Farquhar Park Aquatic Center

York, PA

Thesis Proposal

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Structural Option

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Executive Summary

The Farquhar Park Aquatic Center is a 37,000 square foot natatorium complex that serves the YMCA of York and York County. Located in York, Pennsylvania, the entire facility consists of a 53-foot high natatorium, a 12-foot deep indoor swimming pool, a 3,600 square foot single story masonry bath house, and a large outdoor swimming pool.
The original design of the natatorium was never constructed due to cost and budget concerns and a pre-engineered structure was built instead.

The current structural system of the original design for the Farquhar Park Aquatic Center natatorium is composed of curved, triangular shaped steel HSS trusses with tapered columns that span 130'-0" over the indoor pool area. The proposed thesis will include a redesign of the entire roof structural system, which will have strong architectural impacts as well. New truss configurations will be designed using a king post truss system, wood trusses or glulam members, and a modified space frame. After the proposed truss systems are designed, they will be compared in terms of cost, feasibility, and architectural impact and a final design will be chosen. In the event that the new trusses only take gravity loads, a new lateral force resisting system composed of perimeter steel braced frames will be designed. It will be crucial to ensure that lateral loads applied to the roof actually get transferred to these perimeter braced frames. In addition, the existing concourse level floor system, balcony, and grandstand seating area will be redesigned as an entirely precast structure. Nitterhouse Concrete Products, Inc. will be contacted to investigate the feasibility and design of this precast system. Also, the current steel HSS columns that support the east end of the large trusses will be redesigned as concrete columns. Concrete moment frames may also be used to replace the existing steel braced frames at the grandstand seating area in the North/South direction. A final foundation check will be performed to verify that the existing foundation can adequately carry all loads present with the proposed system.

An architectural depth will be studied due to the introduction of a new truss system into the indoor pool area. Changes in building height and in the shape of the roof will be investigated, as well as effects on the lighting of the space. The overall appearance of the building, both internally and externally, will be affected by each new truss design. Plus, room layouts may need to change due to changes in column locations. A second breadth topic will relate to an analysis of the building enclosure. Material covered in AE 542 (Building Enclosures) will be used to investigate how the design of the building accounts for moisture-related and thermal-related problems due to the fact that the building is a natatorium. The MAE course-related topic will be a continuation of the building enclosure analysis by including information addressed in AE 537 concerning moisture-related problems with buildings. Necessary changes to building elements to account for these problems will also be made. Extensive use of AE 597A (Computer Modeling) will also be necessary to model the proposed trusses and proposed lateral force resisting systems in SAP2000. If time permits, an alternative seismic analysis will be performed by moving the natatorium to a high-seismic zone and analyzing the effects of the higher seismic forces on the structure. This will be supplemented by a redesign of the steel connections of the moment frame in the lobby for these loads, time permitting.

Building Design Summary

The Farquhar Park Aquatic Center is a 37,000 square foot multi-level, state-of-the-art natatorium complex designed by Nutec Design Associates, Inc., a full-service architectural and engineering firm located in York, PA. The facility is located in the city of York and features a 53-foot high natatorium with raised seating, a 12-foot deep indoor swimming pool with diving platforms, a 3,600 square foot single story masonry bath house, and a large outdoor swimming pool, as can be seen in Figure 1. The complex was intended to be used by the YMCA of York, but the original design was never constructed due to cost and budget concerns. The natatorium contains an entry level, a concourse level, and a gallery level. The main entrance opens up into an expansive 24-foot high lobby than spans from one end of the building to the other. The lobby provides access to concessions, men's and women's toilets, and corridors that connect the main lobby to the indoor swimming pool area. The entry level also contains men's and women's lockers and showers, a team room, offices, storage rooms, timer room, utility room, dish room, and trophy display case.

Figure 1 – Arial View of Natatorium Complex

Concrete stairs near the main entrance lead up to the concourse level which houses a mechanical room and a team store. A long precast concrete ramp also connects the ground floor to the second floor. The floor of the concourse level sits about 10 ½' above the ground level and consists of 12" precast hollow core concrete planks, as can be seen in Figure 2. Visitors can overlook the lobby below behind a 3 ½' guardrail. A precast L-shaped concrete balcony spans the entire length of the pool and provides access to the grandstand seating area.

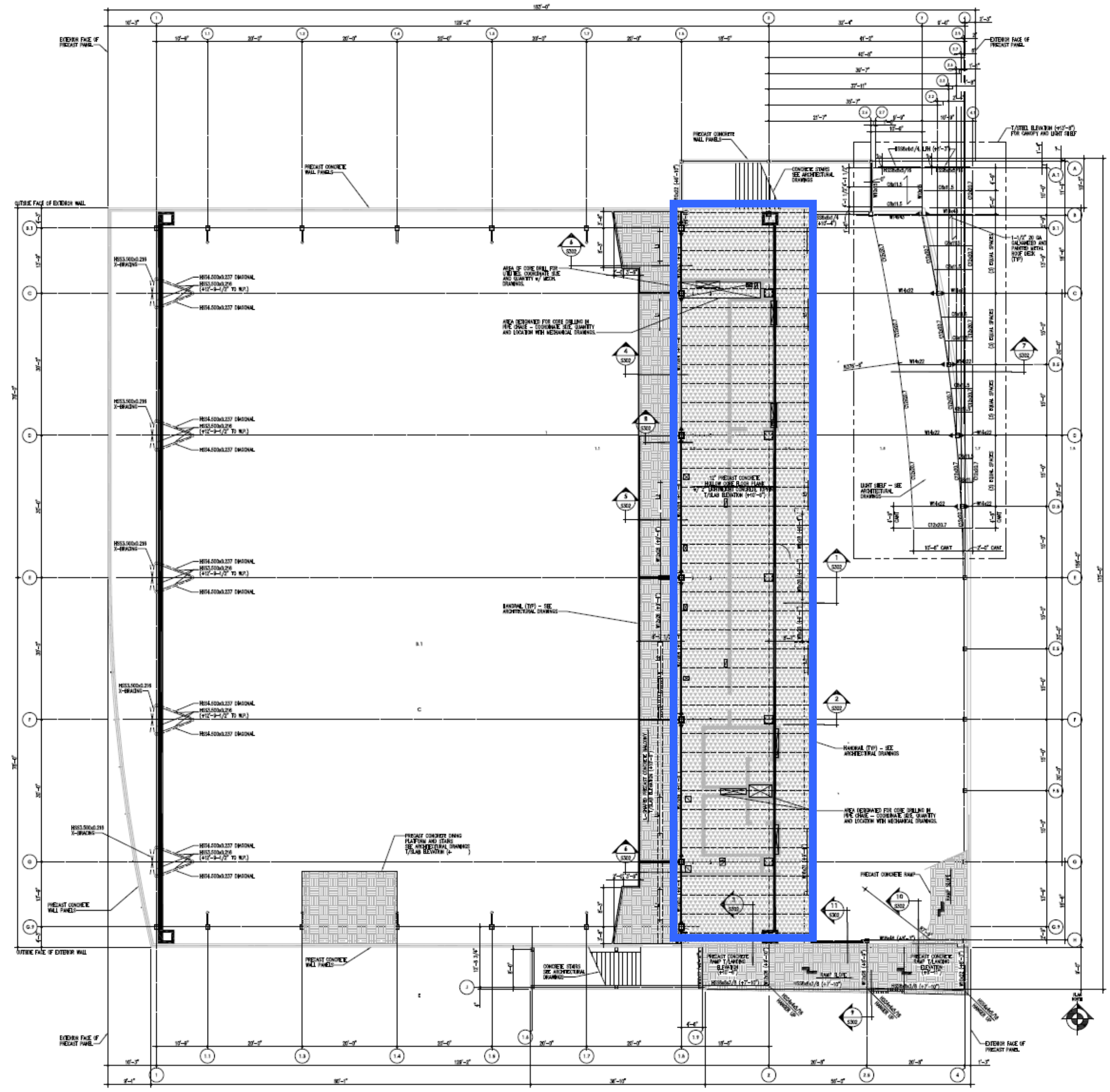


Figure 2 - Concourse Level Framing Plan (12” precast concrete hollow core floor planks are shown in blue – they span 27’-0” and run almost the entire length of the building)

The natatorium’s curved roof spans about 130’0” and is supported by large trusses, creating a very open space. The lower roof above the lobby sits about 14’ below the lowest point of the curved roof and contains most of the mechanical units. Trusses spaced at 15’-0” on-center support the roof and units. The east-facing and west-facing exterior walls of the natatorium are both slightly curved. At each end of the indoor swimming pool area is a large, curved glazed aluminum curtain wall made of Solera-T glazing. These two curtain walls are each 123’-11” long, 21’-0” tall at their highest points, and 8’-0” tall at their shortest points. Precast concrete panels are primarily used as the façade along with a mix of metal wall panels and glazed curtain walls, as can be seen in Figure 3.

