BIM was used solely for clash detection, the project benefited greatly from the added coordination. Redundant and timely mistakes were nearly eliminated, which allowed the Subcontractors to rapidly increase productivity, reduce RFIs, reduce change orders, and accelerate the project schedule.

A third schedule acceleration technique utilized was the sequencing of the work between the three billeting buildings. Barton Malow attempted to create a three week lag between each floor of each building, so that the work could flow from one floor to the next without interruption. This idea was also believed to maximize the use of the equipment on site, so that the equipment did not have to remain on-site any longer than needed. Although the sequencing plan made sense, there were problems keeping the strategy in place, since the Subcontractors continuously shifted crews between the buildings.

Value Engineering Topics

In order to enhance the value of the project, Barton Malow provided the Virginia Army National Guard with a number of value engineering alternatives. The goal of the project team was to provide options that benefited the project and buildings, yet not sacrifice the quality of the work put in place. The Virginia Army National Guard had strict project dates and limited construction funds, so it was critical that alternatives did not compromise the proposed schedule and budget. The project was designed to focus on the future operating costs and provide aesthetically pleasing buildings, so it was also important not to lessen the quality of the end product. In addition, since the billeting buildings are a Department of Defense Building, safety and protection of the occupants were not to be negatively impacted through structural alterations. Since the project was composed of two phases, Barton Malow also had the opportunity to learn from prior troublesome areas from Phase I and looked into alternative designs that could positively impact the construction process. The following items are a list of the value engineering options utilized on the project:

Manufactured Package Fire Pump

The billeting buildings at the Regional Training Institute used a wet pipe fire protection system with sprinklers placed throughout the buildings. The system is part of a centralized loop that runs throughout the campus and branches off of the nearby domestic water line. Where the domestic water line is tapped, a fire pump house was designed and placed to ensure that adequate water pressure is maintained in the case of a fire. The fire pump house was initially designed to be constructed in place, but was later changed to a prefabricated fire pump house. Since the pump house was manufactured off-site, only one trade was involved, which decreased the fabrication time and increased coordination. The pump house did not significantly impact the cost, but expedited the installation process while providing the same quality product to the Owner. By deciding to use a prefabricated pump house, the project team expected to accelerate the project schedule and use the saved time to focus on the finishes phase of the project.

SIPS

SIPS were chosen in lieu of the conventional metal deck, insulation, and protection board assembly, since it was believed to benefit the project's schedule and the buildings' thermal resistances. This option was also chosen for Phase I, but due to the Subcontractor's lack of experience with the panels, the panels showed little value to the project's schedule. Using their experience acquired during Phase I, the roofing Subcontractor was able to capitalize on this value engineering selection and cut into the schedule on Phase II.

Eliminated Second Drainage Pond

The value of the project was significantly heightened by eliminating the second drainage pond that was originally planned. In order to remove the need for the second drainage pond, the site around the first pond was regraded so that the excess water runoff could be directed towards the sole pond. Not only did this save the VAARNG money and time, but it drastically lessened the environmental impact construction had on the surrounding environment. The creation of only one pond made the site much more aesthetically appealing, as well as created more usable land area for recreational purposes.

Light Gauge Frame Shear Walls

In order to counter the lateral loads placed on the billeting buildings, it was necessary to design shear walls at four different locations on each floor of the three buildings. The buildings featured two different shear wall designs, which can be seen below in Fig. 16. The original design used tube steel shear walls that were bulky and costly. In order to reduce the buildings' costs and create more usable floor space, the tube steel shear walls were replaced with cold formed metal stud walls with light gauge diagonal braces. The straps were fastened at the floor and ceiling locations, as well as at various heights above the floor, and required minimal time to install, which made the light gauge straps a preferable alternative.

