Far West Water Ski Club Floating Dock Replacement

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A project based senior project, the Far West Floating Dock Project included the design, procurement and construction of two 20'x 20' floating docks for the Lake Nacimiento based non-profit Far West Water Ski Club. Constructed of polyethylene coated floats, 4x Pressure Treated lumber, hot-dipped galvanized hardware and composite decking, the dock is designed to have a lifespan of at least 35-40 years. This case study provides an overview of the complete project delivery, beginning with the conception and research, transitioning to design and procurement, and finishing with construction and lessons learned. The overall project cost landed at $21,712.00, made possible by donations from Far West Water Ski Club members. An 800SF floating dock, effective segmented construction process allowing a crew to lift, float and attach individual segments of the dock and many other valuable lessons were outcomes of this project.

Key Words: Marine, Construction, Floating, Dock Design, Dock Procurement

Conception

Far West Water Ski Club ("Far West") is a non-profit ski club local to San Luis Obispo County that owns and operates a public slalom course as well as a floating dock for mooring, staging and relaxing purposes. Their existing dock was built in the mid 1980's and by late 2014 was becoming dilapidated mainly because the original construction of non-pressure treated wood structure did not withstand the elements well. During the spring of 2015 I approached Scott Cramer, the President of Far West, about the current condition of the dock and the possibility of using the replacement of it as my senior project. Steve and the other club members responded with great enthusiasm and we began defining a scope of work that would be within the clubs budget. At this time Brian Woods, a Cal Poly alum and Senior Civil Engineer with Cannon, came on board to help head the project for Far West and work with us through every phase. The initial scope was to include the replacement of the entire structure, a total of four 20'x 20' dock segments, however due to the cost of floats, we settled on a final scope of two 20'x20' floating platforms with a target budget of $20,000.00 and a ceiling of $25,000.00.

Research

Around April of 2015 while in Senior Project I, the project was approved by Far West and I began researching the structure layout, buoyancy calculations, hinge connections, and environmentally acceptable float material of floating docks. For structure layout I focused on issued and pending patents, pre-fabricated dock construction, and plans obtained from Mark Robinson of American Muscle Docks®. (See References) However, most of the existing plans I found for floating docks were usually too weak, outdated or large scale commercial assemblies.

Existing patents and prefabricated hinge connectors specialized to floating docks were great sources of information as well. Finally float material was ultimately determined by a Lake Nacimiento ordinance prohibiting exposed Styrofoam and steel barrel floats. (MCWRA Ord. No. 04065) Using these resources I moved forward with great insight into typical floating and stationary dock layouts as well as the correct regulations for Lake Nacimiento.

Design

The design phase was the longest part of this project, taking from April until December to complete and go through many renditions and design changes. I've included the three most distinct prototypes on the right. I used ArchiCAD 16 and Bluebeam Revu extensively to create and compile the plan sets as well as Microsoft Excel for all material lists and buoyancy calculations. (See references for all work mention herein.)

The fundamentals of the project scope could be defined as a 20'x20' floating structure, with roughly 18"-24" of freeboard, which could be duplicated and connected to create a 20'x40' (or larger) floating platform. Our main goals for the project were affordability and longevity. It was critical that if we were going to use most of the club's savings, the dock needed to have a lifespan exceeding 30-40 years. Other design criteria included usability concerns such as ensuring the decking wouldn't get too hot in the sun and that the anchor line was at sufficient depth to clear boat props. Lake Nacimiento environmental regulations, constructability requirements, procurement issues and budget limits all came into play at some point during the design phase as constraints.

The initial design was based off an assumption of receiving sixty 2'x4'x16" floats from Monterey County. Although we never received the float donation (they were used on a separate project), the initial design provided the basic structure layout we would stick with in later renditions. (Top, Fig. 1) Moving on from the original design, we adjusted to using 4'x6'x16" floats, which would provide shear resistance for the 4x structure. (Mid., Fig. 1) From there it was just a matter of adjusting float, bracing and anchor mount layout to come up with the final structure design. (Bot., Fig. 1) The perimeter beams are 4x14's and the interior stringers and braces are 4x6's, connected with ¼" hot dipped galvanized (HDG) steel angle brackets and ½" HDG carriage bolts and washers. The 4x6 and 4x14 beams are connected to each float with seven to eight 3/8"x4" HDG lag bolts through a 2" HDG washer.