Nutec Design Associates designed the facility to comply with certain LEED credits for the project to achieve LEED Silver Certification. Thermal shading effects were provided by a façade plant climbing system that helped to reduce indoor air temperatures. Another green feature was the natural daylighting provided by the large glass curtain walls enclosing the indoor swimming pool area. Other requirements were related to certain materials and ensuring that they are environmentally friendly.

Figure 3 – View of Main Entrance of Natatorium (showing precast concrete panels, metal wall panels, and glazed curtain walls)

Structural System Overview

Foundation

The geotechnical evaluation was performed by GTS Technologies, Inc. on September 30, 2005. The study included five boring tests, only one of which hit water and revealed a water level 12’-0” below existing site grades. The recommended allowable bearing pressure from GTS Technologies for compacted structural fill was 2500 psi. A shallow foundation system consisting of isolated spread footings at various depths was used. Most of the foundations were located about 2’-0” below finished floor elevation, however a few along the west side of the natatorium were located about 15’-0” below finished floor elevation in order to get below the pool structure. This can be seen in Figure 4. Footings range in size from 4’-6”x4’-6”x1’-0” up to 19’-0”x19’-0”x2’-0”. Larger foundations were required to handle the loads carried by the trusses spanning across the indoor pool.

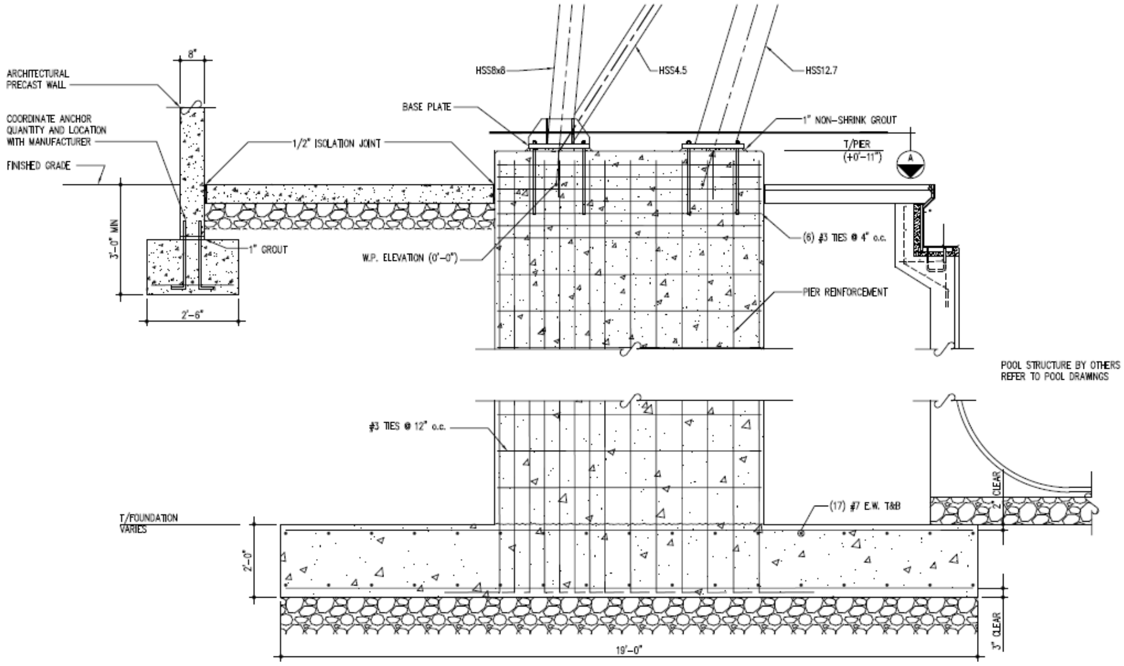


Figure 4 – Detail of Pier Supporting Large Tapered Truss Column

Concrete with a compressive strength of 4,000 psi was used for the footings. Reinforcement in the footings consists of #5, #6, and #7 bars, while reinforcement in the piers consists of #6 and #8 bars, with the #8 bars only being used in the large, deep piers supporting the tapered truss columns. A typical pier detail is shown in Figure 5. Strip footings were 2’-6” wide for interior walls and 2’-0” wide for exterior walls. Geotechnical reports indicate that exterior footings shall be embedded a minimum of 36 inches below final grade for frost protection. Foundations were to be placed on a geotextile layer to minimize the loss of aggregate materials into the subgrade. Due to the proximity of Willis Creek Run and the fact that water was found in one boring test, the geotechnical report suggests that the bottom layer of the pool slab be designed to include a 12-inch No. 57 aggregate drainage layer and pressure release valves to prevent potential floatation due to ground water when the pool is drained.

