Pearland Recreation Center and Natatorium

Pearland, Texas

Final Report

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Pearland Recreation Center and Natatorium

Pearland, Texas

Project Overview:

Use: Community Recreation Center
Size: 105,000 SF of Floor Space
Height: 2 Stories
Construction Dates: May 2009 - June 2010
Construction Cost: ~$17 Million
Delivery Method: Design-Bid Build
Competitive Bid
Lump Sum

Mechanical:

- Three (3) 2000-5000 CFM Outside AHUs
- Eight (8) 3000-19000 CFM Inside AHUs
- Two (2) 1,063,000 BTUH Natrual Gas Boilers
- Two (2) 1,699,000 BTUH Natural Gas Boilers
- Two (2) 138 Ton Chillers
- Seven (7) 100-340 GPM Pumps

Electrical:

- One (1) 600A Surface Mounted Distribution Panel
- One (1) 400 KW Back-Up Generator
- 3000A Building Power Supply

Project Team:

Owner: City of Pearland Texas
Pearland Independent School District
CM: EMJ Corporation
Architect: PBK
Structural Engineer: Conti, Jumper, Gardner, & Assoc.
MEP Engineer: PBK - MEP Group
Pool Consultant: Aquatic Excellence

Architecture:

Natatorium:
- One (1) 50 Meter X 25 Yard Indoor Competition Pool
- One (1) Four (4) Lane X 25 Yard Therapy Pool with Handicap Access Ramp
- Meeting/Training Room

Recreation Center:
- Competition Gym with Four (4) Lane Track
- Weight Room
- Men's/Women's Locker Rooms
- Offices
- Multi-Purpose Rooms

Structural:

Natatorium:
- Concrete Piers
- Glulam Structural Framing
- Concrete Slab on Grade

Recreation Center:
- Concrete Piers
- Structural Steel Framing
- Concrete Slab on Grade and on Elevated Steel Decking

Matt Smiddy
Construction Option

http://www.engr.psu.edu/ae/thesis/portfolios/2010/mds5055/

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Acknowledgements:

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Section 1 - Executive Summary

This report focuses on four construction related analyses of the Pearland Recreation Center and Natatorium building in Pearland, Texas, a Houston, Texas suburb. Two of these four construction related research topics also include a structural analysis and a mechanical analysis. In addition to these analyses this report also contains an overview of the project, including a summary of the project team, the building systems, construction cost, construction schedule, and construction logistics.

Analysis #1 considers replacing the glulam structural system in the natatorium with a concrete column and steel joist structural system. This analysis included a feasibility study as well as a structural analysis to design the structural members. Results from this analysis reflect a construction cost savings of over $600,000 by using the proposed concrete and steel system. Additionally, there are no changes in the construction schedule.

The next analysis looks at replacing the as designed air-cooled chiller mechanical system with a water-cooled chiller and cooling tower mechanical system. This study also includes a mechanical analysis. This study reveals a $48,500 construction cost savings and a $248,000 yearly energy cost savings by using the proposed water-cooled chiller and cooling tower system. Again, this modification has no construction schedule implications.

Next the project team's interaction is analyzed, primarily focusing on the effects of the delivery method. Design-bid-build, the delivery method being used on the project, appears to have resulted in a successful project with no adversarial relationships developing. This project is compared with another project being constructed by the same owner but using the design-build delivery method. It is determined that design-bid-build is the preferred delivery method for public projects, particularly when they are complex such as the Pearland Recreation Center and Natatorium project.

Finally an investigation of the glulam column connection with the concrete footers in the natatorium is conducted. Constructability of the as-designed bolted connection is quite difficult during column erection, as precisely aligning the columns with the bolts is challenging. This analysis considers modifying the connection to a welded connection. Using a welded connection results in no additional construction costs and has no effect on the construction schedule. However, a welded connection would have been much easier to construct.

Section 2 - Introduction

The Pearland Recreation Center and Natatorium project is located at 4141 Bailey Road in Pearland, Texas; a suburb 15 miles south of Houston, Texas. It is being developed through a joint venture between the City of Pearland and the Pearland Independent School District to serve the Pearland community.

The $17 million, 41,817 square foot project began design in March 2007 and construction is scheduled for completion in May 2010. The project, designed by PBK and constructed by EMJ Corporation, is using a design-bid-build delivery method.

The 63,300 square foot recreation center houses a competition gym, indoor running track, racquetball courts, weight room, aerobics room, dance room, locker rooms, administrative offices, and other multi-purpose rooms.

The 41,000 square foot natatorium features a state of the art 25-yard X 50-meter competition pool with two (2) 1-meter and two (2) 3-meter diving boards. There is also a 4-lane 25-yard therapeutic pool with a handicap access ramp.

Section 3 - Project Overview:

3 - 1 Client Information

Pearland Recreation Center and Natatorium is being built to promote recreation and economic activity in Pearland, Texas. The project is being funded by the City of Pearland, Pearland Independent School District, and the Pearland Economic Development Organization as shown below in **Table 3-1.1 - Project Funding Distribution**:

Table 3-1.1 - Project Funding Distribution

Party	Amount Contributed	Source of Funding
City of Pearland, Texas	$13 Million	Tax Revenue
Pearland Independent School District	$3.5 Million and 7-acre building site	School Bond
Pearland Economic Development Organization	$1.5 Million	Tax Revenue

The City of Pearland identified a recreation center and natatorium as 'high' priority in their 2005 master plan. At the same time, Pearland Independent School District recognized a need for a natatorium for their school. The two parties decided to come together to build a joint project. The Pearland Economic Development Organization also recognized the potential economic impacts this project could have on local businesses through additional visitors to the Pearland area. A similar facility nearby, University of Houston's Recreation Center, currently has to turn away requests for facility use due to overbooking, so this new facility could have a significant economical impact on the community.

The master plan called for a project that would serve the community for many years. To meet this goal, the project was flexibly designed to meet any potential changes in regulations. For example the competition pool was designed to be 55 meters long with (2) 2.5 meter wide bulkheads so should regulation pool length change, the facility could easily be modified to meet this new requirement.

The only project deadline is to have the natatorium completed before the start of school in Fall 2010. At this time the project should be completed in June 2010, so this will not be an issue. Currently the project does not have a phased completion and there are no intentions to implement one at this time.

3 - 2 Project Delivery System

A design-bid-build delivery system is being used on the Pearland Recreation Center and Natatorium project. The City of Pearland, Pearland Independent School District, and Pearland Economic Development Organization are building the project as a joint-venture. However, all contracts for the project are held by the City of Pearland. The City of Pearland has hired PBK as the architect and EMJ Corporation as the construction manager for the project.

PBK has selected sub consultants to assist in designing the project. The primary consultants are shown in **Figure 3-2.2 - Project Team Organizational Chart**. The only designer contract held with the City of Pearland is a lump sum Professional Design contract, with payments distributed as shown in the **Table 3-2.1 - Design Contract Payment Distribution**.

Table 3-2.1 - Design Contract Payment Distribution

Deliverable	**% of Lump Sum**
Schematic Design	15%
Complete Design	15%
Construction Documents	20%
Contractor Procurement	25%
Construction Service	25%

EMJ was selected as general contractor through a ‘Best Value’ selection method. The City of Pearland considered items such as cost, schedule history, references, and proposed specialty contractors during this selection process. EMJ contracted specialty contractors to perform all the work on site. They hold lump sum contracts with all their subs as shown in **Figure 3-2.2 - Project Team Organizational Chart**. A complete list of specialty contractors on the project is available in **Appendix 3**.

The project design was essentially completed prior to contractor selection, so the design-bid-build delivery method with a lump sum contract is appropriate for this project.

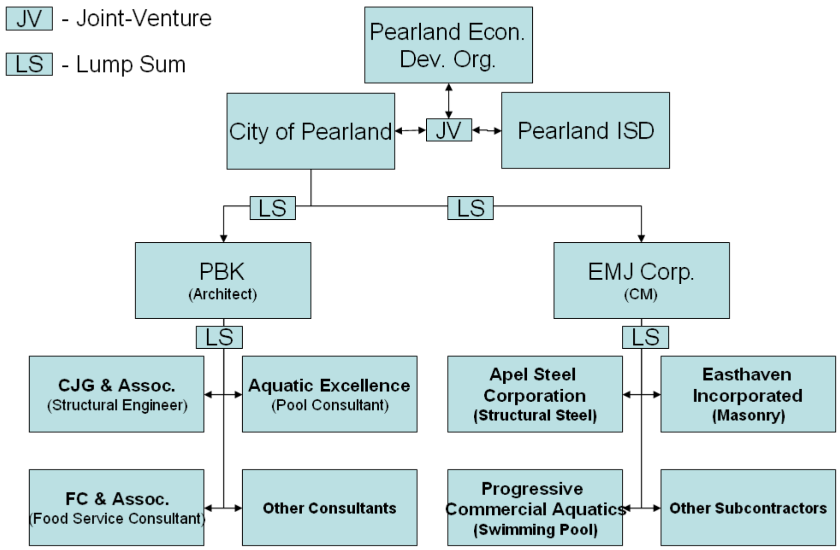


Figure 3-2.2 - Project Team Organizational Chart

The City of Pearland required the following insurance to be held by the contractors and design professionals on the project:

-Worker's Compensation as per Texas State Requirements

-Commercial General Liability Insurance:

-$1,000,000 for each occurrence

-$2,000,000 general aggregate limit

-$2,000,000 product-completed operations aggregate limit

-$1,000,000 personal and advertising injury limit

-Auto liability insurance coverage of $1,000,000

-Employer's liability insurance coverage of $1,000,000 per accident or disease

-Umbrella liability insurance coverage of $5,000,000

-Professional liability insurance coverage of $1,000,000.

-Builder's risk insurance in equivalence to total repair and replacement charges of every incident.

3 - 3 Project Team Contacts

City of Pearland – Andrea Brinkley – Project Manager

EMJ Corporation – Scott Stoltz – Project Manager

EMJ Corporation – Kevin Huff – Project Engineer

EMJ Corporation – Phillip Crissman – Project Superintendent

PBK – Van Franks – Principle

3 - 4 CM Staffing Plan

The CM (EMJ Corp) project team for the Pearland Recreation Center and Natatorium project consists of a Vice-President in Charge, a Project Manager, a Project Engineer, a Superintendent, and an Assistant Superintendent.

The Vice-President in Charge, Project Manager, and Project Engineer work from the EMJ home office in Dallas, TX and visit the project site about twice a month. The Superintendent and Assistant Superintendent are on-site in Pearland, TX at all times.

The Project Engineer, Superintendent, and Assistant Superintendent work full time on the project while the Project Manager and Vice-President in Charge are both part time on the project and oversee other projects as well. **Figure 3-4.1 - CM Organizational Chart** shows the organization of the staff on this project.

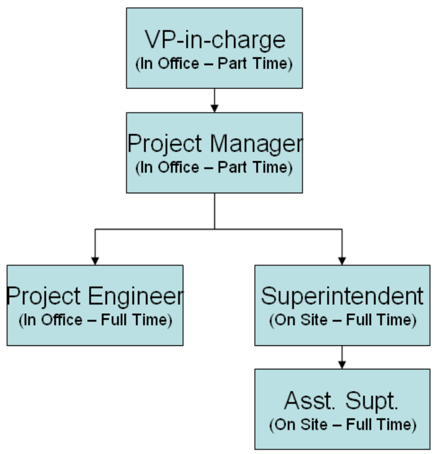
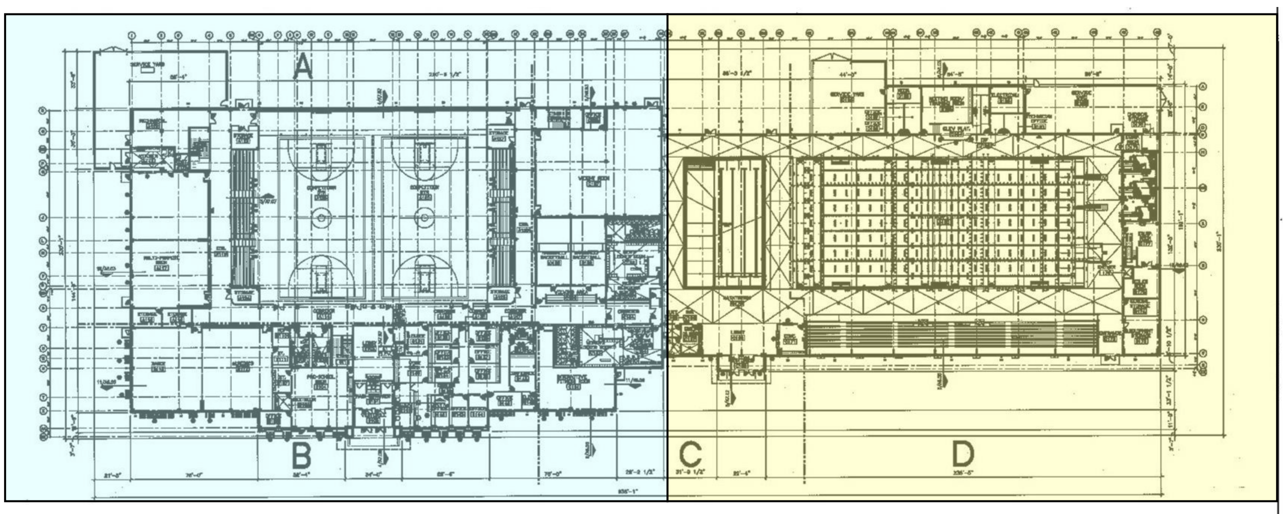


Figure 3-4.1 - CM Organizational Chart

Section 4 - Design and Construction Overview

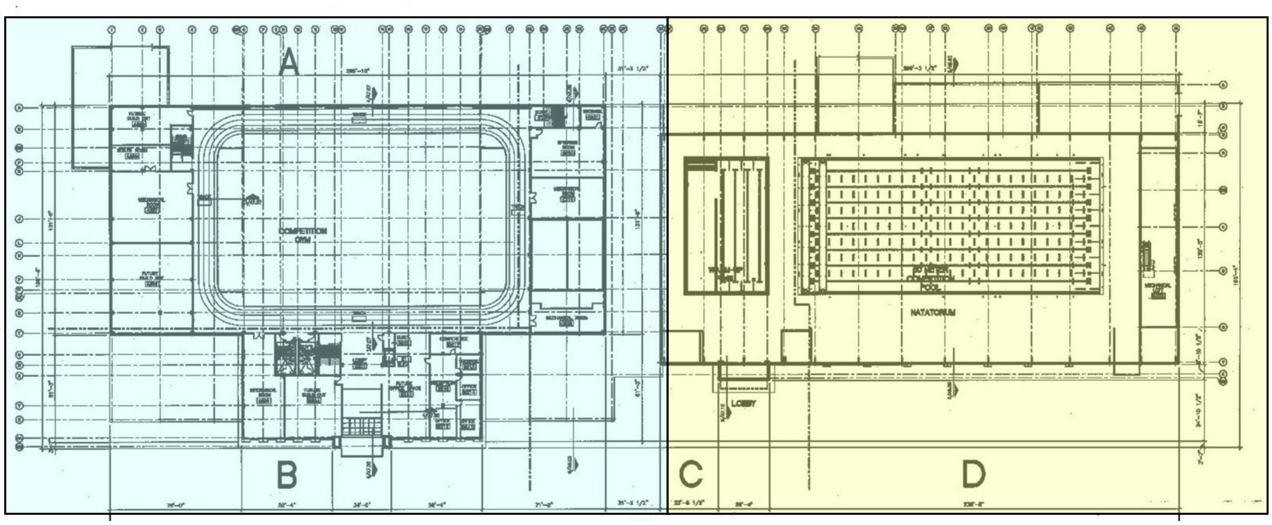
4 - 1 Building Architecture/Enclosure

The Pearland Recreation Center and Natatorium houses a recreation center and natatorium as shown in **Figures 4-1.1 – First Floor Plan** and **4-1.2 – Second Floor Plan**. The building spans 638'-1" and is 230'-1" wide. The natatorium is located on the eastern half of the building and is connected to the recreation center on the opposite half of the building.



Recreation Center **Natatorium**

Figure 4-1.1 - First floor plan



Recreation Center **Natatorium**

Figure 4-1.2: Second floor plan

The 2-story recreation portion of the building contains a double height competitive gym seating 588 spectators and a raised 4-lane running track around the perimeter. There is also a dance room, aerobics room, weight room, 2 racquetball courts, locker rooms, offices, and other multi-purpose rooms.

The double height natatorium contains an 8-lane 50 meter competition pool and a 4-lane 25 yard instructional pool with a handicap ramp. The competition pool includes a moveable bulkhead, (2) 1-meter diving boards, and (2) 3-meter diving boards. There is seating for 694 spectators in bleachers surrounding the competition pool. There are also equipment rooms and training rooms in this portion of the building.

Building Codes

2003 International Building Code

2003 International Plumbing Code

2003 International Mechanical Code

2003 International Electrical Code

2003 International Energy Code

2003 International Fire Code

2003 International Gas Code

1994 Texas Accessibility Standards

1992 Americans with Disabilities Act

Zoning

Zoning District – 'GB' (General Business)

	Requirements	Actual
Minimum Lot Size	22,500 Square Feet	330,090 Square Feet
Minimum Lot Width	150'-0"	727'-7" (Frontage on Bailey Road)
Minimum Lot Depth	125'-0"	453'-8"
Building Setback: Front	25'-0" Minimum	212'-6"
Building Setback: Rear	25'-0" Minimum	32'-9"
Building Setback: Side	10'-0" Minimum	34'-6"
Height Restriction	45'-0" Maximum Height	44'-11"

Historical Requirements

There are no historical requirements on this project.

Building Facades

The facades are primarily face brick on horizontally reinforced 8” CMU with rigid insulation and damp proofing between. The facades by the recreation center and natatorium entrances are calcium silicate masonry units on horizontally reinforced 8” CMU with rigid insulation and damp proofing between. All the glazing is ¼” Tinted Tempered Float Glass.

The south façade, facing Bailey Road is 25% glazing as shown in **Figure 4-1.3 - South Exterior Elevation**.

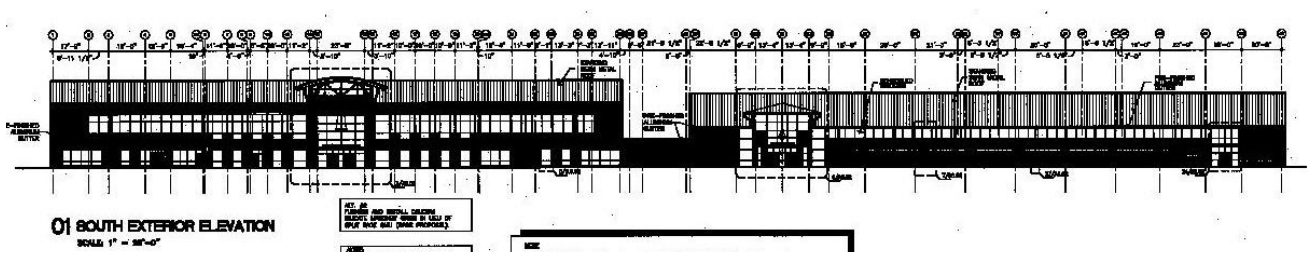


Figure 4-1.3 - South Exterior Elevation

The north façade has 10 windows as shown in **Figure 4-1.4 - North Exterior Elevation.**

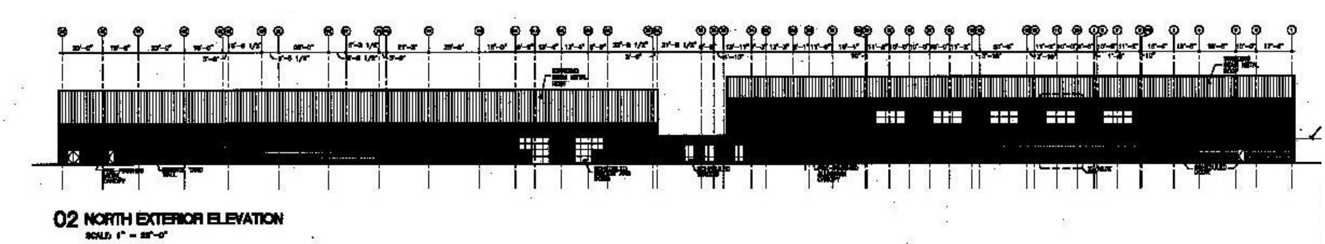


Figure 4-1.4 - North Exterior Elevation

The east façade has a series of strip windows along the recreation center entrance as shown in **Figure 4-1.5 - East Exterior Elevation**.

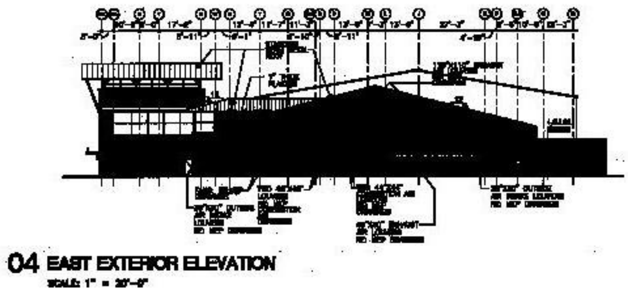


Figure 4-1.5 - East Exterior Elevation

The west façade has 10 windows plus a strip window at the recreation entrance as shown in **Figure 4-1.6 - West Exterior Elevation.**

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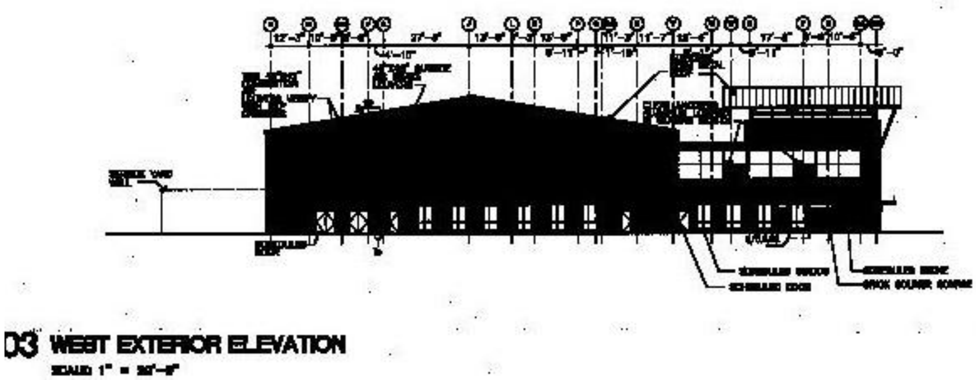

Figure 4-1.6 - West Exterior Elevation

4 - 2 Building Systems

Demolition

No demolition was required.

Excavation

The site is at an elevation of 14' above sea level. It was necessary to excavate to about 14' for the foundations. For this reason it was necessary to dewater the site. This was done using well points throughout the site. Excavation was done with a 1:1 layback so no temporary support was needed.

Structural Framing System

The Recreation center has a structural steel frame. The columns are all tube steel while the beams are W-sections with K-series joists supporting 18ga galvanized 1-1/2" deep non-composite floor decking and 22ga galvanized 1-1/2" deep Type "B" steel non-composite roof decking. All connections between W-sections are bolted and the connections to the tube steel are welded connections. The steel was erected using a 50-Ton and 80-Ton Truck Crane.

The Natatorium has glulam columns supporting glulam purlins which support a 3" wood deck. The glulam system was erected using a 100-Ton and 75-Ton Truck Crane.

Cast-In Place Concrete

The only cast-in-place concrete in this project was the slabs and foundations. The foundation consisted of spread footings on drilled piers. The footings used stick-built forms and were poured with a pump truck. There is a 5" thick reinforced concrete slab-on-grade with a vapor barrier that extends throughout the entire building foundation. There is also a 3" thick concrete slab on WWF on the elevated slabs. The slab-on-grade was placed using a pump truck in 4 different pours. The elevated slabs at the second level and the roof were each poured in 3 pours.

Precast Concrete

There is no precast concrete on this project.

Mechanical System

The recreation center is serviced by five (5) mechanical rooms located as shown below in **Figures 4-2.1 - Rec Center 1st Floor Mechanical Room Locations** and **4-2.2 - Rec Center 2nd Floor Mechanical Room Locations**:

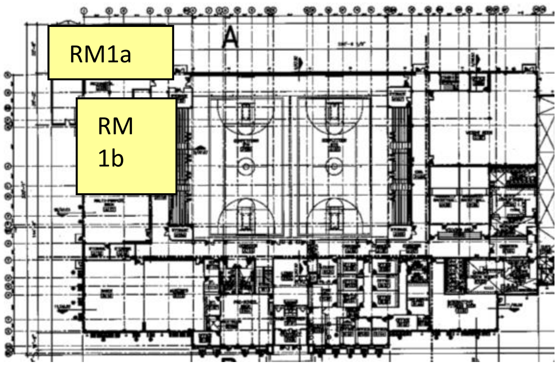

Figure 4-2.1 - Rec Center 1st Floor Mechanical Room Locations

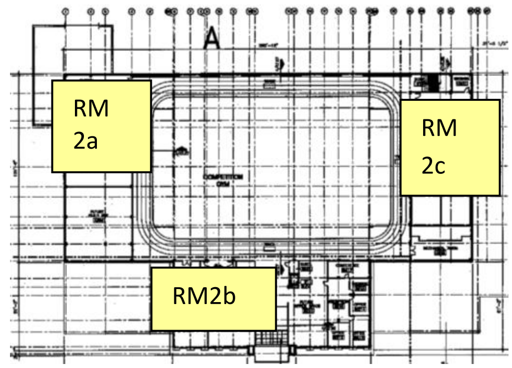

Figure 4-2.2 - Rec Center 2nd Floor Mechanical Room Locations

The Natatorium is serviced by two (2) mechanical rooms as shown below in **Figures 4-2.3 - Natatorium 1st Floor Mechanical Room Location** and **4-2.4 - Natatorium 2nd Floor Mechanical Room Location**:

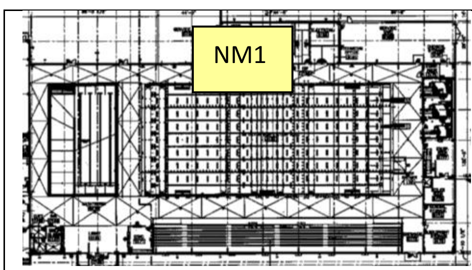

Figure 4-2.3 - Natatorium 1st Floor Mechanical Room Location

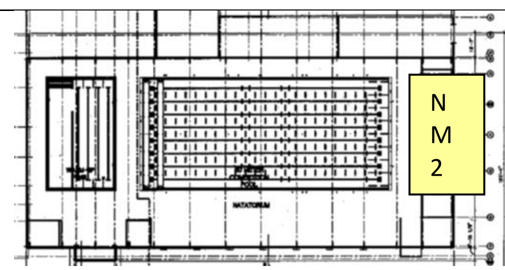

Figure 4-2.4 - Natatorium 2nd Floor Mechanical Room Location

The mechanical rooms contain mechanical equipment as shown in **Table 4-2.5 – Mechanical Room Equipment**.

Table 4-2.5 – Mechanical Room Equipment

Location	**Item**
RM1a	Two (2) Air Cooled Chillers
RM1b	Four (4) End Suction Pumps
RM2a	Two (2) Air Handling Units, Two (2) Boilers, and One (1) End Suction Pump
RM2b	Three (3) Air Handling Units
RM2c	Four (4) Air Handling Units
NM1	One (1) Air Handling Unit and One (1) Condenser
NM2	Two (2) Air Handling Units

Air is distributed throughout the building using rectangular and flex duct. These ducts then connect to Constant Air Volume Terminals in each room.

Fire Suppression System

The building has a Wet Pipe Pre-Action Fire Sprinkler System that is to be installed to a performance spec of:

Public Spaces, Classrooms, and Offices: 0.10 GPM/SF over the most remote 1,500 SF.

Mechanical Rooms, Storage Areas, and Service Areas: 0.15 GPM/SF over 1,500 SF.

Electrical System

The electrical system for the Pearland Recreation Center and Natatorium has a 3000A building supply with a 600A Surface Mounted Distribution Panel. There is also a 400 KW emergency back-up generator for the building.

Masonry

The entire building has an 8" horizontally reinforced non-load bearing CMU enclosure. There is reinforcing at 16" on-center. There is also a bond beam every 8' (12-courses of block).

Attached to the CMU is a face brick veneer connected by masonry ties every 4-courses of CMU. Between the CMU and face brick there is 1 ½ inch rigid insulation and an air space. Additionally, the CMU has a damp proofing applied to it.

