WORCESTER NORTH HIGH SCHOOL

TECHNICAL REPORT 3 :: **ADAM TRUMBOUR** :: CONSTRUCTION MANAGEMENT

ADVISOR: DR. MAGENT :: DECEMBER 1, 2009

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EXECUTIVE SUMMARY

The final Technical Report III discusses issues surrounding and possible improvements to the Worcester North High School Project. After an interview with Gilbane Project Manager Tony Iaccarino, as well as a site tour and meeting, several topics were identified and are detailed in the pages that follow. Specifically, the sections Constructability Challenges, Caveats of Scheduling and Value Engineering pertain to information obtained during a November 2009 visit to the Worcester construction site.

Worcester is hoping for a good rating by a fairly new program known as Massachusetts Cooperative for High Performance Schools (or MA CHPS). CHPS will rate the building from a construction and operative perspective. This has an effect on the decisions made by the architect as well as the construction team. To that end, the Problem Identification and Technical Analysis Methods sections address proposals to investigate sustainability, logistics and construction processes on the project.

Front, November 23, 2009

Rear, November 23, 2009

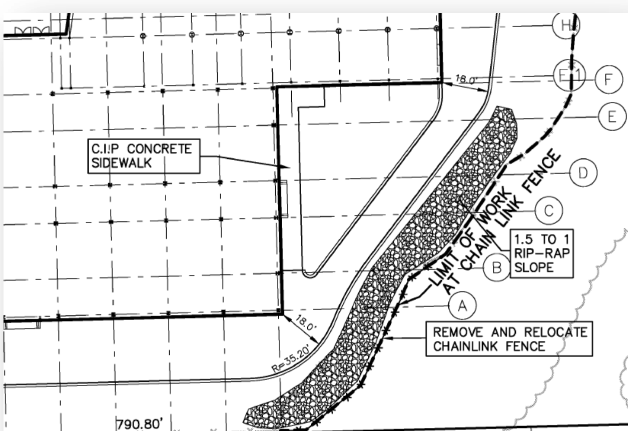
CONSTRUCTABILITY CHALLENGES

Worcester North High School is being built in a roomy site adjacent to the existing facility. The design of the new building is traditional in method; spread footing support a steel superstructure includes cast in place composite beams with an exterior clad in brick and metal panels. The geometry of the building is also traditional with a general L-shape and static floor heights. Considering the rather mundane structural features, this project has not presented any strong constructability issues or challenges in physical work. An interview with the Project Manager, Tony Iaccarino, shed some light on his view of the constructability of the building. The issues they have found pertain more to coordination and design completion than to the physical abilities or techniques needed to complete the project.

SITE RETAINING WALL

One of the first problems the construction management team encountered on this project was a discrepancy between multiple site drawings and intended construction methods. On the southwest corner of the site, the building footings are designated at a depth of 541' and the final grade was drawn at 538'. Furthermore, the steep slope in that area dictated the need for a retaining wall. With all three of these constraints, it was impossible for the team to construct that corner according to plans. Furthermore, final site work plans indicated that an access road would travel through that area and at the indicated dimensions, the slope of the road would be undesirable for any motor vehicles. Obviously the elevation levels would expose the footings, which is far from structurally sound. It was apparent that some rethinking of the area needed to occur.

IMAGE: CORNER AS DESIGNED BY ARCHITECT



The site plan as it stood before the changes proposed by Gilbane were incorporated.

The Project Manager (PM), Tony Iaccarino, proposed a few changes to address this. Dubbed by the Gilbane team as "Piazza Iaccarino", he suggested maintaining a grade of 546' around the corner of the building to the edge of the auditorium, where an egress door is located. Then, he proposed the installation of a prefabricated block retaining wall to allow the access road an acceptable slope down to 531', the finish elevation at the behind the auditorium and gym.

