Executive Summary

This thesis study investigated a redesign of the entire roof structural system of the Farquhar Park Aquatic Center. The original design for the natatorium was over budget and was therefore never constructed. The main goal of this study was to explore various structural systems in an attempt to develop a design that better met the financial needs of the owner while still maintaining a pleasing architectural appearance. The structural system of the original design for the natatorium is composed of curved, triangular shaped steel HSS trusses with tapered columns that span 130'-0" over the indoor pool area. New truss configurations were designed using a king post truss system, steel space frame, and glulam truss system. After the truss systems were designed, they were compared in terms of cost, architectural impact, and feasibility, and a final design was chosen. The glulam trusses were determined to be the best option for the alternate roof system. The glulam structural system offered architectural integrity and a competitive cost while the king post truss system lacked architectural freedom and the steel space frame was determined to be too costly. Laminated decking was then designed for the trusses using a two-span continous layup. It was later determined that achieving diaphragm action with the required three-inch nominal decking is often difficult. Therefore, 3/8" plywood was designed for the given wind and seismic loads and was to be attached to the top of the decking to provide the roof diaphragm with the ability to transfer lateral forces to the lateral force resisting frames. Connections for the glulam truss members were then designed using ¾" diameter bolts and steel side plates. The bolted metal side plates worked well since all of the truss members were designed to have the same width. Final connections were quite large, with twenty-four bolts being required for bottom chord splice connections and twenty-eight bolts being required for top chord connections.

Since the glulam trusses were designed to only take gravity loads, new lateral force resisting systems were designed. Wood braced frames were added to the perimeter in the East/West direction, while other wood braced frames were designed to replace original steel braced frames in the North/South direction along the west end of the natatorium. Steel moment frames and steel braced frames near the precast concrete grandstand were redesigned as reinforced concrete moment frames. Wind columns that transfer lateral loads to the roof diaphragm were also redesigned using wood. Wind loads were recalculated to account for changes in building height and shape due to the glulam truss configurations, and seismic loads were updated to account for the increased weight of the building. The wood roof structural system was found to be much heavier than the original steel system, and the concrete moment frames weighed much more than the steel moment frames used in the original design, thus increasing the seismic loads on the building. Direct shear values and torsional shear values were calculated and appropriately applied to the lateral force resisting frames. SAP2000 was used to model the frames and obtain member forces. The final designs for the lateral systems met the story drift requirements for wind and seismic loads. An overturning check and foundation check were also performed to account for the new lateral loads and building weight. The original foundations were found to have adequate capacity to carry the increased building loads.

An architectural depth was studied due to the introduction of the new truss system into the indoor pool area. Changes in building height and in the shape of the roof were investigated, as well as changes to the overall appearance of the building, both internally and externally. In addition, several room layouts were changed to accommodate new column locations. Since the building is a natatorium, a building enclosure breadth study using material covered in AE 542 (Building Enclosures) was also implemented to investigate how the design of the building accounts for moisture-related and thermal-related problems that often arise with indoor pool environments.

The MAE course-related study involved a continuation of the building enclosure analysis using information addressed in AE 537 (Building Failures) concerning moisture-related problems with buildings. Pressure treatment of wood and problems with wood trusses were also investigated. The Building Enclosure breadth study using information from AE 542 could also count toward the MAE requirements. This study included glass capacity design calculations as well. Extensive use of AE 597A (Computer Modeling) was also necessary to model the proposed trusses and proposed lateral force resisting systems in SAP2000.