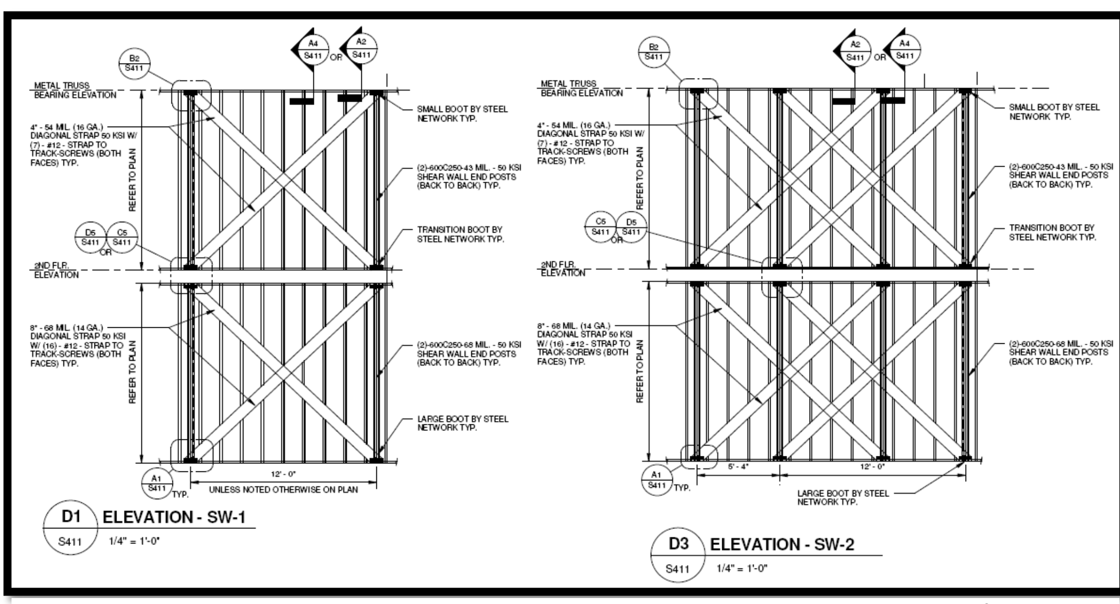

Figure 16: Shear Wall Straps – Courtesy of Barton Malow

Although there were a number of items selected to enhance the value of the project, there were a few options that were not pursued. As mentioned, the Owner stressed a number of goals, but it was critical that none of the changes compromised the quality of the buildings. Many of the following items were considered to be cost cutting efforts, opposed to value engineering alternatives and were not used on the project:

Consolidation of Heat Pumps

The original building design featured a mechanical system that dedicated a heat pump for every 3-5 rooms. The design of the system was believed to be innovative, since it allowed greater control over the air quality. If parts of the buildings were not occupied, it would be easy to turn off the heat pumps to that area, which saves a great deal of energy and money, a significant benefit to the Owner. In order to save money, a value engineering option was presented to consolidate the heat pumps to dedicate more rooms to a given unit and upsize the unit. Although this was appealing from a financial stand point, changing the mechanical system's design would weaken the users' controllability and potentially increase the operating costs attributed to the campus. For these reasons, the VAARNG decided to forego this option.

Reduce Electrical Outlets

Another item that was considered to be more of a cost cutting effort than a value engineering alternative was the reduction of electrical outlets. The costs associated with the electrical outlets from the materials to installation increase with number, but it was believed that instituting this change would diminish the quality of the space. The buildings were solely designed for housing, so it was deemed not to be in the best interest of the occupants and the Owner to enact the proposed option.

Critical Industry Issues

About the PACE Roundtable

The PACE Roundtable commenced for the 20th straight year on November 9, 2011 at the Penn Stater in University Park, PA. The theme of this year's Roundtable was "Building Innovation into Practice: Keeping What Works," an idea that investigates the techniques available to progress within the construction industry while integrating new processes, tools, and industry drivers. In a time of economic turmoil, it is critical for construction firms to continue to develop new construction practices to differentiate themselves, as well as win work. The PACE Roundtable exists for industry professionals and Architectural Engineering students to come together to discuss current industry issues while allowing the students to develop ideas for their Senior Thesis. The Roundtable consisted of two breakout sessions to discuss issues in sustainability/green buildings, process innovation, and technology; areas believed to be prevalent within the current construction market. The breakout sessions were followed by two different panels that looked into ways for construction firms to differentiate themselves in the current economy and ways to achieve hands-on learning in design and construction.