Roofing

The roof in the recreation center is a steel truss system (shown in **Figure 4-2.6 - Construction photo of roof trusses at recreation center**) while the roof in the natatorium is a glulam truss system. The roofing system throughout the recreation center and natatorium consists of a standing seam metal roof on a fully adhered waterproof membrane. The roofing system over the main entrance to the building on the south side, a small strip between the recreation area and natatorium, and a small portion of the north side of the natatorium is modified bitumen.

Figure 4-2.6 - Construction photo of roof trusses at recreation center

Curtain Wall

There are no curtain walls in this building.

Sustainable Features

This building has no sustainable features.

4 - 3 Local Conditions

Labor

The project site is located in a suburb of Houston, TX; the 4th largest city in the US. This location enables easy access to a diversely skilled labor force. For this reason labor availability will not be a problem.

Weather

Houston, TX has a warm and mild climate. While winter weather will not be an issue, there is the potential for tropical weather to affect the project during the fall months. Additionally, since the project is located in a region that is prone to tropical weather, there will be more stringent building codes and inspections.

Geography

The project is located on a 7-acre plot of land in an unpopulated portion of the suburb of Houston, Texas. There is ample area for construction lay down and parking.

The project site is at a very low elevation (+14'). Because of the low site elevation, ground water will be a serious consideration during excavation. It will be necessary to de-water the site during all excavation activities.

Sustainability

Sustainable construction practices are not predominant in the Houston area. It is uncommon for construction projects to apply sustainable practices such as construction material recycling, etc.

Tipping Fees:

It is common practice in the Houston area to not recycle construction material. For this reason, all construction waste is placed in the same dumpster on site. Removal of this waste costs $316 per 40 cubic yard dump. This is $7.9 per cubic yard of waste.

4 - 4 Site Layout Planning

Site layout for the Pearland Recreation Center and Natatorium is greatly simplified due to a large site. Consistent across all phases of the project are the dumpsters in the northeast corner of the site with a dedicated entrance off of Bailey road for access to empty them, porta-potties in the northeast corner of the parking lot, the construction offices on the east side of the site, the temporary transformer in the southeast corner of the building, temporary utilities running to the southeast corner of the building from Bailey Rd, contractor parking on the south side of the site, and the site entrance off of Bailey road on the south side of the site.

Site layout for the excavation phase of construction is shown in **Figure 4-4.1 – Excavation Phase Site Plan**. Excavation will begin from the northwest corner of the building and proceed towards the southeast corner of the building as shown. Dump trucks will arrive and circulate through the site to remove soil as shown.

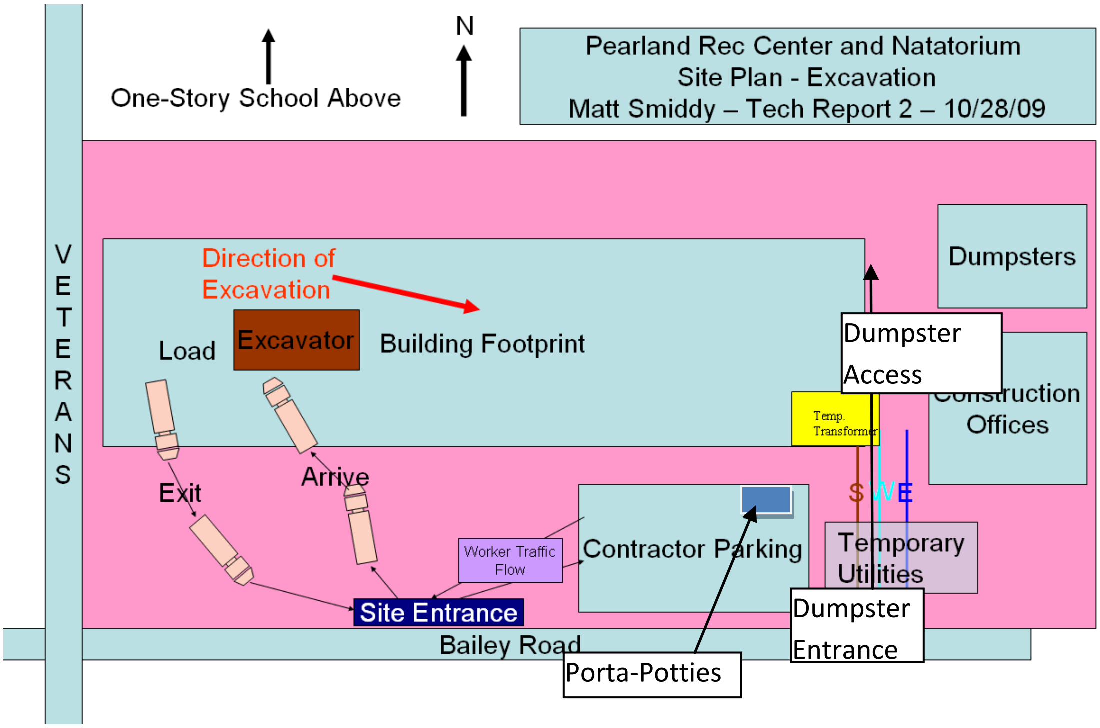

Figure 4-4.1 – Excavation Phase Site Plan

Figure 4-4.2 – Foundations Phase Site Plan shows the site layout for the foundations phase of construction. Foundations work will again progress from the northwest corner to the southeast corner of the building. A rebar yard, with access provided for flatbed rebar truck deliveries, is provided in the southwest corner of the site. The pump truck and concrete trucks will circulate as shown. They will only be present on site during concrete pours. The location of the pump truck will move eastward on the site as work progresses. A contractor material storage area is also provided in the southeast corner of the site.

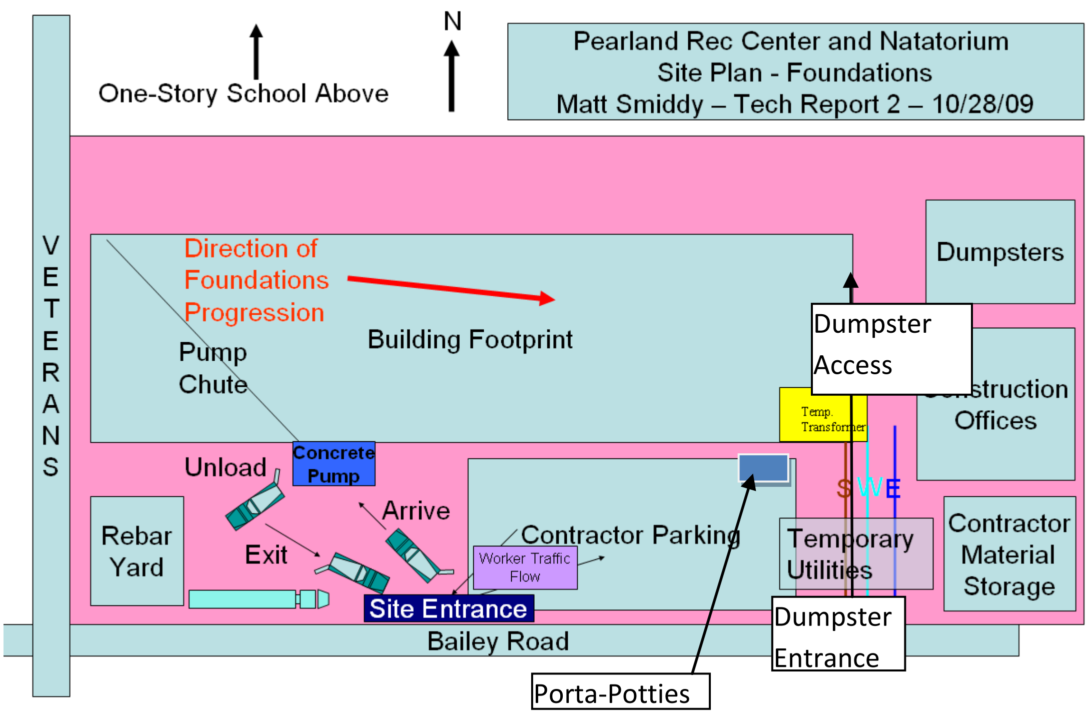

Figure 4-4.2 – Foundations Phase Site Plan

The project site begins to become more congested as the structural framing erection phase of construction begins. Site layout for this phase is shown in **Figure 4-4.3 – Structural Framing Erection Phase Site Plan**. Erection of the steel and glulam will proceed from the west end of the building to the east end. Steel and glulam members will be delivered and unloaded in the shake-out area in the southwest corner of the site. Two cranes will be erecting the steel and glulam on site, one on the north side and one on the south side of the building as shown. Steel joists will be delivered to this shake-out area as well, but will then be moved to the joist shake-out area on the north side of the site to be prepared for final erection. There will be an access point for stocking material to the building located at the southwest corner of the building. This will be done using front loaders.

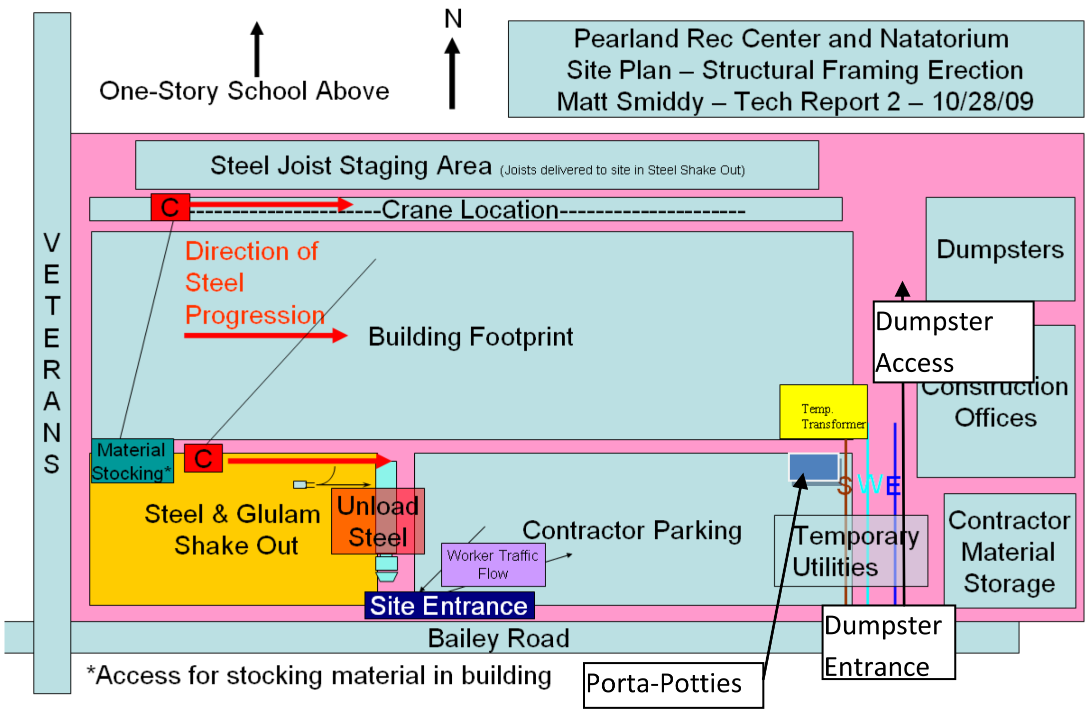

Figure 4-4.3 – Structural Framing Erection Phase Site Plan

Enclosures is the final phase of construction. Work in this phase will progress in a clockwise direction, first around the recreation center than proceeding to go around the natatorium. There will be a contractor material staging area in the southwest corner of the site. This area will be used by contractors to unload materials from trucks as shown. There are also material storage areas on the north side and in the southeast corner of the site. Materials will again be stocked to the building through the access point at the southwest corner of the building using front loaders. **Figure 4-4.4 – Enclosure Phase Site Plan** shows the site layout for this phase of construction.

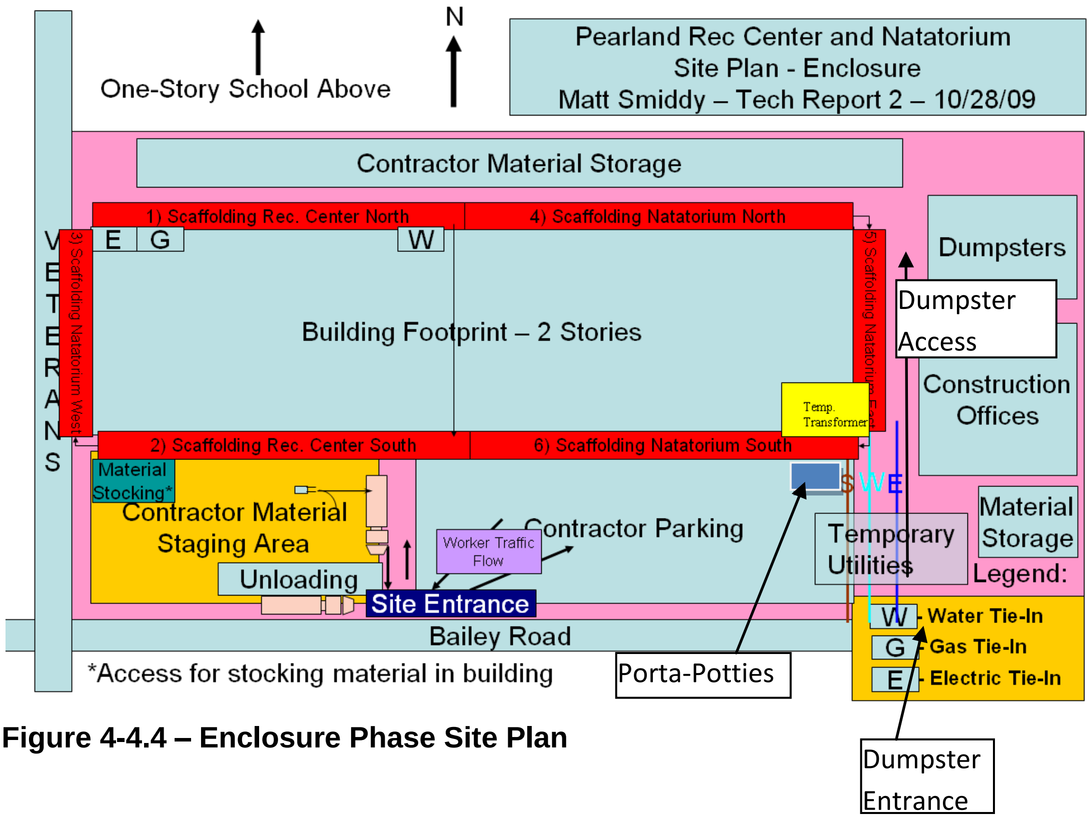

Figure 4-4.4 – Enclosure Phase Site Plan

Section 5 - Project Logistics

The project schedule for the Pearland Recreation Center and Natatorium begins with commencement of design on March 1, 2007 and ends with substantial completion on May 12, 2010.

5 – 1 Milestone Schedule

After site work is completed, the recreation center will be constructed separately from the natatorium. While they are one building, the structural systems and building features of the two portions are completely different so separate construction of the two building sections seems most efficient. Through each phase of construction, the recreation center will generally precede construction of the natatorium.

Site Work

The site work activity contains all work done for site preparation as well as for the parking lot, which will be constructed at the beginning of the project to allow for a cleaner construction site.

Foundations

The foundations in the natatorium will commence once the excavation has been completed for the swimming pools. This excavation will be performed while the foundations are being constructed on the recreation center.

Structural

The structural system in the recreation center is very simple and does not have anything important to note. The natatorium has 14 large glulam beams that will span the swimming pools. The structural system in the natatorium will begin after the recreation center's structural system has been completed and will be constructed by a separate contractor due to the glulam material.

Finishes

The finishes in the recreation center again don't have anything unique to note, however the natatorium must have the interior finishes completed prior to beginning the swimming pool finishes (tiles, etc.) in order to avoid damage to the expensive work that will be put in place in the swimming pool.

The project schedule for this project is relatively simple. The key item to notice when viewing the schedule is the separation in construction of the two (recreation center and natatorium) portions of the building. See **Appendix 5** for the complete project summary schedule.

5 – 2 Detailed Project Schedule

Construction of the Pearland Recreation Center and Natatorium will begin with the Notice to Proceed on April 20, 2009 and conclude with Substantial Completion on May 12, 2010. The complete detailed schedule is available in **Appendix 5**. To create the construction schedule for the project the building was split into two portions: recreation center and natatorium. This was done because these two portions of the building are very different and will be constructed in a different manner due to the swimming pool and glulam structural system in the natatorium. **Table 5-2.1 – Milestone Date Comparison** compares some key construction milestone dates in the recreation center versus the natatorium.

Table 5-2.1 – Milestone Date Comparison

Milestone	Recreation Center	Natatorium
Notice to Proceed	4/20/2009	4/20/2009
Top Out	8/7/2009	8/30/2009
Dry-In	10/23/2009	12/9/2009
Substantial Completion	5/12/2010	4/28/2010

Structure and Enclosure

Construction of the building's structural system and enclosure is sequenced as shown in **Figure 5-2.2 - Structural and Enclosure Trade Construction Sequence**

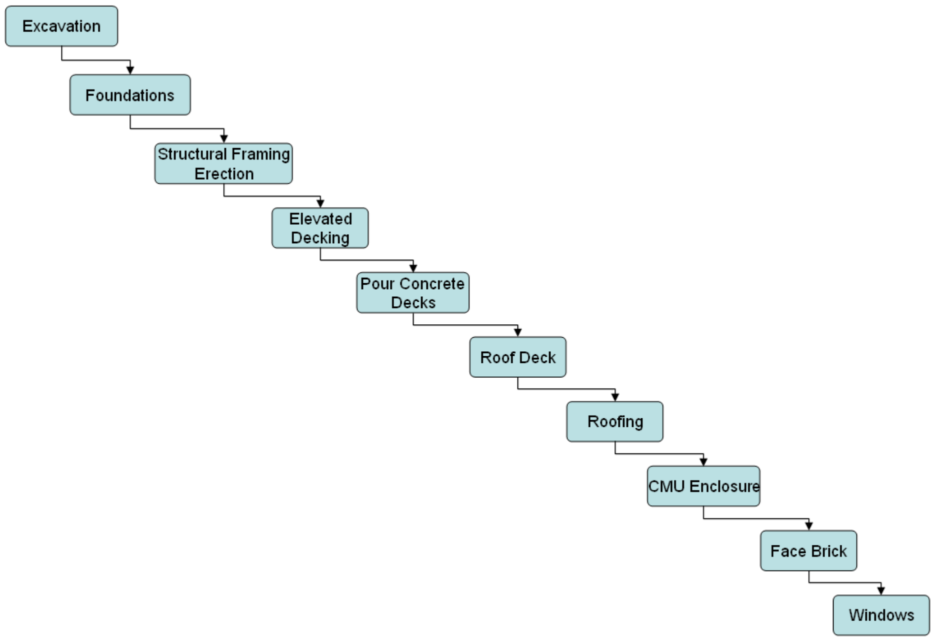

Figure 5-2.2 – Structural and Enclosure Trade Construction Sequence

Interiors

Following 'Dry-In,' a 'parade of trades' construction sequence is applied; that is only one trade works in each space at a time and each trade follows the previous. **Figure 5-2.3 - Interior Trades Construction Sequence** shows the order of the interior 'parade of trades'.

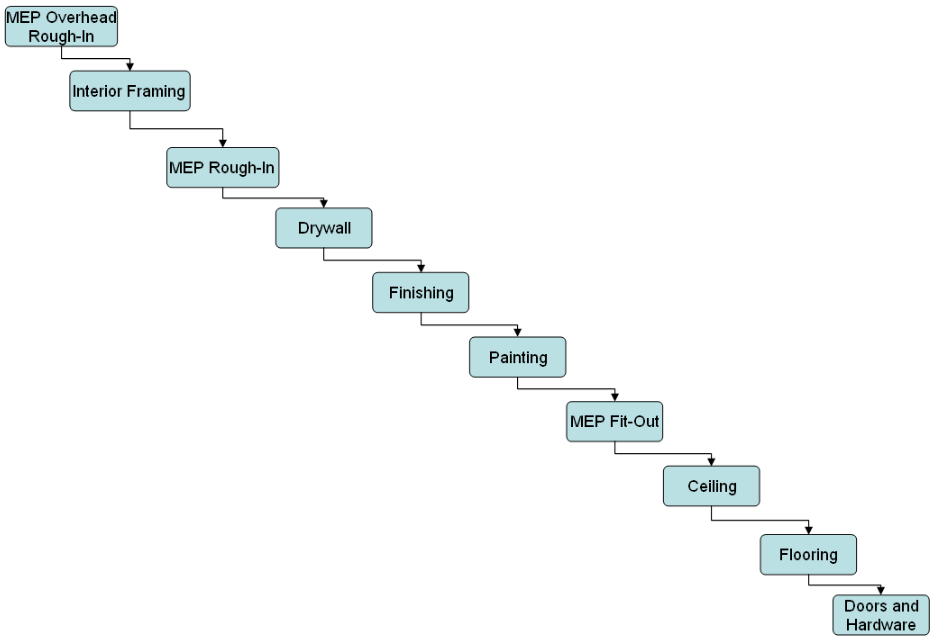

Figure 5-2.3 - Interior Trades Construction Sequence

Following the interior 'parade of trades' a number of specialty items are installed, such as casework, gym flooring, and gym equipment. See the detailed schedule in **Appendix 5** for all activities.

Recreation Center

Construction of the recreation center progresses counterclockwise through the building in three phases. **Figure 5-2.4 – Recreation Center Construction Phase Locations** shows the locations of these three phases.

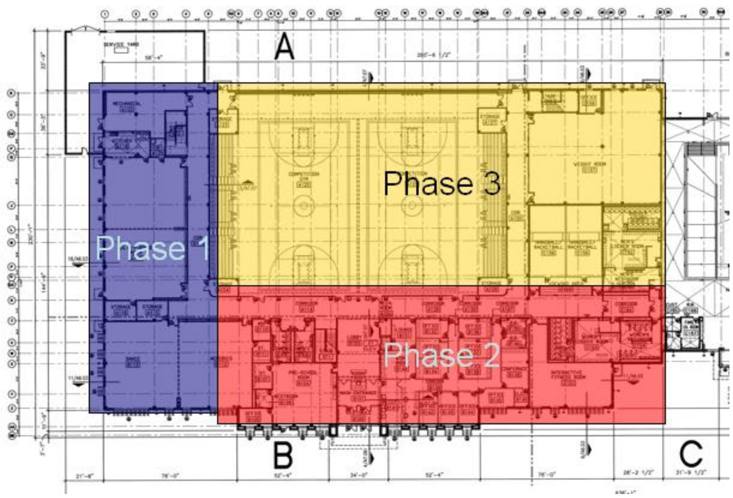

Figure 5-2.4 – Recreation Center Construction Phase Locations

Second floor activities only have two phases since the gym is double height and the small portion of phase three that has a second level is combined with phase 2 for the second floor.

Natatorium

There is no phasing of construction in the natatorium as there was in the recreation center. Construction sequencing in the natatorium will revolve around the swimming pool construction. See **Figure 5-2.5 – Swimming Pool Construction Sequence** for the sequence of swimming pool construction activities.

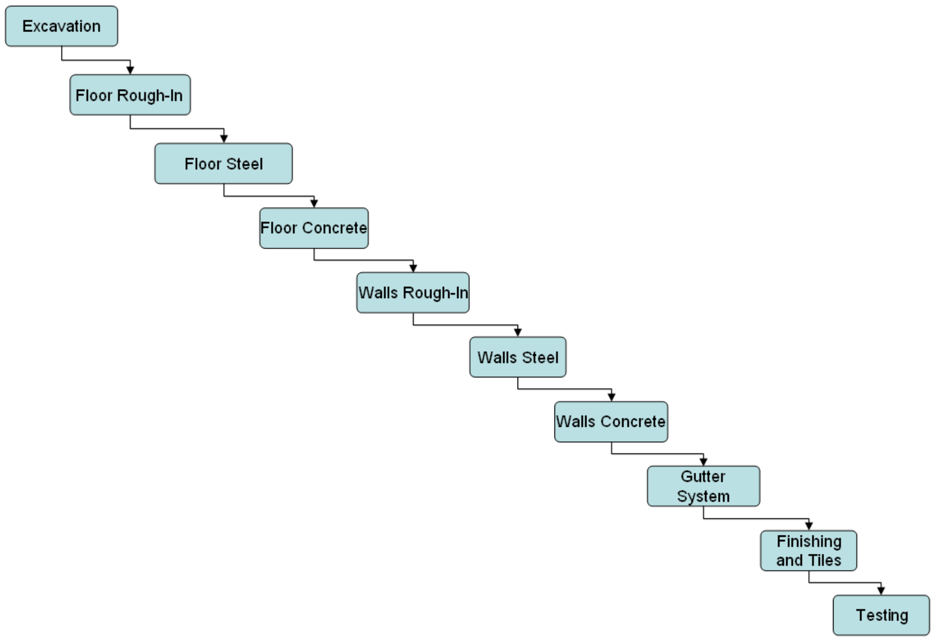

Figure 5-2.5 – Swimming Pool Construction Sequence

Construction of other portions of the natatorium will be occurring throughout the pool construction; however it is critical that the finishing and tiles in the swimming pool are the last activity to occur in the swimming pool area in order to protect the work. Immediately after this is completed, the pool will be filled with water and testing and chemical balancing will begin.

5 – 3 Construction Cost Estimate

Actual Cost

Total Actual Building Construction Cost: $15,137,233

Actual Building Construction Cost/SF: $144.00/SF

Total Project Cost: $16,901,509

Project Cost/SF: $160.79

By System

System	**Total Cost ($)**	**Cost/SF ($)**
Structural Steel (Erection Included)	$1,054,385	$5.8
Cast-In Place Concrete	$1,166,021	$11.09
Masonry	$1,223,500	$11.64
HVAC	$1,907,000	$18.14
Electrical	$41,936	$0.40
Plumbing	$499,027	$4.75
Fire Protection	$195,450	$1.86
Elevators	$41,936	$0.40
Roofing	$609,900	$5.81

NOTE: For confidentiality purposes the actual estimate has not been posted.

Estimated Construction Cost

The estimated cost for the project was created using D4Profiler and RS Means SF Cost Data. D4Profiler takes real cost data from similar past projects and modifies it to meet the specified building requirements.

D4Profiler had a very similar project, a recreation center with a large natatorium, just outside of Cincinnati, Ohio. This project was almost the exact same size as well the Pearland project as well. The cost was within 1% of the actual cost. This cost was the total project cost, not just the construction cost. This total project cost estimate is included in **Appendix 5**.

Obtaining an RS Means estimate was more difficult. A separate cost estimate was obtained for the recreation center (using the 'Gymnasium' building type in RS Means) and the natatorium (using the 'Swimming Pool, Enclosed' building type in RS Means). A problem that arose was that the cost data provided in RS Means was for projects much smaller than the Pearland project. To account for this it was necessary to extrapolate the table values. The cost estimates for these two portions were then combined to obtain a total building cost. This price was again within 1% of the actual cost. This estimate is only for construction costs and is included in **Appendix 5** with all the calculations that were performed.

These estimates are shown in the **Table 5-3.1 - Cost Estimate Comparison** below.

Table 5-3.1 – Cost Estimate Comparison

Method	**Total Cost ($)**	**Cost/SF ($)**	**Price Includes:**
D4Cost	$16,786,542	$159.87	Total Project Cost
RS Means SF Data	$15,043,887	$143.28	Construction Cost

Detailed Structural Cost Estimate

In addition to the Parametric Cost Estimate from D4Profiler and the SF Cost Estimate from RS Means, a detailed structural system construction cost estimate was also performed. A detailed structural system construction cost estimate for the Pearland Recreation Center and Natatorium project yielded just over $4,425,000, or about $42/SF. This cost includes all labor, equipment, and material required for construction of the caissons, concrete, structural steel, steel decking, joists, trusses, wood decking, and glulam structural framing. A break-down of the cost estimate is shown in **Table 5-3.2 – Detailed Structural System Estimate Summary**. The complete estimate as well as the calculations are available in **Appendix 5**.

Table 5-3.2 – Detailed Structural System Estimate Summary

Cost Breakdown Summary		
Dev.	**Item**	**Total Cost**
02465	Caissons	$526,841.25
03220	Rebar	$60,681.51
03221	WWF	$18,041.18
03310	3000 psi concrete	$145,747.62
03311	3500 psi concrete	$36,687.77
03312	Concrete Finishing	$15,161.58
03313	Concrete Forming	$471,115.84
03314	Vapor Barrier	$123,562.53
03315	5" Concrete Edge Form	$2,729.14
03316	3" Pour Stop	$821.42
03500	Roof Deck	$626,272.50
05100	Structural Steel	$702,167.12
05200	Steel Floor Joists	$390,755.16
05300	Metal Deck	$66,784.03
06100	Wood Trusses	$170,000.00
06110	Glulam (Decking, Purlins, and Columns)	$1,070,000.00
	Total Cost	**$4,427,368.67**

Pricing for the estimate was obtained using RS Means 2009 Building Construction Cost Data and contractor information. RM Rodgers provided the glulam pricing and Tectum Inc. provided pricing for the Tectum E roof decking system over the recreation center. All other pricing information came from RS Means.

