Pearland Recreation Center and Natatorium
Pearland, Texas

Technical Report #3

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Section 1: Executive Summary

This technical report is meant to identify problematic aspects of the Pearland Recreation Center and Natatorium that could be used for further investigation. The report begins with an overview of an interview with the project architect and project manager, highlighting key issues that have been encountered on the project, such as constructability challenges, schedule acceleration scenarios, and value engineering items. It concludes with the identification of potential research topics, including problem identification and technical analysis methods for each topic.

A phone interview was conducted with Van Franks, PBK's lead architect for the Pearland Recreation Center and Natatorium on November 17, 2009 to discuss value engineering changes that were made on the project. Six items were identified as modifications that were made during the design phase to better serve the owner's needs. These items are discussed in the Value Engineering section of this report and include the pool deck surface material, the natatorium seating, the flooring in the weight room, the mechanical equipment, the wall finish in the corridors, and modifications to light fixtures throughout the building.

On November 20, 2009 another phone interview was conducted with Scott Stoltz, project manager for EMJ Corporation. During this interview a number of constructability issues were discussed as well as the effect of these on the schedule. Most of these issues were due to the high water content of the soil on site. These issues are detailed in the Constructability Challenges and Schedule Acceleration Scenario sections of this report.

In the final portion of the report, six potential research topics were identified. Additionally, analysis methods for each of these topics were also outlined. The topics included investigating modifications to the structural system of the natatorium, evaluating the acoustical conditions in the natatorium, analyzing the apparent success of the project team, comparing a bolted and welded glulam column connection and considering the effects of implementing Building Information Modeling (BIM) and sustainability into the design and construction of the project. This is all discussed in further detail in the Problem Identification and Technical Analysis Methods of this report.

Section 2: Constructability Challenges

Piers:

A key constructability issue during construction of the Pearland Recreation Center and Natatorium was failure of the drilled concrete piers due to the high water content of the soil on site. About 5 piers experienced this failure. Figure 2-1: Drilled Footing as Designed shows a typical detail for these drilled piers.

To rectify this failure, the soils engineer and structural engineer worked together to develop a fix that enlarged the effected piers to match the size of the bell at the base them. This modified version of the pier is shown in Figure 2-2: Modified Drilled Footing.

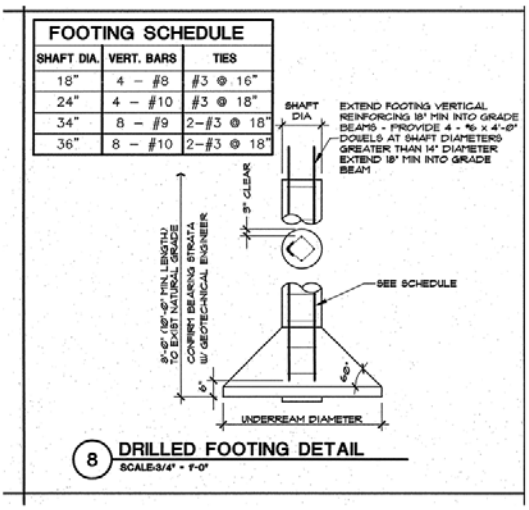

Figure 2-1: Drilled Footing as Designed

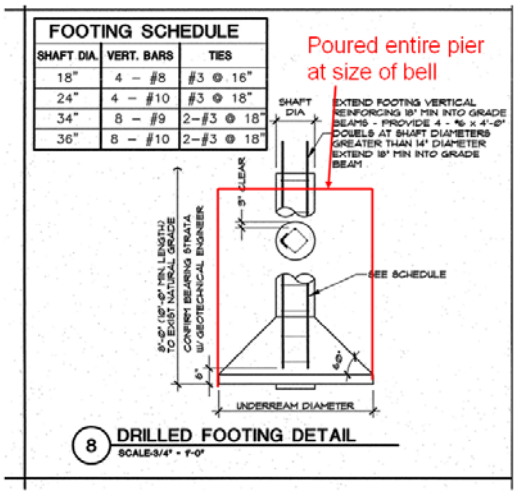

Figure 2-2: Modified Drilled Footing

Failure of these piers had tremendous schedule and cost implications. Construction of these concrete piers was on the project's critical path and delayed it by two weeks. Increased manpower by the foundation contractor resulted in regaining the two weeks that were lost and brought the project back on schedule.