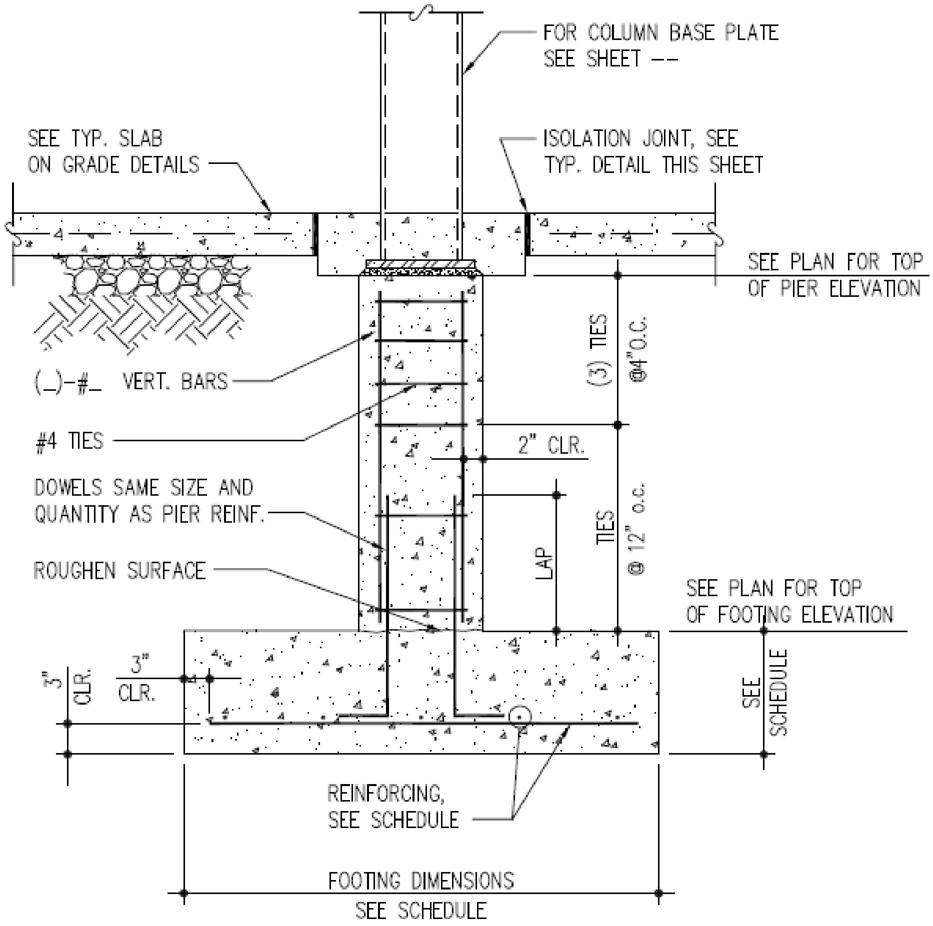


Figure 5 – Typical Pier Detail

Superstructure

The ground floor consists of a 4” concrete slab-on-grade with 6x6 W2.0xW2.0 W.W.F. on 4” crushed stone base and a compressive strength of 4,000 psi. The concession area sits on a recessed concrete slab, and a portion of the floor slab near the pool structure becomes 8” thick with #4 bars at 12” on-center L.W. and #5 bars at 12” on-center S.W. HSS columns in the lobby run along the east wall and support the roof trusses above the lobby. The entry level also contains 12” CMU walls with #5 bars at 32” on-center that are grouted solid full height. These walls enclose parts of the bathrooms, locker rooms, offices, team room, storage rooms, and utility room and are located beneath the grandstand seating area. A floor plan of the entry level is shown in Figure 6. Precast concrete columns help support the 8” precast concrete ramp that runs from the ground floor up to the concourse level. The ramp is also supported by W-shape beams, HSS columns, and hangers.

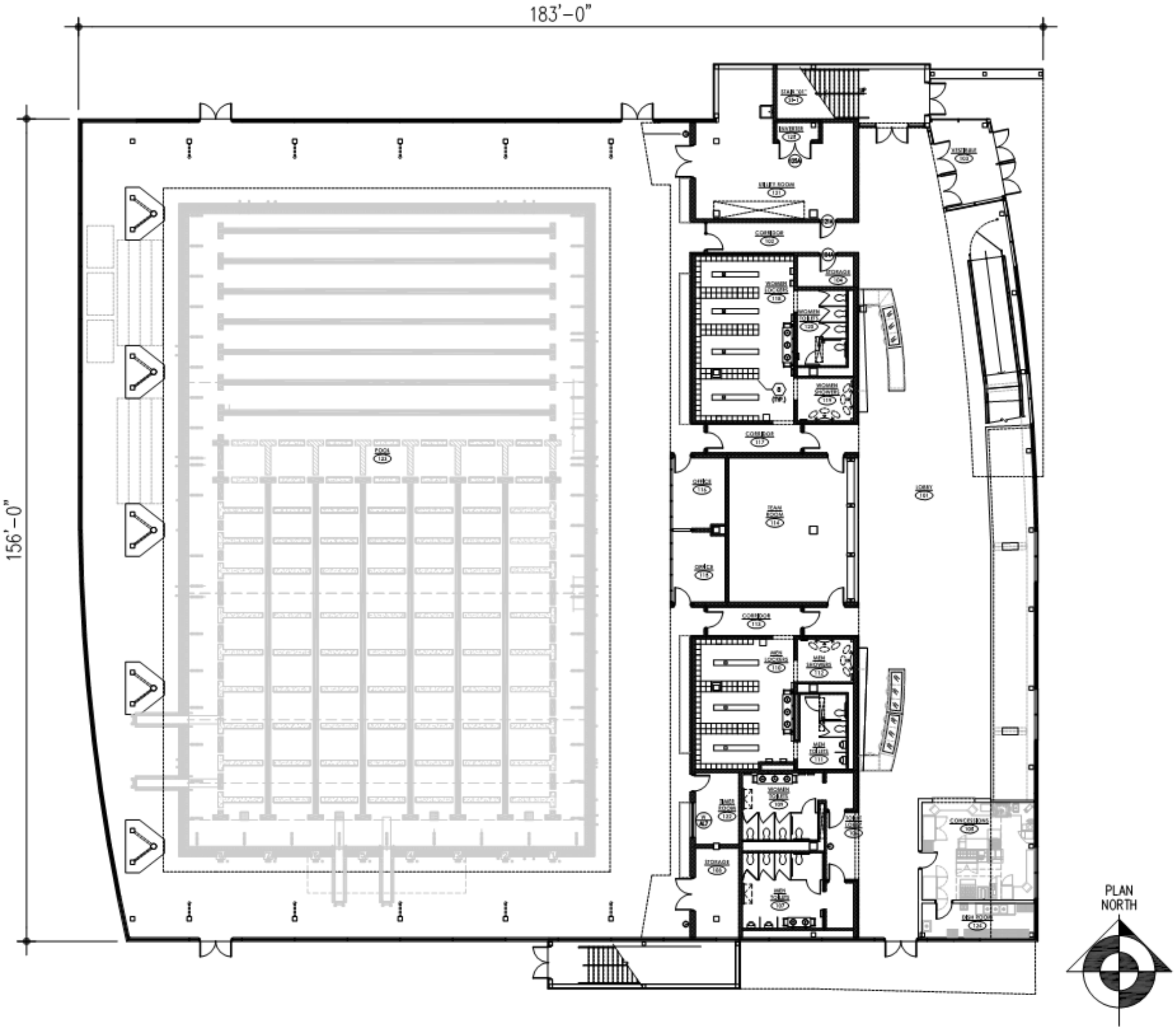


Figure 6 – Entry Level Floor Plan

Triangular HSS trusses spanning 130’-0” support the large curved roof above the indoor swimming pool area and are shown in Figure 7. The columns for these trusses are triangular, tapered, and spaced 30’-0” on center. Both the trusses and the supporting columns are made up of HSS members. Long span deck was used to span between the trusses. The other ends of the large trusses are supported by HSS18x18x5/8 columns. HSS wind column trusses run along the north and south walls in the indoor pool area as well. The trusses are 3’-0” deep and vary in height with the tallest at 51’-2 ¼” above finished floor elevation. The wind column trusses connect into the main roof diaphragm. The rest of the high roof framing primarily consists of HSS6x6 and HSS8x8 members.