The estimate was created by doing a detailed take-off of a typical bay of the building and extrapolating. **Figure 5-3.3 – Location of Typical Bay Used for Estimate** shows the 2520 SF (both levels) area, between gridlines G-J and 1-2, which was used.

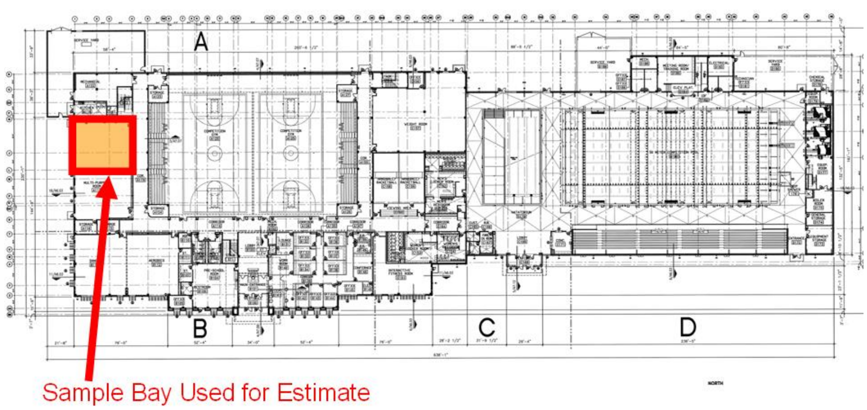

Figure 5-3.3 – Location of Typical Bay Used for Estimate

Recreation Center

Using the total cost estimate obtained from this bay, a cost/SF value was calculated and multiplied by the square footage of the recreation center. This cost/SF did not include the Tectum 'E' roof decking or roof trusses. The cost of these two items was estimated for the entire recreation center then added to the extrapolated cost estimate. See **Appendix 5** for the complete detailed cost estimate.

Natatorium

Modifications had to be made to the cost/SF value to estimate the natatorium's structural system cost since the structural system is glulam instead of steel, like the recreation center. Additionally, there are no elevated slabs in the natatorium. To account for these differences the structural steel and elevated deck costs were subtracted from the recreation center's cost/SF. This new cost/SF was then multiplied by the total square footage of the natatorium. This extrapolated value was added to the glulam columns, purlins, and decking value provided by

RM Rodgers for the total natatorium structural system construction cost. See **Appendix 5** for the complete detailed cost estimate.

General Conditions Estimate

A detailed general conditions cost estimate was also calculated. A general conditions cost of just over under $2 million was estimated for the Pearland Recreation Center and Natatorium project. This estimate was obtained using pricing from RS Means and EMJ Corporation. See **Appendix 5** for the complete estimate.

The general conditions estimate contains 5 portions: project management, temporary facilities, temporary utilities, cleaning, and miscellaneous. Project management and insurance, bond, and O&P are the primary costs in the general conditions, totaling almost $1.9 million. Temporary facilities include items such as job office trailers, temporary sanitary facilities, and barricades. All material hoisting (lifts, cranes etc.) and heavy equipment are to be provided by the contractors so it was not necessary to include these items. Temporary utilities consist of costs for temporary electric, water, and telephone during construction. The cleaning section will pay for weekly site clean-up and final building clean-up. A miscellaneous section with items such as hand tools, safety, and blue prints is also included. A 2% bond, 3% insurance, and 10% overhead and profit are also included in the estimate. These percentages are of the total project cost ($16,786,542 as per Tech #1 estimate).

Section 6: Analysis #1 – Concrete Columns with Steel Trusses Vs. Glulam Structural System (Structural – Breadth Topic #1)

6 – 1 Problem:

Unlike the steel structural system in the recreation center, the natatorium has been designed using a glulam structural system. It is unusual for a natatorium to use a glulam structural system. Additionally, glulam is significantly more expensive than concrete and steel and presents unique challenges during construction. The designer insists that structural steel, even with special coatings, corrodes and deteriorates in the humid environment of natatoriums.

Figure 6-1.1 - Natatorium with steel structural system. Courtesy of Penn State

Figure 6-1.2 - Gymnasium with glulam structural system. Courtesy of Structure Mag

6 – 2 Goal:

Determine the structural and economic feasibility of using a steel structural system in place of the currently designed glulam system in the natatorium, including identifying the durability of steel and glulam in a natatorium's humid environment.

6 – 3 Analysis Method:

1) Determine the durability of concrete, steel and glulam structural systems in a natatorium environment, including all maintenance issues and costs.
2) Design a structural concrete and steel system to replace the glulam system.
3) Calculate the cost savings associated with using a structural concrete and steel system
4) Analyze the schedule impacts of using a structural concrete and steel system
5) Consider the constructability effects of using structural concrete and steel

6 – 4 Resources:

1) Penn State OPP – Chris Musser
2) University of Virginia Capital Projects
3) University of Maryland Capital Projects
4) University of Houston Capital Projects
5) RS Means 2009 Cost Data
6) R.M. Rodgers – Miles Parks
7) Designers with experience in glulam and concrete and steel structural systems in natatoriums.
8) MS Project
9) Pearland Recreation Center and Natatorium project team.

6 – 5 Durability of Concrete, Steel and Glulam:

Initially the objective of this analysis was to design a completely steel structural system in the natatorium. As research of the steel structural system progressed, it was suggested by structural engineers at a number of university's capital projects groups that a structural system consisting of concrete columns and steel girders/joists be used instead. Paint on steel chips very easily and when exposed to water (like the bases of columns would be) the steel would begin to rust. Alternatively, if concrete was used the only concern would be water penetrating the concrete and rusting the rebar. Since the bases of the columns will not be saturated with water this scenario can be ignored. Similarly, since the steel joists and girders would be located up in the ceiling, the chance of paint being chipped on them would be very low. Additionally, the only water concern would be humidity which should not cause the steel to rust, especially if the paint on the steel is not chipped.

6 – 6 Structural System Re-Design:

After a concrete and steel structural system was decided upon it was necessary to design the system. The system was designed using the 2003 International Building Codes shown in **Table 6-1.3 – 2003 IBC Structural Loads**. The roof slope was set at 3:12.

Table 6-1.3 -2003 IBC Structural Loads

Type of Load	Design Load
Roof	20 lb/SF
Dead Weight	20 lb/SF
Wind	120 mph for 30 sec gust – exposure C – importance factor of 1.15

The resulting design consisted of (468) 25' 14k1 joists at 4' o.c. These joists rest on (14) 140' 104SLH22 girders at 25' o.c. The steel system rests on (28) 10" X 10" square concrete columns with 4-#5's. The design calculations as well as the Steel Joist Institute and Concrete Reinforcing Steel Institute sizing sheets that were used are attached in **Appendix 6.** It is important to note that throughout this system redesign it was assumed that the CMU walls in the natatorium would support the structure laterally.

6 – 7 Cost Analysis:

Once a new structural system was designed it was necessary to determine the cost implications of this design modification. To do this RS Means 2009 Cost Data was used. Using this cost data, a total system cost of $469,738 was obtained. This was a $600,262 savings over the $1,070,000 glulam structural system (supplied by R.M. Rodgers, glulam contractor on project) that it replaced. An additional $30,000 was incorporated into the steel system to cover extra connection costs (plates for column-beam connection, etc.) Cost calculations as well as RS Means cut sheets are included in **Appendix 6**.

6 – 8 Schedule Analysis:

A schedule analysis was performed to analyze the effects of this new system on the construction schedule. It was discovered that there was no effect on the schedule. As shown in the modified schedule (shows only the portion of the schedule that included this modification) in **Appendix 6**, the concrete columns are poured while steel is being erected on the Recreation Center and when steel erection is completed on the Recreation Center, the erectors simply continue work on the building with erection in the Natatorium. Prior to the system modification, the steel erectors would have been done once the Recreation Center was complete and the glulam erectors would begin their structural system erection by erecting the glulam members. The only difference with the modified system is that instead of the glulam erectors working on the Natatorium following completion of the Recreation Center's steel, there would be steel erectors erecting steel in the Natatorium.

6 – 9 Constructability Analysis:

Modification of the structural system makes it more easily constructible. The 100 Ton truck crane that was used to erect steel in the Recreation Center would already be on site and would be able to lift all the steel members in the natatorium so no additional cranes would be needed. Additionally, a constructability challenge with the glulam system was the erection of the arches, particularly aligning the bolted connection to the footer. By using the concrete columns this concern could be neglected. Another benefit of this new system is that it would eliminate the need for a glulam subcontractor and would therefore result in one less subcontractor that needs to be on site and managed.

6 – 10 Conclusions and Remarks:

Modification of the natatorium structural system from glulam to steel and concrete resulted in a cost savings, no schedule change, and a more easily constructible building. The objective of this analysis was successful in identifying a preferable alternative to the as-designed natatorium structural system.

Section 7: Analysis #2 – AC Chillers Vs. WC Chiller With Cooling Tower (Mechanical – Breadth Topic #2)

7 – 1 Problem:

During the design phase of construction the owners of the Pearland Recreation Center and Natatorium insisted on using a cooling tower system to cool the water for the building's mechanical system. PBK, the project architect and MEP engineer, convinced them that using a cooling tower system with a water cooled (WC) chiller would be unreasonable since the building was only 105,000 SF. Instead they suggested using an air cooled (AC) chiller system, which would be a more economical choice given the size of the building.

Figure 7-1.1 - Cooling Tower (Courtesy of Zetacorp)

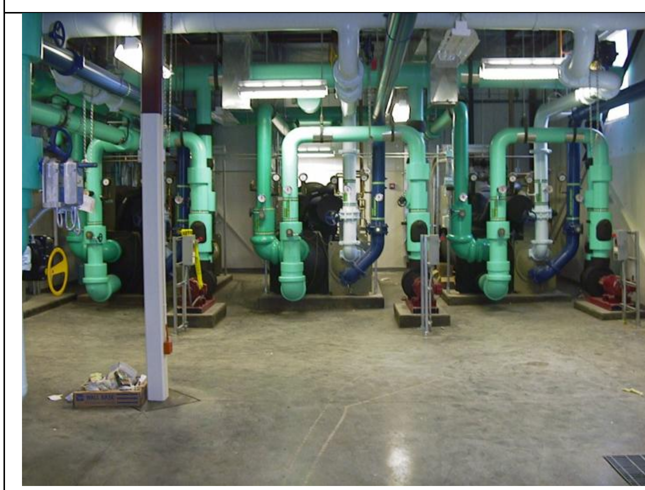

Figure 7-1.2 - Chillers (Courtesy of Tatro Plumbing)

7 – 2 Goal:

The goal of this research topic is to compare the cost of a cooling tower and WC chiller and AC chiller system in order to determine the more economical option. Cost data is already available for the AC chiller system; however it will be necessary to size and develop a construction cost estimate for a WC chiller and cooling tower system.

7 – 3 Analysis Method:

1) Determine the cooling loads on the Pearland Recreation Center and Natatorium
2) Select a cooling tower and WC chiller system that would satisfy the required cooling loads for the building.
3) Obtain construction cost information for the selected WC chiller and cooling tower system.
4) Compare the cost of the WC chiller and cooling tower system to the as designed AC chiller system to determine the more economical option.
5) Consider constructability factors that may make either option more feasible.
6) Consider life-cycle cost and maintenance factors for each option.

7 – 4 Resources:

1) Professor James Freihaut and AE – 310 HVAC Fundamentals course materials
2) Pearland Recreation Center and Natatorium project MEP engineer – PBK MEP
3) Fort Bend Mechanical
4) EMJ Corporation
5) Southland Industries – Nathan Patrick
6) Chesapeake Systems – David Jaworski
7) Boland-Trane – Joe Mulligan

7 – 5 System Selection:

The first step in analyzing the modification of the mechanical system was to design and select a suitable system. As previously mentioned, the current AC chiller would need to be replaced with a WC chiller as well as a Cooling Tower. The 2 as-designed AC chillers each had a capacity of 138 Tons, an entering water temperature of 56d F, a leaving water temperature of 42dF, and a flow rate of 240 GPM. Using these previous design specs and the fact that the project was located in Houston, TX it was determined that the new WC Chiller/Cooling Tower system be designed with a DB temperature of 92dF, a WB temperature of 77dF, a capacity of 276 tons and a 85dF condenser water temperature. Using these parameters it was discovered that the 2 AC chillers could be replaced with only 1 WC chiller. Similarly, the Cooling Tower was sized using an 85dF entering water temperature, a 95dF leaving water temperature and a 828 GPM (3 GPM/ton) flow rate. Product cut sheets for the WC chiller and Cooling Tower supplied by Boland-Trane and Chesapeake Systems are available in **Appendix 7**.

7 – 6 Cost Analysis:

Once the new mechanical system was designed it was then necessary to estimate the cost of the new system and compare it to the previous system. To do this, quotes were obtained from Chesapeake Systems and Trane-Boland for the cooling tower and WC chiller respectively. Labor costs for the installation of this equipment and additional pumps and piping required for the cooling tower were obtained from RS Means 2008 Cost Data. Cost information for the as-designed system was obtained from Fort Bend Mechanical, the mechanical contractor on the project. The new mechanical system offered a $48,523 savings over the previous system. **Table 7-1.3 – Mechanical System Cost Estimate** contains a summary of this comparison and the complete cost estimate calculations are contained in **Appendix 7**.

Table 7-1.3 – Mechanical System Cost Estimate

Item	Cost	Source
Cooling Tower		
Material	$30,171	Chesapeake Systems
Labor	$2,650	RS Means 2008 Cost Data, Pg. 374
Additional Pumps & Piping		
Labor & Material	$26,082	RS Means 2008 Cost Data, Pg. 374
Water Cooled Chiller		
Material	$93,840	Boland-Trane
Labor	$11,700	RS Means 2008 Cost Data, Pg. 373
Additional Structural Support for Cooling Towers		
Labor & Material	$15,557	Fort Bend Mechanical
Total Cost for New System	$180,000	
Total Cost for Old System	$228,523	
Initial Cost Savings with New System	$48,523	

<u>7 – 7 Schedule/Constructability Analysis:</u>

There are three potential constructability issues that would need to be considered with the new WC Chiller/Cooling Tower system that were not present with the old system:

1) The Cooling Tower would require additional structural support in the concrete slab that it would be placed on. This issue should not pose a problem, given the concrete slab is properly reinforced when it is constructed.

2) The Cooling Tower would require a crane for placement. It would be important to properly plan for this and ensure that adequate access is left to the mechanical courtyard on the north side of the building where it would be placed.

3) Previously, the AC chiller had been placed outside in the mechanical courtyard. With the new system, the cooling tower would be placed here and the water cooled chiller would need to be placed inside. There would be room for this equipment in the mechanical room on the northwest corner of the building. However it is important to consider access to this room for chiller installation.

While none of these issues should be a problem, it would be important to give them careful consideration while planning construction to ensure that adequate measures would be taken to account for them. This system modification should have no effect on the schedule since the only additional activities will be cooling tower placement and some extra pumps and piping which could be included in the current mechanical system construction duration.

7 – 8 Energy Cost Analysis:

An energy cost comparison between the two systems was also performed. The old air-cooled chiller system consumed 1.3 KW/Ton for each chiller, or a total of 718 KW. Using a water-cooled chiller and cooling tower the total energy usage would be only 427 KW. Energy information for the water-cooled chiller came from Boland-Trane and for the cooling tower a COP of 4 was assumed and the KW/ton value was calculated from that. Assuming energy costs of 10 cents per KWh in Houston, TX the total energy cost savings using the new system are shown in **Table 7-1.4 - Energy Cost Savings**. All the calculations for this cost comparison can be found in **Appendix 7**.

Table 7-1.4 - Energy Cost Savings

Time Period	Cost Savings
Daily	$698
Monthly	$20,707
Yearly	$248,488

7 – 9 Conclusions and Remarks:

Modification of the mechanical system from an air cooled chiller system to a water cooled chiller with a cooling tower system presents a savings of almost $50,000 in construction costs, almost $250,000 a year in energy costs, and no change in construction schedule duration.

While the new system is preferred economically, there are some additional factors that would need to be taken into consideration during construction such as additional structural reinforcing and construction logistics in mechanical equipment placement. Similarly, a cooling tower will require additional consideration throughout its life-time to ensure that the water in the cooling tower is controlled. Considering the building contains two swimming pools, this water maintenance should not be an issue for the owner as they should already have water control systems in place for the swimming pools and the monitoring of the cooling tower water could just be folded into these duties. In conclusion, a water cooled chiller and cooling tower system could be beneficial for the Pearland Recreation Center and Natatorium project.

Section 8: Analysis #3 – Adversarial Project Team Relationships on Design-Bid-Build Projects and other Delivery Methods for Public Projects (MAE Focus Topic)

8 – 1 Problem:

Projects utilizing the traditional Design-Bid-Build delivery method tend to result in adversarial relationships between project team members. As Pearland Recreation Center and Natatorium approaches completion, it seems that the project is unique in that the project team is still working together effectively and the project is setup for an on-schedule, on-budget completion. It appears that this is a great opportunity to analyze some attributes of a successful project team using this delivery method. Design and construction of the project has been seamless. Throughout the design phase there was beneficial owner-designer interaction that resulted in many features of the building being modified to more effectively meet the owner's needs. During construction there were few problems encountered and the project is currently scheduled to be completed well ahead of schedule.

8 – 2 Goal:

The goal of this research is to determine the factors that contributed to the project's apparent success, including factors such as project team selection and contracting method. Conclusions obtained from this research will be targeted at helping owners select successful teams for their upcoming projects. Additionally, this research will potentially identify an ideal delivery method for public projects.

8 – 3 Analysis Method:

1) Issue questionnaires to project team members to collect their opinions of why the project was successful, as well as to determine if there were any aspects of the project that could have been improved.
2) Compare questionnaire responses to identify commonalities.
3) Interview select project team members to identify specific attributes that have contributed to the project's success.
4) Study the contract documents in order to locate language that contributed to the project's success.
5) Identify aspects of the project team selection process that led to the successful outcome.
6) Interview other public project teams using various delivery methods to potentially identify an ideal project delivery method for public projects.

8 – 4 Resources:

1) Project team surveys
2) Project team interviews
3) Project contract documents
4) Project team selection method
5) Case studies – Other Public Projects
6) AE – 572 Project Development and Delivery Planning course materials

8 – 5 Project Team Analysis:

Analyzing the Pearland Recreation Center and Natatorium's project team began by sending out a survey to the general contractor, EMJ Corporation; owner, City of Pearland; and architect, PBK. Responses were obtained from the general contractor and owner, however after numerous attempts an answer was never received from the architect. These surveys are attached in **Appendix 8**. Upon receipt of the survey responses it became apparent that the project team was working very well together and that all members had a cordial relationship. Additionally, the traditional design-bid-build delivery method was working very well. The City of Pearland was very satisfied with EMJ's work. They were impressed with the management of the company and their effort to achieve a successful project.

After digesting the results from the surveys, phone interviews were executed with the general contractor and architect. These phone interviews developed the concept of 'the ideal delivery method for public projects' - the final result of this research topic. During the phone interviews both the general contractor and owner were strong advocates for the design-bid-build delivery method for public projects such as this. The City of Pearland said they use this delivery method on almost all their projects. This delivery method allocates the risk away from the owner to the other project team members. As a steward of the tax payers, they prefer to do whatever it takes to ensure the community receives a quality project. Consequently on their projects the City prioritizes stewardship of taxpayer funds by valuing quality over an earlier completion schedule

8 – 6 Analysis of Other Delivery Methods on Public Projects:

The City of Pearland is currently also constructing a public service building that will house the police department and other city services. This project is using a design-build delivery method, one of the city's first projects to take this route. City council constrained the project to use this delivery method. The project manager expressed extreme dissatisfaction with the delivery method, citing a lack of checks and balances that normally occur between the general contractor and designer. Since these parties are from the same firm, the owner is no longer the connecting link between these parties and there is much less transparency in the project team's actions.

Another problem that the project manager identified on the project was that there were still design omissions - one of the problems the design-build delivery method is claimed to eliminate. Additionally, construction tends to catch-up to the design and at times has to be put on hold, resulting in schedule extensions and additional costs.

8 – 7 Applications of MAE Concepts:

Analyzing the design-bid-build and design-build delivery methods applied concepts that were learned in a number of graduate level engineering courses, namely AE 572 – Project Development and Delivery Planning, AE 597I – CII Best Practice, and CE 531 – Legal Aspects of Engineering and Construction.

Project Development and Delivery Planning provided knowledge that was critical to understanding how design-bid-build and design-build delivery methods work. Understanding the benefits and drawbacks of these delivery methods allowed for a more effective analysis of the ideal delivery method given the circumstances faced in a public project.

Understanding the legal aspects of construction and engineering was paramount to identifying an ideal delivery method for a public project. Shifting the liability of a public works project away from the owner is a critical legal strategy to consider when selecting the appropriate delivery method.

The Construction Industry Institute's Best Practices course offered an overview of pre-project planning, change management, and equitable risk allocation. These topics enhanced a better understanding of the issues that needed to be considered when selecting a delivery method. Pre-project planning is one of the most important phases of a project as it lays the framework for how a project will be run. This phase can vary greatly based on the delivery method. Change management is also a very important topic, as the number of changes required on a project can have large cost implications. Understanding how a delivery method would affect these changes is important to understand. Again, allocation of risk is a primary concern, particularly for an owner on a public project so it is important to understand how to efficiently shift this risk away from the owner.

8 – 8 Conclusions and Remarks:

Projects using the design-bid-build delivery method are notorious for ending with adversarial relationships between project team members. Pearland Recreation Center and Natatorium has been an exception. Project team members have, in fact, attributed the success of their project to the design-bid-build delivery method. A reason for the project's success using the design-bid-build delivery method has been the City of Pearland's project goal: "Build a quality project on budget". They are not as concerned with completing the project by a specific deadline as they are with controlling costs and producing a project that will serve the community for many years to come.

For complex public projects such as this one, the owner is better served using a design-bid-build delivery method over a design-build delivery method because it effectively allocates liability away from the owner and maintains the beneficial checks and balances between the designer and general contractor.

Section 9: Analysis #4 - Bolted Vs. Welded Glulam Arch Connection

9 - 1 Problem:

In the natatorium of the Pearland Recreation Center and Natatorium a glulam structural system is used, including 14 glulam arches. These glulam arches are connected to the concrete footers using bolts. The bolted connections of these arches were difficult due to the small tolerances of the glulam arches. In hind sight, the contractor suggested that a welded connection would have been more constructible.

Figure 9-1.1 - Glulam Arches (Courtesy of Structural Mag)

9 – 2 Goal:

The goal of this research is to identify the feasibility of using welded connections instead of the as-built bolted connections for the 28 connections (2 per arch) of the 14 glulam arches to the concrete footers.

9 – 3 Analysis Method:

1) Determine the cost of using a welded connection.
2) Identify the time required to construct a welded connection.
3) Compare the cost and time duration for a welded connection with that of a bolted connection.
4) Consider the durability of a welded connection versus a bolted connection.
5) Research the availability of qualified welders in the geographic area.

9 – 4 Resources:

1) Welding contractors
2) Pearland Recreation Center and Natatorium project team.
3) Glulam contractors
4) RS Means Cost Data
5) MS Project

9 – 5 Feasibility/Constructability Analysis:

A welded connection would be easier to construct. The greater Houston area has ample availability of qualified welders. However, connecting dissimilar materials might create problems with the weld.

9 – 6 Design Analysis:

As designed, each connection had (12) 1" diameter stainless steel anchor bolts. This is the equivalent of 12 X 3.14 x $(0.5")^2 = 9.42\ in^2$ of steel connection. To create a weld of equivalent strength, it would be necessary to have 75.36 ($9.42in^2/(1/8in)$) linear inches of 1/8" weld. This would require about 38 inches of 1/8" weld on each side of the connection.

9 – 7 Cost Analysis:

To analyze the costs associated with this connection, it is necessary to identify what would be removed and added. **Table 9-1.2 – Items Added and Removed per Connection** lists these items.

Table 9-1.2 – Items Added and Removed per Connection

Added	Removed
75" of1/8" weld	(12) 1" Anchor Bolts
Metal plate embedded in concrete footer	(12) holes for bolts
	Careful alignment of columns during erection.
	Extra labor to align anchor bolts with holes during erection.

It can be assumed that the material costs associated with the removal of the 12 bolts and the addition of the plate that would be casted into the concrete footer would cancel each other out and could be ignored. Similarly, the labor costs required to insert the plate in the concrete would likely be less and certainly wouldn't be more than the cost to place and brace the anchor bolts during the concrete pour. It is very difficult to properly brace anchor bolts while pouring concrete.

It can also be assumed that the costs associated with field welding the steel plates would be equivalent to the costs of cutting the bolt holes in the steel and the additional labor that would be required to align the anchor bolts with the holes in the steel plate on the base of the glulam column.

9 – 8 Schedule Analysis:

Analyzing the schedule implications of this connection modification is also important. Assuming a 60" long 1/8" weld could be done in 1 hour, .8 connections could be done per hour. The total of 28 connections would only add 35 man hours. Therefore, the schedule implications of this change could be ignored since it would be no more than the time required to set the anchor bolts prior to pouring concrete and aligning the columns with the bolts during glulam erection.

9 – 9 Conclusions and Remarks:

As designed, the bolted connection between the glulam columns and the concrete footer is very difficult to construct. Modifying to a welded connection would eliminate the tedious process of aligning the baseplate of the glulam column with the anchor bolts without increasing the schedule or cost of construction; in fact, it could possibly result in a cost reduction.

Section 10 - Summary and Conclusions:

After performing design, cost, and schedule analysis on the construction of the Pearland Recreation Center and Natatorium the following conclusions have been reached:

1) The structural system in the natatorium should be changed from glulam to structural steel. This change would save over $600,000 in construction costs and have no effect on the construction schedule, durability and life-cycle costs of the building.

2) A water-cooled chiller with a cooling tower mechanical system should replace the air-cooled chiller. This modification would save almost $50,000 in construction costs, almost $250,000 in yearly energy costs, and would have no implications to the construction schedule. A downside to this change would be that the cooling tower would require additional maintenance to control the water in the cooling tower, however since the building contains a swimming pool there should already be qualified maintenance staff on site that could also easily oversee the maintenance of the cooling tower.

3) For complex public buildings such as the Pearland Recreation Center and Natatorium, a design-bid-build delivery method is preferred over design-build. Design-bid-build allocates financial risk away from the owner and includes the all important checks and balances between team members such as the architect and general contractor. These checks and balances are lost in a design-build delivery method because the architect and general contractor are part of the same firm and the owner is no longer included in the interaction between these parties.

4) At the connection between the glulam column and the concrete footers in the natatorium, a welded connection should replace the current, bolted connection. Construction of the bolted connection is difficult as the holes in the column baseplate need to be precisely aligned with the anchor bolts in the footer. A welded connection eliminates this complexity. A welded connection should replace the current bolted connection between the glulam column and the concrete footers in the natatorium.

Making the above modifications to the Pearland Recreation Center and Natatorium would save about $650,000 in construction costs, significantly reduce yearly energy costs, maintain the construction schedule, produce a higher quality product, and create a more constructible building.

Section 11 – Works Cited

General – All Sections:

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Horman, Michael. Class Lecture. AE 476 Building Construction Engineering - 2. The Pennsylvania State University, University Park, PA. Spring 2009.

Magent, Christopher. Class Lecture. AE 472 Building Construction Planning and Management. The Pennsylvania State University, University Park, PA. Spring 2009.

Analysis #1 – Structural system modification:

2009 RS Means Building Construction Cost Data. Kingston, MA: Construction Publishers and Consultants, 2008.

Concrete Reinforcing Steel Institute, Concrete Reinforcing Steel Institue design handbook, 2008. Schaumburg, IL: Concrete Reinforcing Steel Institue, 2008.

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Analysis #2 – Mechanical system modification:

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McQuiston, Parker, Spitler, Heating, Ventilating, and Air Conditioning. Hoboken, NJ: John Wiley & Sons, Inc., 2005.

Freihaut, James. Class Lecture. AE 310 HVAC Fundamentals. The Pennsylvania State University, University Park, PA. Fall 2007.

Analysis #3 – Project Delivery Systems for Public Projects:

Sweet, Schneier, Legal Aspects of Architecture, Engineering, and the Construction Process. Stamford, CT: Cengage Laerning, 2009.

Thomas, Ellis, Interpreting Construction Contracts. Reston, VA: American Society of Civil Engineers, 2007.