The pivotal constraint (and final change proposition by Gilbane) pertains to the gabion retaining wall at the extremity of the area in conflict (SW corner of site). A drop of 10-20' in elevation over a horizontal distance of 15' meant that indeed there needed to be a retaining wall, however the management felt that a cast in place concrete wall would be more suitable. The site engineer liked this and re-engineered the wall to be an 8" cast in place concrete retaining wall with a height of approximately 8'. This allowed the site crew to maintain the finish elevation of 546' at the "piazza", an appropriate slope for the access road, and a safe retaining wall without disturbing soil beyond the limit of work set by the owners.

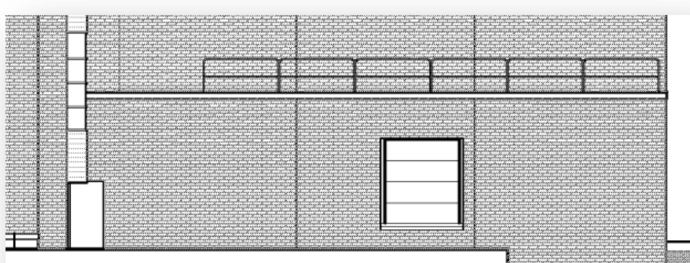
STAGE ACCESS

The second "constructability" issue was also a design issue deemed important by the PM, and couples with the design issues of the corner discussed above. The design of the auditorium stage called for a single egress door to be installed on the wall of the auditorium. Tony (the PM) saw that there was no way for him to bring in a lift for the stage area, specifically due to the small door sizes into the auditorium space. This led him to question the access provided to the auditorium for theatre productions. It was an issue that he could have worked around with an alternative to an aerial lift however he pushed for the owner to review the design.

The PM proposed installing a large, roll-up overhead door to provide access to the stage and fly tower areas of the auditorium. First and foremost, this would allow large pieces of scenery to be moved in and out of back stage with ease. The owners (especially the principal of the school) liked this idea very much since it was a logical design element. This in turn allowed the Gilbane project management team to enclose the space before aerial work was completed in the auditorium. The roll-up door now allows for ease of construction and ease of operability of the space. Furthermore, the re-design of the corner site work allows for a paved surface to abut the stage door (for deliveries, etc.).

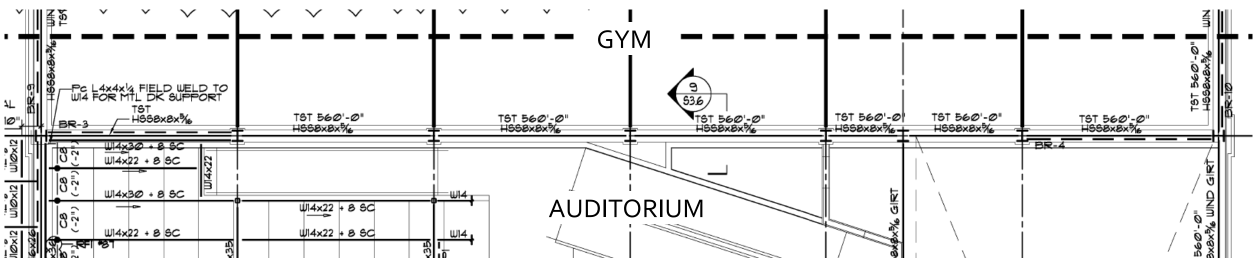
IMAGE: ELEVATION OF EXTERIOR AUDITORIUM WALL

As visible in the image to the right, the initial design called for a standard 36" door (left) which is too small for moving scenery and equipment in/out of the auditorium. The roll-up door (right) furnishes better access.



INCOMPLETE DESIGN DOCUMENTS

The project manager and project engineer both expressed great frustration with the construction documents for the North High School. They are working with incomplete design documents in part because the project was taken on with the expectation of a design impact as it drawings and ideas were finalized. Theoretically, design modifications should not affect work in place. Presumably, the architect is not changing designs he knows are already in the process of being constructed, yet there are areas where work in place has been affected. The roof level of the gymnasium was raised after the supporting columns were in place. (see images below)



When the roof of the gymnasium was raised 8', Gilbane needed to have the steel fabricator design a column splice. The erection team then had to cut the existing connection off, configure and splice in the column extension. This incurred a change order. While this issue presents a snag in the scheduling for the CM, it also presents a cost increase for the owner. Accordingly, constructability issues not only involve schedule and fiscal impacts for the construction manager, they also place the owner with similar risks.