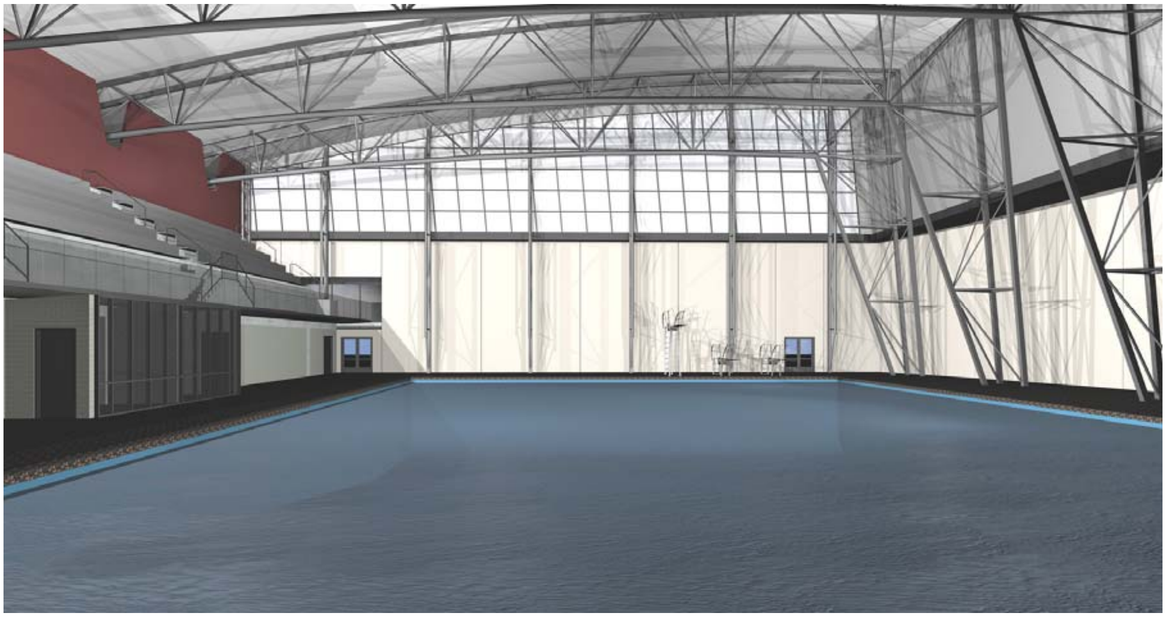


Figure 7 – Rendering of Indoor Pool Area Showing Large Curved Trusses

The precast concrete grandstand seating area that runs from the concourse level to the gallery level is supported by sloped W27x94 beams that frame into the HSS18x18x5/8 members that also support the large curved trusses. The floor system of the concourse level consists of 12” precast concrete hollow core floor planks with 2” lightweight concrete topping, as is shown in Figure 8. Top of slab elevation is 10’-6”. The precast concrete balcony is supported by a 12” CMU wall, and additional strength is provided by a 12” bond beam with two continuous #5 bars. A canopy and light shelf near the main entrance and lobby are slightly higher than the concourse level and are supported by cantilevered W14x22 and W14x43 beams. Additional framing is provided by C8x11.5 beams and curved C12x20.7 beams. Moment connections allow the W14 beams to cantilever from the supporting HSS10x10 columns.

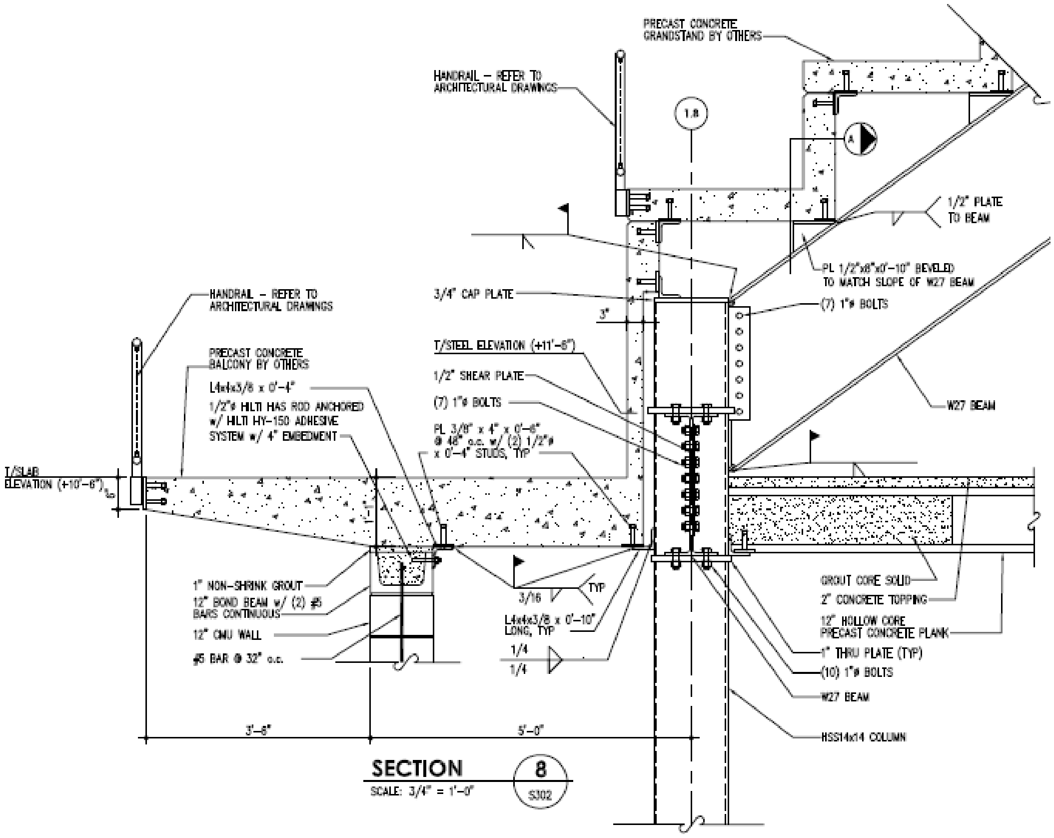


Figure 8 – Section Showing the 12" Hollow Core Precast Concrete Planks, the Precast Concrete Balcony, and the W27x94 Beams Supporting the Concrete Grandstand

The gallery level has HSS roof trusses spanning about 41'-0" and spaced 15'-0" on center (and 2'-5" deep) supporting 6" 18 GA acoustical long span metal roof deck with 18 GA perforated cover and polyencapsulated acoustical batt insulation. The trusses are 2'-5" deep, slightly sloped, and also support the mechanical unit framing above. The top of steel elevation for the mechanical unit support framing is 28'-0", and the framing consists of W8, W10, and C8 beams.

Lateral System

The large truss columns and mezzanine moment frame take the lateral load in the East/West direction, while the braced tapered truss columns, a braced frame between the pool and lobby, and a steel moment frame at the east side of the lobby handle the lateral load in the North/South direction. Seismic loads due to the concourse level floor system and precast concrete balcony are resisted by another steel moment frame. Some of this seismic load goes into the CMU walls as well, but the steel moment frame provides most of the lateral support. The wind columns are designed to simply take the wind force in the North/South direction and transfer it to the roof diaphragm. A mezzanine level framing plan is shown in Figure 9, and a roof framing plan is shown in Figure 10. The wind columns transfer roughly half the load to the ground or base connection and the other half of the load to the high roof diaphragm. The roof diaphragm transfers the load to the large trusses over the indoor pool, which in turn sends part of the load to the five braced tapered truss columns and the rest of the load to the braced frame between the pool and lobby. The large truss columns are laterally braced by HSS3.500x0.216 X-bracing. The two chords of the truss columns are offset by four feet at the base, providing a rather rigid support that can handle high lateral loads. The large trusses and supporting truss columns can be seen in Figure 11, and the wind columns can be seen in Figure 12.

