Pearland Recreation Center and Natatorium

Matt Smiddy
BAE/MAE Construction Option
Concurrent Economics Major

AE Senior Thesis Presentation
4/12/2010

Presentation Outline

- Building Overview
- Analysis #1 – Natatorium Structural Redesign
- Analysis #2 – Mechanical System Modification
- Analysis #3 – Project Delivery Systems on Public Projects
- Analysis #4 – Glulam Connection Modification
- Conclusion and Recommendations
- Acknowledgments and Questions

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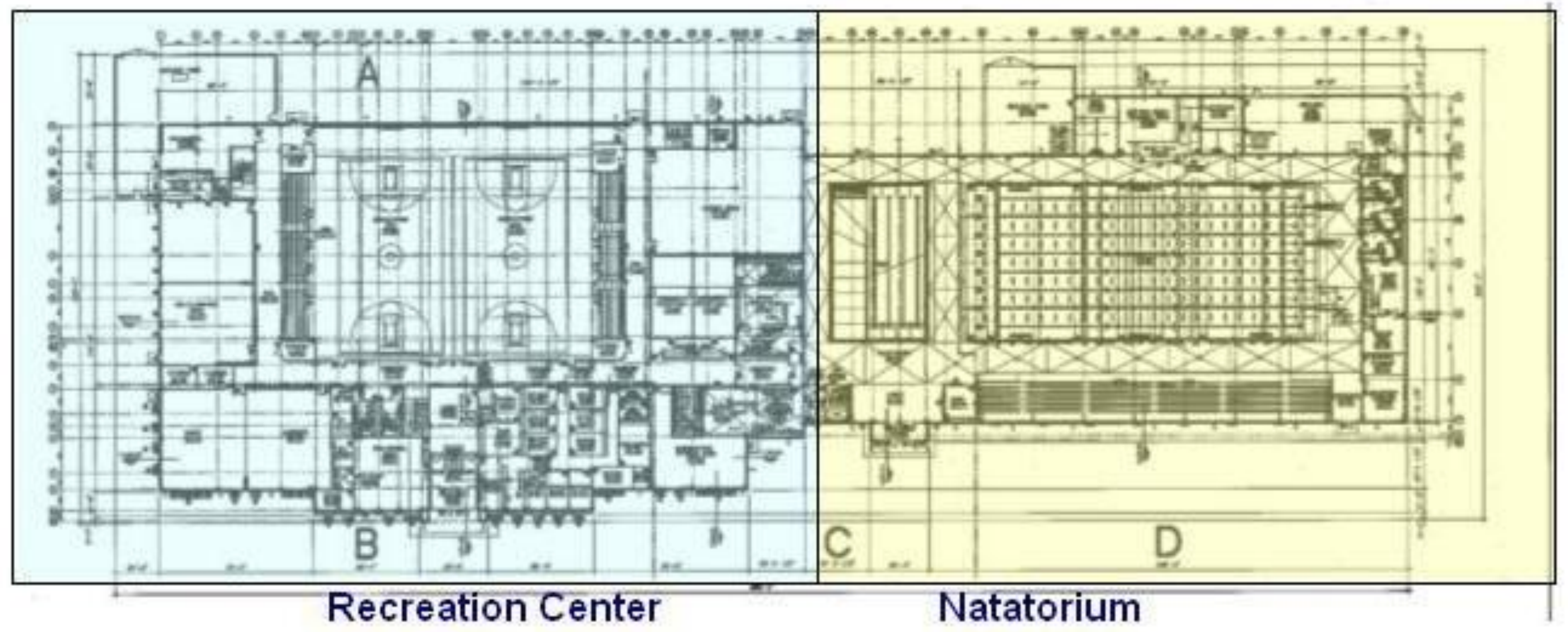
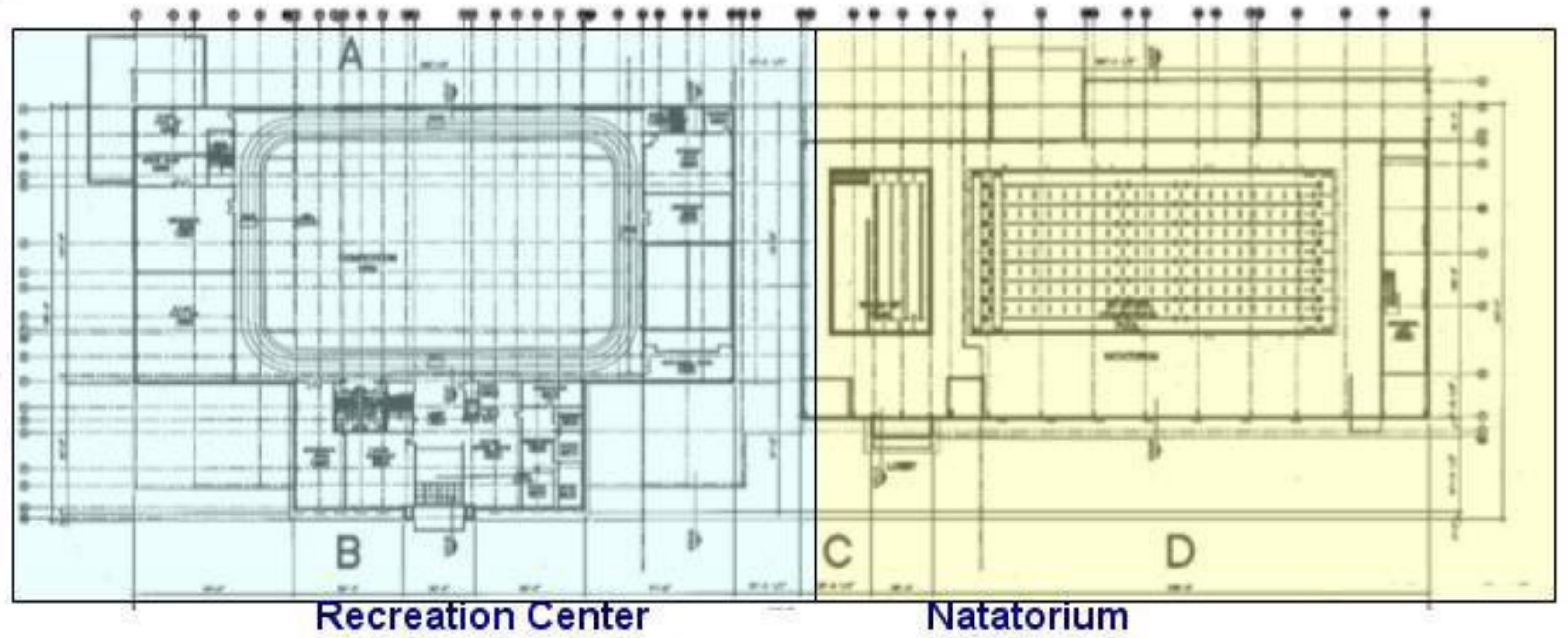
Building Overview