Figure 17: PACE – Courtesy of PACE

Breakout Session 1: Assembling/Procuring an Integrated Team (Process Innovation)

The first breakout session attended was "Assembling/Procuring an Integrated Team." Traditionally, construction has operated using an individual first approach, but with the current state of the economy, it is critical for the industry to come together and work as one. The discussion brought about a number of obstacles that the construction industry must overcome before reaching full integration. The largest component required for success in an integrated project delivery method is trust. Every party must buy in, but it is incredibly difficult to do so with so much risk associated with construction. One individual specifically stated that the insurance companies pose the biggest threat against integration, since there is no product/contract for a single entity to utilize. Another topic that continued to surface was how to get the right team assembled? Many believed that it was crucial to match experience of the players involved, where some thought that getting the older industry members to buy-in would be a struggle. As the discussion continued, it became clear that there was a lack of confusion on what step to take towards assembling a team. Before anything, the Owner must be on board with the IPD approach. In order to get their support, case studies or comparative studies were found to be best suited. The typical Owner takes the construction cost as the most important item to be considered, so if the risk is too great to implement innovative practices then the use of IPD can immediately be dismissed.

IPD remains an innovative approach to construction, and although everyone knows what obstacles exist, there has still been little progress. Every industry professional would admit that trust is hindering progress, but no one is willing to overlook the risk and legal issues associated with construction and simply take a leap of faith. Although project delivery methods are difficult to measure quantitatively, a number of ideas were proposed for investigation. One proposal was to investigate how to deal with the upfront cost of IPD. Using IPD, the design phase's cost becomes elevated, but the potential savings in the construction phase are believed to far outweigh the initial cost. The problem is convincing the Owner that additional spending upfront will be recuperated in the construction process. Another proposal was a comparative analysis of the costs, schedule, and change orders between an integrated delivery system and a traditional delivery system. From the discussion and the knowledge accumulated from research, I was able to compile a number of other ideas, such as prefabrication of rooms in the billeting buildings and the use of prefabricated masonry panels on the façade. Both items would involve a great deal of research using industry professionals who have performed similar work, as well as the use of case studies done on other projects. The Fort Picket Regional Training Institute uses repetitive construction sequences from room to room, so the introduction of prefabricated construction and potentially SIPS could be of great benefit to the project's schedule and budget.

Breakout Session 2: Strategies and Opportunities for Taking BIM into the Field (Technology)

The second breakout session attended was "Strategies and Opportunities for Taking BIM into the Field." This topic went into the new technology associated with BIM, as well as some of the current challenges that it faces. Currently, BIM is primarily being used for coordination, scheduling, and punch list items, but many believe that there exists greater room for incorporation. The idea of using building models for code checking was something that many people were unfamiliar with, but seemed interested in. Using models to check codes would be an enormous design aid, but it appears that the technology is still in need of much work. The introduction of tablets and iPads to the construction field has revolutionized the way information is conveyed. It is much more convenient to have all of the drawings accessible through a small electronic device, opposed to carrying a stack of loose papers. One individual even suggested the use of smart boxes, stations where drawings and information can be accessed in the field for workers. Although BIM has made tremendous strides over the last few years, there still remain a number of drawbacks. The most voiced concern during the discussion was coordination and reliability in regards to the model. Many believed that major legal ramifications could come into play if the model does not match the as-built drawings. If the model is the primary building reference, then it is critical to update the model as changes occur in the field. Other issues, such as differing support for 3D drawings instead of 2D drawings, were a major part of the discussion. Although 3D drawings provide a clearer representation of the construction, the culture shift for older workers accustomed to 2D drawings stands as an enormous obstacle. Another item of concern was convincing the Owners to use BIM on the projects. Owners remain reluctant to pay for the elevated design costs and are not convinced that this spending can be recovered in the building phase. The only way to gain support is to provide statistics and comparative studies of the saving incurred by other projects that decided to proceed down the BIM route.