Anumba, Chimay. Class Lecture.AE 597I CII Best Practices. The Pennsylvania State University, University Park, PA. Fall 2009.

Thomas, Randolph. Class Lecture. CE 531 Legal Aspects of Engineering and Construction. The Pennsylvania State University, University Park, PA. Fall 2009.

Horman, Michael. Class Lecture. AE 572 Project Development and Delivery Planning. The Pennsylvania State University, University Park, PA. Spring 2009.

Analysis #4 – Glulam-Footing Connection Detail:

American Welding Society, Structural welding code. Miami, FL: American Welding Society, 2002.

Parks, Mike. Personal interview. March 2010.

Stoltz, Scott. Personal interview. February 2010.

Appendix 3 – Project Overview References

Specialty Contractor List

SUBCONTRACTORS AND SUPPLIERS
RECREATION CENTER & NATATORIUM
PEARLAND, TX
#5085

PROJ. EST.: LOU ARRIETA
PROJ. MGR.: SCOTT STOLTZ
PROJ. ASST.: MATT LUNA
SUPERINT.: PHILLIP CRISSMAN

JUNE 30, 2009

SUBCTR	CO NAME	CO ADDRESS	CITY STATE ZIP	CONT F NAME	CONT L NAME	PHONE	FAX	SUBCD
0000-1 **OWNER**	City of Pearland							0000-1
0000-2 **ARCHITECT**	PBK Architects							0000-2
0000-3 **STRUCTURAL ENGINEER**								0000-3
0000-4 **MEP ENGINEER**								0000-4
0000-5 **JOBSITE**	EMJ Corporation	4141 Bailey Road	Pearland, TX 77584	Phillip	Crissman			0000-5
5085-0107-030100-00 **CONCRETE**	MCM Commercial Concrete, Inc.	9518 Grant Road	Houston, TX 77070	Matt	Mabry	713-466-7670	713-466-7683	030100-00
5085-0116-034713-00 **CONCRETE DECK**	G.L. Nettles, Inc.	41229 Park 290 Drive	Waller, TX 77484	Bryan	Batchman	936-372-9020	936-372-9032	034713-00
5085-0124-042000-00 **MASONRY**	Easthaven Incorporated	8723 Easthaven Dr.	Houston, TX 77075	Tommy	Grantland	713-944-5361	713-944-2815	042000-00
5085-0101-050000-00 **STRUCTURAL STEEL**	Apel Steel Corporation	2345 Second Avenue N.W.	Cullman, AL 35058	Hank	Apel	256-739-6280	256-739-6304	050000-00
5085-0105-061800-00 **WOOD ROOF DECKING**	R.M. Rodgers, Inc.	6352 Akder Drive	Houston, TX 77081-4404	Max	Rodgers	713-666-2229	713-666-2516	061800-00
5085-0144-062200-00 **MILLWORK**	Victoria Cabinetworks, a subsidiary of Roth Construction, Inc.	2002 Delmar Drive	Victoria, TX 77901	Casey	Roth	361-578-0263	361-578-1271	062200-00
5085-0122-072450-00 **LATH & PLASTER**	Kenyon Plastering of Texas, Inc.	3401 West 11th Street	Houston, TX 77008	Patrick	Troy	832-673-6404	832-673-0406	072450-00
5085-0125-075000-00 **ROOFING**	Admiral Roofing and Sheet Metal, LLC	14521 Old Katy Rd. #224	Houston, TX 77079	E. Eugene	Lauver	281-372-1250	281-372-1252	075000-00
5085-0152-075000-01 **ROOFING**	Threadgill Sheet Metal Works, Inc.	17515A Huffmeister	Cypress, TX 77429	Wayne	Threadgill	281-373-0016	281-373-0010	075000-01

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JUNE 30, 2009

5085-0150-078100-00 **FIREPROOFING**	Alpha Insulation & Waterproofing, Inc.	787 Bradfield Rd.	Houston, TX 77060	David	Wright	281-999-7000	281-999-7005	078100-00
5085-0147-079200-00 **WATERPROOFING/ SEALANTS**	Century Roofing L.L.C.	4411 Airline	Houston, TX 77022	Mike	Martin	713-697-8288	713-697-8299	079200-00
5085-0111-081100-00 **HOLLOW METAL DOORS/WOOD DOORS/FINISH HARDWARE**	Piper-Weatherford Co. Distributor – Architectural Specialties	165 Tecon Cove	Buda, TX 78610	Tom	Buyers	512-420-0726	512-420-9367	081100-00
5085-0134-083323-00 **OVERHEAD DOORS**	ABC Steel Products Co., Inc. dba ABC Doors	5100 South Willow	Houston, TX 77035	Bob	Casson	713-729-9700	713-729-8611	083323-00
5085-0126-084000-00 **STOREFRONT**	Ranger Specialized Glass, Inc.	19031 Aldine Westfield	Houston, TX 77073	Omar	Maalouf	281-821-3777	281-821-3785	084000-00
5085-0142-090600-00 **DRYWALL/ CARPENTRY**	PC Unlimited, Inc.	211-E Randon Dyer Road	Rosenberg, TX 77471	Josef	Poncik	281-344-1900	281-344-1922	090600-00
5085-0123-093000-00 **CERAMIC TILE**	ASA Carlton, Inc.	5224 Palmero Court, Suite 200	Buford, GA 30518	Scott	Hester	770-945-2195	770-945-5640	093000-00
5085-0118-096433-00 **GYM FLOOR/ RAQUETBALL COURT/ SCOREBOARD SYSTEM**	Jellison Inc., dba Jelco	1109 Regal Row	Austin, TX 78748	Don	Jellison	800-366-8306	512-282-4070	096433-00
5085-0148-096433-01 **EPOXY FLOOR**	Polymer Systems, Inc.	17320 E. State Hwy 29	Buchanan Dam, TX 78609	Carl	Taylor	512-793-6575	512-793-2779	096433-00
5085-0146-096500-00 **TILE/BASE/CARPET**	Marek Brothers Systems, Inc.	2115 Judiway	Houston, TX 77018	Mike	Holland	713-681-2626	713-681-6540	096500-00
5085-0143-099113-00 **PAINTING**	Zaxon Commercial Painting, LLC	2116 Kyle Circle	Heath, TX 75032	Bryan	Jobe	214-538-2911	214-206-1146	099113-00
5085-0149-100610-13 **SIGN WORK**	Atlas Sign Services, Inc.	6411 Airline Drive	Houston, TX 77076	Michael	Johnson	713-699-1121	713-699-2211	100610-13
5085-0112-101100-00 **BULLETIN BOARDS, ACCORDIAN**	Klinger Specialties Direct, Inc.	2611 Couch	Houston, TX 77008	Benny	Castro	713-861-4213	713-861-4471	101100-00

SUBCONTRACTORS AND SUPPLIERS
RECREATION CENTER & NATATORIUM
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PROJ. MGR.: **SCOTT STOLTZ**
PROJ. ASST.: **MATT LUNA**
SUPERINT.: **PHILLIP CRISSMAN**

JUNE 30, 2009

DOORS, POSTER CASE, SWINSUIT DRYER								
5085-0119-102113-00 **TOILET/DRESSING/ SHOWER COMPARTMENTS**	Victoria Builder Supply Company, Inc.	5301 N. John Stockbauer	Victoria, TX 77904	Dan	Gorfido	361-572-8929	361-572-8992	102113-00
5085-0127-102813-00 **TOILET ACCESSORIES**	Tri-Tech Building Products LLC	4301 Founder's Way Drive, Suite C	Chattanooga, TN 37416	Ted	Wilkes, Jr.	423-892-7307	423-622-4736	102813-00
5085-0138-105100-00 **BENCHES/ LOCKERS/ SHELVING**	Silicon Valley Shelving & Equipment Co., Inc.	18522 Bridoon	Cypress, TX 77433	Michael	Lacey	281-550-9975	281-550-9980	105100-00
5085-0117-107313-00 **FLAGPOLES**	Assoc. Bldrs Specialties, Inc. Dba Kronberg's Flags & Flagpoles	7106 Mapleridge	Houston, TX 77081	Jeff	Gifford-Weaver	713-661-9222	713-661-7022	107313-00
5085-0133-107310-00 **ALUMINUM CANOPIES**	Luebe-Jones, Inc. dba Avadek	9201 Winkler	Houston, TX 77017	Will	Sims	713-944-0988	713-944-5815	107313-00
5085-0132-107313-01 **ALUMINUM SUN SCREENS**	Sign and Awning Services, Inc.	4711 Vermont	Fort Worth, TX 76115	Todd	Price	817-926-7270	817-926-7311	107313-01
5085-0141-114000-00 **STAINLESS STEEL**	Classic Stainless, Inc.	4330 Bronze Way	Dallas, TX 75237	Gus	Macias	214-467-8700	214-467-8705	114000-00
5085-0136-114000-01 **RESIDENTIAL EQUIPMENT**	Manna Distributors, Inc.	8708 West Park	Houston, TX 77063	Alan	Nahman	713-977-3318	713-789-7513	114000-01
5085-0140-114000-02 **KITCHEN EQUIPMENT**	Alliance Food Equipment Corp.	2225 E. Beltline Rd.	Carrollton, TX 75006	Al	Berger	972-820-8352	972-820-6021	114000-02
5085-0113-115213-00 **GYMNASIUM EQUIPMENT**	Game Court Services, Inc.	10901 Circle Drive	Austin, TX 78736	David	Henderson	512-394-0461	512-394-0480	115213-00
5085-0121-115213-00 **PROJECTOR**	Daersed Enterprises dba	3645 Fredricksburg Rd.	San Antonio, TX 78201	G'Anna	Parkey	210-732-9327	210-732-9347	115213-00

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JUNE 30, 2009

SCREENS	Southwest Décor							
5085-0120-122000-00 **HORIZONTAL BLINDS**	Longhorn Blinds of Austin, LLC	4201 S. Congress Ave., #312	Austin, TX 78745	Ron	Newhouse	512-447-5496	512-707-7315	122000-00
5085-0115-131100-00 **SWIMMING POOL**	Progressive Commercial Aquatics, Inc.	2510 Farrell Road	Houston, TX 77073	Tim	Phelps	281-982-0212	281-443-1524	131100-00
5085-0137-133416-00 **ALUMINUM BLEACHERS**	Southern Bleacher Company, Inc.	801 Fifth Street	Graham, TX 76450	Jim	McCain	800-433-0912	940-549-1365	133416-00
5085-0106-142000-00 **ELEVATOR**	ThyssenKrupp Elevator Corporation	14820 Tomball Pkwy., Suite 190	Houston, TX 77086	Adam	Meyer	713-289-0289	713-896-4660	142000-00
5085-0109-211300-00 **FIRE PROTECTION**	Firecheck of Texas, Inc.	11500 N. 10th Street	McAllen, TX 78504-0222	Hal	Wychopen	956-383-3473	956-380-3473	211300-00
5085-0139-212000-00 **FIRE EXTINGUISHERS/ CABINETS**	PBJ Specialties	7800 Bissonnet Street, Suite 350	Houston, TX 77074	Scott	Harmon	713-774-5701	713-774-5717	212000-00
5085-0110-221000-00 **PLUMBING**	Johnston Commercial Plumbing, LLC	800 Wilcrest Dr., Suite 150	Houston, TX 77042	Michael	Johnston	713-532-4202	713-532-9906	221000-00
5085-0108-230000-00 **HVAC**	Fort Bend Mechanical, LTD	13625 Stafford Road	Stafford, TX 77477	Pete	Medford	281-403-4822	281-403-4823	230000-00
5085-0104-260000-00 **SITE/BUILDING ELECTRIC**	Quinco Electrical of Dallas, Inc.	3016 W. Story Rd.	Irving, TX 75038	Richard	Cavazos	972-258-9105	972-258-9107	260000-00
5085-0129-272000-00 **ALARM/ VIDEO/ SECURITY CAMERA**	NetVersant Solutions, LLC	9750 W. Sam Houston Parkway N., Suite 100	Houston, TX 77064	Steven	Davis	832-487-1973	832-487-1901	272000-00
5085-0131-280000-00 **SOUND SYSTEM**	FireTron, Inc.	10101A Stafford Centre Dr.	Stafford, TX 77477	Richard	Phillips	281-499-1500	281-499-3711	280000-00
5085-0130-283100-00 **FIRE ALARM/ TELEPHONE**	Wilson Fire Equipment & Service Company, Inc.	7303 Empire Central Drive	Houston, TX 77040	Waylan	Gandy	832-310-2469	832-310-2569	283100-00
5085-0102-310600-00	W.T. Byler Co.,	15203 Lillja Road	Houston, TX	Jeremy	Perkins	281-445-2070	281-445-4356	310600-00

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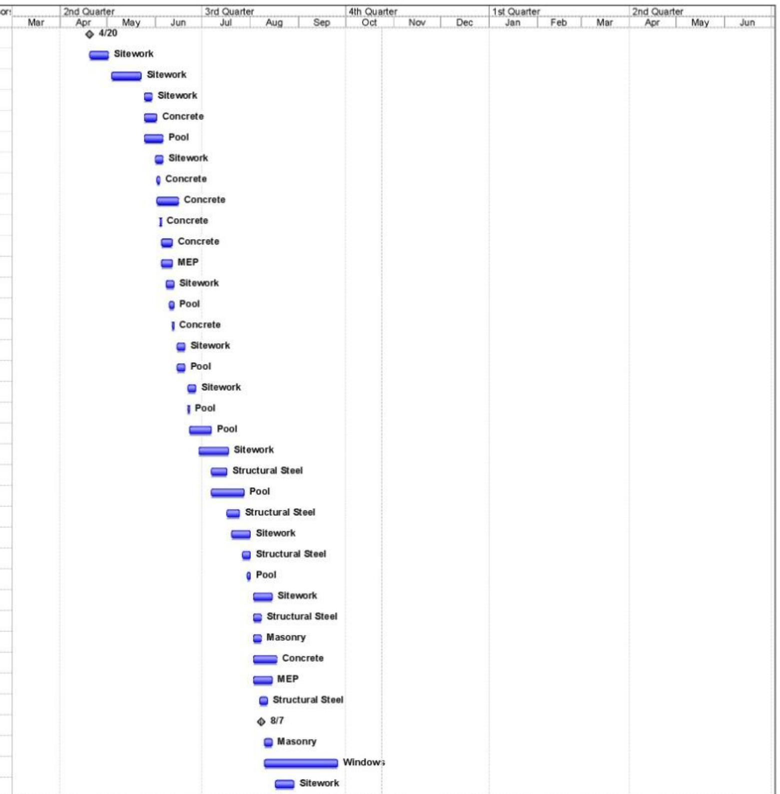
EARTHWORK/ ASPHALT PAVING	L.P.		77060-5299					
5085-0145-313116-00 **SOIL POISONING**	Aroco Pest Management, L.L.C.	4321 Pepperbush	Fort Worth, TX 76137	Ron	Muse	817-920-5950	817-847-5754	313116-00
5085-0135-321723-00 **PAVEMENT MARKINGS**	Arkansas Line Marking, Inc.	10524 Dreher Road	Little Rock, AR 72206	Michael	Griffin	501-888-5052	501-888-1080	321723-00
5085-0151-323100-00 **FENCING**	Foster Fence LTD	16700 Old Hwy 90 East	Houston, TX 77049	Daniel	Greak	281-456-7273	281-456-0221	323100-00
5085-0114-329000-00 **LANDSCAPE & IRRIGATION**	Site Landscape Development LLC	762 E. Business 121	Lewisville, TX 75057	Kirk	Boyd	972-221-2205	972-221-2208	329000-00
5085-0103-334000-00 **WATER/SEWER**	Joslin Construction Company, Inc.	21518 West Wallis	Porter, TX 77365	Ray	Joslin	281-354-5840	281-354-5840	334000-00

Appendix 5 – Project Logistics References

Detailed Project Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	Notice to Proceed	0 days	Mon 4/20/09	Mon 4/20/09	
2	Recreation Center - Excavation	10 days?	Mon 4/20/09	Fri 5/1/09	1
3	Natatorium - Excavation	15 days?	Mon 5/4/09	Fri 5/22/09	2
4	Storm Water Utility Connection	5 days?	Mon 5/25/09	Fri 5/29/09	1
15	Recreation Center - Drill Piers	6 days?	Mon 5/25/09	Mon 6/1/09	2
113	Natatorium - Pool Excavation	10 days	Mon 5/25/09	Fri 6/5/09	3
5	Sanitary Sewer Utility Connection	5 days	Mon 6/1/09	Fri 6/5/09	4
16	Recreation Center - Form/Reinforce Spread Footings	2 days?	Tue 6/2/09	Wed 6/3/09	15
120	Natatorium - Drill Piers	10 days	Tue 6/2/09	Mon 6/15/09	15
17	Recreation Center - Pour Spread Footings	1 day?	Thu 6/4/09	Thu 6/4/09	16
18	Recreation Center - Form/Reinforce Slab-On-Grade	5 days?	Fri 6/5/09	Thu 6/11/09	17
20	Recreation Center - Underground MEP	5 days?	Fri 6/5/09	Thu 6/11/09	17
6	Domestic Water Utility Connection	5 days?	Mon 6/8/09	Fri 6/12/09	5
114	Natatorium - Pool Floor Rough-In	3 days	Wed 6/10/09	Fri 6/12/09	113
19	Recreation Center - Pour Slab-On-Grade	1 day?	Fri 6/12/09	Fri 6/12/09	18,20
7	Gas Utility Connection	5 days?	Mon 6/15/09	Fri 6/19/09	6
115	Natatorium - Pool Floor Steel Placement	5 days	Mon 6/15/09	Fri 6/19/09	114
8	Electric Utility Connection	5 days?	Mon 6/22/09	Fri 6/26/09	7
116	Natatorium - Pool Floor Concrete Placement	1 day?	Mon 6/22/09	Mon 6/22/09	115
117	Natatorium - Pool Walls Rough-In	10 days	Tue 6/23/09	Mon 7/6/09	116
9	Parking Lot Underground Electric	15 days?	Mon 6/29/09	Fri 7/17/09	8
21	Recreation Center - Structural Steel Phase 1	8 days?	Tue 7/7/09	Thu 7/16/09	19
118	Natatorium - Pool Walls Steel Placement	15 days	Tue 7/7/09	Mon 7/27/09	117
22	Recreation Center - Structural Steel Phase 2	6 days?	Fri 7/17/09	Fri 7/24/09	21
10	Grade Parking Lot	10 days?	Mon 7/20/09	Fri 7/31/09	9
23	Recreation Center - Structural Steel Phase 3	5 days?	Mon 7/27/09	Fri 7/31/09	22
119	Natatorium - Pool Walls Concrete Placement	2 days	Thu 7/30/09	Fri 7/31/09	118
12	Blue Top at Parking Lot	10 days?	Mon 8/3/09	Fri 8/14/09	10
24	Recreation Center - Steel Roof Trusses	5 days?	Mon 8/3/09	Fri 8/7/09	23
41	Recreation Center - CMU West Wall	5 days?	Mon 8/3/09	Fri 8/7/09	23
121	Natatorium - Form and Reinforce Spread Footings	11 days	Mon 8/3/09	Mon 8/17/09	119
122	Natatorium - MEP Underground	10 days	Mon 8/3/09	Fri 8/14/09	119
26	Recreation Center - 2nd Floor Metal Decking Phase A	3 days	Fri 8/7/09	Tue 8/11/09	21
25	Recreation Center - Topping Out	0 days	Fri 8/7/09	Fri 8/7/09	24
42	Recreation Center - CMU North Wall	5 days?	Mon 8/10/09	Fri 8/14/09	41
47	Recreation Center - Windows	35 days?	Mon 8/10/09	Fri 9/25/09	41
11	Pave Parking Lot	10 days?	Mon 8/17/09	Fri 8/28/09	12

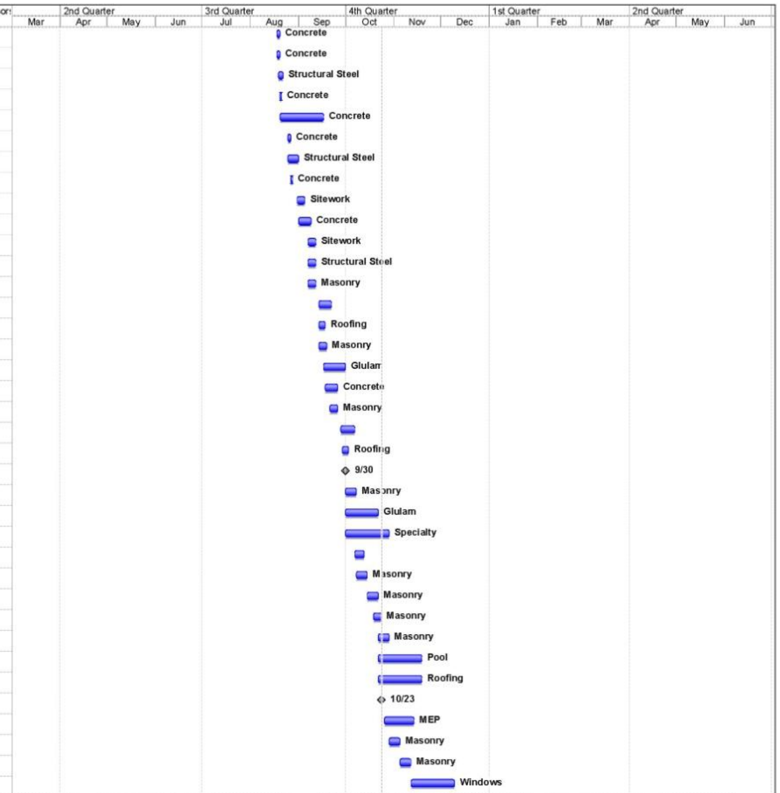


Project: Pearland Rec Center and Nat
Date: Sat 10/24/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Page 1

ID	Task Name	Duration	Start	Finish	Predecessors
28	Recreation Center - Reinforce 2nd Floor Deck Phase A	2 days	Tue 8/18/09	Wed 8/19/09	26
123	Natatorium - Pour Slab-On Grade	2 days	Tue 8/18/09	Wed 8/19/09	122,121
27	Recreation Center - 2nd Floor Metal Decking Phase B	3 days	Wed 8/19/09	Fri 8/21/09	22
29	Recreation Center - Pour Concrete 2nd Floor Deck Phase A	1 day?	Thu 8/20/09	Thu 8/20/09	28
124	Natatorium - Steel Erection	20 days	Thu 8/20/09	Wed 9/16/09	123,23
30	Recreation Center - Reinforce 2nd Floor Deck Phase B	2 days	Tue 8/25/09	Wed 8/26/09	27,28
32	Recreation Center - Roof Decking Phase A	5 days	Tue 8/25/09	Mon 8/31/09	24
31	Recreation Center - Pour Concrete 2nd Floor Deck Phase B	1 day?	Thu 8/27/09	Thu 8/27/09	30,29
13	Sidewalks at Parking Lot	5 days?	Mon 8/31/09	Fri 9/4/09	11
35	Recreation Center - Light Weight Concrete Phase A	6 days	Tue 9/1/09	Tue 9/8/09	32
14	Island Fill at Parking Lot	5 days?	Mon 9/7/09	Fri 9/11/09	13
33	Recreation Center - Roof Decking Phase B	5 days	Mon 9/7/09	Fri 9/11/09	32
43	Recreation Center - CMU South Wall	5 days?	Mon 9/7/09	Fri 9/11/09	42
34	Recreation Center - Roof Decking Phase C	6 days	Mon 9/14/09	Mon 9/21/09	33
38	Recreation Center - Built-up Roofing Phase A	4 days	Mon 9/14/09	Thu 9/17/09	35
44	Recreation Center - Brick West Wall	5 days?	Mon 9/14/09	Fri 9/18/09	43
125	Natatorium - Glulam Erection	10 days	Thu 9/17/09	Wed 9/30/09	124
36	Recreation Center - Light Weight Concrete Phase B	6 days	Fri 9/18/09	Fri 9/25/09	33,35
45	Recreation Center - Brick North Wall	5 days?	Mon 9/21/09	Fri 9/25/09	44
37	Recreation Center - Light Weight Concrete Phase C	7 days	Mon 9/28/09	Tue 10/6/09	34,36
39	Recreation Center - Built-up Roofing Phase B	4 days	Tue 9/29/09	Fri 10/2/09	36,38
126	Natatorium - Top Out	0 days	Wed 9/30/09	Wed 9/30/09	125
127	Natatorium - CMU North Wall	5 days	Thu 10/1/09	Wed 10/7/09	126
133	Natatorium - Roof Decking	15 days	Thu 10/1/09	Wed 10/21/09	125
144	Natatorium - Pool Deck	20 days	Thu 10/1/09	Wed 10/28/09	126
40	Recreation Center - Built-up Roofing Phase C	4 days	Wed 10/7/09	Mon 10/12/09	37,39
128	Natatorium - CMU East Wall	5 days	Thu 10/8/09	Wed 10/14/09	127
129	Natatorium - CMU South Wall	5 days	Thu 10/15/09	Wed 10/21/09	128
46	Recreation Center - Brick South Wall	5 days?	Mon 10/19/09	Fri 10/23/09	45
130	Natatorium - Face North Wall	5 days	Thu 10/22/09	Wed 10/28/09	129
136	Natatorium - Pool Gutter System	20 days	Thu 10/22/09	Wed 11/18/09	133
137	Natatorium - Standing Seam Roofing System	20 days	Thu 10/22/09	Wed 11/18/09	133
48	Recreation Center - Dry-In	0 days	Fri 10/23/09	Fri 10/23/09	46,47
49	Recreation Center - 1st Floor MEP Overhead Rough-In Phase A	15 days?	Mon 10/26/09	Fri 11/13/09	48
131	Natatorium - Brick East Wall	5 days	Thu 10/29/09	Wed 11/4/09	130
132	Natatorium - Brick South Wall	5 days	Thu 11/5/09	Wed 11/11/09	131
134	Natatorium - Windows	20 days	Thu 11/12/09	Wed 12/9/09	132