- Located in Pearland, Texas; about 15 miles south of Houston, TX
- 105,000 SF
- Building houses:
  - Gymnasium
  - Multi-Purpose Rooms
  - Offices
  - Classrooms
  - Weight Room
  - Locker Rooms
  - Aerobics Room
  - (1) 25-yard X 50-meter Competition Pool
  - (1) 4 Lane X 25-yard instructional pool





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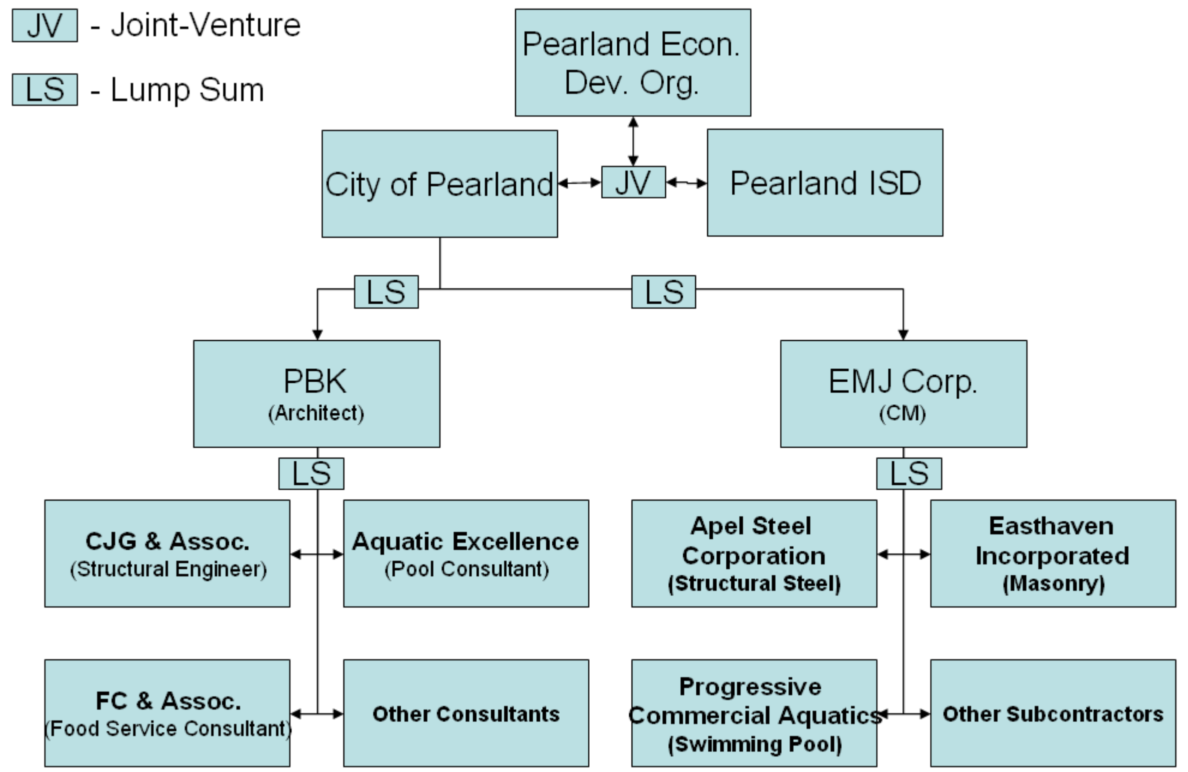
Building Overview