Column Splice at Gym/Auditorium

While incomplete drawings may not be a direct constructability challenge, the indirect effect they have on the entire job equates to a need for constant problem-solving on the site. Small changes can affect large amounts of work in place, and it is extremely important for the CM and architect to be on the same page. As such, open communication is the keystone to a fluid construction process, and that is how the CM tries to address the constructability issues they face.

CAVEATS OF SCHEDULING

The scheduling team employed a critical path method on the high school project. The constraining date is the crucial occupation/use date of September 8, 2011. This is the last possible date for any work to complete, as the students will need the facility to begin the school year. The community expects a substantial completion of May 2011, however, in order that they may use some primary spaces for summer camps and continuing education courses. Gilbane must finish the final punch-list by July 13, 2011 to provide community access for the summer. The management team included sufficient float time into their schedule (though they would not divulge how much and in what phases) to ensure that they do not go over the deadline. They are comfortable with the requirements in the given time frame, but they are not pleased with the amount of changes currently being made to the design. Additionally, 82 days of float (though it is scheduled as a phase of construction) are provided on the schedule for design impacts. This fills the majority of time from July until September 2011.

The critical path, as described by the PM, started with the structural steel and currently, MEP coordination, which has been the most troublesome. The MEP coordination has been particularly stressful because, according to Tony, "every time we coordinate an area, the architect changes the design". There is a need for strong communication during coordination, especially when design changes impact the work in place. The management team has combated this and lowered their risks by carefully documenting each change and requiring the owner to sign off on the subsequent schedule changes.

As mentioned above, the construction documents are not final in the eyes of the architect, who continues to issue changes and addenda. The risks Gilbane has on the schedule, therefore, are documentation of design change impacts. They hold monthly meetings with their scheduler who inputs schedule impacts into Primavera. The scheduler then notifies the owner of updates and of the fact that the schedule keeps getting pushed (again, due to design changes). Furthermore, the changes have prompted Gilbane to write letters to the stake holders each time a design change impacts the schedule to ensure that everyone is on the same page. So far, they have had one major change order submitted and approved.

Another risk Tony mentioned was the fact that often subcontractors are apprehensive about discussing possible schedule impacts. He is adamant about meeting his subcontractor teams, learning their names and establishing the communication lines early. Tony feels that they can come to him and confer the status of their work and any foreseen schedule impacts, whether they're delays or accelerations.

In terms of actual methods for accelerating the schedule, the PM could not think of any methods they would or could employ in the future. He did bring up, however, the fact that Gilbane worked with the owner to purchase the brick masonry and metal panels as soon as they were chosen. Since this design completed later than the structure, Gilbane did not bid the exterior until fall 2009. The exterior skin was a long lead-time item. The owner was able to calculate the amount of materials needed and order them, having them on site as soon as the masonry contractor was ready to install. This shaved significant time off of the schedule.

Other ways in which the project management has tried to accelerate the schedule is with consultation during some of the designs. They have tactfully informed the architects and owners of how certain designs will be built and the durations required to execute them. One example was given where a shelf above the toilets would have required a separate build-out in each stall. Discussing the issue with the architect, Gilbane suggested putting the shelf to the side and pushing the toilet back to the wall, saving significant time on the plumbing. Tony stressed the need to approach such design alternatives carefully, as many owners/architects do not appreciate the construction manager attempting to change their design without significant warrant.

VALUE ENGINEERING TOPICS

A fundamental value of the project management team on any project is keeping a shrewd eye on construction techniques and subsequent costs. So-called "value engineering" can save both owners and contractors significant amounts of money. Not surprisingly, the Project Manager on WNHS strives to build things the most economical way possible, including evaluating cheaper alternatives.