Project: Pearland Rec Center and Nat
Date: Sat 10/24/09

Task | Progress | Summary | External Tasks | Deadline
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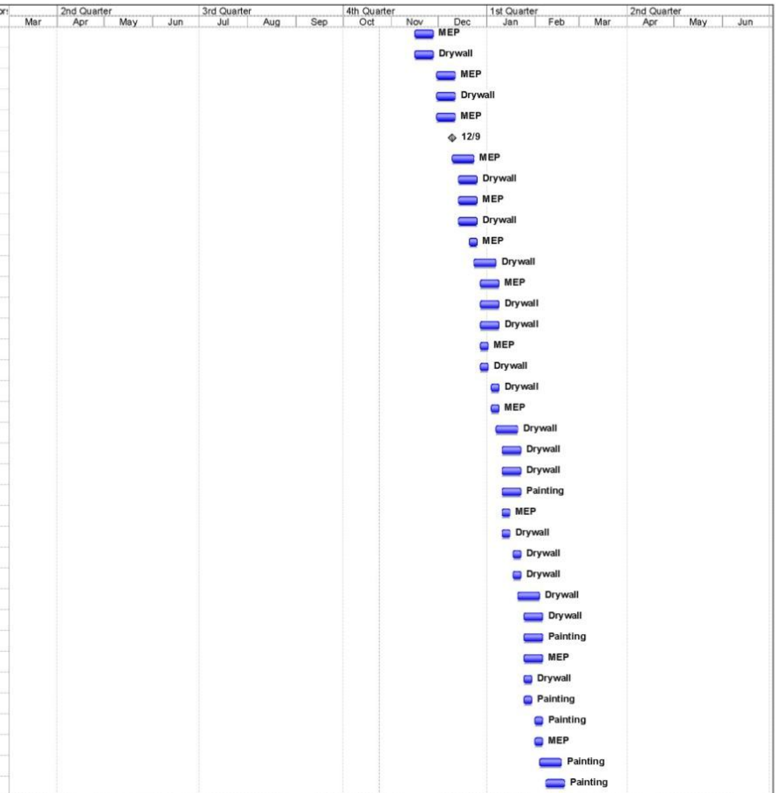
ID	Task Name	Duration	Start	Finish	Predecessors
50	Recreation Center - 1st Floor MEP Overhead Rough-In Phase B	10 days?	Mon 11/16/09	Fri 11/27/09	49
52	Recreation Center - 1st Floor Interior Framing Phase A	10 days	Mon 11/16/09	Fri 11/27/09	49
51	Recreation Center - 1st Floor MEP Overhead Rough-In Phase C	10 days?	Mon 11/30/09	Fri 12/11/09	50
53	Recreation Center - 1st Floor Interior Framing Phase B	10 days	Mon 11/30/09	Fri 12/11/09	50,52
55	Recreation Center - 1st Floor MEP Rough-In Phase A	10 days	Mon 11/30/09	Fri 12/11/09	52
135	Natatorium - Dry-In	0 days	Wed 12/9/09	Wed 12/9/09	134
138	Natatorium - Overhead Rough-in	10 days	Thu 12/10/09	Wed 12/23/09	135
54	Recreation Center - 1st Floor Interior Framing Phase C	10 days	Mon 12/14/09	Fri 12/25/09	51,53
56	Recreation Center - 1st Floor MEP Rough-In Phase B	10 days	Mon 12/14/09	Fri 12/25/09	53,55
58	Recreation Center - 1st Floor Drywall and Insulation Phase A	10 days	Mon 12/14/09	Fri 12/25/09	55
70	Recreation Center - 2nd Floor MEP Overhead Rough-In Phase A	5 days	Mon 12/21/09	Fri 12/25/09	51
139	Natatorium - Interior Framing	10 days	Thu 12/24/09	Wed 1/6/10	138
57	Recreation Center - 1st Floor MEP Rough-In Phase C	10 days	Mon 12/28/09	Fri 1/8/10	54,56
59	Recreation Center - 1st Floor Drywall and Insulation Phase B	10 days	Mon 12/28/09	Fri 1/8/10	56,58
61	Recreation Center - 1st Floor Finishing Phase A	10 days	Mon 12/28/09	Fri 1/8/10	58
71	Recreation Center - 2nd Floor MEP Overhead Rough-In Phase B	5 days	Mon 12/28/09	Fri 1/1/10	70
72	Recreation Center - 2nd Floor Interior Framing Phase A	5 days	Mon 12/28/09	Fri 1/1/10	70
73	Recreation Center -2nd Floor Interior Framing Phase B	5 days	Mon 1/4/10	Fri 1/8/10	71,72
74	Recreation Center - 2nd Floor MEP Rough-In Phase A	5 days	Mon 1/4/10	Fri 1/8/10	72
140	Natatorium - Drywal & Insulation	10 days	Thu 1/7/10	Wed 1/20/10	139
60	Recreation Center - 1st Floor Drywall and Insulation Phase C	10 days	Mon 1/11/10	Fri 1/22/10	57,59
62	Recreation Center - 1st Floor Finishing Phase B	10 days	Mon 1/11/10	Fri 1/22/10	59,61
64	Recreation Center - 1st Floor Painting Phase A	10 days	Mon 1/11/10	Fri 1/22/10	61
75	Recreation Center - 2nd Floor MEP Rough-In Phase B	5 days	Mon 1/11/10	Fri 1/15/10	73,74
76	Recreation Center - 2nd Floor Drywall & Insulation Phase A	5 days	Mon 1/11/10	Fri 1/15/10	74
77	Recreation Center - 2nd Floor Drywall & Insulation Phase B	5 days	Mon 1/18/10	Fri 1/22/10	75,76
78	Recreation Center - 2nd Floor Finishing Phase A	5 days	Mon 1/18/10	Fri 1/22/10	76
141	Natatorium - Finishing	10 days	Thu 1/21/10	Wed 2/3/10	140
63	Recreation Center - 1st Floor Finishing Phase C	10 days	Mon 1/25/10	Fri 2/5/10	60,62
65	Recreation Center - 1st Floor Painting Phase B	10 days	Mon 1/25/10	Fri 2/5/10	62,64
67	Recreation Center - 1st Floor MEP Fitout Phase A	10 days	Mon 1/25/10	Fri 2/5/10	64
79	Recreation Center - 2nd Floor Finishing Phase B	5 days	Mon 1/25/10	Fri 1/29/10	77,78
80	Recreation Center - 2nd Floor Painting Phase A	5 days	Mon 1/25/10	Fri 1/29/10	78
81	Recreation Center - 2nd Floor Painting Phase B	5 days	Mon 2/1/10	Fri 2/5/10	79,80
82	Recreation Center - 2nd Floor MEP Fitout Phase A	5 days	Mon 2/1/10	Fri 2/5/10	80
142	Natatorium - Painting	10 days	Thu 2/4/10	Wed 2/17/10	141
66	Recreation Center - 1st Floor Painting Phase C	10 days	Mon 2/8/10	Fri 2/19/10	63,65



Project: Pearland Rec Center and Nat
Date: Sat 10/24/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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ID	Task Name	Duration	Start	Finish	Predecessors	
68	Recreation Center - 1st Floor MEP Fitout Phase B	10 days	Mon 2/8/10	Fri 2/19/10	65,67	MEP
83	Recreation Center - 2nd Floor MEP Fitout Phase B	5 days	Mon 2/8/10	Fri 2/12/10	81,82	MEP
84	Recreation Center - 1st Floor Ceiling Phase A	5 days	Mon 2/8/10	Fri 2/12/10	67	Ceiling
90	Recreation Center - 2nd Floor Ceiling Phase A	5 days	Mon 2/8/10	Fri 2/12/10	82	Ceiling
87	Recreation Center - 1st Floor Flooring Phase A	5 days	Mon 2/15/10	Fri 2/19/10	84	Flooring
91	Recreation Center - 2nd Floor Ceiling Phase B	5 days	Mon 2/15/10	Fri 2/19/10	83	Ceiling
92	Recreation Center - 2nd Floor Flooring Phase A	5 days	Mon 2/15/10	Fri 2/19/10	90	Flooring
100	Recreation Center - Gym Flooring	15 days	Mon 2/15/10	Fri 3/5/10	83	Specialty
143	Natatorum - Ceiling	7 days	Thu 2/18/10	Fri 2/26/10	142	Ceiling
149	Natatorium - Pool Tile and Finishing	10 days	Thu 2/18/10	Wed 3/3/10	142	Pool
69	Recreation Center - 1st Floor MEP Fitout Phase C	10 days	Mon 2/22/10	Fri 3/5/10	66,68	MEP
85	Recreation Center - 1st Floor Ceiling Phase B	5 days	Mon 2/22/10	Fri 2/26/10	68	Ceiling
93	Recreation Center - 2nd Floor Flooring Phase B	5 days	Mon 2/22/10	Fri 2/26/10	91	Flooring
94	Recreation Center - 1st Floor Doors and Hardware Phase A	5 days	Mon 2/22/10	Fri 2/26/10	87	Doors
97	Recreation Center - 2nd Floor Doors and Hardware Phase A	5 days	Mon 2/22/10	Fri 2/26/10	92	Doors
106	Recreation Center - Raquetball Court Systems	25 days	Mon 2/22/10	Fri 3/26/10	66	Specialty
88	Recreation Center - 1st Floor Flooring Phase B	5 days	Mon 3/1/10	Fri 3/5/10	85	Flooring
98	Recreation Center - 2nd Floor Doors and Hardware Phase B	5 days	Mon 3/1/10	Fri 3/5/10	93	Doors
104	Recreation Center - Casework	1 day?	Mon 3/1/10	Mon 3/1/10	93	Specialty
145	Natatorium - Flooring	10 days	Mon 3/1/10	Fri 3/12/10	143	Flooring
150	Natatorium - Bleachers	5 days	Thu 3/4/10	Wed 3/10/10	149	Specialty
152	Natatorium - Pool Testing	10 days	Thu 3/4/10	Wed 3/17/10	149	Pool
86	Recreation Center - 1st Floor Ceiling Phase C	5 days	Mon 3/8/10	Fri 3/12/10	69	Ceiling
95	Recreation Center - 1st Floor Doors and Hardware Phase B	5 days	Mon 3/8/10	Fri 3/12/10	88	Doors
105	Recreation Center - Specialties	1 day?	Mon 3/8/10	Mon 3/8/10	98	Speacilty
108	Recreation Center - MEP Systems Testing	10 days?	Tue 3/9/10	Mon 3/22/10	83	MEP
89	Recreation Center - 1st Floor Flooring Phase C (Gym)	5 days	Mon 3/15/10	Fri 3/19/10	86	Flooring
146	Natatorium - MEP Trim-Out	7 days	Mon 3/15/10	Tue 3/23/10	145	MEP
147	Natatorium - Casework	7 days	Mon 3/15/10	Tue 3/23/10	145	Specialty
148	Natatorium - Doors and Hardware	7 days	Mon 3/15/10	Tue 3/23/10	145	Doors
153	Natatorium - MEP Testing	10 days	Thu 3/18/10	Wed 3/31/10	152	MEP
96	Recreation Center - 1st Floor Doors and Hardware Phase C	5 days	Mon 3/22/10	Fri 3/26/10	89	Doors
99	Recreation Center - Gym Equipment	15 days	Mon 3/22/10	Fri 4/9/10	89	Specialty
101	Recreation Center - Gym Seating/Bleachers	8 days	Mon 3/22/10	Wed 3/31/10	89	Specialty
103	Recreation Center - Lockers and Benches	8 days	Mon 3/22/10	Wed 3/31/10	89	Specialty
107	Recreation Center - Folding Partitions	8 days	Mon 3/22/10	Wed 3/31/10	89	Specialty
102	Recreation Center - Track Flooring	8 days	Tue 3/23/10	Thu 4/1/10	93	Specialty

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ID		Task Name	Duration	Start	Finish	Predecessors
151		Natatorium - Specialties	5 days	Wed 3/24/10	Tue 3/30/10	146
109		Recreation Center - Punchlist	10 days?	Thu 4/1/10	Wed 4/14/10	106,107,101
154		Natatorum - Punchlist	5 days	Thu 4/1/10	Wed 4/7/10	153
155		Natatorium - Punchlist Completion	10 days	Thu 4/8/10	Wed 4/21/10	154
110		Recreation Center - Punchlist Correction	15 days?	Thu 4/15/10	Wed 5/5/10	109
156		Natatorium - Final Inspections	5 days	Thu 4/22/10	Wed 4/28/10	155
157		Natatorium - Substantial Completion	0 days	Wed 4/28/10	Wed 4/28/10	156
111		Recreation Center - Final Inspections	5 days?	Thu 5/6/10	Wed 5/12/10	110
112		Recreation Center - Substantial Completion	0 days	Wed 5/12/10	Wed 5/12/10	111
158		Building Substantial Completion	0 days	Wed 5/12/10	Wed 5/12/10	157,112

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Parametric Cost Estimate – D4Profiler

Wednesday, September 16, 2009

Statement of Probable Cost

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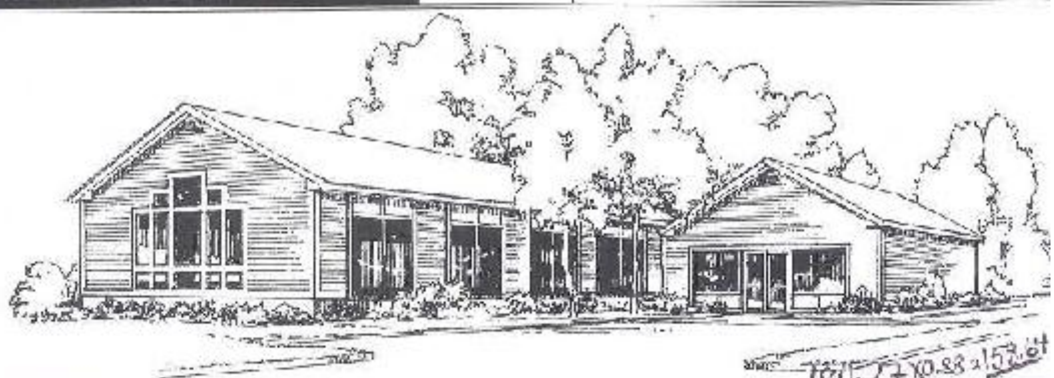
Pearland Natatorium - Aug 2009 - TX - Houston

Prepared By:	Moody/Nolan, Ltd. + HOK 1776 East Broad Street Columbus, OH 43203 Fax:	Prepared For:	Fax:
Building Sq. Size:	150943	Site Sq. Size:	418176
Bid Date:	6/1/2009	Building use:	Recreational
No. of floors:	2	Foundation:	CON
No. of buildings:	1	Exterior Walls:	MAS
Project Height:	52	Interior Walls:	GYP
1st Floor Height:	16	Roof Type:	MET
1st Floor Size:	90000	Floor Type:	TER
		Project Type:	NEW

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**2.48**	**2.58**	**389,439**
	Bidding Requirements	2.48	2.58	389,439
03	**Concrete**	**5.10**	**5.30**	**800,197**
	Concrete	5.10	5.30	800,197
04	**Masonry**	**17.25**	**17.95**	**2,709,962**
	Masonry	17.25	17.95	2,709,962
05	**Metals**	**15.96**	**16.60**	**2,506,241**
	Metals	15.96	16.60	2,506,241
06	**Wood & Plastics**	**0.60**	**0.62**	**93,806**
	Wood & Plastics	0.60	0.62	93,806
07	**Thermal & Moisture Protection**	**8.21**	**8.54**	**1,288,653**
	Thermal & Moisture Protection	8.21	8.54	1,288,653
08	**Doors & Windows**	**3.03**	**3.15**	**475,665**
	Doors & Windows	3.03	3.15	475,665
09	**Finishes**	**7.29**	**7.59**	**1,145,575**
	Finishes	7.29	7.59	1,145,575
10	**Specialties**	**0.82**	**0.85**	**128,865**
	Specialties	0.82	0.85	128,865
11	**Equipment**	**0.36**	**0.38**	**56,852**
	Equipment	0.36	0.38	56,852
12	**Furnishings**	**0.39**	**0.41**	**61,590**
	Furnishings	0.39	0.41	61,590
13	**Special Construction**	**12.39**	**12.89**	**1,945,298**
	Special Construction	12.39	12.89	1,945,298
14	**Conveying Systems**	**0.36**	**0.37**	**55,905**
	Elevators	0.36	0.37	55,905
15	**Mechanical**	**16.54**	**17.21**	**2,598,132**
	Mechanical	16.54	17.21	2,598,132
16	**Electrical**	**9.23**	**9.60**	**1,449,261**
	Electrical	9.23	9.60	1,449,261
Total Building Costs		**100.00**	**104.05**	**15,705,442**
02	**Site Work**	**100.00**	**2.59**	**1,081,100**
	Site Work	100.00	2.59	1,081,100
Total Non-Building Costs		**100.00**	**2.59**	**1,081,100**
Total Project Costs		–	–	**16,786,542**

RS Means Data for Natatorium

COMMERCIAL/INDUSTRIAL/ INSTITUTIONAL	M.650	Swimming Pool, Enclosed



180.27 x 0.88 = 158.64

41,817

Costs per square foot of floor area

Exterior Wall	S.F. Area	10000	16000	20000	22000	24000	26000	28000	30000	32000
	L.F. Perimeter	420	510	600	640	660	684	706	740	737
Face Brick with Concrete Block Back-up	Wood Truss	[illegible]	[illegible]	203.70	206.65	200.65	201.25	199.10	193.00	195.[illegible]
	Precast Conc.	271.15	246.20	24[illegible].10	223.70	225.0[illegible]	[illegible]	229.65	[illegible]	[illegible]
Metal Sandwich Panel	Wood Truss	229.90	[illegible]	210.65	[illegible]	[illegible]	205.05	203.45	202.65	200.[illegible]
Precast Concrete Panel	Precast Conc.	241.[illegible]	[illegible]	219.40	217.63	[illegible]	213.09	211.30	[illegible]	[illegible]
[illegible] Concrete Block	Wood Truss	228.[illegible]	210.75	210.35	205.[illegible]	[illegible]	[illegible]	203.20	202.[illegible]	[illegible]
	Precast Conc.	[illegible]	[illegible]	[illegible]	220.15	[illegible]	217.38	215.20	[illegible]	[illegible]
Perimeter Adj., Add or Deduct	Per 100 L.F.	[illegible]	[illegible]	[illegible]	7.90	[illegible]	6.43	6.00	5.89	[illegible]
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	2.10	1.50	1.50	1.42	1.33	1.35	[illegible]	1.28	[illegible]
For Basement, add $25.95 per square foot of basement area										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs for this type of structure range from $103.30 to $303.70 per S.F.

Common additives

Description	Unit	$ Cost
Bleachers, Telescoping, manual		
To 15 tier	Seat	11[illegible] - 140
To 20 tier	Seat	[illegible] - 258
[illegible] tier	Seat	240 - 300
For power operation, add	Seat	45.30 - 71.50
Emergency lighting, 25 watt, battery operated		
Lead battery	Each	232
Nickel cadmium	Each	[illegible]
Lockers, Steel, single tier 60" or 72"	Opening	191 - 310
2 tier, 60" or 72" total	Opening	10[illegible] - 161
5 tier, box lockers	Opening	[illegible] - 81.[illegible]
Locker bench, lam. maple top only	L.F.	21
Pedestal, steel pipe	Each	63.50
Pool Equipment		
Diving stand, 3 meter	Each	12,800
1 meter	Each	6400
Diving board, 16' aluminum	Each	3700
Fiberglass	Each	30[illegible]
Lifeguard chair, fixed	Each	30[illegible]
Portable	Each	30[illegible]
Lights, underwater, 12 volt, 300 watt	Each	320

Description	Unit	$ Cost
Sauna, Prefabricated, complete		
6' x 4'	Each	[illegible]
6' x 6'	Each	[illegible]
6' x 9'	Each	[illegible]
8' x 8'	Each	[illegible]
8' x 10'	Each	[illegible]
10' x 12'	Each	[illegible]
Sound System		
Amplifier, 250 watts	Each	2050
Speaker, ceiling or wall	Each	[illegible]
Trumpet	Each	[illegible]
Steam Bath, Complete, to 140 C.F.	Each	20[illegible]
To 300 C.F.	Each	2[illegible]
To 800 C.F.	Each	[illegible]
To 2500 C.F.	Each	[illegible]

RS Means Data for Recreation Center

COMMERCIAL/INDUSTRIAL/ INSTITUTIONAL	M.310	Gymnasium

$ 150.98 X 0.88 = 132.86

63,300

Costs per square foot of floor area

Exterior Wall	S.F. Area	12000	16000	20000	25000	30000	35000	40000	45000	50000
	L.F. Perimeter	440	520	600	700	758	780	841	910	979
Reinforced Concrete Block	Lam. Wood Arches	154.80	147.75	143.85	140.85	135.00	[illegible]	[illegible]	131.45	132.50
	Rigid Steel Frame	164.60	157.75	155.75	150.35	145.10	141.95	142.80	141.25	140.70
Face Brick with Concrete Block Back-up	Lam. Wood Arches	180.75	171.90	166.15	160.40	152.65	149.95	[illegible]	145.75	144.50
	Rigid Steel Frame	[illegible]	180.80	174.95	170.20	162.50	159.75	[illegible]	155.55	154.20
Metal Sandwich Panel	Lam. Wood Arches	150.50	144.20	140.45	135.40	[illegible]	[illegible]	130.10	129.15	[illegible]
	Rigid Steel Frame	162.90	156.05	151.90	147.20	141.10	[illegible]	139.90	137.65	139.20
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.50	4.90	3.95	3.15	2.50	2.20	[illegible]	1.75	1.55
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	0.90	0.80	0.80	0.70	0.60	0.55	0.55	0.50	0.50

Basement—Not Applicable

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $72.05 to $1[illegible]6.00 per S.F.

Common additives

Description	Unit	$ Cost
Bleachers, telescoping, manual		
To 15 tier	Seat	115 - 160
16-20 tier	Seat	235 - 283
21-30 tier	Seat	249 - 303
For power operation, add	Seat	45.50 - 71.50
Gym Divider Curtain, Mesh top		
Manual roll-up	S.F.	11.60
Gym Mats		
2" naugahyde covered	S.F.	3.95
2" nylon	S.F.	6.05
1-1/2" wall pads	S.F.	9.05
1" wrestling mats	S.F.	6.15
Scoreboard		
Basketball, one side	Each	3175 - 11,700
Basketball Backstop		
Wall mtd., 6' extended, fixed	Each	2125 - 2725
Swing up, wall mtd.	Each	3275 - 6775

Description	Unit	$ Cost
Lockers, Steel, single tier, 60" or 72"	Opening	172 - 310
2 tier, 60" or 72" total	Opening	107 - 141
5 tier, box lockers	Opening	65 - 63.50
Locker bench, lam. maple top only	L.F.	21
Pedestals, steel pipe	Each	63.50
Sound System		
Amplifier, 250 watts	Each	2180
Speaker, ceiling or wall	Each	191
Trumpet	Each	365
Emergency lighting, 25 watt, battery operated		
Lead battery	Each	282
Nickel cadmium	Each	805

Important: See the Reference Section for Location Factor

Data for Estimate Location Adjustment

Location Factors

STATE/ZIP	CITY	Residential	Commercial
NORTH DAKOTA (CONT'D)			
556	Dickinson	.76	.84
557	Minot	.81	.87
558	Williston	.76	.85
OHIO			
430-432	Columbus	.93	.95
433	Marion	.89	.84
434-436	Toledo	1.00	.98
437-438	Zanesville	.88	.89
439	Steubenville	.93	.93
440	Lorain	.98	.96
441	Cleveland	1.01	1.00
442-443	Akron	.98	.96
444-445	Youngstown	.96	.94
446-447	Canton	.93	.92
448-449	Mansfield	.93	.92
450	Hamilton	.92	.91
451-452	Cincinnati	.92	.92
453-454	Dayton	[illegible]	.91
455	Springfield	.92	.91
456	Chillicothe	.94	.93
457	Athens	.87	.88
458	Lima	.90	.92
OKLAHOMA			
730-731	Oklahoma City	.79	.84
734	Ardmore	.78	[illegible]
735	Lawton	.80	.83
736	Clinton	.76	[illegible]
737	Enid	.76	.82
738	Woodward	.76	.80
739	Guymon	.67	.79
740-741	Tulsa	.77	.80
743	Miami	.81	.82
744	Muskogee	.71	.74
745	McAlester	[illegible]	[illegible]
746	Ponca City	[illegible]	.80
747	Durant	[illegible]	.80
748	Shawnee	[illegible]	.80
749	Poteau	[illegible]	[illegible]
OREGON			
970-972	Portland	1.01	1.03
973	Salem	[illegible]	1.03
974	Eugene	.98	1.02
975	Medford	.95	1.00
976	Klamath Falls	.95	1.00
977	Bend	1.00	1.00
978	Pendleton	.95	.97
979	Vale	.97	.92
PENNSYLVANIA			
150-152	Pittsburgh	.95	.98
153	Washington	.95	.96
154	Uniontown	.93	.95
155	Bedford	.87	.95
156	Greensburg	.93	.96
157	Indiana	.91	.95
158	Dubois	.89	.95
159	Johnstown	.89	.94
160	Butler	.91	.95
161	New Castle	.91	.95
162	Kittanning	.91	.95
163	Oil City	.88	.94
164-165	Erie	.93	.95
166	Altoona	.87	.92
167	Bradford	.88	.95
168	State College	.90	.95
169	Wellsboro	.90	.96
170-171	Harrisburg	.94	.95
172	Chambersburg	.88	.93
173-174	York	.90	.95
175-176	Lancaster	.90	.97
177	Williamsport	.86	.93
178	Sunbury	.90	.92
179	Pottsville	.91	.91
180	Lehigh Valley	1.01	1.02
181	Allentown	1.03	1.03
182	Hazleton	.90	.92
183	Stroudsburg	.91	.97
184-185	Scranton	.95	.97
186-187	Wilkes-Barre	.93	.94
188	Montrose	.90	.94
189	Doylestown	1.05	1.05
PENNSYLVANIA (CONT'D)			
190-191	Philadelphia	1.16	1.13
193	Westchester	1.10	1.07
194	Norristown	1.09	1.05
195-196	Reading	.97	.95
PUERTO RICO			
009	San Juan	.75	.81
RHODE ISLAND			
028	Newport	1.06	1.05
029	Providence	1.06	1.05
SOUTH CAROLINA			
290-292	Columbia	.64	.80
293	Spartanburg	.64	.78
294	Charleston	.67	.85
295	Florence	.60	.78
296	Greenville	.63	.78
297	Rock Hill	.62	.77
298	Aiken	[illegible]	.86
299	Beaufort	.67	.76
SOUTH DAKOTA			
570-571	Sioux Falls	.79	.83
572	Watertown	.75	.80
573	Mitchell	.77	.80
574	Aberdeen	.77	.82
575	Pierre	.77	.81
576	Mobridge	.75	.80
577	Rapid City	.78	.82
TENNESSEE			
370-372	Nashville	.84	.88
373-374	Chattanooga	.75	[illegible]
375,380-381	Memphis	.81	.86
376	Johnson City	.70	.80
377-379	Knoxville	[illegible]	.79
382	McKenzie	[illegible]	.80
383	Jackson	[illegible]	[illegible]
384	Columbia	.71	.79
385	Cookeville	.71	[illegible]
TEXAS			
750	McKinney	.75	[illegible]
751	Waxahachie	.72	[illegible]
752-753	Dallas	.82	.85
754	Greenville	.67	[illegible]
755	Texarkana	[illegible]	.78
756	Longview	.67	.74
757	Tyler	[illegible]	.80
758	Palestine	.65	.72
759	Lufkin	.71	.74
760-761	Fort Worth	.81	.82
762	Denton	.75	[illegible]
763	Wichita Falls	.75	.80
764	Eastland	.71	[illegible]
765	Temple	[illegible]	.76
766-767	Waco	.75	.81
768	Brownwood	.68	.73
769	San Angelo	.71	.76
770-772	Houston	.86	.88
773	Huntsville	.68	[illegible]
774	Wharton	.69	.71
775	Galveston	.83	.86
776-777	Beaumont	.83	.82
778	Bryan	.73	.80
779	Victoria	.73	.77
780	Laredo	.72	.77
781-782	San Antonio	.80	.82
783-784	Corpus Christi	.77	.78
785	McAllen	.75	.76
786-787	Austin	.79	.81
788	Del Rio	.66	.71
789	Giddings	.68	[illegible]
790-791	Amarillo	.76	.81
792	Childress	.74	.77
793-794	Lubbock	.74	.80
795-796	Abilene	.74	[illegible]
797	Midland	.75	[illegible]
798-799,885	El Paso	.73	.76
UTAH			
840-841	Salt Lake City	.81	.85
842,844	Ogden	.78	.84
843	Logan	.79	.84

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Detailed Structural System Cost Estimate Hand Take-Offs

Recreation Center 1 of 4

Structural System Hand Take-Off

From Gridlines G-J/1-4

1) Caissons: (2) @ 48" dia, (2) @ 42" dia and (2) @ 30" dia. All 12' length

Concrete:

2x5.58 CYD

2x4.27 CYD

2x2.18 CYD

Total Concrete: 24.06 CYD - 3000psi

Reinf. Steel:

Vertical All 6: 8-#10

6x8x12' = 576 lft of #10

Ties: 2-#3 @ 18" ⇒ 8 ties (12'/1.5')

(2) - 12.56' ⇒ (2)(8)(12.56) = 201'

(2) - 10.99' ⇒ (2)(8)(10.99) = 176'

(2) - 7.85' ⇒ (2)(8)(7.85') = 126'

503' of #3

So: #3: 0.376 lb/ft #10: 4.303 lb/ft

$\frac{503' \times 0.376\ lb/ft}{2000\ lb/ton} = 0.1$ Ton

$\frac{576' \times 4.303\ lb/ft}{2000\ lb/Ton} = 1.24$ Ton

⇒ 1.34 Ton of Rebar

2) Footings: (5) 2'x2'x2' FTGs

Concrete: $\frac{40}{27}$ = 1.48 CYDs - 3000psi

Forming: 16 SFCA x 5 = 80 SFCA

Steel: 2-#7 T+B

5x(4)(2') = 40 lft of #7

#7: 2.044 lb/ft

$\frac{40 \times 2.044}{2000}$ = 0.04 Ton

3) Grade Beam:

Total Length: 73.5'

Concrete: 2' x 1.1' x 73.5' = 161.7 CF

6 CYDs - 3000psi

Forming: 4' x 73.5' = 294 SFCA

Steel: 2-#7 T+B

4 x 73.5' = 294 ft of #7

#3 Stirrups @ 10" o.c. = 88 Stirrups

6.2' x 88 = 546' of #3

$\frac{0.376 \times 546 + 294 \times 2.044}{2000}$ = 0.403 Tons

4) Slab-on Grade: Area = 27.25' x 46.25' = 1260 SF

Concrete: 1260 SF x 5/12 = 525/27 = 19.44 CYD - 3000psi

Vapor Barrier: 1260 SF

5" Edge Form: 27.25'

Steel: #3 @ 14" o.c. EW
↳ 1.17'

$\frac{27.25}{1.17} + \frac{46.25}{1.17} = 24 + 40 = 64$ lft of #3

$\frac{0.376 * 64}{2000} = 0.01$ Ton

Finishing: 1260 SF

5) Elevated Slab: 1260 SF

Concrete: 1260 x 3/12 = 11.67 CYD - 3500psi

9/16" Deck: 1260 SF

3" Pour Stop: 27.25 LF

Finishing: 1260 SF

Reinforcing: 1260 SF of 6x6 WWF

*Note: These are for entire bldg. (Rec Center) 4054

*6) Roof Deck: 319' x 181' = 57,739 SF x 1.033 = 59,645 SF

7¼" Tectum E Roof Deck: 59,645 SF

*7) Wood Trusses: 68 LHSP @ 5' o.c.