Although the potential of BIM is clear, there remains an overwhelming amount of hurdles to overcome. Many ideas are still limited by technology gaps, lack of trained personnel, and minimal support from the involved parties. From the discussion, numerous ideas were suggested that could be beneficial for my research. The idea of virtual mockups was a feasible research opportunity, due to the model that is available and the complexity of the curtain wall design. The billeting buildings' facades at Fort Pickett feature a mixture of precast concrete, smooth CMU block, and split face CMU block that ranges from all colors, textures, patterns, sizes, and mortars. The time allocated performing the physical mockups was significant, making the adoption of virtual mockups something that could greatly benefit the project's schedule and budget. Another possible idea proposed was the investigation of the difference in cost, time, and efficiency between similar projects that utilized BIM coordination for MEP systems. The Regional Training Institute utilized limited clash detection between the MEP systems, so it could be advantageous to looking into further design coordination.

Panel Discussion: Differentiation in a Down Economy

The panel discussion focused on the methods being adapted by companies to differentiate oneself when bidding work. It was stated there is an 18 month delay for construction work to pick up after the economy improves and an additional 18 months until construction firms can charge fees. Although many are speculating that the economy is beginning to swing favorably, the construction industry will still be negatively impacted for at least 3 more years. The market is currently at a standstill, so construction firms must change their practices in order to survive. A lot of companies are changing the projects that they are pursuing, such as beginning to chase smaller projects to increase project volume. Others are focusing on different niches, particularly government work, since it is the most dependable for future work. Companies are also being forced to restructure their current staffs. The economy has created less Architects, so more CMs are being required to fill design gaps. Architects are receiving less pay, so there is less incentive to do more work, specifically design models. This in turn is creating a necessity to hire more personnel within the construction firms to handle the increasing integration and BIM demand.

I was able to generate a few ideas from the panel that involved ways to aid in the process to win work. Companies are being forced to change methods to improve efficiency while operating under tight bid numbers. There are little fees being attached to bids, but the only way to significantly increase profits is to implement new technology, personnel, and practices. The idea of prefabrication off site for both the rooms and exterior façade appears to be very appealing, since it has the capacity to greatly cut into the project schedule, reduce problems in the field, and reduce project overhead. Another idea considered was the investigation of the impacts new requirements for Disadvantaged Business Enterprises (DBEs) and Woman Business Enterprises (WBEs) are making within the construction industry. A lot of projects, specifically government work are heavily turning to the requirement of various workers. Companies that have the ability to partner with some of these smaller businesses will have the opportunity to capitalize on a lot of the available work.

Problem Identification and Technical Analysis

Although Phase II of the Fort Pickett Regional Training Institute has been a success up to this point, there are a number of problematic areas that could be addressed for further improvement. The design of the campus features a practical, simplistic approach that emphasizes best value. With a limited budget, the VAARNG attempted to gain the most occupiable space while taking into account the funds available, but not at the sacrifice of compromising the project's stringent dates and quality requirements. After investigating the project from design to construction, there are a number of areas that hold a capacity for improvement.

Construction of Load Bearing Walls

Upon completion of the slab-on-grade for each building, the load bearing walls for the first floor could begin construction. Although the work was aided by sequencing between the three buildings, erection of the precast hollow-core planks were delayed until the load bearing walls could be completed. This stage of construction was one of the most critical elements of the project schedule and was dire to meet the necessary dates so that the project was not delayed. As soon as the load bearing walls could be completed, the planks could be placed, followed by a similar situation for the second floor and the roof trusses. If the load bearing walls were erected faster, it would allow the building enclosure and interior trades to begin work much sooner.