- Construction began in May 2009 and is scheduled for completion in June 2010
- Design-Bid-Build delivery method
- Competitive bid/lump sum contract with general contractor
- $17 million project (Contract with general contractor)

Project Team:



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Building Overview

Structural System:

- Steel in Recreation Center and Glulam in the Natatorium

Mechanical System:

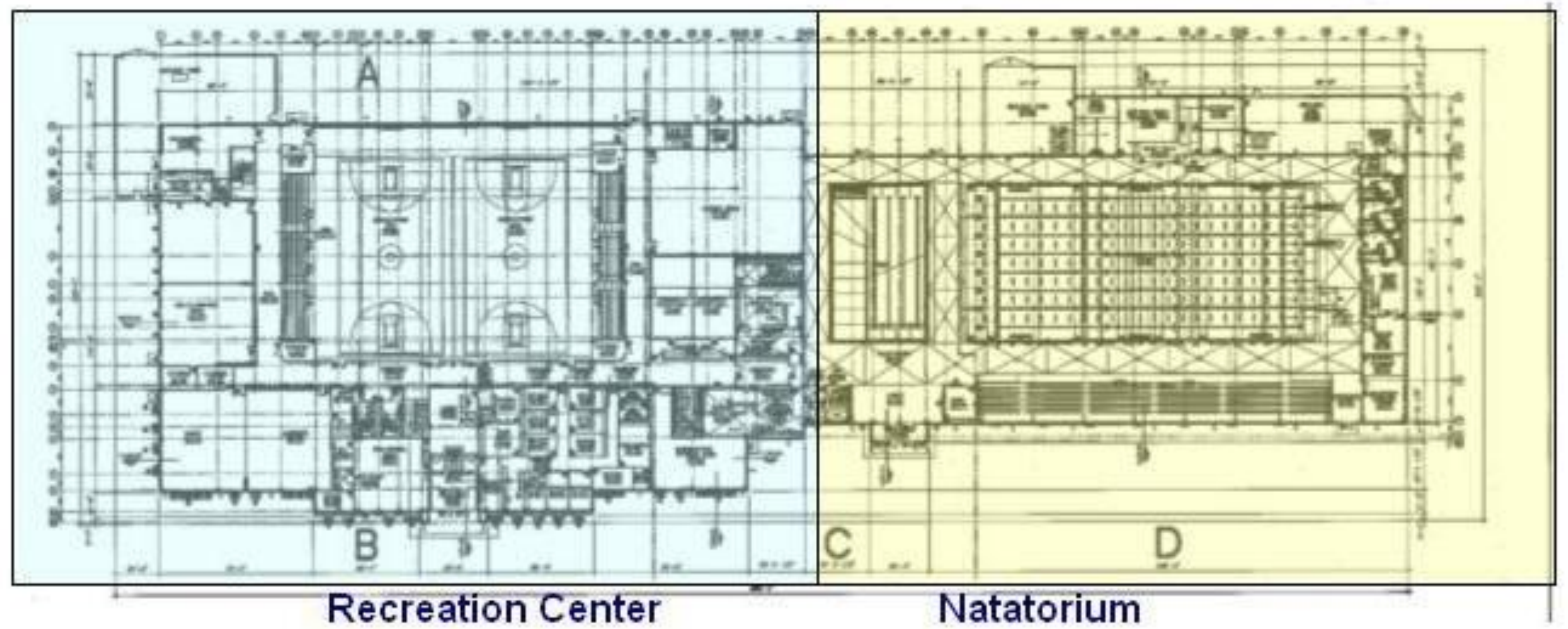
- Chillers (2 Air-Cooled) and Air Handling Units (12) with VAV boxes