8) Steel:

Columns: (4) TS 10x10x3/8" - 27'
(1) TS 8x8x3/8" - 27'

Beams: (2) W 27x84 - 27.25'
(1) W 16x26 - 45.5'
(1) W 30x90 - 27.25'

Floor Joists: (11) 28LH12 - 45.5'

Detailed Structural System Estimate

Recreation Center: Gridlines G-J and 1/2 (2520 SF)

Item	Units	Quantity	Labor ($/unit)	Material ($/unit)	Equipment ($/unit)	Total ($/unit)	Labor	Material	Equipment	Total	RS Means
Caissons											
9' Bell diameter, 48" shaft	EA	5.00	$975.00	$450.00	$1,100.00	$1,430.00	$4,875.00	$2,250.00	$5,500.00	$12,625.00	Page 592
Footings											
Concrete - 3000 psi	CYD	1.48	$33.50	$101.00	$123.15	$257.65	$49.58	$149.48	$182.26	$381.32	Page 64, 65
Concrete Forming	SFCA	80.00	$2.93	$0.70	$124.15	$127.78	$234.40	$56.00	$9,932.00	$10,222.40	Page 46
Reinforcing Steel	TON	0.04	$680.00	$1,475.00	$125.15	$2,280.15	$27.20	$59.00	$5.01	$91.21	Page 59
Grade Beams											
Concrete - 3000 psi	CYD	6.00	$12.05	$101.00	$4.39	$117.44	$72.30	$606.00	$26.34	$704.64	Page 64, 65
Concrete Forming	SFCA	294.00	$2.93	$0.70	$0.00	$3.63	$861.42	$205.80	$0.00	$1,067.22	Page 46
Reinforcing Steel	TON	0.40	$890.00	$2,440.00	$0.00	$3,330.00	$358.67	$983.32	$0.00	$1,341.99	Page 58
Slab-On-Grade											
Concrete - 3000 psi	CYD	19.44	$16.70	$101.00	$6.10	$123.80	$324.65	$1,963.44	$118.58	$2,406.67	Page 64, 65
Concrete Finishing	SF	1260.00	$0.18	$0.00	$0.00	$0.18	$226.80	$0.00	$0.00	$226.80	Page 66
5" Concrete Edge Form	LF	27.25	$2.02	$0.38	$0.00	$2.40	$55.05	$10.36	$0.00	$65.40	Page 47
Vapor Barrier	SF	1260.00	$1.15	$1.20	$0.00	$2.35	$1,449.00	$1,512.00	$0.00	$2,961.00	Page 192
Reinforcing Steel	TON	0.01	$620.00	$1,475.00	$0.00	$2,095.00	$6.20	$14.75	$0.00	$20.95	Page 59
Elevated Slab											
Concrete - 3500 psi	CYD	11.67	$15.50	$104.00	$5.65	$125.15	$180.89	$1,213.68	$65.94	$1,460.50	Page 64
Concrete Finishing	CYD	1260.00	$0.18	$0.00	$0.00	$0.18	$226.80	$0.00	$0.00	$226.80	Page 66
3" Pour Stop	SF	6.81	$3.33	$1.47	$0.00	$4.80	$22.69	$10.01	$0.00	$32.70	Page 44
6 X 6 WWF Reinforcing	CSF	12.60	$24.50	$32.50	$0.00	$57.00	$308.70	$409.50	$0.00	$718.20	Page 60
9/16" Metal Decking	SF	1260.00	$0.36	$1.72	$0.03	$2.11	$453.60	$2,167.20	$37.80	$2,658.60	Page 124
Steel Columns											
TS 10x10x3/8"x16'	LF	6.75	$51.00	$1,625.00	$36.50	$1,712.50	$344.25	$10,968.75	$246.38	$11,559.38	Page 110
TS 8x8x3/8"x14'	LF	1.93	$49.00	$880.00	$35.00	$964.00	$94.50	$1,697.14	$67.50	$1,859.14	Page 110
Steel Beams											
W 27x84	LF	54.50	$2.96	$139.00	$1.58	$143.54	$161.32	$7,575.50	$86.11	$7,822.93	Page 114
W 16x26	LF	45.50	$2.44	$43.00	$1.74	$47.18	$111.02	$1,956.50	$79.17	$2,146.69	Page 114
W 30x90	LF	27.25	$2.94	$163.00	$1.56	$167.50	$80.12	$4,441.75	$42.51	$4,564.38	Page 114
Floor Joists											
28LH12	LF	500.50	$1.96	$28.00	$1.12	31.08	980.98	14,014.00	560.56	$15,555.54	Page 121
Total Structural System Cost*:										**$80,719.45**	
Total Cost/SF*:										**$32.03**	

Recreation Center Structural System (Except Roof Deck and Trusses)											
Structural System	SF	63300	$32.03							$2,027,499.00	NA
Roof Deck											
7 1/4" Tectum E Roof Deck	SF	59645.00	$3.50	$7.00	$0.00	$10.50	$208,757.50	$417,515.00	$0.00	$626,272.50	NA
Wood Trusses											
130' LHSP Wood Joist Trusses	EA	68	$500.00	$1,500.00	$500.00	$2,500.00	$34,000.00	$102,000.00	$34,000.00	$170,000.00	NA
Total Recreation Center Structural System Cost:										**$2,823,771.50**	

*Note: This cost does not include the Roof Deck and Wood Trusses

Natatorium (2520 SF)

Item	Units	Quantity	Labor ($/unit)	Material ($/unit)	Equipment ($/unit)	Total ($/unit)	Labor	Material	Equipment	Total	RS Means
Caissons											
9' Bell diameter, 48" shaft	EA	5.00	$975.00	$450.00	$1,100.00	$1,430.00	$4,875.00	$2,250.00	$5,500.00	$12,625.00	Page 592
Footings											
Concrete - 3000 psi	CYD	1.48	$33.50	$101.00	$123.15	$257.65	$49.58	$149.48	$182.26	$381.32	Page 64, 65
Concrete Forming	SFCA	80.00	$2.93	$0.70	$124.15	$127.78	$234.40	$56.00	$9,932.00	$10,222.40	Page 46
Reinforcing Steel	TON	0.04	$680.00	$1,475.00	$125.15	$2,280.15	$27.20	$59.00	$5.01	$91.21	Page 59
Grade Beams											
Concrete - 3000 psi	CYD	6.00	$12.05	$101.00	$4.39	$117.44	$72.30	$606.00	$26.34	$704.64	Page 64, 65
Concrete Forming	SFCA	294.00	$2.93	$0.70	$0.00	$3.63	$861.42	$205.80	$0.00	$1,067.22	Page 46
Reinforcing Steel	TON	0.40	$890.00	$2,440.00	$0.00	$3,330.00	$358.67	$983.32	$0.00	$1,341.99	Page 58
Slab-On-Grade											
Concrete - 3000 psi	CYD	19.44	$16.70	$101.00	$6.10	$123.80	$324.65	$1,963.44	$118.58	$2,406.67	Page 64, 65
Concrete Finishing	SF	1260.00	$0.18	$0.00	$0.00	$0.18	$226.80	$0.00	$0.00	$226.80	Page 66
5" Concrete Edge Form	LF	27.25	$2.02	$0.38	$0.00	$2.40	$55.05	$10.36	$0.00	$65.40	Page 47
Vapor Barrier	SF	1260.00	$1.15	$1.20	$0.00	$2.35	$1,449.00	$1,512.00	$0.00	$2,961.00	Page 192
Reinforcing Steel	TON	0.01	$620.00	$1,475.00	$0.00	$2,095.00	$6.20	$14.75	$0.00	$20.95	Page 59
Total Structural System Cost*:										**$32,114.60**	
Total Cost/SF*:										**$12.74**	

Natatorium Structural Costs (Except Glulam Materials											
Structural System	SF	41817	$12.74							$532,911.20	NA
Glulam											
Glulam Framing	SF	41230.00	$7.34	$15.90	$0.00	$25.95	$302,485.00	$655,725.00	$0.00	$1,070,000.00	NA
Wood Deck	SF	41230.00		$2.71	$0.00			$111,790.00	$0.00		NA
Total Natatorium Structural System Cost:										**$1,602,911.20**	

*Note: This cost does not include Glulam Products

Total Structural Costs

Natatorium Structural Cost	$1,602,911.20
Recreation Center Structural Cost	$2,823,771.50
Total Structural Cost	**$4,427,368.67**
Total Structural Cost/SF	**$42.12**

General Conditions Estimate

General Conditions Estimate

Item	Unit	Unit Cost	Quantity	Total Cost
General Contractor Personnel (RS Means Page 10)				
Admin/Secretary	MTH	$3,200.00	5	$2,555.00
Assistant Superintendant	MTH	$7,600.00	13	$98,800.00
Superintendant	MTH	$8,227.00	13	$106,951.00
Project Engineer	MTH	$7,145.00	13	$92,885.00
Project Manager	MTH	$8,346.00	6.5	$54,249.00
Senior Project Manager	MTH	$8,660.00	1.5	$12,990.00
Temporary Facilities (EMJ Corporation)				
Jobsite Office	MTH	$486.67	15	$7,300.00
Temporary Toilets	MTH	$513.33	15	$7,700.00
Barricades	MTH	$66.67	15	$1,000.00
Construction Signs	MTH	$60.00	15	$900.00
Dumpsters	MTH	$133.33	15	$2,000.00
Temporary Utilities (EMJ Corporation)				
Temporary Electric	MTH	$1,000.00	15	$15,000.00
Temporary Water	MTH	$46.67	15	$700.00
Temporary Telephone	MTH	$646.67	15	$9,700.00
Cleaning (EMJ Corporation)				
Misc. Clean-up	MTH	$233.33	15	$3,500.00
Site Clean-up	LS	$2,500.00	1	$2,500.00
Final Building Clean-up	LS	$37,000.00	1	$37,000.00
Miscellaneous (EMJ Corporation)				
Trash Removal	MTH	$966.67	15	$14,500.00
Blueprints	LS	$3,500.00	1	$3,500.00
Safety (Drug Testing, Equipment, etc.)	LS	$1,500.00	1	$1,500.00
Hand Tools	LS	$6,000.00	1	$6,000.00
Engineering and Layout	LS	$2,000.00	1	$2,000.00
Incidentals	LS	$4,000.00	1	$4,000.00
Insurance	% of Contract	$16,786,542.00	3%	$503,596.26
Bonds	% of Contract	$16,786,542.00	2%	$335,730.84
O&P	% of Contract	$16,786,542.00	4%	$671,461.68
Total				$1,998,018.78

Appendix 6 – Analysis #1 (Natatorium Structure) References

Natatorium Structural System Design Calculations

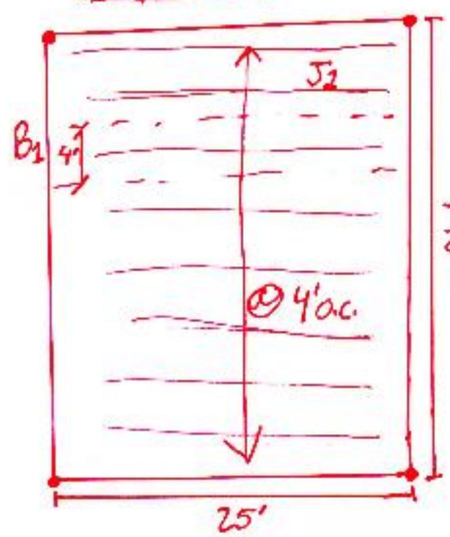
Natatorium Structural System Calcs

2003 IBC

- Roof: 20 lb/SF
- Dead: 20 lb/SF
- Wind: 120mph for 30 sec gust, exp. C, Imp. Factor of 1.15

Roof Slope = 3:12

Sample Bay



J1 | 40 lb/SF × 4' = 160 lb/LF ⇒ Use a 14K1 which can support up to 180 lb/LF @ 25' spans
We will need 36 of these per bay = Total of 468

B1 | Treat joist loads as uniform load:
160 lb/LF × 25' = 4000 lb/4' = 1000 lb/LF ⇒ Use a 104SLH22 which supports 1034 lb/LF @ 141' spans
We will need a total of 14 of these. (our span is only 140')

Concrete Columns:

Axial Load:

40 lb/SF x 70' x 25' = 70,000 lb/column.

This would use a 10"x10" square concrete column with 4-#5's.

We would need 28 of these columns

STANDARD ASD LOAD TABLE

OPEN WEB STEEL JOISTS, K-SERIES

Based on a 50 ksi Maximum Yield Strength
Adopted by the Steel Joist Institute November 4, 1985
Revised to November 10, 2003 - Effective March 01, 2005

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of **ASD K-Series** Steel Joists. The weight of DEAD loads, including the joists, must be deducted to determine the LIVE load-carrying capacities of the joists. Sloped parallel-chord joists shall use span as defined by the length along the slope.

The figures shown in **RED** in this load table are the nominal LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be obtained by multiplying the figures in **RED** by 1.5. In no case shall the TOTAL load capacity of the joists be exceeded.

The approximate joist weights per linear foot shown in these tables do not include accessories.

The approximate moment of inertia of the joist, in inches[4] is;

$I = 26.767(W_{LL})(L^3)(10^{-6})$, where W_{LL} = **RED** figure in the Load Table and L = (Span - 0.33) in feet.

For the proper handling of concentrated and/or varying loads, see Section 6.1 in the Code of Standard Practice for Steel Joists and Joist Girders.

Where the joist span exceeds the unshaded area of the Load Table, the row of bridging nearest the mid span shall be diagonal bridging with bolted connections at the chords and intersections.

ASD

STANDARD LOAD TABLE FOR OPEN WEB STEEL JOISTS, K-SERIES
Based on a 50 ksi Maximum Yield Strength - Loads Shown in Pounds per Linear Foot (plf)

In each cell, the first figure is the black (total load) figure and the second is the red (live load) figure.

Joist Designation	8K1	10K1	12K1	12K3	12K5	14K1	14K3	14K4	14K6	16K2	16K3	16K4	16K5	16K6	16K7	16K9
Depth (in.)	8	10	12	12	12	14	14	14	14	16	16	16	16	16	16	16
Approx. Wt. (lbs./ft.)	5.1	5.0	5.0	5.7	7.1	5.2	6.0	6.7	7.7	5.5	6.3	7.0	7.5	8.1	8.6	10.0
Span (ft.)																
8	550 / 550															
9	550 / 550															
10	550 / 480	550 / 550														
11	532 / 377	550 / 542														
12	444 / 288	550 / 455	550 / 550	550 / 550	550 / 550											
13	377 / 225	479 / 363	550 / 510	550 / 510	550 / 510											
14	324 / 179	412 / 289	500 / 425	550 / 463	550 / 463	550 / 550	550 / 550	550 / 550	550 / 550							
15	281 / 145	358 / 234	434 / 344	543 / 428	550 / 434	511 / 475	550 / 507	550 / 507	550 / 507							
16	246 / 119	313 / 192	380 / 282	476 / 351	550 / 396	448 / 390	550 / 467	550 / 467	550 / 467	550 / 550	550 / 550	550 / 550	550 / 550	550 / 550	550 / 550	550 / 550
17		277 / 159	336 / 234	420 / 291	550 / 366	395 / 324	495 / 404	550 / 443	550 / 443	512 / 488	550 / 526	550 / 526	550 / 526	550 / 526	550 / 526	550 / 526
18		246 / 134	299 / 197	374 / 245	507 / 317	352 / 272	441 / 339	530 / 397	550 / 408	456 / 409	508 / 456	550 / 490	550 / 490	550 / 490	550 / 490	550 / 490
19		221 / 113	268 / 167	335 / 207	454 / 269	315 / 230	395 / 287	475 / 336	550 / 383	409 / 347	455 / 386	547 / 452	550 / 455	550 / 455	550 / 455	550 / 455
20		199 / 97	241 / 142	302 / 177	409 / 230	284 / 197	355 / 246	428 / 287	525 / 347	368 / 297	410 / 330	493 / 386	550 / 426	550 / 426	550 / 426	550 / 426
21			218 / 123	273 / 153	370 / 198	257 / 170	321 / 212	386 / 248	475 / 299	333 / 255	371 / 285	447 / 333	503 / 373	548 / 405	550 / 406	550 / 406
22			199 / 106	249 / 132	337 / 172	234 / 147	292 / 184	353 / 215	432 / 259	303 / 222	337 / 247	406 / 289	458 / 323	498 / 351	550 / 385	550 / 385
23			181 / 93	227 / 116	308 / 150	214 / 128	266 / 160	322 / 188	395 / 226	277 / 194	308 / 216	371 / 252	418 / 282	455 / 307	507 / 339	550 / 363
24			166 / 81	208 / 101	282 / 132	196 / 113	244 / 141	295 / 165	362 / 199	254 / 170	283 / 189	340 / 221	384 / 248	418 / 269	465 / 298	550 / 346
25						180 / 100	225 / 124	272 / 145	334 / 175	234 / 150	260 / 167	313 / 195	353 / 219	384 / 238	428 / 263	514 / 311
26						166 / 88	209 / 110	251 / 129	308 / 156	216 / 133	240 / 148	289 / 173	326 / 194	355 / 211	395 / 233	474 / 276
27						154 / 79	194 / 98	233 / 115	285 / 139	200 / 119	223 / 132	268 / 155	302 / 173	329 / 188	366 / 208	439 / 246
28						143 / 70	180 / 88	216 / 103	265 / 124	186 / 106	207 / 118	249 / 138	281 / 155	306 / 168	340 / 186	408 / 220
29										173 / 95	193 / 106	232 / 125	261 / 139	285 / 151	317 / 167	380 / 198
30										161 / 86	180 / 96	216 / 112	244 / 126	266 / 137	296 / 151	355 / 178
31										151 / 78	168 / 87	203 / 101	228 / 114	249 / 124	277 / 137	332 / 161
32										142 / 71	158 / 79	190 / 92	214 / 103	233 / 112	259 / 124	311 / 147

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VULCRAFT LOAD TABLE
SUPER LONGSPAN STEEL JOISTS, SLH-SERIES

Based on a 50 ksi Maximum Yield Strength

ASD

Joist Designation	Approx. Wt. in Lbs. per Linear Ft. (Joists Only)	Depth in Inches	Safe Load* in Lbs. Between	CLEAR SPAN IN FEET**															
			96-128	129	132	135	138	141	144	147	150	155	160	165	170	175	180	185	190
96SLH17	52	96	70,000	540	517	495	474	456	438	421	405	380	357	335	316	298	281	266	252
				389	363	339	318	298	280	263	247	224	204	186	170	156	143	132	122
96SLH18	59	96	78,800	606	583	559	535	518	493	475	457	430	406	381	360	340	322	305	289
				443	413	385	362	340	319	300	282	256	232	212	194	178	163	150	139
96SLH19	66	96	94,200	727	697	667	639	611	585	561	539	505	474	445	419	396	373	353	334
				502	469	438	410	385	361	340	320	290	264	241	220	202	186	171	158
96SLH20	74	96	106,000	824	789	754	722	691	662	635	610	571	536	504	475	448	423	400	378
				569	531	496	465	436	409	386	362	329	299	272	249	229	210	193	178
96SLH21	90	96	133,000	1027	982	940	900	864	829	797	766	719	675	635	598	564	533	504	477
				696	652	611	571	535	503	473	445	404	367	335	306	281	258	238	220
96SLH22	102	96	149,000	1150	1108	1067	1028	991	957	921	888	832	782	736	694	656	620	587	556
				811	757	708	663	622	584	549	517	469	426	389	355	326	300	276	255
			104-137	138	141	144	147	150	155	160	165	170	175	180	185	190	195	200	205
104SLH18	59	104	76,800	664	532	512	499	472	444	418	396	374	354	335	318	302	287	273	260
				426	400	375	353	332	301	274	250	229	209	192	177	164	152	140	130
104SLH19	67	104	93,400	674	647	622	599	574	539	507	478	452	427	404	383	364	346	325	312
				484	453	425	401	377	342	311	284	260	238	218	201	186	172	160	148
104SLH20	75	104	105,000	764	739	714	688	661	621	583	548	516	487	460	435	413	391	371	353
				546	513	483	453	427	387	352	321	293	269	247	228	210	195	181	167
104SLH21	90	104	132,000	956	917	881	847	813	763	718	677	639	604	571	541	514	488	464	441
				678	[illegible]	593	558	525	476	433	395	361	331	301	280	259	240	222	206
104SLH22	104	104	148,000	1077	1034	999	956	924	883	830	793	738	698	660	626	594	564	536	511
				783	734	689	649	610	553	503	459	420	385	353	326	301	278	258	240
104SLH23	109	104	163,000	1181	1141	1096	1052	1009	945	887	834	785	741	700	662	626	595	565	537
				819	768	721	679	638	578	526	480	439	403	370	341	315	291	270	250
			112-146	147	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220
112SLH19	67	112	91,900	623	600	564	530	500	472	446	424	402	382	362	345	329	314	300	286
				466	439	398	362	330	302	276	255	234	216	200	186	172	160	149	140
112SLH20	78	112	104,000	710	688	649	610	575	543	514	488	463	440	417	398	379	361	345	330
				526	497	450	410	374	342	313	288	266	246	227	210	195	181	169	156
112SLH21	91	112	131,000	891	858	805	757	713	673	637	603	572	543	516	491	468	446	426	407
				650	612	555	504	460	421	386	355	327	301	279	259	240	224	208	195
112SLH22	104	112	147,000	999	967	918	871	824	778	736	697	661	628	596	568	541	516	492	470
				756	711	644	586	535	489	449	412	380	350	324	301	279	260	242	226
112SLH23	110	112	162,000	1102	1067	1012	959	901	848	800	756	716	679	644	612	582	554	528	504
				790	744	674	613	560	512	469	431	397	367	340	316	293	272	253	236
112SLH24	131	112	192,000	1304	1263	1199	1139	1074	1014	959	909	862	819	778	741	706	673	642	613
				957	901	817	743	678	620	569	523	481	444	411	381	354	329	307	287
			102-164	165	170	175	180	185	190	195	200	205	210	215	220	230	235	240	
120SLH20	77	120	56,000	597	564	532	505	479	456	434	414	395	376	359	344	329	315	302	290
				430	393	361	332	306	282	261	242	225	209	195	182	170	159	149	140
120SLH21	92	120	123,000	748	706	667	632	599	570	542	516	492	469	449	428	410	392	376	360
				530	485	444	409	376	347	321	298	277	259	243	224	209	196	184	173
120SLH22	104	120	141,000	855	815	770	729	692	658	626	596	568	542	517	495	473	453	434	416
				616	564	516	475	438	404	374	347	322	300	279	261	244	228	214	201
120SLH23	111	120	156,000	943	896	848	804	763	725	690	657	626	596	569	545	519	496	475	455
				644	590	541	497	458	423	391	363	336	313	292	272	255	238	224	210
120SLH24	132	120	185,000	1117	1062	1008	960	902	868	816	777	741	706	675	645	617	591	566	543
				781	715	656	603	555	512	474	440	408	380	354	330	309	289	271	255
120SLH25	152	120	212,000	1284	1218	1162	1092	1036	984	936	891	850	811	775	741	709	678	650	623
				915	837	768	706	650	600	555	515	478	445	415	387	362	339	318	298

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SQUARE TIED COLUMNS 10" x 10"

Short columns – no sidesway
Bars symmetrical in 4 faces

f'_c = 4,000 psi f_y = 60,000 psi
ϕM_n in inch-kips ϕP_n in kips

BARS	RHO	Max Cap		0% f_y		25% f_y		50% f_y		100% f_y		ε_t = 0.005		Zero Axial Load
		ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n
[illegible]	1.24	200	215	311	170	36?	14?	335	[illegible]	380	8?	41?	53	264
[illegible]	1.7?	[illegible]	[illegible]	3??	170	38?	14?	4??	[illegible]	4??	7?	451	11	[illegible]
[illegible]	2.4?	216	21?	3?9	159	415	153	440	122	473	64	497	25	429
[illegible]	3.1?	2?7	2??	4?1	201	45?	160	484	124	525	67	5??	5	5?4
[illegible]	4.0?	2?7	?45	4?6	21?	482	168	525	126	587	51	61?	-12	[illegible]
[illegible]	5.08	2??	3??	4??	2?1	509	177	581	128	647	[illegible]	6??	15	[illegible]
[illegible]	6.24	2??	3??	[illegible]	211	558	179	611	123	6??	1?	686	35	[illegible]
[illegible]	2.48	2?1	2??	3??	?82	390	157	414	127	438	[illegible]	4??	9	450
[illegible]	3.5?	2?4	2??	3??	210	435	168	464	152	50?	65	531	21	[illegible]
[illegible]	4.8?	2??	3??	4??	232	456	181	523	157	5?5	5?	604	3?	[illegible]

SQUARE TIED COLUMNS 12" x 12"

BARS	RHO	Max Cap ϕM_n	Max Cap ϕP_n	0% ϕM_n	0% ϕP_n	25% ϕM_n	25% ϕP_n	50% ϕM_n	50% ϕP_n	100% ϕM_n	100% ϕP_n	ε_t=0.005 ϕM_n	ε_t=0.005 ϕP_n	Zero Axial ϕM_n
4 #?	1.22	3?1	30?	529	2?2	31?	211	663	179	[illegible]	12?	775	9?	442
4 #7	1.67	36?	32?	5?4	2??	[illegible]	219	724	162	773	120	857	7?	?73
4 #8	2.19	383	3??	82?	27?	731	226	793	157	8??	115	940	6?	721
4 #?	2.78	394	3??	6?9	28?	7?7	238	865	1?1	9?0	108	1042	45	878
[illegible]	3.53	?14	?0?	747	307	8??	251	964	1?8	1031	10?	1156	[illegible]	[illegible]
[illegible]	4.33	[illegible]	?30	800	324	?31	258	1008	1?5	11??	5?	1196	[illegible]	1??7
[illegible]	6.25	[illegible]	519	897	?72	10??	?64	1184	2??	1?51	57	1389	4?	474
[illegible]	1.?2	?4?	330	5?6	26?	6??	[illegible]	8??	1?5	71?	124	803	61	?08
[illegible]	2.44	364	358	590	28?	6??	?05	796	1?3	814	119	?09	34	[illegible]
[illegible]	3.3?	383	396	665	30?	77?	221	847	221	92?	11?	1?8?	1	?0?1
[illegible]	4.39	405	44?	730	33?	8??	27?	950	210	1?5?	104	1171	-41	11??
[illegible]	5.56	42?	490	810	3?4	9??	2??	1069	220	1195	94	1313	-3?	1?63
[illegible]	7.06	459	55?	910	401	10??	21?	1192	2?7	1?66	79	1463	-155	1?05

SQUARE TIED COLUMNS 14" x 14"

BARS	RHO	Max Cap ϕM_n	Max Cap ϕP_n	0% ϕM_n	0% ϕP_n	25% ϕM_n	25% ϕP_n	50% ϕM_n	50% ϕP_n	100% ϕM_n	100% ϕP_n	ε_t=0.005 ϕM_n	ε_t=0.005 ϕP_n	Zero Axial ϕM_n
4 #7	1.??	5??	41?	?32	?02	98?	2?5	1072	24?	1157	178	1?14	13?	71?
4 #8	1.51	5?4	440	2?0	?64	1067	3?3	1168	2?5	12??	174	1450	12?	?57
4 #?	2.??	21?	46?	970	?70	?1?3	31?	1270	251	1?01	170	1591	112	1112
4 #10	2.??	515	498	1029	3?6	1??1	34?	1398	2??	1551	165	1735	95	1?27
[illegible]	3.?8	?25	5?0	1148	412	1362	3?5	1503	27?	1675	15?	1?54	64	1623
[illegible]	4.??	72?	611	1250	499	161?	372	1775	28?	2017	1??	2215	0	21?5
[illegible]	1.??	?15	420	7?0	3?0	922	20?	1007	2?3	1073	1??	1?31	1?	715
8 #6	1.8?	??5	45?	851	376	1014	3?2	1108	261	1217	179	1392	9?	1011
8 #7	?.45	??1	485	935	390	1??7	32?	?231	27?	1367	175	1552	67	132?
8 #8	3.22	621	?2?	103?	42?	1247	34?	1373	28?	1547	1?6	1738	30	1677
[illegible]	4.0?	6??	?92	1?35	455	1363	36?	1537	295	1735	1??	1910	-7	197?
8 #10	?.1?	6?7	645	12?0	4?6	1527	39?	1720	?11	1975	1??	2212	60	2??
8 #11	6.?7	72?	714	1333	529	1672	421	1?78	321	2?4?	1??	2395	-1?0	2315

(1) "0% f_y" indicates zero tension on the bars on the tension side; "50% f_y" indicates 50% f_y stress in bars on the tension side and "100% f_y" indicates 100% f_y stress (i.e., balance point) in bars on the tension side.