To resolve this issue there are a number of feasible solutions that can be implemented, including the most drastic, the prefabrication of the bedrooms and bathrooms. Observed below in Fig. 18, the buildings share a repetitive room layout. For the most part, a given bathroom is

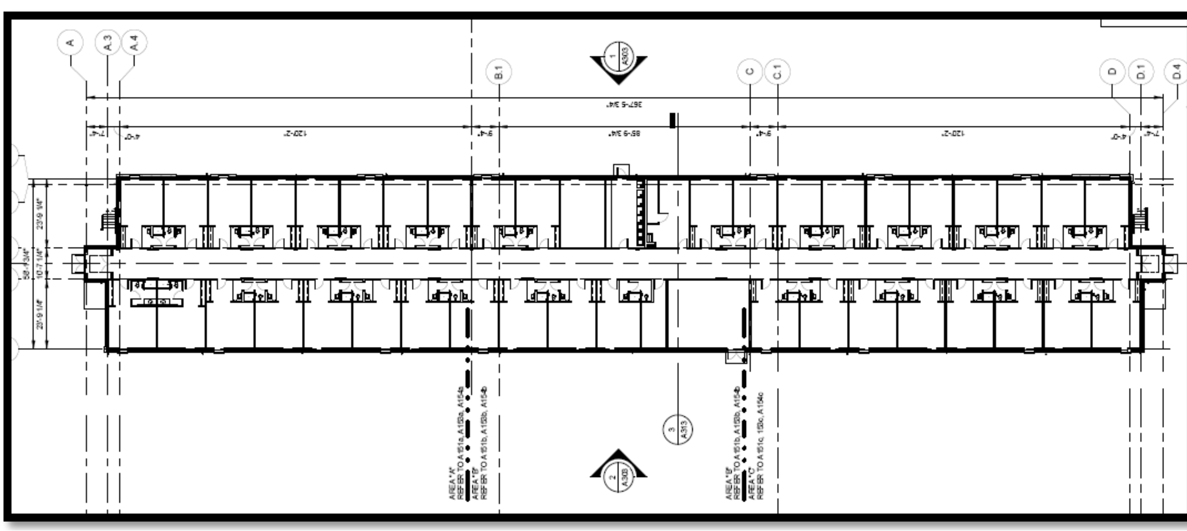

Figure 18: Building Layout – Courtesy of Barton Malow

shared by two bedrooms, where each group of rooms is identical to the next. The load bearing walls are located around the perimeter and the corridors for each building, which happen to be walls that are also shared by the rooms. Although there are a few deviations from the typical group of rooms, the buildings are primarily composed of similar groups of rooms that provide a tremendous opportunity for modularization. In addition, prefabricating the rooms allows for MEP rough-in and other interior work to gain a jump in the schedule. The billeting buildings provide an ideal opportunity to prefabricate the rooms and deeply cut into the schedule.

In order to get a better understanding of the feasibility of prefabricating the rooms on the project, it would be incredibly valuable to investigate similar case studies. Buildings with repetitive building floor layouts, such as hospitals, dorms, or jails would be ideal examples. The best way to gather information would be to contact General Contractors and Construction Management Firms with experience in the area. It would be necessary to look into shop costs by contacting companies that are familiar with the work, such as Truland and Southland for the electrical and mechanical systems respectively. Possible breadths could be developed in the mechanical and electrical options for prefabrication and possible redesign.

Sequencing Between Buildings

The billeting buildings share nearly identical floor layouts, which makes sequencing and crew management important. On-site, the Foreman of each trade was responsible for distributing labor in the buildings where attention was needed. Although Barton Malow hoped to keep a one week separation in work between each building, Building 600 fell behind the other two.

In order to increase the productivity and strengthen control of the project schedule, short interval production schedules (SIPS) could be implemented. The work in each building is repetitive, which creates the perfect situation for using SIPS. Initially, work could be directed towards the varying building spaces, such as stairs, mechanical rooms, and common areas, which would eliminate possible interruptions in flow for the bedrooms and bathrooms. Once these unique items have been completed, the remaining rooms could be worked on continuously without changes in work.

In order to conduct this analysis, multiple industry professionals could be consulted, specifically Hensel Phelps, because of their great deal of experience using SIPS. Statistical data could be presented to demonstrate the benefit that SIPS can have on a project’s schedule. SIPS could be manufactured for multiple stages of construction and areas, but are of primary focus on the bedrooms and bathrooms. Regarding breadths, SIPS could be attached to the installation of the MEP systems.

