Analysis 3

Structural Column Redesign Breadth

Problem

The main structural system in the Warrenton Aquatic and Recreation Center is steel. However, the architect chose to use cast in place concrete for the structural columns in the two aquatic portions of the building. From construction standpoint this increases coordination and congestion problems on site and adds duration to the schedule.

Goal

The goal of this analysis is to decide whether there is a viable alternative to the cast in place concrete columns in the pool area. The proposed alternatives that will be analyzed are structural steel columns and masonry pilasters. To conclude this I will compare total cost, schedule durations, column sizes, and constructability.

Methodology

1. Determine the building loads that the cast in place columns support
2. Design a steel system with the calculated loads
3. Design the reinforced masonry pilasters
3. Analyze the systems based on the cost, schedule, and constructability
4. Select the best structural system

Tools

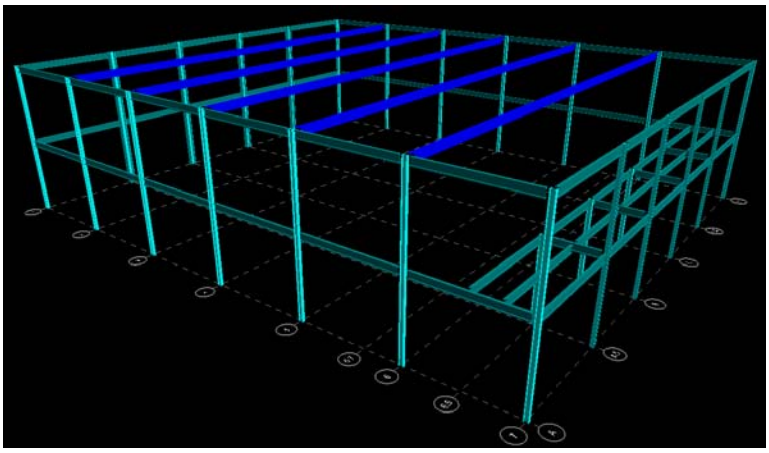
1. Warrenton Aquatic and Recreation Center Construction Documents
2. R.S. Means 2006
3. Penn State Architectural Engineering Faculty
4. Forrester Construction Company
5. Microsoft Excel
6. AISC Steel Construction Manual 13th ed.
7. RAM Model
8. Masonry Designer's Guide, 4th ed.

Expectations

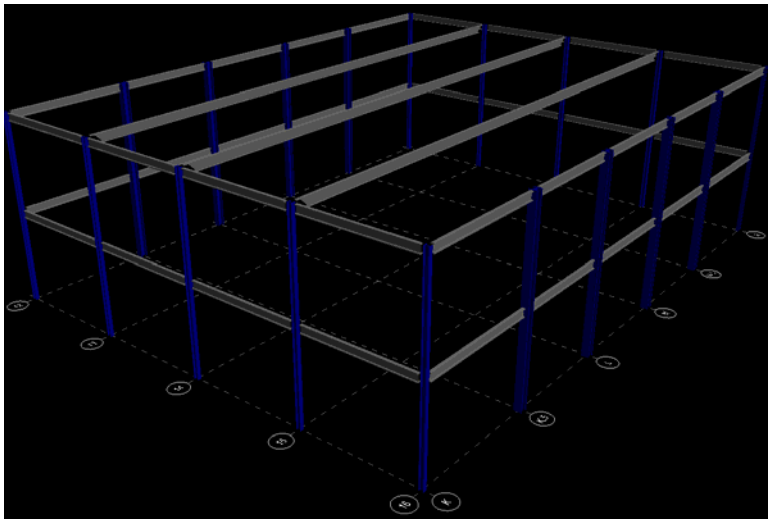
The expected outcome of this analysis should indicate that the proposed steel structural system will save money, reduce installation time, and improve constructability with the pilaster also being more economical than the concrete system.