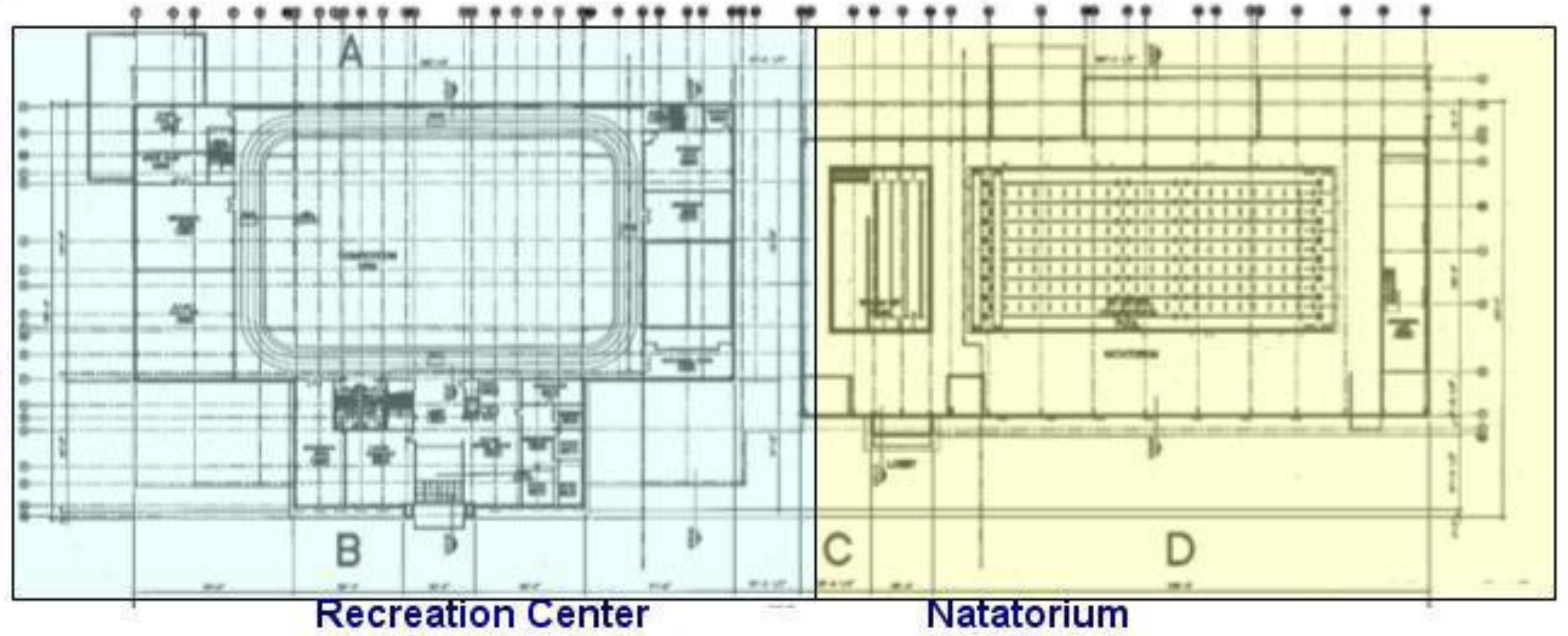
Electrical System:

- 3000 A Source, 29 Surface Mounted Panel Boards (15-408/277V and 14-208/120V), emergency generator

Fire Protection System:

- Wet pipe pre-action fire sprinkler system





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Analysis #1 – Structural System

Structural - Breadth Topic #1

Problem:
The glulam structural system in the natatorium is very expensive.

Goal:
Identify an economical alternative structural system in the natatorium that will be of the same quality as the current glulam system.

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Analysis #1 – Structural System

Structural - Breadth Topic #1

Alternative Structural System Comparisons:

Steel

- Cheapest
- Paint on steel can chip, particularly on accessible columns, causing steel corrosion.

Steel Joists and Concrete Columns **– Selected System!**

- Less Corrosive
- Concrete columns would not corrode
- Paint on steel joists would not chip since they are not easily accessible.

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Analysis #1 – Structural System

Structural - Breadth Topic #1

System Redesign:

Using 2003 IBC Code:

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

Design*:

Member	Quantity	Size	Spacing/Reinforcing
Concrete Columns	28	10” X 10”	25’ on center/4-#5s
Steel Joists	468	25’ - 14k1	4’ on center
Steel Beams	14	104’ - 104SLH22	25’ on center

*Sized using the Steel Joist Institute Handbook and Concrete Reinforcing Steel Institute Manual

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Analysis #1 – Structural System

Structural - Breadth Topic #1

Cost:

As-Designed System - Glulam

Members	Cost
All Glulam	$1,070,000
Total	$1,070,000

Proposed System – Concrete and Steel

Members	Cost
Concrete Columns	$22,320
Steel Beams	$165,620
Steel Joists	$143,910
Metal Decking	$107,888
Additional connection and coatings	$30,000
Total	$469,738

System Cost Comparison

System	Cost
As-Designed System (Glulam)	$1,070,000
Proposed System (Concrete and Steel)	$469,738
Savings with Proposed System	**$600,262**

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Analysis #1 – Structural System

Structural - Breadth Topic #1

Recommendation: Replace the glulam structural system in the natatorium with a concrete and steel system

- Save over $600,000
- Eliminate problematic connection
- Maintain durability
- No change to construction duration

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Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Problem:
Owner was persuaded to use (2) air-cooled chillers instead of a water-cooled chiller and cooling tower mechanical system

Goal:
Determine if a water-cooled chiller and cooling tower system should have been used instead of an air-cooled chiller system.