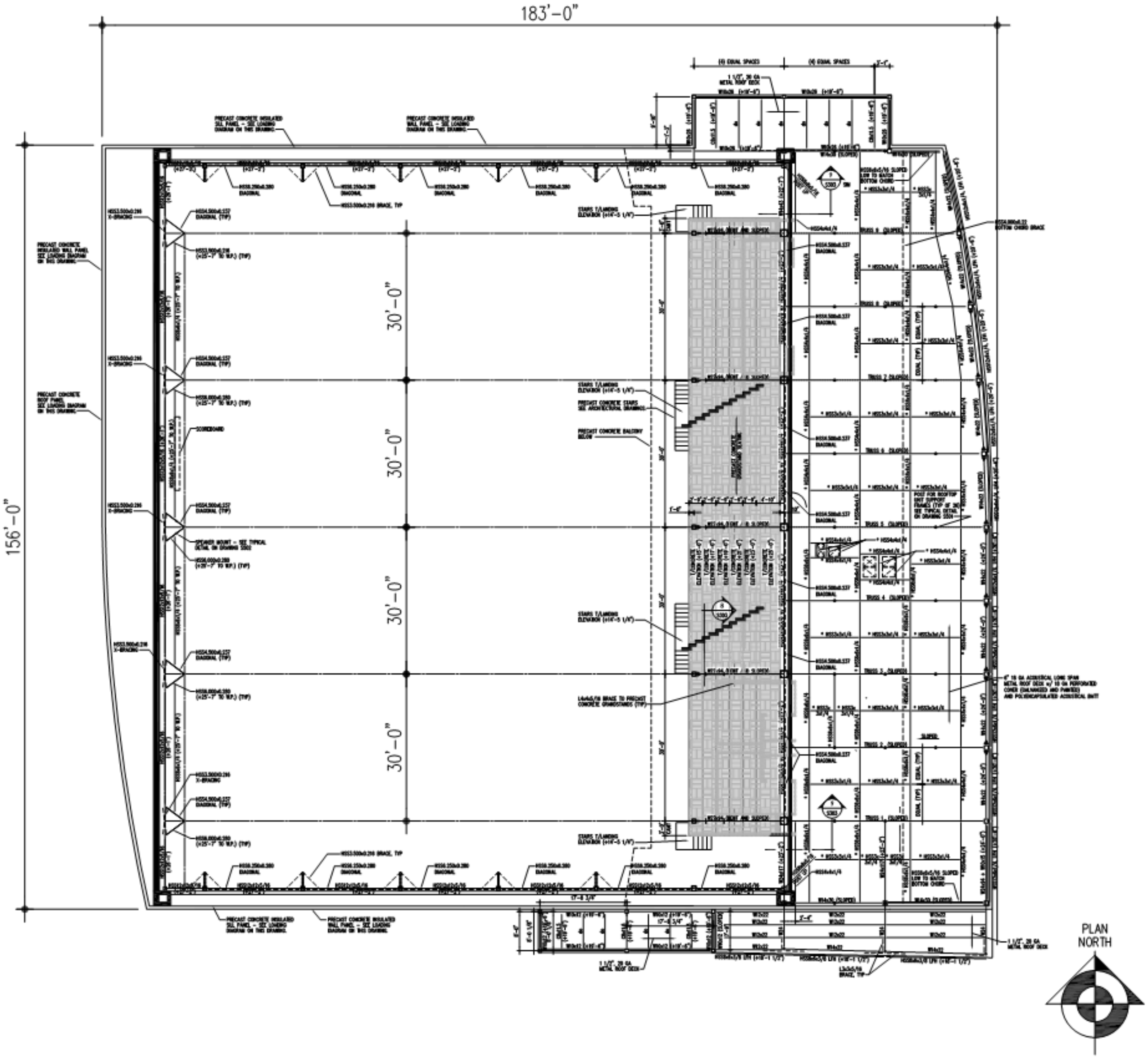


Figure 9 – Gallery/Mezzanine Level Framing Plan (the shaded portion is the grandstand seating area)

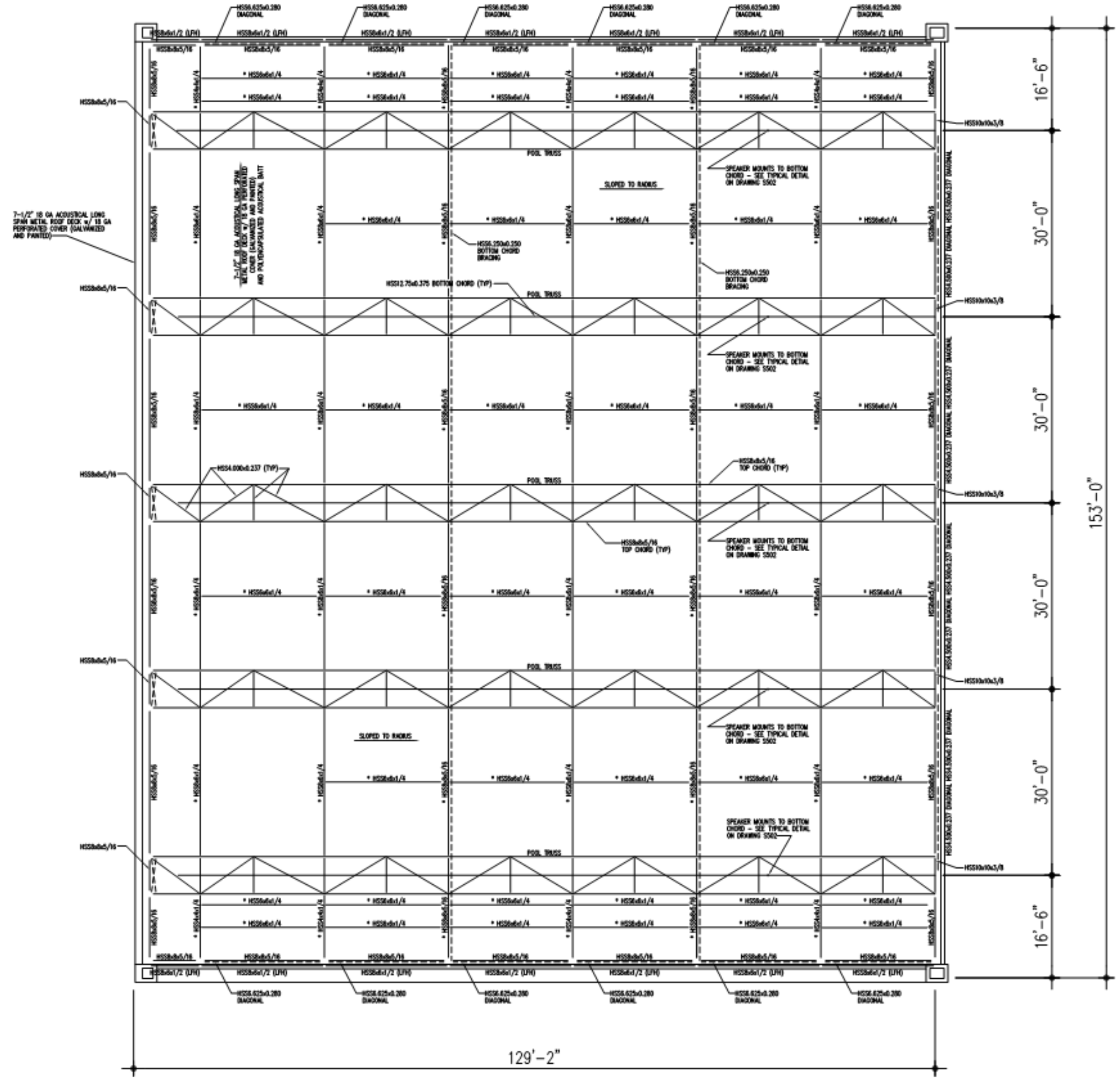


Figure 10 – Roof Framing Plan (including the five large trusses above the pool area spaced 30’-0” on center and additional framing)

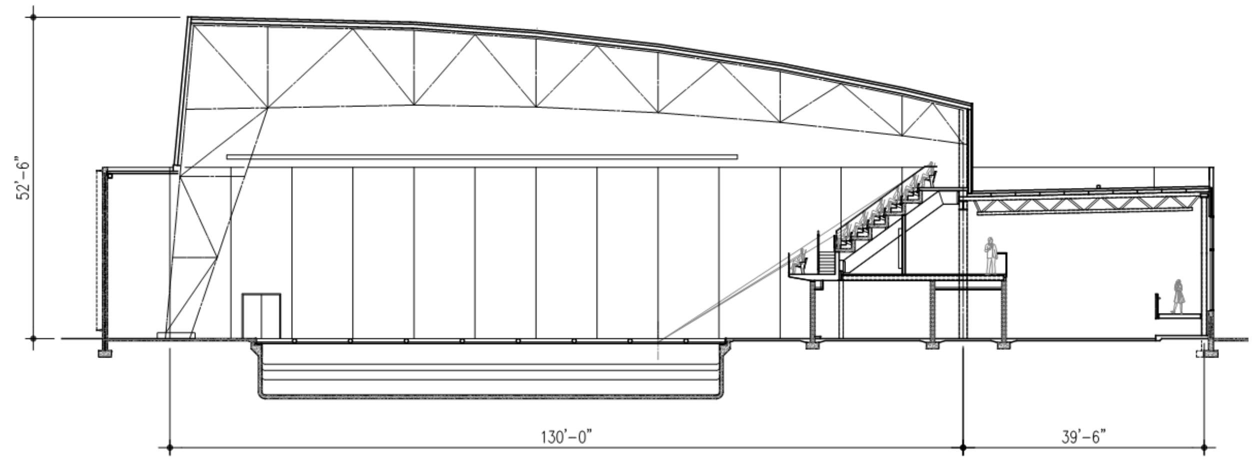


Figure 11 – Cross Section Through Center of Building (Looking North)