SQUARE TIED COLUMNS 16" x 16"

Short columns – no sidesway
Bars symmetrical in 4 faces

f'_c = 4,000 psi f_y = 60,000 psi
ϕM_n in inch-kips ϕP_n in kips

BARS	RHO	Max Cap		0% f_y		25% f_y		50% f_y		100% f_y		ε_t = 0.005		Zero Axial Load
		ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n	ϕP_n	ϕM_n
4 #8	1.23	566	546	1232	465	1453	392	1625	332	1782	2??	2061	1??	1092
4 #9	1.56	598	570	1321	481	1590	402	1762	338	1950	237	2255	17?	1344
4 #10	1.98	636	602	1432	499	1724	116	1072	345	2150	234	2402	155	1661
4 #11	2.44	683	636	1547	514	1853	425	2036	351	2322	224	2609	141	1963
4 #14	3.52	744	717	1508	561	2168	458	2433	372	2793	210	3161	55	2698
4 #18	6.25	725	904	2412	681	2911	546	3209	419	3523	106	4754	-35	4722
8 #6	1.38	551	556	1170	481	1418	402	1560	339	1586	243	1968	160	1317
8 #7	1.88	557	594	1775	501	1513	110	1700	349	1856	240	2206	135	1602
8 #8	2.47	577	559	1795	530	1682	420	1076	351	2119	238	2477	107	2143
8 #9	3.13	749	568	1525	560	1846	459	2066	374	2371	236	2765	73	2513
8 #10	3.97	1071	752	1169	590	2049	487	2304	391	2556	230	3122	28	3256
8 #11	4.88	1041	520	1551	635	2207	512	2504	405	2832	214	3370	-47	3152
8 #14	7.07	1157	562	2252	733	2709	585	3088	447	3525	191	4158	-175	3576
12 #10	5.95	1176	901	2316	880	2447	635	2782	442	3325	221	3924	-62	3852

SQUARE TIED COLUMNS 18" x 18"

BARS	RHO	Max Cap ϕM_n	Max Cap ϕP_n	0% ϕM_n	0% ϕP_n	25% ϕM_n	25% ϕP_n	50% ϕM_n	50% ϕP_n	100% ϕM_n	100% ϕP_n	ε_t=0.005 ϕM_n	ε_t=0.005 ϕP_n	Zero Axial ϕM_n
4 #9	1.23	1215	651	1736	800	2118	613	2336	475	2576	337	3048	250	1576
4 #10	1.57	1257	722	1872	817	2273	615	2527	433	2831	334	3348	240	1952
4 #11	1.93	1335	755	2315	832	2433	525	2708	439	3086	290	3575	220	2322
4 #14	2.78	1435	835	2450	878	2821	550	3163	459	3651	282	4245	183	3211
4 #18	4.91	1629	1044	3275	797	3794	645	4252	512	5035	280	5730	80	6313
8 #6	1.08	1135	676	1556	811	1909	531	2095	425	2285	314	2680	228	1421
8 #7	1.48	1225	714	1650	828	2067	571	2272	435	2499	312	2915	208	1850
8 #8	1.95	1237	759	1824	850	2234	510	2460	452	2775	310	3317	183	2407
8 #9	2.47	1312	808	1950	880	2424	562	2706	461	3076	307	3561	154	2873
8 #10	3.14	1375	872	2176	719	2681	590	2991	481	3456	304	4136	115	3677
8 #11	3.85	1429	940	2377	756	2895	615	3261	495	3810	297	4462	66	4332
8 #14	5.56	1591	1103	2840	854	3468	687	3943	535	4705	256	5451	-61	5407
12 #10	4.70	1543	1021	2556	820	3148	681	3558	631	4215	290	6142	85	4597
12 #11	5.78	1675	1174	2939	878	3457	712	3905	635	4711	257	5638	-48	5598

SQUARE TIED COLUMNS 20" x 20"

BARS	RHO	Max Cap ϕM_n	Max Cap ϕP_n	0% ϕM_n	0% ϕP_n	25% ϕM_n	25% ϕP_n	50% ϕM_n	50% ϕP_n	100% ϕM_n	100% ϕP_n	ε_t=0.005 ϕM_n	ε_t=0.005 ϕP_n	Zero Axial ϕM_n
4 #9	1.00	1673	825	2230	733	2749	617	3055	525	3326	356	3983	327	1806
4 #10	1.27	1743	857	2387	751	2987	625	3258	533	3620	353	4318	319	2244
4 #11	1.56	1745	831	2759	766	3127	639	3472	507	3996	370	4642	302	2550
4 #14	2.25	1913	972	2931	510	3577	671	4008	557	4006	371	6476	274	3723
4 #18	4.00	2200	1175	3815	528	4658	757	5285	613	6317	356	7382	109	6213
8 #7	1.20	1627	848	2159	758	2678	696	2958	559	3232	392	3880	288	2156
8 #8	1.58	1687	863	2425	755	2880	655	3169	551	3551	390	4259	264	2770
8 #9	2.00	1731	943	2725	814	3101	677	3460	565	3949	390	4741	238	3430
8 #10	2.54	1840	1028	2735	858	3379	705	3792	582	4311	386	5294	204	4258
8 #11	3.12	1873	1075	2375	880	3658	731	4113	595	4730	370	5741	152	3061
8 #14	4.50	2032	1237	3525	980	4324	803	4912	641	5526	370	6999	49	6859
8 #18	8.00	2524	1649	4827	1042	5899	985	5672	755	8395	306	9570	244	9447
12 #10	3.81	2081	1156	3150	956	3947	781	4451	637	5221	382	6509	121	5893
12 #11	4.68	2181	1258	3517	1014	4328	873	4899	653	5610	372	7161	57	6803
12 #14	6.75	2415	1522	4254	1168	5271	934	6022	735	7209	309	8946	-54	5743
16 #10	5.08	2226	1305	3937	1060	4614	833	5161	657	6151	384	7731	53	7593

Natatorium Structural System Costs

Structural System Costs

Columns:

10"x10" ⇒ Use 12"x12" cost

Need: 10"x10" x 20' (height) x 28 (# of columns) = 388.89 ft³ / 27 = 14.4 CYD of concrete

Cost: $1550/CYD (pg. 61) (Min. Reins) x 14.4 = **$22,320**

Beams

104SLH: 140' x 14 = 1960 lft

Cost: $84.50/lft (pg. 120) x 1960 = **$165,620**

Soists

14K1: 25' x 468 = 11,700 lft

Cost: $12.30/lft (pg. 121) x 11,700 lft = **$143,910**

Decking

22Ga. - Over 500 squares: $2.58/SF (pg. 124)

Cost: 41,817 SF x $2.58/SF = **$107,888**

+30k in plates, misc. hardware.

Total New System Cost: $469,738
Old System Cost: $1,070,000

Savings: **$600,262**

03 23 Stressing Tendons

03 23 05 – Prestressing Tendons

03 23 05.50 Prestressing Steel			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
							2009 Bare Costs				
1050	42 kip	G	C-3	4200	.015	Lb.	1.12	.62	.02	1.76	2.08
1200	Ungrouted strand, 50' span, 100 kip	G	C-4	1275	.025		.67	1.08	.02	1.77	2.55
1250	200 kip	G		1475	.022		.52	.93	.02	1.47	2.10
1400	100' span, 100 kip	G		1500	.021		.57	.96	.02	1.60	2.27
1450	300 kip	G		1650	.019		.62	.87	.02	1.51	2.10
1600	200' span, 100 kip	G		1500	.021		.52	.96	.02	1.50	2.27
1650	300 kip	G		1700	.019		.62	.85	.02	1.49	2.08
1800	Ungrouted bars, 50' span, 42 kip	G		1400	.023		.78	1.03	.02	1.85	2.55
1850	143 kip	G		1700	.019		.72	.85	.02	1.55	2.20
2000	75' span, 42 kip	G		1800	.018		.78	.80	.02	1.60	2.16
2050	143 kip	G		2200	.015		.78	.65	.02	1.45	1.93
2220	Ungrouted single strand, 100' slab, 25 kip	G		1200	.027		.67	1.20	.02	1.94	2.67
2250	35 kip	G		1475	.022		.62	.98	.02	1.62	2.30

03 24 Fibrous Reinforcing

03 24 05 – Reinforcing Fibers

03 24 05.30 Synthetic Fibers			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	SYNTHETIC FIBERS										
0100	Synthetic fibers, add to concrete					Lb.	4.40			4.40	4.84
0110	1-1/2 lb. per C.Y.					C.Y.	6.85			6.85	7.55

03 24 05.70 Steel Fibers			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	STEEL FIBERS										
0150	Steel fibers, add to concrete	G				Lb.	.70			.70	.77
0155	25 lb. per C.Y.	G				C.Y.	17.50			17.50	19.25
0160	50 lb. per C.Y.	G					35			35	38.50
0170	75 lb. per C.Y.	G					54			54	59.50
0180	100 lb. per C.Y.	G					70			70	77

03 30 Cast-In-Place Concrete

03 30 53 – Miscellaneous Cast-In-Place Concrete

03 30 53.40 Concrete In Place			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	CONCRETE IN PLACE										
0020	Including forms (4 uses), reinforcing steel, concrete, placement,										
0050	and finishing unless otherwise indicated	R033053-60									
0300	Beams, 5 kip per L.F., 10' span		C-14A	15.62	12.804	C.Y.	400	515	49	964	1,300
0350	25' span			15.55	12.702		430	450	41	901	1,200
0500	Chimney foundations, industrial, minimum		C-14C	32.22	3.476		165	133	.80	299.80	390
0510	Maximum			23.71	4.724		203	81	.89	355.37	505
0700	Columns, square, 12" x 12", minimum reinforcing		C-14A	11.96	16.722		400	670	64	1,134	1,550
0720	Average reinforcing	R033053-60		10.13	19.743		720	790	75.50	1,585.50	2,100
0740	Maximum reinforcing			5.03	22.148		1,150	890	84.50	2,124.50	2,750
0800	16" x 16", minimum reinforcing			6.22	12.220		315	495	47	857	1,175
0820	Average reinforcing			12.57	15.911		625	640	61	1,326	1,750
0840	Maximum reinforcing			10.75	15.012		1,025	760	74.50	1,879.50	2,400
0900	24" x 24", minimum reinforcing			23.66	8.453		375	340	32.50	747.50	965
0920	Average reinforcing			27.72	11.293		370	455	43	1,068	[illegible]
0940	Maximum reinforcing			14.13	13.134		765	555	54	1,384	1,700
1000	36" x 36", minimum reinforcing			35.69	5.924		249	238	22.50	509.50	670
1020	Average reinforcing			30.32	8.576		515	345	33	893	1,125

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05 21 Steel Joist Framing

05 21 16 – Longspan Steel Joist Framing

05 21 16.50 Longspan Joists			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
							2009 Bare Costs				
2320	28LH06, 16 lb/LF	G	F-7	1800	.044	L.F.	15.05	1.96	1.12	21.13	24.50
2340	28LH11, 25 lb/LF	G		1800	.044		25	1.96	1.12	31.08	35.50
2360	32LH08, 17 lb/LF	G		1800	.044		15.20	1.96	1.12	22.28	25.50
2380	32LH13, 30 lb/LF	G		1800	.044		34	1.96	1.12	37.08	42
2400	36LH09, 21 lb/LF	G		1800	.044		25.50	1.96	1.12	28.58	30.50
2420	36LH14, 36 lb/LF	G		1800	.044		40.50	1.96	1.12	43.58	49
2440	40LH10, 21 lb/LF	G		2200	.036		23.50	1.60	.91	26.01	30
2460	40LH16, 36 lb/LF	G		2200	.036		40.50	1.60	.91	43.01	48.50
2480	44LH11, 22 lb/LF	G		2200	.036		25	1.60	.91	27.51	31.50
2500	44LH17, 42 lb/LF	G		2200	.036		47.50	1.60	.91	50.01	56
2520	48LH11, 22 lb/LF	G		2200	.036		25	1.60	.91	27.51	31.50
2540	48LH15, 42 lb/LF	G	↓	2200	.036	↓	47.50	1.60	.91	50.01	56
2600	For less than 40-ton job lots										
2602	For 30 to 39 tons, add						10%				
2604	20 to 29 tons, add						20%				
2606	10 to 19 tons, add						30%				
2607	5 to 9 tons, add						50%	25%			
2608	1 to 4 tons, add						75%	50%			
2609	Less than 1 ton, add						100%	100%			
4010	For welded construction, add							20%			

05 21 19 – Open Web Steel Joist Framing

05 21 19.10 Open Web Joists			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**OPEN WEB JOISTS**										
0015	Made from recycled materials										
0020	K series, 40 ton lots, horiz. bridging, spans to 30', shop primer, minimum	G	E-7	15	5.333	Ton	1,525	235	134	2,154	2,550
0050	Average	G		12	6.667		2,050	294	167	2,511	2,950
0080	Maximum	G		9	8.889	↓	2,450	390	223	3,063	3,525
0410	8K1, 5.1 lb/LF	G		1200	.067	L.F.	5.20	2.94	1.67	9.81	12.55
0440	10K1, 5.0 lb/LF	G		1200	.067		5.10	2.94	1.67	9.71	12.45
0460	12K3, 5.7 lb/LF	G		1500	.053		5.80	2.35	1.34	9.49	11.55
0480	14K3, 6.0 lb/LF	G		1500	.053		6.10	2.35	1.34	9.79	12.30
0500	16K3, 6.3 lb/LF	G		1800	.044		6.40	1.95	1.12	9.48	[illegible]
0520	16K6, 8.1 lb/LF	G		1800	.044		8.25	1.96	1.12	11.33	13.70
0540	18K5, 7.7 lb/LF	G		2000	.040		7.85	1.76	1	10.61	12.80
0560	18K9, 10.2 lb/LF	G		2000	.040	↓	10.40	1.76	1	13.16	15.60
0600	Span 30' to 50', minimum	G		17	4.706	Ton	1,775	208	118	2,101	2,450
0640	Average	G		17	4.706		2,000	208	118	2,326	2,700
0680	Maximum	G		10	8	↓	2,175	355	201	2,731	3,150
0720	20K5, 8.2 lb/LF	G		2000	.040	L.F.	8.20	1.76	1	10.96	13.15
0740	20K9, 10.8 lb/LF	G		2000	.040		10.80	1.76	1	13.56	16.05
0760	22K5, 8.8 lb/LF	G		2000	.040		8.80	1.76	1	11.56	13.65
0780	22K9, 11.3 lb/LF	G		2000	.040		11.30	1.76	1	14.06	16.60
0800	24K6, 9.7 lb/LF	G		2200	.036		9.70	1.60	.91	12.21	14.45
0820	24K10, 13.1 lb/LF	G		2200	.036		13.10	1.60	.91	15.61	18.20
0840	26K6, 10.6 lb/LF	G		2200	.036		10.60	1.60	.91	13.11	15.45
0860	26K10, 13.8 lb/LF	G		2200	.036		13.80	1.60	.91	16.31	19
0880	28K8, 12.7 lb/LF	G		2400	.033		12.70	1.47	.84	15.01	17.40
0900	28K12, 17.1 lb/LF	G		2400	.033		17.10	1.47	.84	19.41	22.50
0920	30K8, 13.2 lb/LF	G		2400	.033		13.20	1.47	.84	15.51	17.95
0940	30K12, 17.6 lb/LF	G	↓	2400	.033	↓	17.60	1.47	.84	19.91	23
1000	For less than 40-ton job lots										
1002	For 30 to 39 tons, add						10%				

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05 21 Steel Joist Framing

05 21 13 – Deep Longspan Steel Joist Framing

05 21 13.50 Deep Longspan Joists			Crew	Daily Output	Labor-Hours	Unit	2009 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
3230	600LH13, 29 Lb/LF	G	E-7	2000	.040	L.F.	35	1.75	1	37.75	42.50
3300	600LH17, 57 Lb/LF	G		2000	.040		62.50	1.75	1	65.25	72.50
3320	640LH13, 31 Lb/LF	G		2200	.036		37	1.60	.91	39.51	45
3340	640LH17, 57 Lb/LF	G		2200	.036		62.50	1.60	.91	65.01	72.50
3360	680LH13, 37 Lb/LF	G		2200	.036		44.50	1.60	.91	47.01	53
3380	680LH18, 61 Lb/LF	G		2200	.036		73.50	1.60	.91	76.01	84.50
3400	720LH14, 41 Lb/LF	G		2200	.036		49.50	1.60	.91	52.01	58
3420	720LH19, 70 Lb/LF	G	↓	2200	.036	↓	84	1.60	.91	86.51	96.50
3500	For less than 40-ton job lots										
3502	For 30 to 39 tons, add						10%				
3504	20 to 29 tons, add						20%				
3506	10 to 19 tons, add						30%				
3507	5 to 9 tons, add						50%	25%			
3508	1 to 4 tons, add						75%	50%			
3509	Less than 1 ton, add						100%	100%			
4010	SLH series, 40-ton job lots, bolted cross bridging, shop primer										
4020	Spans to 200' (shipped in 3 pieces), minimum	G	E-7	16	5	Ton	2,200	221	126	2,547	2,950
4040	Average	G		13	6.154		2,475	271	155	2,901	3,375
4060	Maximum	G		11	7.273	↓	2,950	320	183	3,453	3,975
4200	80SLH15, 40 Lb/LF	G		1500	.053	L.F.	49.50	2.35	1.34	53.19	60
4220	80SLH20, 75 Lb/LF	G		1500	.053		92.50	2.35	1.34	96.19	108
4240	85SLH16, 46 Lb/LF	G		1500	.053		57	2.35	1.34	60.69	68
4260	85SLH21, 89 Lb/LF	G		1500	.053		110	2.35	1.34	113.69	127
4280	90SLH17, 52 Lb/LF	G		1500	.053		64	2.35	1.34	67.69	75
4300	90SLH22, 102 Lb/LF	G		1500	.053		126	2.35	1.34	129.69	145
4320	104SLH18, 59 Lb/LF	G		1800	.044		73	1.96	1.12	76.08	84.50
4340	104SLH25, 109 Lb/LF	G		1800	.044		135	1.96	1.12	138.08	153
4360	112SLH19, 67 Lb/LF	G		1800	.044		82.50	1.96	1.12	85.58	95.50
4380	112SLH24, 131 Lb/LF	G		1800	.044		162	1.96	1.12	165.08	183
4400	120SLH20, 77 Lb/LF	G		1800	.044		95	1.96	1.12	98.08	110
4420	120SLH25, 152 Lb/LF	G	↓	1800	.044	↓	188	1.96	1.12	191.08	211
6100	For less than 40-ton job lots										
6102	For 30 to 39 tons, add						10%				
6104	20 to 29 tons, add						20%				
6106	10 to 19 tons, add						30%				
6107	5 to 9 tons, add						50%	25%			
6108	1 to 4 tons, add						75%	50%			
6109	Less than 1 ton, add						100%	100%			

05 21 16 – Longspan Steel Joist Framing

05 21 16.50 Longspan Joists			Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	LONGSPAN JOISTS										
2000	LH series, 40-ton job lots, bolted cross bridging, shop primer										
2015	Made from recycled materials										
2020	Spans to 96', minimum	G	E-7	18	4	Ton	2,050	221	126	2,397	2,725
2040	Average	G		13	6.154		2,250	271	155	2,676	3,125
2060	Maximum	G		11	7.273	↓	2,675	320	183	3,178	3,675
2200	18LH04, 12 Lb/LF	G		1400	.057	L.F.	13.55	2.52	1.44	17.51	21
2220	18LH05, 19 Lb/LF	G		1400	.057		21.50	2.52	1.44	25.46	29.50
2240	20LH04, 12 Lb/LF	G		1400	.057		13.55	2.52	1.44	17.51	21
2260	20LH05, 19 Lb/LF	G		1400	.057		21.50	2.52	1.44	25.46	29.50
2280	24LH05, 13 Lb/LF	G		1400	.057		14.70	2.52	1.44	18.66	22
2300	24LH10, 23 Lb/LF	G	↓	1400	.057	↓	26	2.52	1.44	29.96	34.50

05 31 Steel Decking

05 31 23 – Steel Roof Decking

05 31 23.50 Roof Decking		Crew	Daily Output	Labor-Hours	Unit	Material	2009 Bare Costs Labor	Equipment	Total	Total Incl O&P
2500 50-500 squares	G	E4	4900	.007	S.F.	[illegible]	.30	.03	2.33	2.75
2600 Over 500 squares	G		5100	.006		1.85	.25	.03	2.13	[illegible]
2620 20 gauge, under 50 squares	G		3865	.008		3.05	.37	.03	3.45	4.04
2650 50-500 squares	G		4700	.005		2.42	.35	.03	2.80	3.27
2700 Over 500 squares	G		4800	.007		2.18	.34	.03	2.55	3.00
2900 18 gauge, under 50 squares	G		3800	.008		3.31	.38	.04	4.58	5.05
2950 50-500 squares	G		4100	.008		3.13	.35	.03	3.51	4.11
3000 Over 500 squares	G		4300	.007		2.82	.34	.03	3.19	3.73
3050 16 gauge, under 50 squares	G		3600	.009		5.25	.39	.04	5.68	6.55
3060 50-500 squares	G		4000	.008		4.21	.36	.03	4.60	5.30
3100 Over 500 squares	G		4200	.008		3.79	.34	.03	4.16	4.82
3150 For intermediate rib instead of wide rib, deduct	G					.04			.04	.05
3160 For narrow rib instead of wide rib, add	G					.79			.79	.87

05 31 33 – Steel Form Decking

05 31 33.50 Form Decking		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010 **FORM DECKING**										
0015 Made from recycled materials										
6100 Slab form, steel, 28 gauge, 9/16" deep, uncoated	G	E4	4000	.008	S.F.	1.72	.36	.03	2.11	2.57
6200 Galvanized	G		4000	.008		1.57	.36	.03	1.96	2.35
6220 24 gauge, 1" deep, uncoated	G		3900	.008		1.57	.37	.03	2.27	2.76
6240 Galvanized	G		3900	.008		2.20	.37	.03	2.60	3.12
6300 24 gauge, 1-5/16" deep, uncoated	G		3800	.008		1.95	.38	.04	2.41	[illegible]
6400 Galvanized	G		3800	.008		2.34	.38	.04	2.76	3.23
6500 22 gauge, 1-5/16" deep, uncoated	G		3700	.009		2.50	.39	.04	2.93	3.43
6600 Galvanized	G		3700	.009		2.55	.39	.04	2.98	3.50
6700 22 gauge, 2" deep uncoated	G		3600	.009		3.28	.40	.04	3.72	4.32
6800 Galvanized	G		3600	.009		3.22	.40	.04	3.66	4.30
7000 Sheet metal edge closure form, 12" wide with 2 bends, galv										
7100 18 gauge	G	E14	360	.022	L.F.	5.30	1.04	.37	6.71	8.10
7200 16 gauge	G		360	.022		7.20	1.04	.37	8.61	10.15

05 35 Raceway Decking Assemblies

05 35 13 – Steel Cellular Decking

05 35 13.50 Cellular Decking		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010 **CELLULAR DECKING**										
0015 Made from recycled materials										
0200 Cellular units, galv, 2" deep, 20-20 gauge, over 15 squares	G	E4	1460	.022	S.F.	10.20	.99	.09	11.28	13.30
0250 18-20 gauge	G		1420	.023		11.60	1.02	.09	12.71	14.90
0300 18-18 gauge	G		1390	.023		11.95	1.04	.10	13.09	15.30
0320 16-18 gauge	G		1360	.024		14.20	1.06	.10	15.36	17.60
0340 16-16 gauge	G		1330	.024		15.85	1.09	.10	17.04	19.45
0400 3" deep, galvanized, 20-20 gauge	G		1375	.023		11.25	1.05	.10	12.40	14.50
0500 18-20 gauge	G		1350	.024		13.60	1.07	.10	14.77	16.90
0600 18-18 gauge	G		1290	.025		13.55	1.12	.10	14.77	17.05
0700 16-18 gauge	G		1230	.026		15.25	1.18	.11	16.54	18.95
0800 16-16 gauge	G		1150	.028		16.65	1.26	.12	18.03	20.50
1000 4-1/2" deep, galvanized, 20-18 gauge	G		1100	.029		15.70	1.31	.12	17.13	19.70
1100 18-18 gauge	G		1040	.031		15.60	1.39	.13	17.12	19.75
1200 16-18 gauge	G		980	.033		17.55	1.40	.14	19.17	22
1300 16-16 gauge	G		935	.034		19.15	1.55	.14	20.84	24

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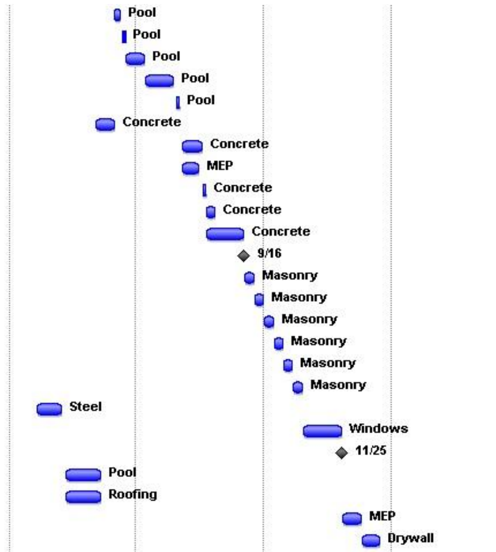
Modified Schedule – Without Glulam in Natatorium

Natatorium - Pool Floor Steel Placement	5 days	Mon 6/15/09	Fri 6/19/09	114	Pool
Natatorium - Pool Floor Concrete Placement	1 day?	Mon 6/22/09	Mon 6/22/09	115	Pool
Natatorium - Pool Walls Rough-In	10 days	Tue 6/23/09	Mon 7/6/09	116	Pool
Natatorium - Pool Walls Steel Placement	15 days	Tue 7/7/09	Mon 7/27/09	117	Pool
Natatorium - Pool Walls Concrete Placement	2 days	Thu 7/30/09	Fri 7/31/09	118	Pool
Natatorium - Drill Piers	10 days	Tue 6/2/09	Mon 6/15/09	15	Concrete
Natatorium - Form and Reinforce Spread Footings	11 days	Mon 8/3/09	Mon 8/17/09	119	Concrete
Natatorium - MEP Underground	10 days	Mon 8/3/09	Fri 8/14/09	119	MEP
Natatorium - Pour Slab-On Grade	2 days	Tue 8/18/09	Wed 8/19/09	122,121	Concrete
Natatorium - Form, Reinforce, and Pour Columns	5 days	Thu 8/20/09	Wed 8/26/09	123	Concrete
Natatorium - Steel Erection	20 days	Thu 8/20/09	Wed 9/16/09	23,123	Concrete
Natatorium - Top Out	0 days	Wed 9/16/09	Wed 9/16/09	125,124	All
Natatorium - CMU North Wall	5 days	Thu 9/17/09	Wed 9/23/09	126	Masonry
Natatorium - CMU East Wall	5 days	Thu 9/24/09	Wed 9/30/09	127	Masonry
Natatorium - CMU South Wall	5 days	Thu 10/1/09	Wed 10/7/09	128	Masonry
Natatorium - Face North Wall	5 days	Thu 10/8/09	Wed 10/14/09	129	Masonry
Natatorium - Brick East Wall	5 days	Thu 10/15/09	Wed 10/21/09	130	Masonry
Natatorium - Brick South Wall	5 days	Thu 10/22/09	Wed 10/28/09	131	Masonry
Natatorium - Roof Decking	15 days	Mon 4/20/09	Fri 5/8/09		Steel
Natatorium - Windows	20 days	Thu 10/29/09	Wed 11/25/09	132	Windows
Natatorium - Dry-In	0 days	Wed 11/25/09	Wed 11/25/09	134	All
Natatorium - Pool Gutter System	20 days	Mon 5/11/09	Fri 6/5/09	133	Pool
Natatorium - Standing Seam Roofing System	20 days	Mon 5/11/09	Fri 6/5/09	133	Roofing
Natatorium - Overhead Rough-in	10 days	Thu 11/26/09	Wed 12/9/09	135	MEP
Natatorium - Interior Framing	10 days	Thu 12/10/09	Wed 12/23/09	138	Drywall