Swimming Pool Walls:

Another constructability issue that was encountered on the project was the construction of the competition pool walls. The pool contractor had planned on using spray on shotcrete to construct the pool walls, allowing him to avoid having to over excavate and form the walls for concrete placement. However, due to the high water content of the soil the excavated walls in the deep end of the pool collapsed. This required the contractor to over excavate and form the walls anyway. Spray on shotcrete was still used in the shallow end. Figure 2-3:

Section View of Wall Placement Methods and Figure 2-4: Plan View of Wall Placement Methods shows the portions of the pool walls that were formed and the portions that were constructed using spray on shotcrete.

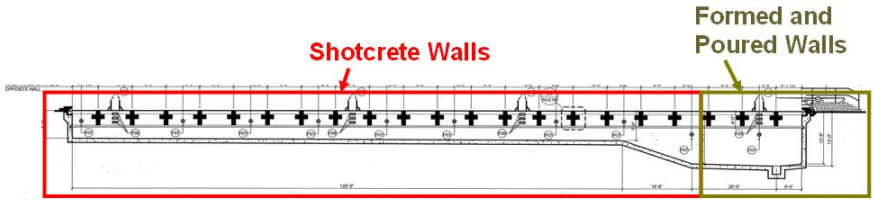

Figure 2-3: Section View of Wall Placement Methods

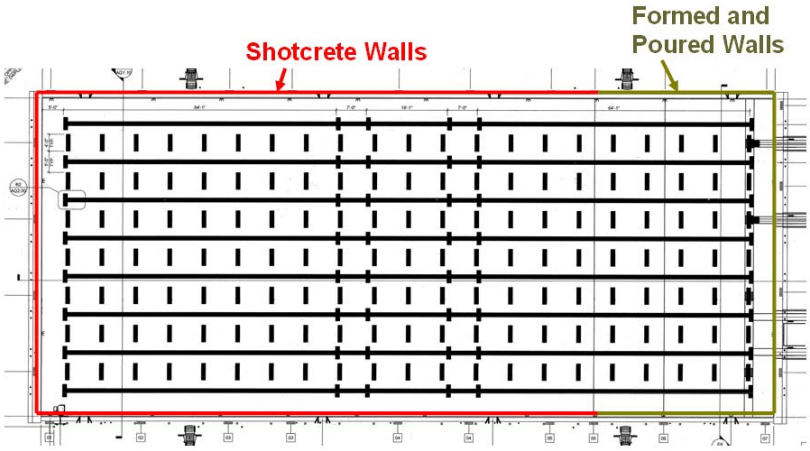

Figure 2-4: Plan View of Wall Placement Methods

Three weeks were lost on the schedule due to this issue. Since the swimming pool construction was not on the critical path, this loss was never regained and did not affect project completion

Glulam Base Plates:

The glulam columns in the natatorium were connected to base plates mounted on concrete footers. These columns were connected to the base plates with anchor bolts that had been cast in the concrete footer. Erection of the glulam columns was difficult since it was necessary to perfectly align the columns with the cast-in-place anchor bolts. A welded connection would have simplified the glulam column erection process. Figure 2-5: Glulam Column Connection Detail shows the as designed and constructed connection.