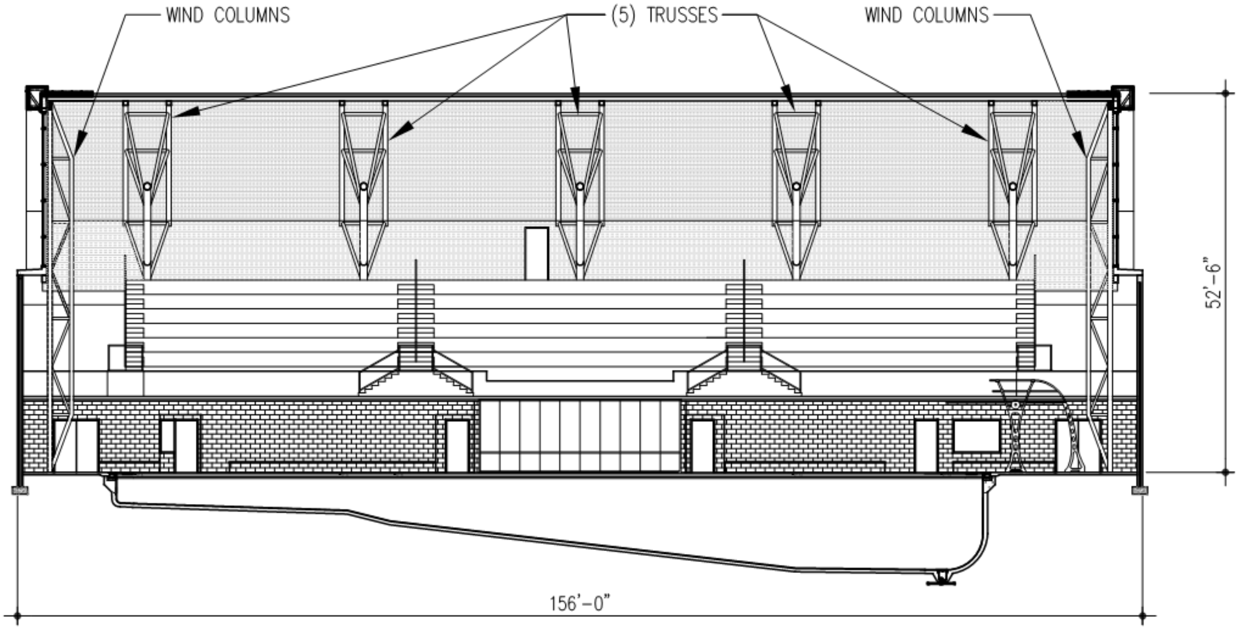


Figure 12 –Cross Section Through Indoor Pool Area Showing the Wind Columns (Looking East)

Problem Statement

The original design for the Farquhar Park Aquatic Center natatorium was over budget and hence was never constructed. The natatorium was actually built as a less expensive pre-engineered building that better met the financial needs of the YMCA. Although the original structural system that was proposed was fancy, it is evident that it did not work for the purpose of the project. A YMCA is focused on providing for the community; therefore it did not really make sense to design a structurally complicated, expensive building for the natatorium complex. Money spent by the YMCA should be spent on the people, not on an overly-extravagant building (particularly in a place like York, PA). The overall goal of this thesis is to investigate potential solutions for the design of the natatorium that provide a "happy medium" in between the original design and the building that was finally constructed. The final design will attempt to incorporate alternative structural systems while still maintaining the architectural integrity of the original design.

Proposed Solution

Currently, the roof over the indoor pool area is supported by five large triangular shaped steel trusses with tapered columns. Each truss spans about 130'-0" and provides gravity resistance as well as lateral resistance both parallel to the span of the truss and perpendicular to the span of the truss. Three alternative systems for the trusses will be investigated:

Alternative #1:	King-post truss system
Alternative #2:	Wood truss system or glulam members
Alternative #3:	Steel space frame

Designs for each system will be sketched and then modeled in SAP2000. Gravity loads will be applied to each truss and every member of the trusses will be designed. The three alternative systems will be compared in terms of cost, feasibility, and architectural impact to determine which is the most efficient and economical solution. In the event that the proposed trusses only take gravity loads, the design of a new lateral system will be required. New perimeter braced frames will be designed to take lateral forces, and the entire roof diaphragm will be designed to ensure that all lateral forces at the roof actually do get transferred to the outside braced frames. A foundation analysis will also be performed to determine whether the existing foundations can carry the new loading or if a new foundation design is required.

In addition, the existing concourse level floor system is composed of 12" precast concrete hollow core planks along with a separate precast balcony. Steel HSS columns and bent and sloped W27 beams support the precast concrete grandstand seating above. In regards to this area, an investigation will be performed to determine whether the floor system and grandstand seating area can be designed as a completely precast concrete structure. The steel HSS columns will be redesigned as concrete columns, and a concrete moment frame will most likely need to be designed to replace the steel braced frame in this area in the North/South direction. Use of ACI 318-08 will be necessary for these designs. Collaboration with Nitterhouse Concrete Products, Inc. will be attempted in order to determine the feasibility of using an entirely precast system and to help develop a design for the precast system.

Solution Method

Common truss designs and roof systems used in natatoriums will be researched, focusing in particular on king post trusses, wood trusses or glulam members, and modified space frames. Sketches of design ideas for each proposed system will then be created, taking into account the architectural impacts of each design as well. Each proposed system will also be investigated in terms of feasibility for the given span of 130’-0”, and the required spacing for each truss system will be estimated for the design of the entire roof system. Dead loads and live loads will be determined using ASCE 7-05. The appropriate gravity loads will then be applied to each truss based on tributary area, and load distribution to columns and other supporting members will be determined for initial estimation purposes. Hand calculation methods for spot checks of each proposed truss type will then be researched. After the shape of each proposed truss has been designed, a model for each truss system will be created using SAP2000. Each new truss system will be analyzed by applying the appropriate gravity loads to the models and determining the internal forces in each member. Every member of each proposed system will then be designed by hand. The AISC Manual of Steel Construction will be used to design steel members, and the 2005 National Design Specification for Wood Construction will be used to design wood members. Finally, the proposed truss type that works best for the project both structurally and architecturally will be determined. A cost analysis for each new system will be performed, and the architectural impacts, as well as impacts on other building systems, of each truss design will be evaluated.

Once a new truss system has been chosen, the weight of the building will need to be updated. Seismic forces will then be recalculated using ASCE 7-05 with the updated building weight. Wind loads will also need to be verified or recalculated using ASCE 7-05 accounting for any changes in building height or shape. Sketches of design ideas for the proposed braced frames will then be created, and confirmation that the roof diaphragm can actually transfer the roof lateral loads to the perimeter braced frames will be necessary. New braced frames will mostly likely be required in the North/South direction as well along the west side of the pool in between the tapered truss columns since the new trusses may be designed as gravity-only elements. Then, the appropriate lateral loads will be distributed to the new perimeter braced frames in the East/West direction and North/South direction. Next, SAP2000 will be used to the model the frames, and appropriate lateral loads will be applied. Member internal forces will then be determined from SAP2000, and each member of each braced frame will be sized by hand calculations. The AISC Manual of Steel Construction will be used for the design of the steel braced frames.

Dead loads and live loads applied to the concourse level floor system and grandstand seating area will be determined in accordance with ASCE 7-05. Nitterhouse Concrete Products, Inc. will be contacted in order to investigate the possibility of redesigning the concourse level floor system and grandstand as an entirely precast concrete system. Nitterhouse is located very close to York, PA, and the company provided the 12” precast hollow core floor planks for the original design. Nitterhouse will most likely be helpful with the design of a completely precast system for this area of the natatorium as well. Loads applied to each column will be determined based on tributary area including the self weight of the new proposed precast concrete system. Concrete columns will then be designed, and concrete moment frames may be used to replace the existing steel braced frames in the North/South direction at the grandstand area. Finally, a foundation system check will be performed to determine if the existing foundation can adequately carry all loads present with the proposed system or if a new foundation design will be required.