Appendix 7 – Analysis #2 (Mechanical System) References

Mechanical System Cost Calculations

Mechanical System Pricing

Cooling Tower:

Material: $30,171 (supplier's price)

Labor: $2,650 (RS Means 2008, pg. 374)

Additional Pumps + Piping:

Labor + Material: $94.50/Ton x 276 Tons = $26,082 (RS Means 2008, pg. 374)

Chiller (WC):

Material: 276 Tons x $340/Ton = $93,840 (Supplier's Price)

Labor: $11,700 (RS Means 2008, pg. 373)

Add'l Structural Support For Cooling Towers:

Labor + Material: $15,557 (estimate from MC)

Total Cost for New Design: $180,000

Previous Mechanical System Cost: $228,523 (from Mechanical Contractor)

Initial Savings of: **$48,523**

23 64 Packaged Water Chillers

23 64 26 – Rotary-Screw Water Chillers

23 64 26.10 Rotary-Screw Type Water Chillers		Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	Equipment	Total	Total Incl O&P
0140	320 ton	Q-7	.12	275	Ea.	163,500	12,400		175,900	198,000
0200	Packaged unit, water cooled, not incl. tower									
0210	80 ton	Q-7	[illegible]	[illegible]	Ea.	38,500	10,000		48,500	57,500
0220	100 ton		.14	230		45,200	10,300		55,500	65,000
0230	150 ton		.13	240		64,500	10,900		75,300	87,000
0240	200 ton		.13	251		72,500	11,300		83,800	97,000
0250	250 ton		.12	260		81,000	11,700		92,700	107,000
0260	300 ton		.12	266		95,000	12,000		107,000	122,500
0270	350 ton		.12	275		134,500	12,400		146,900	166,500
1450	Water cooled, tower not included									
1560	135 ton cooling, screw compressors	Q-7	.14	235	Ea.	55,000	10,600		65,600	76,500
1580	150 ton cooling, screw compressors		.13	240		63,500	10,800		74,300	86,000
1620	200 ton cooling, screw compressors		.13	250		84,500	11,200		95,700	113,500
1660	291 ton cooling, screw compressors		.12	260		91,500	11,700		103,200	115,500

23 64 33 – Direct Expansion Water Chillers

23 64 33.10 Direct Expansion Type Water Chillers		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**DIRECT EXPANSION TYPE WATER CHILLERS,** With standard controls									
8000	Direct expansion, shell and tube type, for built up systems									
8020	1 ton	Q-5	2	8	Ea.	5,975	340		6,315	7,075
8030	5 ton		1.90	8.421		9,900	355		10,255	11,400
8040	10 ton		1.70	9.412		12,300	400		12,700	14,100
8050	20 ton		1.50	10.667		14,000	450		14,450	16,100
8060	30 ton		1	16		17,900	680		18,580	20,700
8070	50 ton		.90	17.778		28,700	755		29,455	32,700
8080	100 ton	Q-6	.90	26.667		51,000	1,175		52,175	58,000

23 65 Cooling Towers

23 65 13 – Forced-Draft Cooling Towers

23 65 13.10 Forced-Draft Type Cooling Towers		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
0010	**FORCED-DRAFT TYPE COOLING TOWERS,** Packaged units D3030-310									
0070	Galvanized steel									
0080	Induced draft, crossflow									
0100	Vertical, belt drive, 61 tons	Q-6	90	.267	TonAC	96	11.75		107.75	123
0150	100 ton		100	.240		76	10.55		86.55	99.50
0200	115 ton		109	.220		74	9.70		83.70	96
0250	131 ton		120	.200		65.50	8.80		74.30	85.50
0260	162 ton		132	.182		55	8		63	72.50
1000	For higher capacities, use multiples									
1500	Induced air, double flow									
1900	Vertical, gear drive, 167 ton	Q-6	126	.190	TonAC	102	8.40		110.40	125
2000	297 ton		129	.186		73	8.20		81.20	92.50
2100	582 ton		132	.182		60.50	8		68.50	78.50
2150	849 ton		142	.169		49.50	7.45		56.95	65.50
2200	1016 ton		150	.160		57	7.05		64.05	73
3500	Blow through, centrifugal type									
3510	50 ton	Q-6	2.28	10.526	Ea.	10,400	465		10,865	12,200
3520	75 ton		1.52	15.789		13,500	695		14,195	15,900
3524	100 ton		1.22	19.672		15,900	865		16,765	18,800
3528	125 ton	Q-7	1.31	24.427		19,600	1,100		20,700	23,300
3532	200 ton		.82	39.216		24,300	1,750		26,050	29,300

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23 65 Cooling Towers

23 65 13 – Forced-Draft Cooling Towers

23 65 13.10 Forced-Draft Type Cooling Towers	Crew	Daily Output	Labor-Hours	Unit	Material	2008 Bare Costs Labor	2008 Bare Costs Equipment	2008 Bare Costs Total	Total Incl O&P
2536 250 ton	C-7	.65	49.231	Ea.	29,000	2,200		31,200	35,300
2540 300 ton		.54	59.259		33,400	2,650		36,050	40,700
2544 350 ton		.47	68.085		37,700	3,050		40,750	46,100
2548 400 ton		.41	78.049		39,300	3,500		42,800	48,500
2552 450 ton		.36	88.154		47,300	3,950		51,250	58,000
2556 500 ton		.32	100		50,500	4,500		55,000	62,500
2560 550 ton		.30	107		54,500	4,825		59,325	67,000
2564 600 ton		.27	117		57,000	5,275		62,275	70,500
2568 650 ton		.25	127		63,500	5,725		69,225	78,000
2572 700 ton		.23	137		74,500	6,175		80,675	91,000
2576 750 ton		.22	145		79,500	6,600		86,100	97,500
2580 800 ton		.21	152		86,500	6,850		93,350	105,500
2584 850 ton		.20	159		91,500	7,050		98,550	111,500
2588 900 ton		.20	164		97,000	7,250		104,250	117,500
2592 950 ton		.19	170		102,500	7,650		110,150	124,000
2596 1000 ton		.18	180		105,500	8,125		113,625	129,000
2700 Axial fan, induced draft									
2710 50 ton	Q-6	2.28	10.526	Ea.	9,000	465		9,465	10,600
2720 75 ton		1.52	15.789		10,600	695		11,295	12,700
2724 100 ton		1.22	19.672		11,200	865		12,065	13,600
2728 125 ton	Q-7	1.31	24.427		13,800	1,100		14,900	16,800
2732 200 ton		.82	39.216		23,400	1,750		25,150	28,400
2736 250 ton		.65	49.231		28,400	2,200		30,600	34,300
2740 300 ton		.54	59.259		30,900	2,550		33,450	37,900
2744 350 ton		.47	68.085		33,000	3,050		36,050	40,900
2748 400 ton		.41	78.049		37,800	3,500		41,300	46,900
2752 450 ton		.36	88.154		42,000	3,950		45,950	52,000
2756 500 ton		.32	100		44,600	4,500		49,100	56,000
2760 550 ton		.30	107		49,800	4,825		54,625	62,500
2764 600 ton		.27	117		52,500	5,275		57,775	66,000
2768 650 ton		.25	127		57,500	5,725		63,225	71,500
2772 700 ton		.23	137		65,500	6,175		71,675	81,500
2776 750 ton		.22	145		68,000	6,600		74,600	84,500
2780 800 ton		.21	152		71,000	6,850		77,850	88,500
2784 850 ton		.20	159		71,500	7,050		78,550	89,000
2788 900 ton		.20	164		74,000	7,250		81,250	92,000
2792 950 ton		.19	170		78,000	7,650		85,650	97,000
2796 1000 ton		.18	180		82,500	8,125		90,625	102,500
3000 For higher capacities, use multiples									
3500 For pumps and piping, add	Q-6	38	.632	Ton	48	28		76	99.50
4000 For absorption systems, add					75%	75%			
4100 Cooling water chemical feeder	Q-5	3	5.333	Ea.	292	226		518	660
5000 Fiberglass									
5010 Draw-thru									
5100 60 ton	Q-6	1.50	16	Ea.	3,450	705		4,155	4,850
5120 125 ton		.99	24.242		7,050	1,075		8,125	9,350
5140 300 ton		.43	55.814		16,500	2,450		18,950	21,800
5160 600 ton		.22	109		29,600	4,800		34,400	39,800
5180 1000 ton		.15	160		51,000	7,025		58,025	66,500
6000 Stainless steel									
6010 Induced draft, crossflow, horizontal, belt drive									
6100 57 ton	Q-6	1.50	16	Ea.	9,675	705		10,380	11,700
6120 91 ton		.99	24.242		13,900	1,075		14,975	16,900

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Water Cooled Chiller Spec Sheet

Southland - Houston Chiller Study
RTHD-1

General

Capacity: **276.00 tons**	Compressor configuration: **C2**
Efficiency: **0.667 kW/ton**	IPLV: **0.512 kW/ton**
NPLV: **0.549 kW/ton**	

Evaporator

Evap configuration: **D3**	Evap pressure drop: **5.50 ft H2O**
Evap leaving temp: **42.00 F**	Evap fouling factor: **0.00010 hr-sq ft-deg F/Btu**
Evap flow rate: **470.90 gpm**	Evap fluid concentration: **0.00 %**
Minimum evap flow rate: **324.00 gpm**	Evap fluid freeze point: **32.00 F**
Evap entering temp: **56.00 F**	Evap fluid type: **Water**
Number of evap passes: **3 Pass**	

Condenser

Cond configuration: **E3**	Cond fouling factor: **0.00025 hr-sq ft-deg F/Btu**
Cond entering temp: **85.00 F**	Cond fluid concentration: **0.00 %**
Cond flow rate: **792.80 gpm**	Cond tube type: **Enhanced Fin - Copper**
Cond leaving temp: **95.00 F**	Cond water side pressure: **150psi/10.5Bar Condenser Water Pressure**
Number of cond passes: **2 Pass**	Cond fluid type: **Water**
Cond pressure drop: **11.10 ft H2O**	

Electrical

Unit voltage: **460/60/3**	Max overcurrent protection: **600.00 A**
Starter type: **Wye-delta**	Starter expected inrush: **469.00 A**
Unit power: **184.00 kW**	Motor locked rotor amps: **1453.00 A**
Run load amps: **266.50 A**	Max RLA (for starter sizing): **364**
Min circuit ampacity: **333.10 A**	

Miscellaneous

Full load sound pressure (ARI Condition): **83 dBA**	Shipping weight: **14002.0 lb**
Refrigerant charge (HFC-134a): **490.0 lb**	ARI certification: **ARI certified**
Oil cooler: **Without Oil Cooler**	Rated capacity (ARI): **307.30 tons**
ARI certified selection: **Yes**	Distribution channel: **United States**
Operating weight: **15044.0 lb**	Pressure vessel code: **ASME Pressure Vessel Code**

Test

Performance test options: **No Performance Test**	Factory tolerance test: **No performance test**

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Cooling Tower Spec Sheet

Chesapeake Systems

7400 Coca-Cola Drive
Hanover, MD 21076
Phone:-443-561-1600 Fax:-443-561-1601
Web Address: www.chesapeakesys.com

Offer of Sale

Reference No. 13643

To: Matt Smiddy
Attn:

Date: 2/19/2010

Business Fax:

Job Name: **Penn State Project**

Job Engineer:

Thank you for requesting a quotation on the following equipment:

Danfoss Variable Frequency Drive(s)
Evapco Cooling Tower(s)

We are pleased to submit our offer based on the conditions indicated.

[CT-1] Quantity (1) Evapco Cooling Tower(s), Model AT-19-99

276 Ton Induced Draft Counterflow Cooling Tower. CTI Certified to Cool 828 GPM of Water from 95 F to 85 F @ 77 F Entering Wet Bulb Temperature - Qty (1) 20 HP Fan (460/3/60)

Base Price Includes:

- "EVAPCOAT" G-235 Galvanized Construction (Casing & Panels & Basin)
- Stainless Steel Strainers
- PVC EVAPAK Fill & Drift Eliminators (Drift Rate Not To Exceed 0.001% of Recirculation Flow)
- "Sight Tight" PVC Air Inlet Louvers & Screen Design (Prevents Light From Entering the Basin)
- 100% Corrosion Free Water Distribution System
- Solid Backed/Multi-Grooved "Power Band" Belt Drive
- Pillow Block Bearings With a Minimum L-10 Life of 75,000 Hours
- Cast Aluminum Drive Sheaves
- External Motor/Belt Drive Adjustment
- Extended Lubrication Lines
- Internal Working Platform for Service of Water Distribution System and Fan/Motor Drive System
- EVAPCO Thermal Performance Guarantee
- CTI Certified
- IBC Compliant
- 5-Year Motor & Drive Parts Warranty

Note: Motors are Shipped Loose for Field Mounting by Others on 8.5'Wide Units
Note: Unless Noted Otherwise All Accessories Ship Loose for Field Installation

2/19/2010

Reference No. 13643
Page 1

Energy Cost Calculations

Cooling Tower/Chiller Energy Cost

W-C Chiller: $0.667 \frac{kW}{Ton}$ (Supplier) $\times 276\ Ton = 184\ KW$

Cooling Tower: Assume COP of 4 => $kW/Ton = \frac{12}{COP \times 3.412} = \frac{12}{4 \times 3.412} = 0.879 \frac{kW}{Ton}$

$0.879 \frac{kW}{Ton} \times 276\ Ton = 243\ KW$

Total Energy Usage of New System: 427 KW

Total Energy Usage of Old System:

2 A-C Chillers @ $1.3 \frac{kW}{Ton}$ ea $= 2.6 \frac{kW}{Ton} \times 276\ Tons = 718\ KW$

Save: 291 KW

Energy Costs: ~10¢/kW·h in Houston, Tx

So each day, $291 \times 24 \times 0.1 =$ \$698/Day Savings

Month: \$20,707

Year: \$248,488

Appendix 8 – Analysis #3 (Delivery Methods) References

Response from General Contractor's Survey

The purpose of this survey is to investigate the interaction of the Pearland Recreation Center and Natatorium project team. This survey has been designed to capture the general contractor's viewpoint.

1) If you were to redo the project, would you change the delivery method? If so, what would you change it to and why? If not, what were the advantages of the Design-Bid-Build delivery method chosen? ***A: The architect & I have spoken often that this should have been a CM @ Risk type contract. That is because of the difficult design features, there have been many small changes to the contract that would be easier to resole if the CM @ Risk method had been used. Typically the CMR anticipates these challenges and has allowances to care for that.***

2) How frequently did you interact with the designers? ***A: We meet a minimum of once a week with the architect, and he often visits the site once or twice more during the week to consult with the superintendents.***

3) How frequently did you interact with the owners? ***A: We meet every other week at a progress meeting.***

4) What was the most common method of communication with designers? ***A: Telephone conversations, with email a close second.***

5) What was the most common method of communication with the owners? ***A: Telephone.***

6) What are the *main* criteria that were used to select the subcontractors and suppliers? Would you modify any of these criteria if you were to do it over again? ***A: As a hard bid, the primary selection criteria were price, with ability to perform the project second. It is hard to modify this criterion when the project is a hard bid. Selection of a better qualified sub, but at a higher cost might make our bid higher, and thus we would not be the low bidder.***

7) What types of contracts were held between the subcontractors/suppliers and general contractor? ***A: I have attached a sample contract.***

8) What language would you add/remove/change in these contracts if you were to do it over again? ***A: We re content with our current contract.***

9) What language was specifically effective? ***A: We find the duration language, and that the days allowed for various work to run concurrent helps the superintendent to push the project.***

10) How frequently were Owner-Architect-Contractor meetings held? Was this frequency adequate? ***A: Meetings are held every other week. This is adequate.***

11) How often would the architect and/or owner representative visit the construction site? ***A: Owner at least once every other week, and sometimes once a week. The architect is on site a minimum of once a week, and the architect has a construction representative on site every day for at least ½ day.***

Response from Owner's Survey

The purpose of this survey is to investigate the interaction of the Pearland Recreation Center and Natatorium project team. This survey has been designed to capture the owner's viewpoint.

1) Why was the Design-Bid-Build delivery method chosen?
This is the typical method chosen by the City for complex projects such as this.

2) If you were to redo the project, would you change the delivery method? If so, why? If not, what were the advantages of the Design-Bid-Build delivery method chosen?
No, this method is the best. CMAR & DB would not have served the City well for this type of project. Simple big box stores and office buildings might lend themselves to other methods -- see pg 2 #2

3) What *main* criteria were used to select the designer?
-- Familiarity with similar projects
-- Familiarity with key funding stakeholder & user
-- Understanding of concept of project & working on municipal projects

4) What would you change in these criteria if you were to do it over again?
None

5) What *main* criteria were used to select the general contractor?
Competitive sealed proposal criteria, as attached, from the Instructions to Bidders (pg 1-3)

6) What would you change in these criteria if you were to do it over again?
None.

7) Did the contract with the contractor and designer contain any specific language requiring interaction between the two parties? If so, what?
There is no contract btwn contractor & designer. The contract is with the owner & specified coordination with the owner on certain items, as well as with other agencies, see attached sec 0800

8) What language would you add/remove/change in the contract if you were to do it over again? None.

9) How frequently were Owner-Architect-Contractor meetings held? Was this frequency adequate? Meetings were held every 2 weeks, or more frequently if certain situations required

10) How often would the architect and/or owner representative visit the construction site?
Owner's rep is on site daily, as specified in the consultant contract. (architect also provides construction management oversight.)

#2 The DBB method allows the designer & owner to review all aspects of the proposed facility before construction starts. The user group & stakeholders have more time to provide input at all stages of design.

#5 Pg1

13. Opening of Bid Proposals

Bid Proposals will be opened and (unless obviously non-responsive) read aloud publicly. An abstract of the amounts of the base Bid Proposals and major alternates (if any) will be made available to Bidders after the opening of Bid Proposals. Bid Proposals, in their entirety, shall be open for public inspection after the contract is awarded, with the exception of any trade secrets or confidential information contained therein, provided Bidder has expressly identified any specific information contained therein as being trade secrets or confidential information.

14. Bid Proposals to Remain Subject to Acceptance

All Bid Proposals will remain subject to acceptance for sixty (60) days after the day of the Bid Proposal opening, but Owner may, in its sole discretion, release any Bid Proposal and return the bid security prior to that date.

15. Award of Contract

15.1 Owner reserves the right to reject any and all Bid Proposals, to waive any and all informalities not involving price, time or changes in the Work and to negotiate contract terms with the Successful Bidder. Owner may reject a bid as non-responsive if: 1) Bidder fails to provide required Bid Security; 2) Bidder improperly or illegibly completes or fails to complete all information required by the Bidding Documents; 3) Bidder fails to sign the Bid Proposal or improperly signs the Bid Proposal; 4) Bidder qualifies its Bid Proposal; 5) Bidder tardily or otherwise improperly submits its Bid Proposal; 6) Bidder fails to submit the Qualifications of Bidder as required under section 3 of these Instructions to Bidders; or 7) Bid Proposal is otherwise non-responsive. In determining the best value for the Owner, and in determining to whom to award a contract, Owner may consider: 1) purchase price; 2) reputation of the Bidder and Bidder's goods or services; 3) quality of Bidder's goods or services; 4) extent to which the goods or services meet the Owner's needs; 5) Bidder's past relationship with the Owner; 6) impact on the ability of Owner to comply with laws and rules relating to contracting with historically underutilized businesses and nonprofit organizations employing persons with disabilities; 7) total long-term cost to Owner to acquire Bidder's goods or services; 8) the Qualifications of Bidder; and 9) any other relevant criteria specifically listed in the Bidding Documents. Discrepancies in the multiplication of units of Work and unit prices will be resolved in favor of the unit prices. Discrepancies between the indicated sum of any column of figures and the correct sum thereof will be resolved in favor of the correct sum.

15.1.1 For exact Selection Criteria, Refer to "Exhibit A", Sheet 00200-Exhibit A

15.2 In evaluating Bid Proposals, Owner will consider the Qualifications of the Bidders, whether or not the Bid Proposals comply with the prescribed requirements, and such alternates, unit prices and other data, as may be requested in the Bid Proposal form or prior to the Notice of Award.

pg 2

Exhibit "A"

SELECTION CRITERIA

DETERMINATION OF SUCCESSFUL RESPONDENT AND AWARD OF CONTRACT

A. In determining the Selected Offeror, the Owner will evaluate the information derived from the Offeror's (Contractor's) Qualification Statement required herein, the information submitted on the Proposal Form, and other selection criteria including, but not be limited to the following:

	Criteria	*Source*	*Scoring Procedure*	*Score*	*Factor*	*Total*
1.	*Base* Proposal	*Proposal* Form	*Contractor to submit their Competitive Sealed* Proposals on the forms included in the Specification Manual, Alternates proposed and Mark-up for Changes. Low Price = 45 pts. For Subsequent Proposer's, the low Proposers price shall be divided by the Subsequent Proposer's price to get a percentage (factor) that is multiplied by the score to get the total.	45	1	45
2.	*Contractor's* Reputation	*AIA 305*	*References in Houston Area are asked to rate the* contractor. a. Reference responses from Project Owners and A/E's on similar projects. b. Reference questions on budget, schedule, reporting/ communications and responsiveness. c. Record of Claims Incidences and litigation experiences over the past five years. d. Reputation of Change Orders. Responses are scored as follows: Excellent = 10 pts; Very Good = 8 pts; Average = 5 pts; Fair = 2 pts; Poor = 0 pts Points from multiple references are averaged	10	1	10
3.	Experience	*AIA 305* (type and size)	*Count number of similar projects in the Houston* that fall within a +/- 25% range of the project budget. a. Past experience on projects of similar scope, scale, Complexity and type. b. References in the Houston area if contractor brings appropriate resources (personnel & equipment) to assure project completion by contract target end dates. Contractor earns one point for each project up to a maximum of 10 points.	10	1	10
4.	*Maintenance* of Schedule	*References*	*References in Houston Area are asked whether or* not the schedule was met on their project Responses are scored as follows: Completed ahead of schedule overcoming uncontrollable circumstances = 5 pts, Completed ahead of schedule = 4 pts Completed on schedule = 3 pts, Completed less than two weeks behind schedule = 1 pt, Completed more than two weeks behind schedule = 0 pts Points from multiple references are averaged	5	1	5

00200 – Exhibit A

Pg 3

5.	*Project Team*	*Proposal* Information (resumes)	***Resumes for Project Manager and Superintendent*** will each be evaluated and points given to the team for the following: Time in business (for each individual): 10+ yrs – 4 pts; 8-9 yrs – 3 pts; 5-7 yrs – 2 pts; 2-4 yrs – 1 pt, and less than 2 yrs = 0 pts. Number of similar projects completed (for each individual): 4 – 4 pts; 3 – 3 pts; 2 – 2 pts; 1 – 1 pt; 0 – 0 pts. Time with the Company (for each individual) 5+ yrs – 5 pts; 4 yrs – 4 pts; 3 yrs – 3 pts; 2 yrs – 2 pts; 1 yr – 1 pt. and less than 1 yrs = 0 pts. Number of projects completed as a team: 5+ = 5 pts; 4 = 4 pts; 3 – 3 pts; 2 – 2 pts; 1 – 1 pt; and less than – 0 pts.	*36*	*0.2778*	*10*
6.	*Approach*	*Proposal* Information	***The Project Plan or Approach proposed.*** a. Quality and clarity of proposer's workplan including schedule, logistics/phasing plan, understanding of the work and sensitivity to ongoing operations in the Community. Responses are scored as follows: Excellent – 5 pts; Very Good – 4 pts; Average = 3 pts; Fair = 2 pts; Poor – 0 pts.	*5*	*1*	*5*
7.	*Proposed Subcontractors*	*Proposal* Information	***The Major Subcontractors proposed by Contractor.*** a. Quality of Major Subcontractors listed. b. Experience of Major Subcontractors with Projects of similar scope and size. c. References in Houston if Subcontractors bring appropriate resources (personnel and equipment) to assure project completion by contract target end dates. Responses are scored as follows: Excellent – 5 pts; Very Good = 4 pts; Average – 3 pts; Fair – 2 pts; Poor = 0 pts. Points from multiple references are averaged.	*5*	*1*	*5*
8.	*Safety* Rating	*AIA 305*	***Contractors to provide the Owner with their*** Experience Modifier Rate (EMR). Those with EMR of 0.50 or less = 5 pts, EMR of 0.51 – 0.85 – 4 pts; EMR of 0.86 – 0.99 – 3 pts; EMR greater than 1.00 = 0 pts. a maximum of 5 points.	*5*	*1*	*5*
9.	*Warranty*	*References*	***References in Houston Area are asked to rate the contractor,*** Responses are scored as follows: Excellent = 5 pts; Very Good – 4 pts; Average = 3 pts; Fair = 2 pts; Poor – 0 pts Points from multiple references are averaged.	*5*	*1*	*5*

Total Possible Score 100

00200 – Exhibit A

#7

CITY OF PEARLAND SPECIAL CONDITIONS OF AGREEMENT

Section 00800

SPECIAL CONDITIONS OF AGREEMENT

The following Special Conditions modify the General Conditions, Document 00700. Where a portion of the General Conditions is modified or deleted by these Special Conditions, the unaltered portions of the General Conditions shall remain in effect.

1.01 Add the following paragraph to the end of Article 1.01:

The OWNER'S representative on the project is: Andrea Brinkley, 3501 E. Orange, Phone 281 652-1797.

4.23 Add the following Notes at the end of Article 4.23:

1. Contractor shall note that any work in the roadways (Bailey Road and Veterans Drive) is limited to the hours between 9:00 AM and 2:00 PM.
2. Contractor shall contact and coordinate work in the roadways with the School Hours and Bus times with the Pearland Independent School District.
3. Contractor shall notify BDD #4 (Brazoria Drainage District) prior to any drainage work to be performed in either Springfield Ditch to the North of the property and Cowarts Creek to the south of the property.
4. Contractor shall contact the City of Pearland prior to any work on the new Sanitary Sewer line along Veterans Drive and for any storm sewer outfalls or tie-ins to existing drainage.

ACADEMIC VITA of Matt Smiddy

Matt Smiddy
137 H. Alley Apt. 201
State College, PA 16801
msmiddy5055@gmail.com

Education: Bachelor of Architectural Engineering, Penn State University, Spring 2010
Bachelor of Arts in Economics, Penn State University, Spring 2010
Honors in Architectural Engineering
Thesis Title: Pearland Recreation Center and Natatorium
Thesis Supervisor: James A. Faust

Related Experience:

Intern, ExxonMobil Development Company (Houston, TX) 05/09 – 08/09

- Re-wrote the Construction Coordination Procedure Pro-Forma for use in all project contracts.
- Assisted in expediting first oil on the Banyu Urip ($2 B) project in Indonesia
- Created an outline for a Temporary Facilities Global Practice

Intern, The Alexander Building Company (State College, PA) 12/08-5/09

- Led the implementation of Building Information modeling into the company.
- Used a 3-story office building as a prototype

Intern, Facchina-McGaughan LLC. (Miami, FL) 05/07 – 08/07, 05/08 – 08/08

- Assisted in management of construction of concert hall designed by Frank Gehry - $100M
- Assisted in management of construction of 43-Story Condominium project - $130M

Intern, The Whiting-Turner Contracting Company (Miami, FL) 05/06 – 08/06

- Assisted in management of construction of 33-Story Condominium project - $90M
- Bid out 4 scope of works
- Oversaw the project's quality control program, submitting 10 QC reports/week

Research Assistant, Pennsylvania Transportation Institute 03/08 – 12/08

- Assisted in testing bearing capacities of asphalt cores for PENDOT

Teaching Assistant, Penn State University 09/08 - Present

- Coordinated exam and homework grading for 75 students in Environmental Economics and 75 students in Material Science for Civil Engineers courses

BIM Execution Guide Project 09/08 – 12/08

- Created a publicly available guide for using BIM for cost estimating.
- Performed a BIM case study on the New World Symphony Concert Hall

Awards:

Engineer-In-Training
Golden Key International Honour Society
Schreyer Honors College Scholar
2009 Hettema Leadership Award Recipient
Tau Beta Pi Engineering Honor Society
Phi Kappa Phi Honor Society Member
Phi Alpha Epsilon Honor Society Member

Presentations/Activities:

President and Web Master, Student Chapter of Partnership for Achieving Construction Excellence
Member, 2005-2006 Penn State Men's Varsity Swim Team
Member and Web Master, Penn State Water Polo Team
President and Web Master, Penn State Club Swim Team
Family Member Chair, Robert J. Smiddy Memorial Scholarship Award Committee
Volunteer, Special Olympics
Envoy, Penn State Engineering Coop & Internship Program