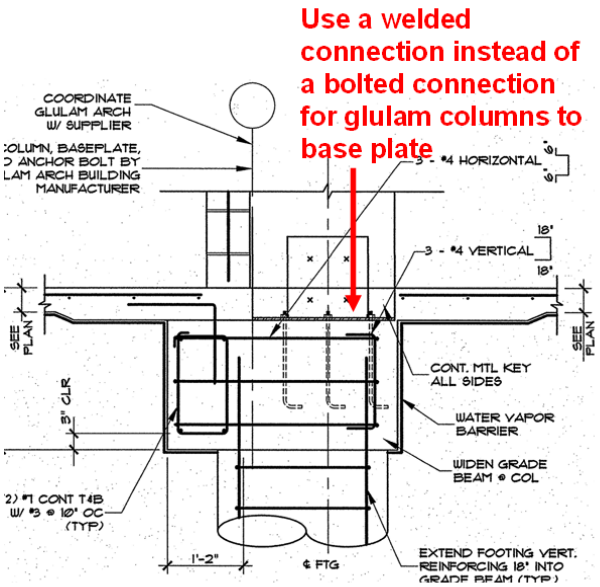

Figure 2-5: Glulam Column Connection Detail

Section 3: Schedule Acceleration Scenarios

Pearland Recreation Center and Natatorium's construction schedule has a critical path that is similar to most typical buildings. It begins with the construction of the concrete piers and foundations then transitions into structural steel. Once the building is topped out, activities related to building dry-in fall on the critical path. These activities are exterior framing and masonry, waterproofing, roofing, and window installation. After the building is dried in, the critical path shifts to interior finishes such as drywall, painting, and other finishes. Finally, the critical path ends with MEP testing and final inspections.

The biggest risks to on time project completion are foundations, structural steel, MEP equipment, specialty items, and MEP testing. Foundations are critical to on time completion because foundations are the first significant phase of construction and it tends to dictate the project's success. Structural steel fabrication requires significant time and if the steel arrives on site late it can delay steel erection, and therefore the critical path. MEP equipment such as air handlers and chillers are long lead items that tend to be custom made for each project. For this reason it is important that they are ordered far enough in advance so as to ensure arrival at site in time for on-schedule installation. As with the MEP equipment, specialty equipment such as the telescoping bleachers in the gym tends to be fabricated specifically for the project. Custom fabrication required large lead time, so it is important that procurement of these items is carefully managed.

Should the need arise, a key area for schedule acceleration would be in the installation of specialty equipment. Currently the schedule has finishes proceeding through the building based on location. For example finishes in the offices on the south side of the recreation center are completed prior to the finishes in the multi-purpose rooms on the west end. Instead the finishes in each space could be sequenced so that spaces such as the gym and the weight room that have specialty equipment and flooring that require lengthier installation are completed first. While this method would be less productive since it requires the trades to move around the building more, it would certainly reduce the schedule by allowing the spaces that require more construction time to be begin work earlier.

Something that has already allowed for a reduction in the construction schedule was the construction of the parking lot and curbs while foundations were being constructed. While it will be necessary to perform some repair work due to damage that will occur during construction, it has allowed the project team to remove this activity from the back-end of the project. In addition to a reduction in schedule length, this has allowed for a cleaner construction site by reducing the presence of mud on site.

Section 4: Value Engineering Topics

Pool Deck Coating:

Initially the owner wanted ceramic tile on the pool deck in the natatorium. Ceramic tile becomes slippery when it gets wet, so it would be a bad flooring material for a pool deck. It was suggested by the designer that an elastomeric coating be used instead. This ¼" thick coating has a resilient texture similar to rubber and has much better slip resistance than ceramic tile. Additionally, the elastomeric coating is only about $3/SF whereas ceramic tile costs $6/SF.

Prior to agreeing on using the elastomeric coating, the owner also considered simply placing mats on the concrete slab. The designer advised against this option due to the growth of mold and mildew under the mats.

Mechanical Equipment:

The owner was adamant about using water cooling towers for the central water cooling plant. Cooling towers far exceeded what was necessary to supply the 105,000 SF building. Water cooled chillers were encouraged by the designer as an economical alternative. Chillers only cost $260,000 as opposed to $480,000 for the cooling towers. The chillers were adequate for the building demand and the owner consented to using them.