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Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Design Criteria:

Chiller:
- Capacity: 276 Tons
- Entering Water Temperature: 56d F
- Leaving Water Temperature: 42d F
- Flow Rate: 240 GPM

Cooling Tower:
- Leaving Water Temperature: 95d F
- Entering Water Temperature: 85d F
- Flow Rate: 3 GPM/Ton = 828 GPM

General:
- Dry Bulb Temp: 92d F
- Wet Bulb Temp: 77d F

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Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Cost Analysis:

New System Costs

Item	Cost	Source
Cooling Tower - Material	$30,171	Chesapeake Systems
Cooling Tower – Labor	$2,650	RS Means
Additional Pumps & Piping (Labor and Material)	$26,082	RS Means
Water-Cooled Chiller (Material)	$93,840	Boland-Trane
Water-Cooled Chiller (Labor)	$11,700	RS Means
Additional Structural Support for Cooling Towers (Labor & Material)	$15,557	Estimate from Southland
Total Cost for Proposed System (Labor & Material)	$180,000	

Systems Cost Comparison

Item	Cost
Old System Cost	$228,523
Proposed System Cost	$180,000
Construction Cost Savings with Proposed System	**$48,523**

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Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Energy Costs:

Old System – (2) Air Cooled Chillers at 1.3 KW/Ton each
Energy Usage = 2 X 1.3 KW/Ton X 138 Tons = 358 KW

New System – (1) Water Cooled Chiller at 0.667 KW/Ton
(1) Cooling Tower at 0.879 KW/Ton

Chiller Energy Usage = 0.667 KW/Ton X 276 Tons = 184 KW
Cooling Tower Energy Usage = 0.879 KW/Ton X 276 Tons = 243 KW
Total Energy Usage = 427 KW

Total Additional Energy Costs** with Proposed System: 427 KW – 358 KW = 69 KW

Energy Added Costs**: 69 KW X 24 Hours X $0.1/KWHr = $165.6/Day Additional Cost

**This is assuming 100% load all day

Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Payback Period:

- 293 days operating 24 hours/day at full load
- System would likely not be run at full load, much less all day
- Additional energy adjustments required

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Analysis #2 – Mechanical System

Mechanical – Breadth Topic #2

Recommendation: Selection of an ideal system would require additional research on energy costs.

- Save $48, 523 in construction costs
- Increase energy costs
- Have no effect on the duration of construction
- Additional construction considerations

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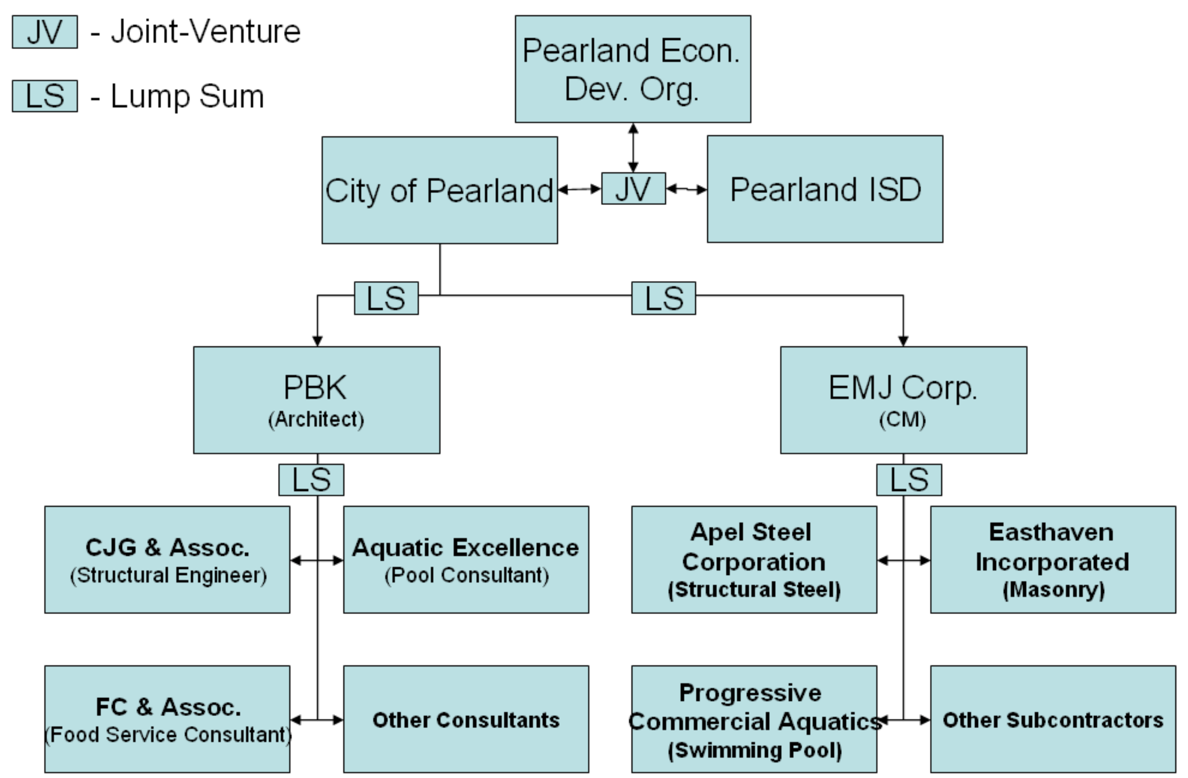
Analysis #3 – Project Delivery

MAE Focus Topic

Problem:
Design-Bid-Build delivery methods frequently result in adversarial relationships between project team members.

Goal:
Determine when it is best to use a Design-Bid-Build delivery method.