Construction of Masonry Curtain Wall

An area of continuous concern to the project team was the completion of the curtain wall. The exterior was composed of load bearing metal stud walls, exterior sheathing, vapor/air barrier, and a combination of façade elements. The veneer was made-up of precast concrete, smooth-face CMU block, and split-face CMU block, which varied in size, color, texture, pattern, and mortar. Due to the magnitude of the work involved, constructing the curtain wall on-site presented a lengthy duration. The curtain wall was incredibly complex and was responsible for the start of construction of the interior trades, which made it a key concern for analysis.

An analysis topic to resolve this issue is the use of prefabricated panels or tilt-up panels. Using prefabricated panels would expedite the construction schedule by moving a majority of the work from the construction site to the shop. Work in a controlled environment promotes faster productivity, cheaper labor, safer work conditions, and eliminates weather delays. In addition, the work can be performed simultaneously with the superstructure, so the panels can be erected immediately after the superstructure is completed. Tilt-up concrete panels offer a different perspective, but would cut into the schedule as well. The panels could be poured in place as the superstructure is being constructed, which would allow the panels to be stood up immediately after the trusses were set. Both changes to the enclosure would provide better activity durations and potentially save money and reduce injuries.

Again, the best way to investigate both of these methods would be to speak with an industry professional who has used both of these systems on their projects. Research would be dedicated to finding the advantages between shop and field fabrication techniques. In addition to using the panels as an construction management analysis topic, the panels could be studied for thermal resistances and structural impacts on the buildings, which would provide mechanical and structural breadths.

Tracking of Materials and Prefabricated Items

Although the use of precast hollow-core planks and SIPS on the roof have given the project team a great opportunity to accelerate the project schedule, they also carry a significant amount of risk. With the possible introduction of prefabricated rooms and façade panels, there is a significant amount of coordination and planning that needs to be allocated to the materials. Many of the materials have long lead times, are manufactured off site, and require careful planning for deliveries.

In order to combat the chaos introduced with so many prefabricated and shop manufactured items, a material tracking system could be utilized. There are currently a number of software programs that are on the market, including Vela and LocateWare. Both programs involve a complex tracking system that range from the actual construction of the product to the installation of the item on site. LocateWare uses radio frequency identification (RFID) tags on materials, so that the materials can be tracked easily. The RFID tags have the capability of storing installation, delivery, storage, and warranty information within the tag.

To investigate the effects that the material tracking software could have on the site, it would be beneficial to look into other case studies. For example, Giant's Stadium was constructed using RFID tags on the precast concrete elements, which made coordination and the erection sequence remarkably efficient. The costs of the software, tags, scanners, and overhead required to establish the use of this system could also be investigated. As a possible breadth item, RFID tags could be used for tracking MEP equipment and conduit as well.

Masonry Facade Mockups

An item that was considered an enormous consumer of time was the physical mockups of the masonry veneer on the billeting buildings. Due to the complexity involved with the design, a number of mockups needed to be constructed, so that the quality could be inspected by the Army Corps of Engineers.

To accelerate the schedule and save on labor costs, the physical mockups could be replaced with virtual mockups. A complete BIM model was produced for clash detection purposes, so the additional time required to create virtual mockups of the façade would be negligible. The model was created in Revit, but other models could be created in SketchUp, which would allow a clearer depiction of the work necessary. Constructability could also be demonstrated on the models by animating the sequence of work required.

To analyze this topic, the BIM model could be manipulated to produce virtual mockups of the façade. The model could also be replicated in Google SketchUp, so constructability animations could be performed. Virtual mockups' impacts could be researched from a cost, quality, and scheduling perspective. Industry professionals could be addressed, including Architects, Construction Managers, and Subcontractors. The mockups could be used to test the mechanical advantages of using various enclosures, such as tilt-up and prefabricated panels over the traditional construction in place method.