Pool Bleachers:

Pool deck space in the natatorium was very important to the swimming and diving coaches because it gave them an area to do dry land training. In order to maximize available deck area, the owner requested using telescoping bleachers around the pool. Due to the humid atmosphere in natatoriums, bleacher manufacturers would not warranty the bleachers in the natatorium because the mechanical system of the telescoping bleachers would corrode within 5 years. Since this would require significant maintenance the owner certainly did not want to install the telescoping bleachers without a warranty. Upon the designer's suggestion, a fixed bleacher system was chosen for this area.

Figure 4-1: Telescoping bleachers. Courtesy of Hahn Enterprises

Figure 4-2: Fixed bleachers. Courtesy of Polymer Services.

Weight Room:

Recreational manager for the Pearland Recreation Center and Natatorium had worked at a university that had a roll-out flooring system and suggested similar flooring for the weight room in the Recreation Center. The roll-out flooring system consisted of 6' wide rolls of flooring that were rolled out like carpet and chemically welded together. The designer's past experience with this type of flooring, was that the material tends to delaminate from the concrete floor due to expansion. To investigate this issue, a number of gyms were contacted, including several LA Fitness facilities. They all confirmed the delamination problem. Tuflex flooring, flooring that consists of 30" squares about 3/8" thick and is installed similar to tile as shown in Figure 4-3, was instead suggested by the designer. This suggestion was adopted.

Figure 4-3: Tuflex Flooring Courtesy of Floor Guide.

Concrete Masonry:

During design, there was a debate regarding what type of wall finish to use in the corridors. An exposed split faced CMU block was designed; however when the project team toured an identical project in Louisiana that had the same proposed split faced CMU block finish. After only 5 years the block had become discolored due to body oils that had gotten on the block by people rubbing against it. This influenced the project team to change the split faced CMU block finish to a painted non-split faced CMU block finish.

Light Fixtures:

A minor cost savings change that was made to the design was changing all the 2X4 Lay-in fixtures from Supreme grade to Commercial grade. This change had no effect on visual appearance or fixture longevity, but saved a significant amount of money.

Section 5: Problem Identification

Natatorium Structural System:

A key aspect of the Pearland Recreation Center and Natatorium that would be interesting for investigation is the structural system in the natatorium. Unlike the steel structural system in the recreation center, the natatorium has been designed using a glulam structural system. As a competitive swimmer that has traveled across the nation competing in natatoriums, I have never seen a natatorium with a glulam structural system. Additionally, glulam is significantly more expensive than structural steel and presents unique challenges during construction. The designer feels that structural steel, even with special coatings, corrodes and deteriorates in the humid environment of natatoriums. It would be interesting to research the performance of structural steel in natatoriums as well as to do a cost-benefit analysis of steel versus glulam structural systems in order to obtain specific cost differences.

Figure 5-1: Natatorium with steel structural system. Courtesy of Penn State

Figure 5-2: Gymnasium with glulam structural system. Courtesy of Structure Mag

Natatorium Acoustics:

Many natatoriums have acoustically reverberant environments. In many cases the reverberation causes announcements over a public announcement system to be inaudible to people in the building. The designers of the Pearland Recreation Center and Natatorium have taken this fact into account and have included Duct Sox (sound attenuating air duct, see Figure 5-3: Duct Sox applied in a natatorium) and acoustical tiles on the wall of the natatorium. Research into the adequacy of these features in acoustical attenuation could be a potential topic for further investigation.

Figure 5-3: Duct Sox applied in a natatorium. Courtesy of Duct Sox

Project Team Interaction:

While interviewing the designer of the Pearland Recreation Center and Natatorium, it was discovered that many problematic features of the building were eliminated thanks to constructive interaction by the project team. Additionally, the contractor could not come up with any improvements or modifications that could have been made to have a more successful project. Many projects run into problems during the construction and operation phases due to flaws that occurred during the design phase. If the project continues to run problem free, it may be interesting to look at the project team structure and project delivery method to identify what has caused this project to be such a success.