Structural Steel Design

The selection of steel for the redesign is based upon the uniformity of the building. All other structural members in the building are steel shapes, so therefore to reduce site congestion and coordination issues, steel should be considered as a possible alternative. To conduct the steel redesign of the concrete columns, the Ram structural system application was used. Using the axial loads given by the structural engineer as well as the column heights taken from the construction documents, I was able to enter the data into the program for the steel column generation. Upon completing this task, two types of columns were generated for the competition and leisure pool rooms, W10x33 and W10x39. Both columns were checked for slenderness and load capacity using the AISC Steel Construction Manual to ensure proper design was obtained. The following three dimensional models are the results of the design process. You will notice that the roof truss members were modeled as joists with the same loading properties for simplicity. Also it should be noted that the current roof truss system connection is a steel plate that will be welded to the top of the structural steel columns



Competition Pool Structural Steel Design



Leisure Pool Structural Steel Design

Masonry Pilaster Design

The reason for the design of the masonry pilaster is because concrete masonry units are already being placed in between and around the concrete columns. Having the masons put the pilaster directly into the wall will again reduce site congestion and coordination issues because it lessens the subcontractors on site. To actually calculate the size of the pilaster, again the loads and heights were taken from the structural engineer and construction documents. The calculations were then conducted based on the Masonry Designers Guide, section 12.3.3, design considerations for reinforced pilasters. The appropriate calculations can be found in Appendix G. After completing the design, it was determined that a 24”x 24” reinforced masonry pilaster would support the required loading. This size was maintained so as to not disrupt the current spacing of the current concrete columns.

Cost Comparison

The cost of switching the systems can be based on the structure alone for the two alternative solutions because the means and methods of installing the pilaster and steel are already on site. As a result, the following Table 3.1 is a cost comparison with values from R.S. Means and Contractors from the Warrenton Aquatic and Recreation Facility.

Structural Column Cost Comparison				
Type of Column	Quantity	Material Cost	Labor Cost	Total Cost
Concrete	156.4	$305.00	$365.00	$104,788.00
Steel	1056	$40.00	$2.37	$44,742.72
Pilaster	1056	$37.00	$25.00	$65,472.00

Table 3.1

As you can see, the cast in place concrete system is the most expensive by nearly double. The pilaster installation price is significantly higher than the steel labor cost because the amount of time to install and the number of crew members it takes is significantly reduced by using steel. From a cost perspective, the steel is the most viable alternative.

Schedule Comparison

Being on schedule is one of the most important aspects to a project and finding a way to cut schedule to get ahead on a project is extremely valuable. For this purpose, I have compared the durations for each type of structural column in the aquatic portions of the building. The results can be found in the following Table 3.2

Structural Column Schedule Comparison

Type of Column	Quantity	Daily Output/Crew	No. Crews	Total Duration
Concrete	156.4cy	17.7cy	1.0	8.8
Steel	1056lf	1025lf	1.0	1.0
Pilaster	1056vlf	18vlf	3.0	19.6

Table 3.2

As you can see, the erection time for the steel columns is by far the most efficient with the ability to place all the columns in one day. This can be attributed to the ease of

connection of members with a crane and small crew. The placement of the concrete columns is the second quickest, followed by the erection of the pilasters. The problem with the pilaster is that erection of the CMU wall is also going on at the same time, reducing efficiency of work on pilasters and increasing site congestion with increased crew sizes. Therefore, steel is the fastest and most beneficial to the schedule.

Constructability Comparison

The three systems in question require different means of construction to erect the columns. The original cast in place concrete column requires formwork, a pump for placement, and scaffolding for erection. The problem that arises from this is that the scaffolding used will be different than the scaffolding used by the masons which means it will have to be set up, torn down, and then different scaffolding will be put into place. This results in wasted labor and cost. The formwork is also an additional cost compared to both the steel and masonry systems.

To erect the structural steel columns, the first item to be addressed is the crane size. The weight of the proposed steel columns however will not increase the crane size because the members are significantly lighter than the roof trusses that rest on top. Furthermore, the columns will use the same bearing plates to attach to the substructure and roof truss system, the only difference being that the plate on top is welded to the column, which is a minimal schedule increase. The concern of corrosion to the members is not a factor because concrete masonry units will surround the column exactly like the current concrete system.

The masonry pilaster construction requires scaffolding, but this will already be in place while the masons construct the joining concrete masonry walls that are in between columns. This will not significantly impact the schedule in terms of duration of installation, but the masons schedule will have to start earlier to accommodate the setting of the roof trusses. Like the concrete columns system, the masonry pilasters will be joined to the substructure and roof truss system using the exact same bearing plates and anchoring systems.

Breadth Conclusion

The structural steel column is the most efficient in terms of schedule duration, cost, and causes no constructability issues. The savings from the current concrete system total $60,045. The change in schedule erection time will also allow for the roof truss members to be erected earlier, saving eight days of crane rental costs as well. The pilaster system is also a viable alternative compared to the concrete system, saving a total of $39,316. However this change would cause a delay in the schedule of eleven days, which would be unacceptable to the project. Therefore, my recommendation is that the structural steel column should be used for the columns located in the aquatic spaces of the facility.