The most significant value engineering that took place involved the roofing system for the building, and ended up being a significant "green" choice. Originally, the architect specified a Firestone rubber roof. This ¼" black rubber membrane came with a 40 year warranty. The construction management team had experience with roof membranes and recalled that rubber roofing is not recyclable. After 40 or so years, when the roof needs to be replaced, it will go into a landfill. Furthermore, the black color means high heat absorption. Gilbane proposed a white PVC roof as an alternative. Interestingly enough, the PVC roof came with a 30 year warranty, so Tony called the manufacturer and demanded a 40 year warranty; he got the warranty and the owner agreed to use it instead. The benefits of this change are three-fold: the PVC roof is recyclable when it comes time to replace it, a white color means low heat absorption and subsequent lower cooling loads in the winter, and finally the cost was less, at a savings of $250,000.

Another major cost savings was achieved when working with the brick to be used on the interior of the school's stairwells. The architect chose a 2-faced brick. From experience, the PM knew that 2-faced bricks can be expensive, running at about $15/SF. This brickwork would only have one exposed face, so the management team sought a similar product that was less expensive. They found several substitutes and presented them to the architect. Eventually, the architect settled on an 8" glazed CMU block.

First, savings are felt because the actual cost per square foot is less—the 2-sided brick is $15 while the CMU is $8. Second, the labor costs are cut in half since the CMU is larger than the brick. This resulted in a savings of about $150,000 in material costs alone, plus much more in labor costs.

The aforementioned value-engineered alternatives presented cost savings to the owner with minimal design impacts. Since the owner is attempting to achieve MA-CHPS, the switch to a recyclable roof means points gained in the rating of the building. That change enhanced the owner's goals in construction. As for the bricks—while the architect may have had a vision, the owner has a functional and fiscal goal; the switch to a cheaper masonry material may have thwarted the architect's design but it helped the owner out by saving money.

PROBLEM IDENTIFICATION

On the Worcester North High School, most of the issues with construction pertain to the actual design phase of the building during construction. The ongoing design affects many areas of the project from work in place to scheduling far down the line. There are very few project-specific problems that the construction team faces otherwise. Holistically, the process may be reviewed to find ways things could be done more efficiently. Alternatively, the sustainability (which is indeed a problem with today's buildings) should be analyzed to ensure every cost savings is sought and every design/construction choice makes sense for the occupants and the environment.

MA CHPS CERTIFICATION

The project is being built with a goal of achieving Massachusetts Cooperative for High Performance schools. This is a program adopted by several states: California, Colorado, Massachusetts, Nebraska, New York, Texas and Washington. CHPS "is leading a national movement to improve student performance and the entire educational experience by building the best possible schools". To participate in the program, new schools undergo a rating system similar to LEED. The incentive (aside from cultural) is up to 2% rebate on the cost of the school.

Certification of this project seems unsure as the construction managers do not know where it stands in the certification process. Furthermore, there is an allowance for a Photovoltaic system on the roof, as well as conduit to run piping for a solar hot water system. These two features as well as the CHPS program require a holistic review of the project and could be an area to research.

PHOTOVOLTAIC SYSTEM

As mentioned above, there is an allowance for a solar photovoltaic system, to be installed on the roof. The system does not have a schematic design yet, providing a good place to begin analysis. Designing and installing this system would create an energy savings for the owners of the building.

ELECTRONIC SUBMITTALS

Currently, the management team and architect are using a paper submittal process. After sitting in on a weekly meeting, it is apparent that some time is spent sending and waiting for submittals. It is crucial to save time whenever possible and moving to an electronic submittal process may prove advantageous.

MEP COORDINATION WITH BIM

As mentioned earlier, the MEP coordination is an ongoing headache for all parties involved on the project. With today's technology, a lot of time and effort can be saved by modeling a space in 3D or 4D. Considering the large amount of design changes and disruption to the coordination, modeling could be a way out of the nightmare.