Building Information Modeling:

Pearland Recreation Center and Natatorium did not have any aspects of Building Information Modeling (BIM) implemented on the project. Only 2-dimensional CAD drawings were created for the project. While there have not been any apparent additional costs or delays due to coordination and estimating errors, it may be appropriate to do an analysis of the potential costs and benefits that would have been incurred had BIM been used on the project. Some specific applications of BIM that could be looked at are quantity take-off and cost estimation, 3-D MEP coordination, site logistics planning, and 4-D scheduling.

Sustainability:

Sustainability was not a goal during design and construction of the Pearland Recreation Center and Natatorium. There were no sustainable features implemented on the project. Sustainability analysis could be separated into two categories: design and construction. During the design analysis, features such as insulation, mechanical equipment efficiency, lighting efficiency, and material selection could be considered. Research into the construction phase could include issues such as construction material and waste recycling, material procurement methods, and site disturbance minimization. A life-cycle analysis could be performed to compare both the economic and environmental costs and benefits of the implementation of sustainability.

Glulam Column Connection:

As discussed in the 'Constructability' section of this report, erection of the glulam columns in the natatorium of the Pearland Recreation Center and Natatorium proved to be difficult because they were connected by anchor bolts to base plates that were mounted on concrete footers. This required perfect alignment of the columns and allowed little room for error in fabrication. In hind sight it appears that a welded connection may have been a better choice for the column-base plate connection. An analysis of the cost and schedule implications this connection change could be valuable.

Section 6: Technical Analysis Methods

Natatorium Structural System:

To compare the steel and glulam structural system in the natatorium it will be necessary to first do a cost comparison of the two systems. Since the cost of the glulam system is already known, it will only be necessary to obtain cost information for the steel system. This could be achieved by consulting RS Means Cost Data or contacting the steel contractor on the project. To determine the required quantity of structural steel it may be necessary to do a structural design analysis. A structural design analysis should also be conducted to ensure that a structural steel system can adequately support the required loads and meet the necessary open spans in the natatorium. A discussion with the general contractor should also be conducted to identify any potential schedule and logistical modifications that would be required with the modified structural system.

Once it has been confirmed that the initial cost of a steel structural system is economically preferred over a glulam system, it will be necessary to consider the durability of steel versus glulam. This analysis could be performed by contacting natatoriums that have used steel structural systems to discuss the durability of the structural steel in their building and the costs incurred to maintain the system. It may also be useful to contact natatoriums that have used a glulam system to see if they have any notable maintenance issues.

Natatorium Acoustics:

Analyzing the acoustics in the natatorium will begin by conducting an acoustical study of the reverberation times that would result with the current design. This analysis can be done using the fundamental reverberation time equations learned in AE 309 – Architectural Acoustics. These resulting reverberation times will need to be compared to 'satisfactory' reverberation times. 'Satisfactory' reverberation times can be obtained by contacting natatoriums that do not have acoustical problems and determining their reverberation times. If the comparison of reverberation times proves that the acoustical attenuation needs to be modified, it will be necessary to identify how to achieve this ideal attenuation level. Should the current design already provide the ideal sound attenuation level, alternative methods could be identified that acheive the same attenuation level while reducing construction cost and schedule.

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Modifying the acoustical attenuation methods in the natatorium will require analyzing alternative materials and locations for sound attenuation in the natatorium. Contacting an acoustical consultant and acoustical material manufacturer may be helpful during this process.

Project Team Interaction:

Based on the interviews with the architect and general contractor, it appeared that the project team interacted very well. If this is indeed the case, it would be beneficial to determine what factors contributed to this success. To confirm this indication, the owner could be interviewed to determine if the project team indeed interacted successfully. Given that the owner's view of the project parallels the architect and owner's views, the analysis should continue with a thorough investigation of the contracts between all parties on the project.
In addition to an analysis of the contracts, documents such as the requests for proposal and processes such as contractor pre-qualification should also be studied.