Breadth Studies

Breadth Topic 1 - Architectural

The incorporation of a different roof structural system over the indoor pool area will have a significant impact on the architecture of the building. Reshaping of the roof due to different truss configurations will change the appearance of the building both internally and externally. The visual effects of each proposed truss configuration will be investigated to help determine which truss system will work best for the project. Visits to the natatorium on campus, as well as the natatorium that was actually built for this project, will be performed to help get a feel for whether or not visitors really notice the roof structural system when they walk into a typical natatorium building. If the general public does not get an awe-inspiring feeling when they walk into the space, then this will support the possibility of using a more cost-effective solution for the truss system than that of the original design. Basically, this will investigate whether or not people really care what the roof structural system looks like inside the building. Changes in building height will also affect the interior lighting of the natatorium. An investigation into using various types of lights to better accommodate a higher roof may need to be implemented. In addition, if the large glazed curtain walls enclosing the indoor pool area are resized or reshaped, the amount of daylight entering the space will be affected. A room layout study will also be necessary if truss locations and the corresponding column locations vary from the original design. The steel HSS columns supporting the eastern side of the large trusses pass through some of the rooms on the ground floor. Any movement of columns will affect the way the space in each room works. Overall, an attempt will be made to keep a pleasant appearance from outside the building while better meeting the needs of the client from the inside.

Breadth Topic 2 – Building Enclosure

What makes this building unique is the fact that it is a natatorium. Natatoriums are often difficult to design due to the inherent problems related to moisture and thermal effects. Therefore, it was deemed necessary to perform an analysis on the existing system and proposed systems to determine whether the façade and other building elements were properly designed to accommodate any moisture-related or thermal-related issues. Use of AE 542 (Building Enclosures) will be necessary for this analysis.

Due to extremely high moisture levels, natatoriums are often susceptible to problems including corrosion of interior elements, condensation within walls and roofs, and condensation on interior surfaces. Keeping the interior warm is of utmost importance, and high R-values for walls and roofs are therefore essential. Building elements must be designed for high humidity, and windows, curtain walls, and doors need to be high-performance. Condensation resistance of curtains walls and windows will be evaluated, and methods of heating window components to eliminate condensation problems will be investigated. Wall details will be analyzed to determine whether proper design of vapor retarders was administered to prevent “vapor drive” issues. Moisture often moves from areas of high moisture content to areas of low moisture content and can diffuse through materials like concrete. The water can condense if the area gets cold enough, which can lead to efflorescence and steel corrosion. Analysis of wall details can also supplement the architectural breadth study. In addition, the corrosion resistance of interior building components will be investigated.

MAE Course-Related Study – Facade

The MAE topic will involve a continuation of the building enclosure breadth topic. Topics addressed in AE 537 (Building Failures) dealing with moisture-related problems in buildings will be applied to the analysis. Studies will focus on wall sections and proper design of walls to adhere to moisture-related issues. Necessary changes to building elements to account for these problems will also be made. In addition to AE 537, extensive use of AE 597A (Computer Modeling) will be necessary to model the proposed trusses and proposed lateral force resisting systems in SAP2000. Information from AE 534 (Steel Connections) will also be implemented for the design of connections, both for proposed truss elements and for the proposed steel braced frames. Connection design of the existing steel moment frame at the east side of the lobby will also be investigated.

If time permits, an alternative MAE topic will involve moving the building to a high seismic zone and analyzing the resulting effects that higher seismic loads would have on the building. This study will simulate the idea that the YMCA is looking at two different places to construct the natatorium and wants to compare the required natatorium design for a high seismic region with that of the original design located in York, PA. This analysis would be performed after a final truss design is selected. A redesign of the steel connections of the moment frame at the east side of the lobby to account for these loads will be performed as a supplement to the seismic analysis.

Tasks and Tools

A) Redesign of Trusses

Task 1: Research various truss types and create initial designs
  - (a) Research common truss designs/roof systems used in natatoriums besides the existing steel HSS trusses
  - (b) Investigate design methods used for king post trusses, wood trusses, glulam members, and modified space frames
  - (c) Create sketches of design ideas for each proposed system
  - (d) Determine feasibility of each system for given spans
  - (e) Estimate required spacing of trusses for design of entire roof system

Task 2: Determine loads to be applied to trusses
  - (a) Determine dead loads and live loads in accordance with ASCE 7-05
  - (b) Apply correct loads to trusses based on tributary area and determine load distribution to columns and other supporting members (based on tributary area – initial estimation of column loads)

Task 3: Research hand calculation methods for spot checks of members of each proposed truss type

Task 4: Model each proposed truss system in SAP2000

Task 5: Analysis of each truss type
  - (a) Apply appropriate gravity loads to models of each proposed truss design in SAP2000
  - (b) Determine forces in each member due to gravity loads
  - (c) Design each member of each proposed truss system
    - (i) Use 2005 NDS for wood members
    - (ii) Use AISC Manual of Steel Construction for steel members

Task 6: Determine which proposed truss type works best for the project
  - (a) Perform a cost analysis for each new truss system
  - (b) Incorporate architectural impacts (as well as impacts on other building systems) of each new truss design into evaluation
  - (c) Determine which new truss system is best suited for the natatorium

B) Lateral System

Task 7: Determine lateral loads to be applied to lateral force resisting system
  - (a) Recalculate the building weight with the new proposed trusses
  - (b) Recalculate the seismic forces with the updated building weight
  - (c) Verify/Recalculate the wind loads determined using ASCE 7-05 accounting for any changes in building height or shape

Task 8: Design of new lateral force resisting system
  - (a) In the event that the new trusses only take gravity loads, determine

lateral forces that would be distributed to new perimeter braced frames in the East/West direction and, if needed, braced frames in the North/South direction in between the new trusses

(b) Create sketches of design ideas for proposed braced frames
(c) Ensure that roof diaphragm can transfer the lateral loads to the perimeter braced frames
(d) Use SAP2000 to model the new braced frames
(e) Apply appropriate lateral forces to each braced frame
(f) Determine forces in each member
(g) Design each member of each braced frame using AISC Manual of Steel Construction

C) Redesign of Concourse Level and Grandstand Seating Area

Task 9: Determine loads to be applied to concourse level floor system and grandstand seating area

(a) Determine dead loads and live loads in accordance with ASCE 7-05

Task 10: Redesign of floor system, balcony, and grandstand seating area as an entirely precast concrete system

(a) Contact Nitterhouse Concrete Products, Inc. to investigate using an entirely precast system
(b) Work with Nitterhouse to design an entirely precast system (replacing all steel HSS columns in this area with concrete columns as well)

Task 11: Design of concrete columns

(a) Determine loads applied to columns based on tributary area (including self weight of proposed precast concrete system)
(b) Design concrete columns using ACI 318-08

Task 12: Investigate using concrete moment frames to replace the existing steel braced frames at the grandstand seating area in the North/South direction (design would require use of ACI 318-08)

D) Foundation System

Task 13: Verify that existing foundation system can adequately carry all loads present with proposed system

E) Breadth Topic 1 – Architecture

Task 14: Evaluate architectural impacts of each proposed truss system

(a) Analyze the effects each truss system imposes on the space
    (i) Changes in building height
    (ii) Changes in shape of roof
    (iii) Lighting and natural day lighting (if glazed curtain walls are resized)
    (iv) Overall appearance of the building (both internally and externally)

- (b) Determine effects of changing column locations (if any columns were relocated – perhaps due to changes in spacing of proposed trusses as compared to locations of originally designed trusses)
- (c) Incorporate architectural impacts on selection of final truss design (this overlaps with Step A: "Redesign of Trusses")