PRECAST PANELS

Very little precast concrete is used on this project, aside from sills and lintels. The exterior façade has a look that is conducive to precast panels. Introducing this system over traditional masonry could mean savings of time in the schedule and money in labor. Additionally, precast may be of interest for sustainability reasons.

LIGHTING/ELECTRICAL SYSTEM

Fluorescent lamps are specified, with typical wall switches for controls. While the electrical system is tied into an energy monitoring and control system, occupancy sensors and electronic switching is not part of the design. Assessing the benefits and pitfalls of such a system would explore the possibility of further CHPS points and energy savings. This analysis could also couple with the renewable energy sources (solar) on site.

TECHNICAL ANALYSIS METHODS

The underlying theme in the technical analysis is researching ways in which the owner can save time and money while (more importantly) creating a long-lasting building that is equally friendly to its occupants and the environment. This applies to all four topics listed below, and will be a recurring theme in the Thesis Report on Worcester North High School.

ENERGY ANALYSIS ON CURRENT BUILDING CONFIGURATION

Starting with the designed configuration of Worcester North High School, a detailed energy analysis would provide information on key areas to address for improvement. Data such as climate, sunshine, usage type and schedule, electrical loads and cooling requirements can be input for a comprehensive assessment of the building's performance. This stage would present the owner with the projected costs of maintaining the building.

Secondary to the preliminary analysis would be the modeling of alternative methods. This may include renewable energy, alternative mechanical systems, and architectural features. Here, ideas on improvement could be tested in order to weight their potential importance in the overall efficiency of the building. Completing this phase of an energy analysis would provide the owner with an idealized version of their building, operating at the maximum efficiency (given the major design constraints) and aid in the selection of better building systems. Benefits include decreased lifecycle cost of the building, decreased carbon footprint, increased community presence (leading by example) and an increased responsibility to the environment.

CHPS FEASIBILITY ANALYSIS OF PROJECT

Looking to the Cooperative for High Performance Schools, there are multiple rating sectors, including educational display, innovation, pollutant controls, indoor air quality, site design features, and occupant training. Different from the energy analysis on the building, a CHPS feasibility study looks at the project as a whole, from design to construction to use, ensuring that each step is not only energy efficient but that it strives for the betterment of the students and faculty.

A review of the credits achieved with the current design would provide a basis for improvement. From fundamental design choices to materials selection, construction methods, and commissioning, an outline of the project's sustainability would indicate areas for enhancement. Integrating findings from the energy study undoubtedly would help in achieving a better rating. The CHPS survey may also present some process changes rather than mechanical or structural changes that would be beneficial. A direct result of improving the CHPS score means a larger instant rebate by the Massachusetts government and a better return on investment for the community.

IT SYSTEMS FOR CONSTRUCTION MANAGEMENT

Continuously improving systems are available for managing a construction job. Apparent from the frustration of coordination to the time wasted on submittal shipment, the WNHS project may benefit from the implementation of a program to handle this. Gilbane does have solid IT applications that it has developed. These are proprietary and available for sale. Looking into 3D/4D MEP coordination involves assessing the degree of complexity of the systems specified in the building. Aside from that, researching similar cases would provide solid evidence of whether or not it would work on the WNHS project. Finally, costs need to be considered: both the setup and maintenance costs of such systems and the value-added to the project by eliminating these problematic manual processes.

MATERIALS ANALYSIS

As mentioned above, exploring the use of precast panels over traditional masonry may indicate benefits warranting the architectural switch. Here, it is important to evaluate the desires of the architect and seek materials of similar quality and appearance. It may be of interest to find any sustainable products in this category. Next, the switch to precast (or another material) should be reflected in the schedule. Does the alternative material increase or decrease schedule durations? This data can then be integrated with materials cost to produce a comparison between installed costs of the masonry v. precast. It will also be crucial to evaluate site logistics such as deliveries, storage and placement of precast panels.