Each project team member should then be re-interviewed with the purpose of identifying specific aspects of the contracts and project team selection process that were fundamental to the project's success. Similarly, they should attempt to identify flaws that could have provided an even more successful project. It is important that they keep in mind past projects they have been involved in. This will allow them to better identify these critical contractual items.

It could also be useful to look at contractual documents from some unsuccessful projects to compare and contrast problematic features in the documents. Additionally, interviews with project team members from some of these flawed projects could glean beneficial information.

Building Information Modeling:

A first step in investigating the use of Building Information Modeling (BIM) on the Pearland Recreation Center and Natatorium is to determine why BIM was not used. Assuming BIM was not used due to project team inexperience with BIM or another avoidable reason, it will be necessary to determine which uses will be investigated. A discussion with the project team regarding some more specific project issues could help identify the most beneficial BIM uses to research.

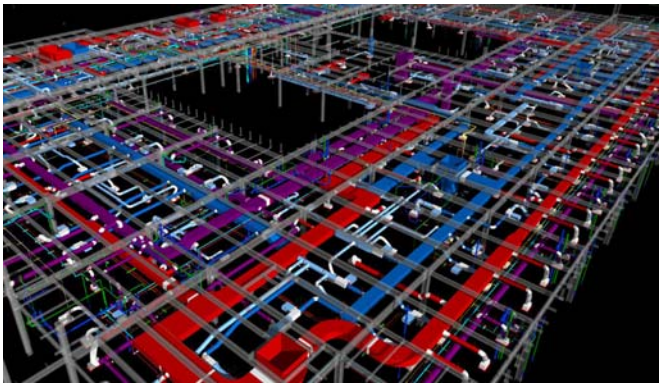

Figure 6-1: 3-D MEP Coordination. Image courtesy of MediaCAD.

For each BIM use, a cost-benefit analysis should be done to determine the feasibility of the implementation of the use on the project. This analysis should specifically focus on the benefits during construction, but also consider effects over the entire life-cycle of the project. For example, an analysis of the use of MEP coordination would consider saved costs and schedule as a result of clashes that would be avoided out in the field during construction as well as the benefit of providing a 3-dimensional as-built model to the owner so objects that are hidden behind walls can be easily located in the future.

In order to investigate BIM uses, it will probably be necessary to create a 3-dimensional model of the building in Revit Architecture. A potential limitation in completing this analysis will be the lack of 3-dimensional CAD drawings and the limited access to 2-dimensional CAD drawings of the project.

Sustainability:

It appears that sustainability was not considered at all during the design and construction of the Pearland Recreation Center and Natatorium. An analysis of not only how sustainability could be implemented on the project, but also why no sustainable features were included in the project could prove to be an interesting research topic.

Figure 6-2: Construction waste recycling area. Courtesy of the State of Vermont.

Analyzing the implementation of sustainable features on the Pearland Recreation Center and Natatorium would begin by identifying some specific features to be implemented. A cost-benefit analysis of each of the features will need to be performed to identify the economic benefit associated with the implementation of the feature. During this analysis it is critical that all construction related effects are considered, such as any changes to the waste handling system due to construction waste recycling or modifications that would need to be made to the construction schedule to meet the procurement of materials necessary to meet local material requirements.

To determine why sustainability was not considered on this project, interviews with the project team members as well as an in depth investigation of the project goals will be necessary. An analysis of the owner's organizational objectives could also shed light on why the building was designed and constructed in the manner it was.

Glulam Column Connection:

Comparing a welded versus bolted connection for the glulam column-base plate interface in the natatorium is a possible area of interesting research. To achieve this comparison it would be necessary to assess the cost and schedule differences between the two connection types. Further discussion with the Pearland Recreation Center and Natatorium project team about the pros and cons of the bolted connection could be an initial starting point for this research. It would also be helpful to look at buildings that have used a welded connection with glulam columns to identify some of the benefits and drawbacks of this connection type. This analysis could provide some useful results for glulam column connections on future buildings