Project Team:



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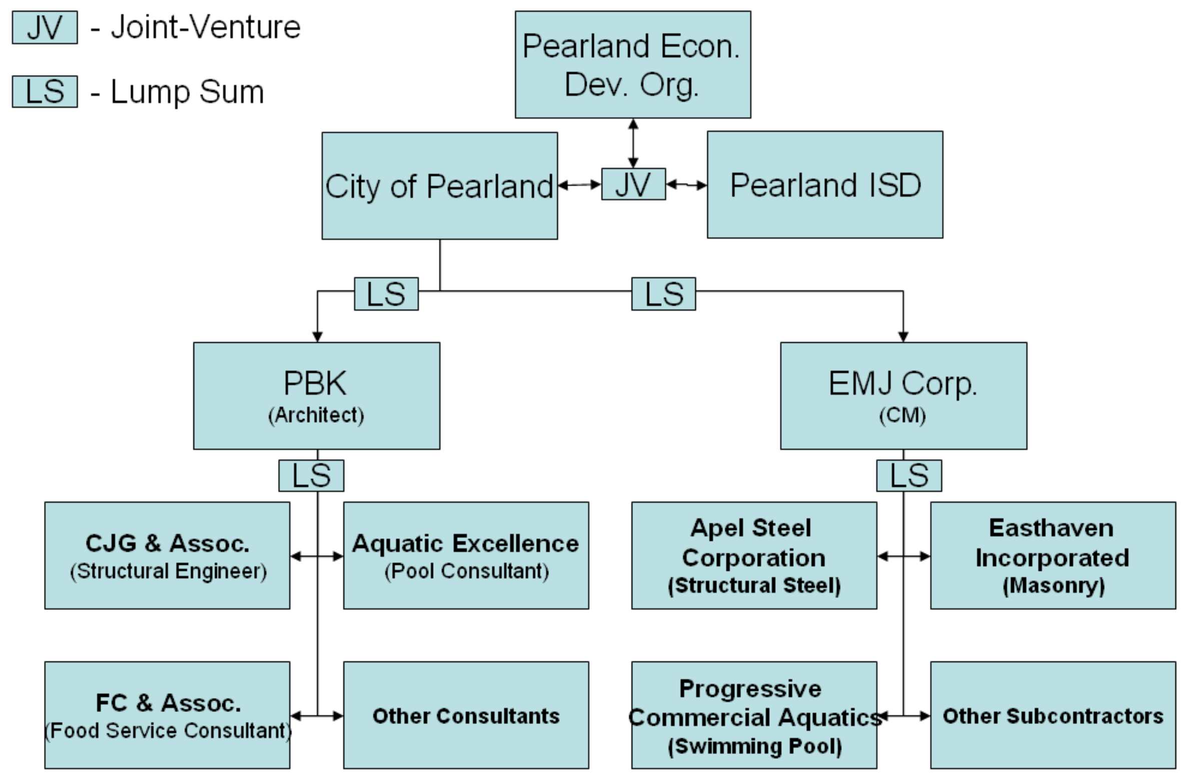
Analysis #3 – Project Delivery

MAE Focus Topic

Analysis Process:

- Issued questionnaires
- Interviewed select team members
- Interviewed project team members from similar projects using different delivery methods.

Project Team:



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Analysis #3 – Project Delivery

MAE Focus Topic

Project Comparison:

Recreation Center and Natatorium (DBB):

- Financial risk. – **Pro**
- Better Design– **Pro**
- Cost and Schedule were managed – **Pro**
- Long Construction Duration– **Con**

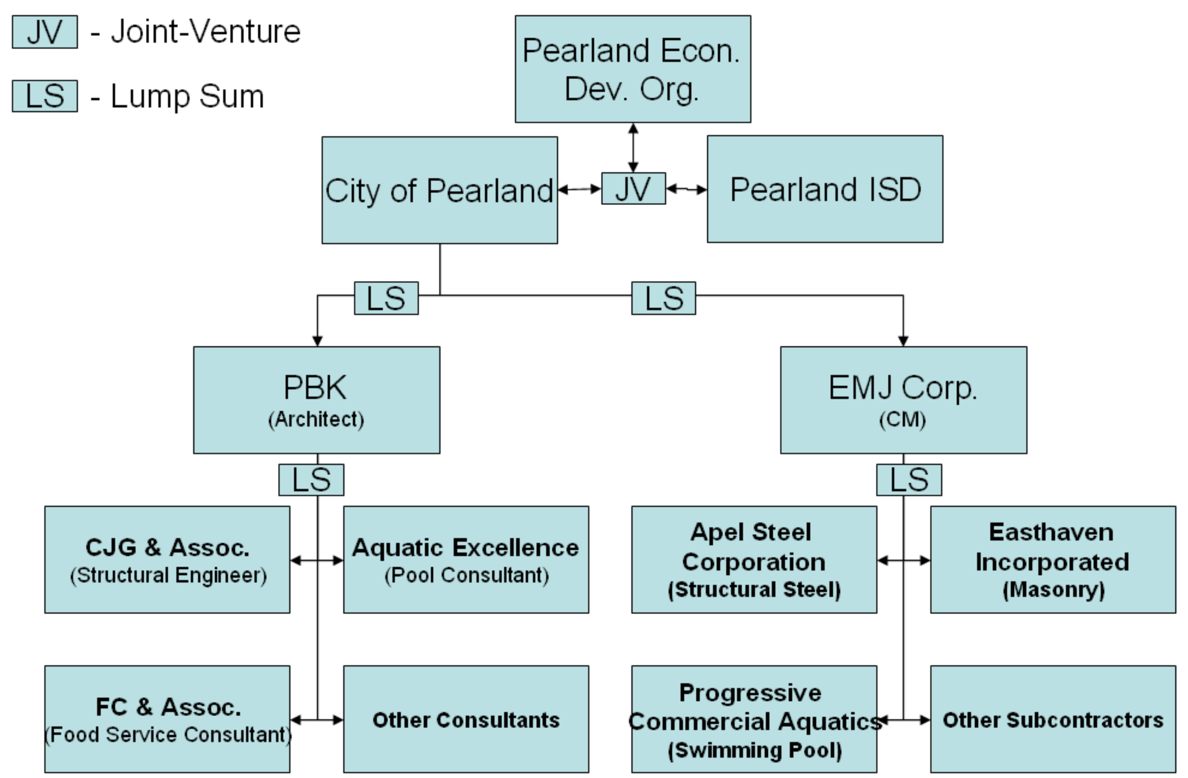
In Summary: Quality, on budget project with longer construction duration.