G) Breadth Topic 2 – Building Enclosure

Task 15: Determine if existing system and proposed changes are adequately designed to handle moisture-related and thermal-related problems (primarily using AE 542 – Building Enclosures)

- (a) Investigate corrosion issues on various existing and proposed building materials due to the indoor swimming pool
- (b) Effects of high levels of humidity inside
- (c) Determine if R-values for walls and roof are adequate
- (d) Condensation resistance of windows and curtain walls
- (e) Investigate "vapor drive" and proper design of vapor retarder
- (f) Proper design of wall intersections and wall-to-roof interfaces to eliminate moisture problems due to air flow

F) MAE Course-Related Study – Facade

Task 16: Continue building enclosure analysis by applying concepts learned in AE 537 concerning moisture-related problems

- (a) Wall details
- (b) Material corrosion issues

Task 17: Make any necessary changes to existing and proposed building elements to better accommodate moisture-related and thermal-related problems (both from MAE Course-Related Study and Breadth Topic 2)

Task 18: Alternative: If time permits, recalculate seismic forces due to high-seismic zone

- (a) Relocate the building to a high-seismic zone
- (b) Recalculate seismic forces using updated building weight
- (c) Compare impacts that a high-seismic zone would have on the natatorium design compared to the original design

Task 19: Alternative: If time permits, redesign steel connections

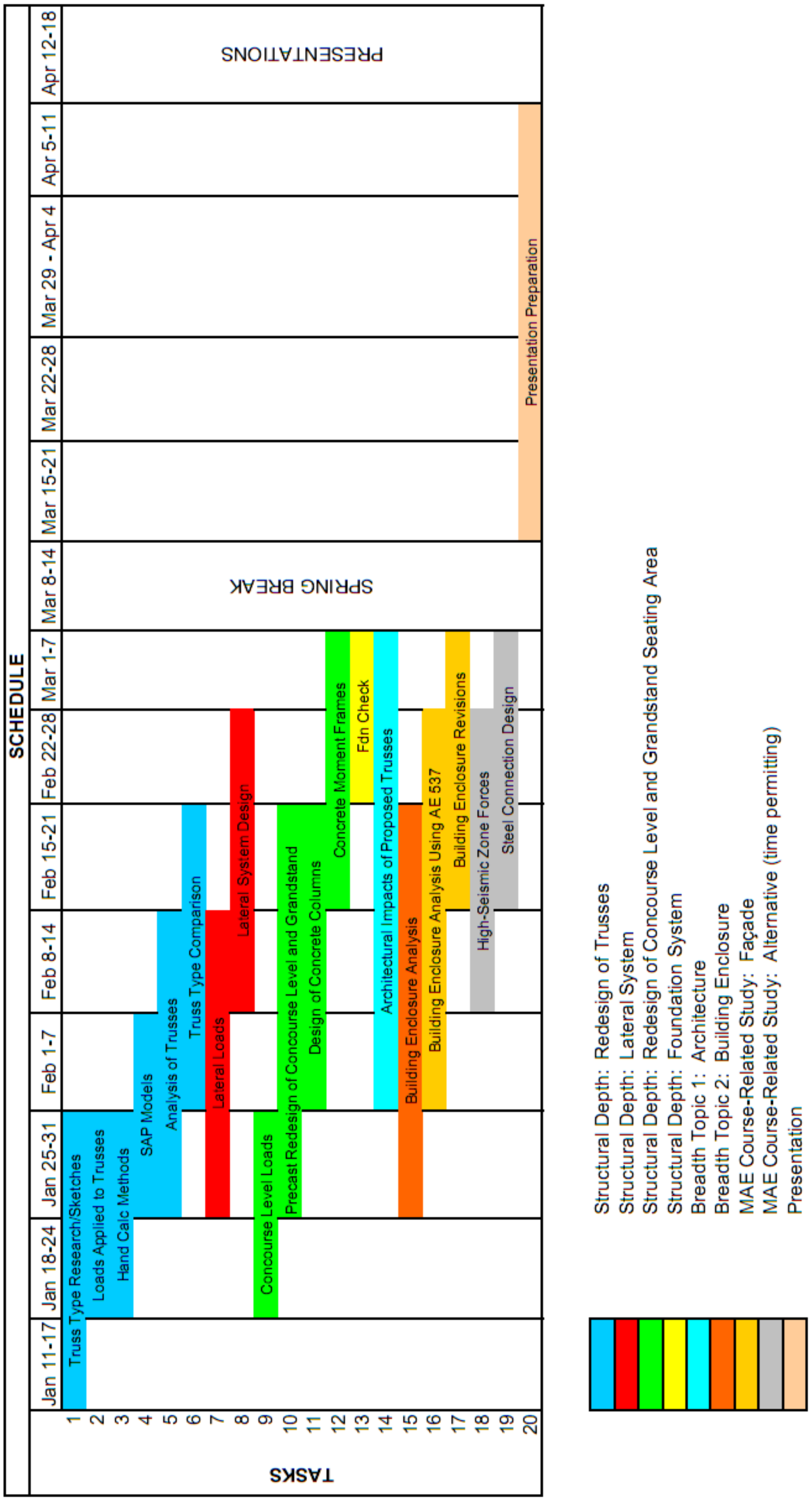
- (a) Obtain copy of AISC Seismic Design Manual
- (b) Redesign steel connections of moment frame in east part of lobby for higher seismic forces

H) Presentation

Task 20: Prepare presentation

- (a) Powerpoint
- (b) Final report
- (c) Update CPEP website with any final information

Timetable


SCHEDULE
TASKS
Jan 11-17
Jan 18-24
Jan 25-31
Feb 1-7
Feb 8-14
Feb 15-21
Feb 22-28
Mar 1-7
Mar 8-14
Mar 15-21
Mar 22-28
Mar 29 - Apr 4
Apr 5-11
Apr 12-18
1
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20
Truss Type Research/Sketches
Loads Applied to Trusses
Hand Calc Methods
SAP Models
Analysis of Trusses
Truss Type Comparison
Lateral Loads
Lateral System Design
Concourse Level Loads
Precast Redesign of Concourse Level and Grandstand
Design of Concrete Columns
Concrete Moment Frames
Fdn Check
Architectural Impacts of Proposed Trusses
Building Enclosure Analysis
Building Enclosure Analysis Using AE 537
Building Enclosure Revisions
High-Seismic Zone Forces
Steel Connection Design
Presentation Preparation
SPRING BREAK
PRESENTATIONS
Structural Depth: Redesign of Trusses
Structural Depth: Lateral System
Structural Depth: Redesign of Concourse Level and Grandstand Seating Area
Structural Depth: Foundation System
Breadth Topic 1: Architecture
Breadth Topic 2: Building Enclosure
MAE Course-Related Study: Façade
MAE Course-Related Study: Alternative (time permitting)
Presentation

Conclusion

In the spring semester, an alternative roof system will be designed by investigating three different types of trusses. The main intent of this proposal is to redesign elements of the building to better meet the financial needs of the owner. This will be accomplished by designing and comparing a king post truss system, a wood truss system, and a modified space frame. Each system will be evaluated based on cost, feasibility, and architectural impact. SAP2000 will be used to model each proposed truss system and to determine member forces to be used in the design of each member. In addition, the concourse level floor system, adjacent balcony, and grandstand seating area will be redesigned as an entirely precast concrete structure. The first breadth study will specifically investigate the architectural impacts of each proposed truss design, including changes in building height and changes in room layouts for any new column locations. The second breadth study will examine the building enclosure and interior materials in terms of moisture-related and thermal-related problems. Finally, the MAE course-related study will continue to analyze the façade using information learned in AE 537. Necessary changes to building elements to better handle moisture-related and thermal-related issues will be made as well. If time permits, an alternative seismic analysis will be performed by moving the building to a high-seismic region and analyzing the effects this will have on the building. This will be supplemented by redesigning the connections of the steel moment frame at the east part of the lobby for higher seismic forces.