Public Safety Building (DB):

- Owner bears financial responsibility– **Con**
- Design falls behind– **Con**
- Short construction duration - **Pro**

In Summary: A quickly constructed building, lacking in quality and resulting in cost overruns

Project Team:



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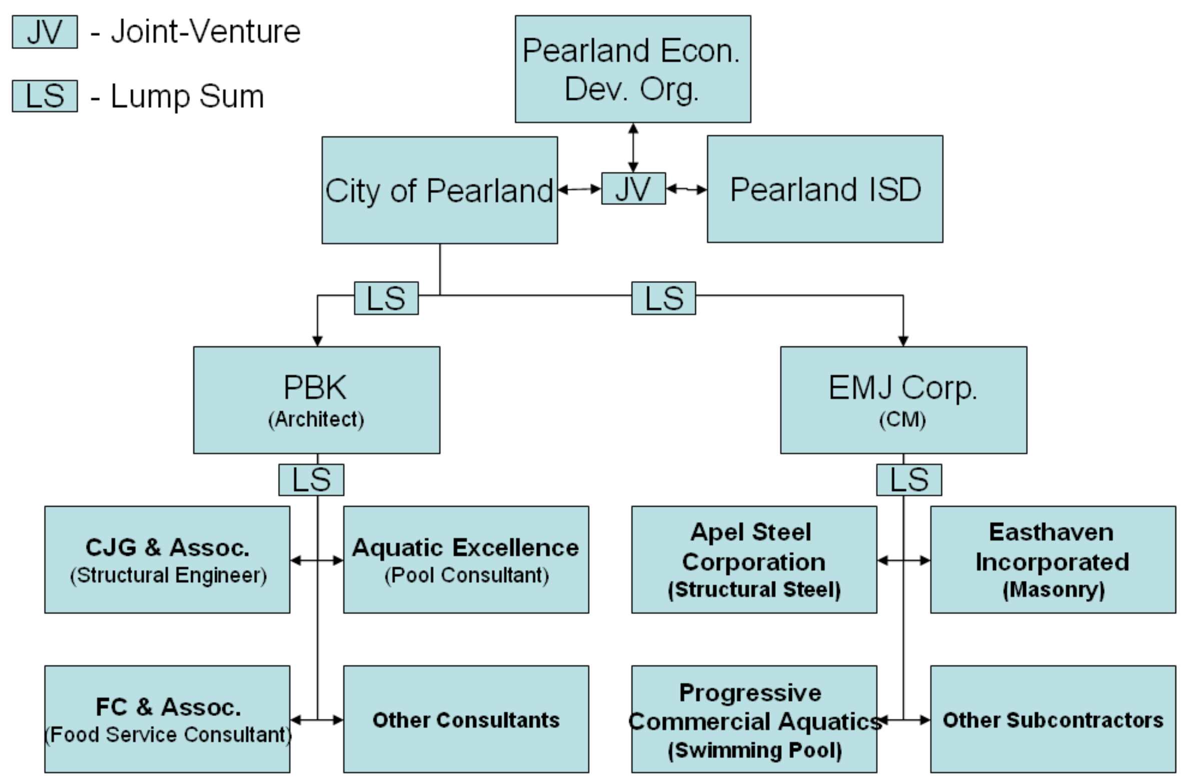
Analysis #3 – Project Delivery

MAE Focus Topic

Recommendation: Use a Design-Bid-Build delivery method for public projects!

- For a public project the owner's number one priority is to be a good steward of taxpayer's monies.
- DBB efficiently allocates financial risk away from the owner.

Project Team:



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Analysis #3 – Project Delivery

MAE Focus Topic

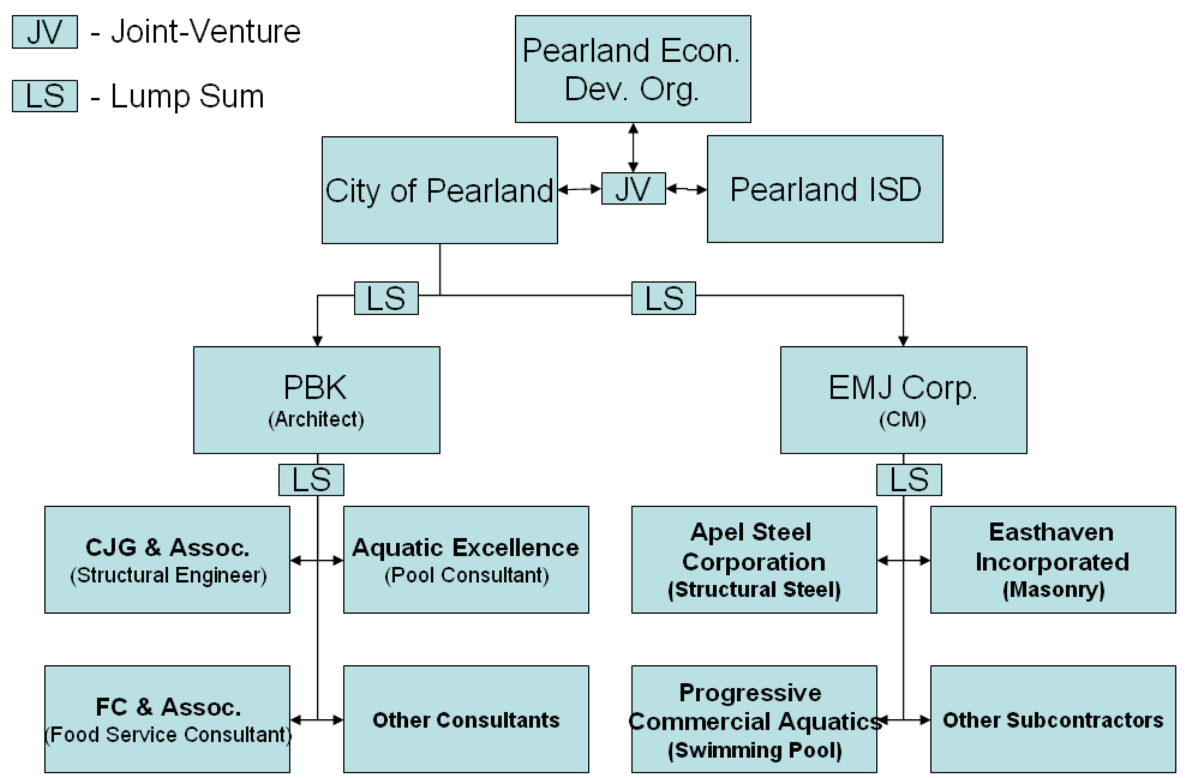
MAE Course Applications:

AE 572 – Project Development and Delivery Planning:
- Delivery Methods
- Contracting Methods

AE 597I – CII Best Practices
- Pre-project planning
- Change Management
- Equitable Risk Allocation

CE 531 – Legal Aspects of Engineering and Construction
- Risk Allocation
- Contract Interpretation

Project Team:



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Analysis #4 – Glulam Connection

Problem:
A bolted connection between the glulam columns and the concrete footers in the natatorium proved difficult during erection.

Goal:
Determine the feasibility of using a welded connection in place of a bolted connection between the glulam columns and concrete footers in the natatorium.

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Analysis #4 – Glulam Connection

Design Analysis:

Steel contact area with (12) 1" diameter anchor bolts:

12 X 3.14 X (.5")^2 = 9.42in^2

Quantity of 1/8" weld required to obtain equivalent strength:

9.42in^2 / (1/8") = 75.36" of 1/8" weld

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Analysis #4 – Glulam Connection

Cost Analysis:

The costs associated with using a welded connection are equivalent to the cost of a bolted connection.

Schedule Analysis:

Assuming 60" of 1/8" weld can be performed per hour, each connection would take 1.25 hours and with 28 connections a total of 35 man-hours of welding would be added. This addition is small enough that it can be neglected

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Analysis #4 – Glulam Connection

Recommendation: Use a welded connection in place of a bolted connection.

- Have no effect on construction cost
- Not change the construction duration
- Simplify erection of the glulam columns

Conclusions and Recommendations

Analysis #1 – Structural Modification:

Use a Concrete & Steel System

- $600,000 cost savings
- No change in durability
- No change in construction duration

Analysis #2 – Mechanical Modification

More research on energy costs required to determine ideal system

- $48,500 construction cost savings
- No change in construction duration
- Higher energy costs



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Conclusions and Recommendations

Analysis #3 – Project Delivery Method

Use Design-Bid-Build delivery method for public projects

- Owner wants to avoid financial risk on public projects
- Design-Bid-Build efficiently allocates risk away from owners

Analysis #4 – Glulam Column Connection

Use a welded connection instead of a bolted connection

- Easier to construct
- No effect on cost
- No change in construction duration


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Acknowledgments and Questions

Questions?

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