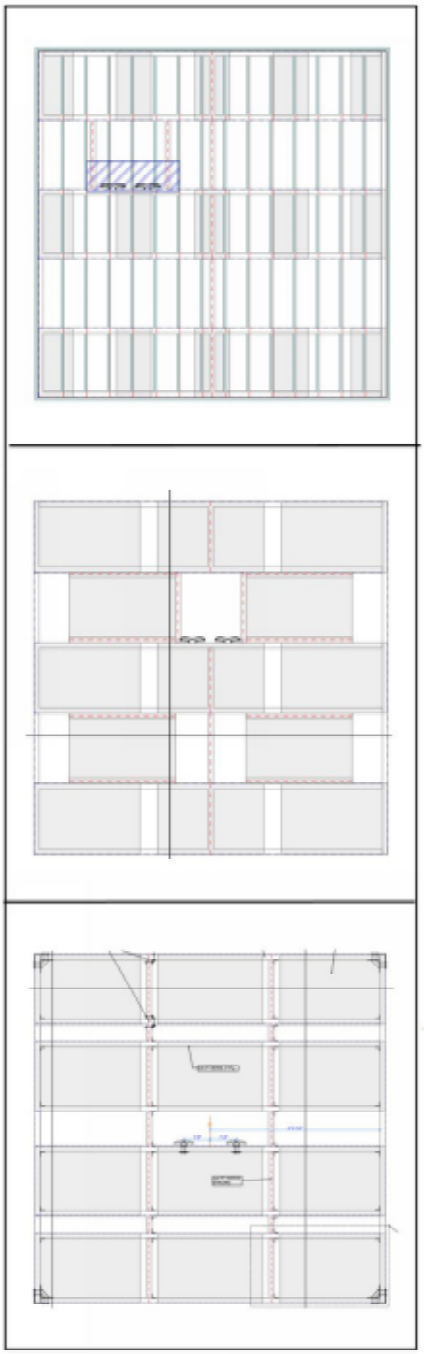

Figure 1 - Design Progression

Above and perpendicular to the 4x6 stringers are 2x8 pressure treated joists at 16" on center and attached at the 4x14's with Z-Max coated joist hangers from Simpson. The joists are also connected to the second and fifth 4x6 stringer with 9" galvanized twist ties, also from Simpson. Above the joists, the decking runs over the entire structure creating a 20'x20' lid, flushing out with the perimeter beams.

In order to ensure the dock would float, specifically at the correct height, I had to calculate the overall dock weight in relation to the carrying capacity of the floats. To get the overall weight of a section I took the material list and summed the weight of all components. Because I already had all the lengths of wood members or individual counts of hardware in my estimate, I simply added a column in Excel to multiply the unit-count by unit-weight to come up with total weight as if it was total cost. I then assumed a live-load of 2000 lbs. per dock section and landed at a total weight of 10,100 pounds per section. In order to calculate freeboard, or the height of the deck off the water, I took the buoyancy of each float when fully submerged which is 1,780 lbs. multiplied it by 12 floats per dock to come up with 21,360 lbs. and divided it by the depth of the float, 16", to arrive at 1,335 lbs. of buoyancy per inch the floats were submerged (uniformly). Dividing the dock weight of 10,100 lbs. by 1,335 lbs./inch submerged shows us that the floats will be 8 inches submerged when the dock is fully loaded, leaving roughly 20 inches of freeboard.

Please refer to the Plan Set and other calculation sheets in the References section of this binder for more detailed plans, specifications and calculations.

Procurement

In December of 2015, once a nearly complete design had been developed, I began researching materials and obtaining costs from local suppliers to develop an accurate estimate. In order to withstand the elements all wood components are pressure treated with .40 ACQ wood preservative and all steel components are hot dipped galvanized. Finally, we chose a composite decking specifically designed for use on docks. With a final material list in hand, I sent out bid requests to local suppliers and started creating an estimate in Excel. The items that were hardest to procure were the floats, dock specific hardware and decking. There are very few, if any, manufacturers of polyethylene coated Styrofoam dock floats in the Western U.S., so we ended up having them shipped from Arkansas along with all the dock specific hardware. All pressure treated wood components, decking, general hardware and fasteners were sourced from Hayward Lumber in SLO. With quotes from Hayward and HarborWare, I compiled an estimate which can be found in the reference section. The original estimate for two complete 20'x20' sections came out to be $19,870.00. This included a waste/safety factor of roughly 10% for everything except the 4x structure.

In early January we had a final and approved design to move forward with and I began compiling final material lists that would be sent to our suppliers for orders. One roadblock we ran into was procuring our original choice of decking, as the only supplier on the West Coast had discontinued it. We switched to a product called DockSider, also a composite, but this added roughly $2,600.00 onto my original estimate. You can see how my estimate compared to what we actually spent in Figure 2. Figure 3 highlights the material categories related by their relative

costs. The decking, floats/hardware and the wood structure were the three largest costs. The large difference in estimated and actual costs of the decking resulted from the product change mentioned above. The Hayward invoice was also more expensive than I was expecting, most likely resulting from added shipping costs due to multiple deliveries or possibly from extra materials bought during construction. The final construction cost came out to $21,712.00 and a summary of all costs can be found in the Reference section of this binder. By early February all materials were on order and slated to be delivered to Brian Woods' house in the Lake Nacimiento neighborhood of Heritage Ranch before our first build weekend.

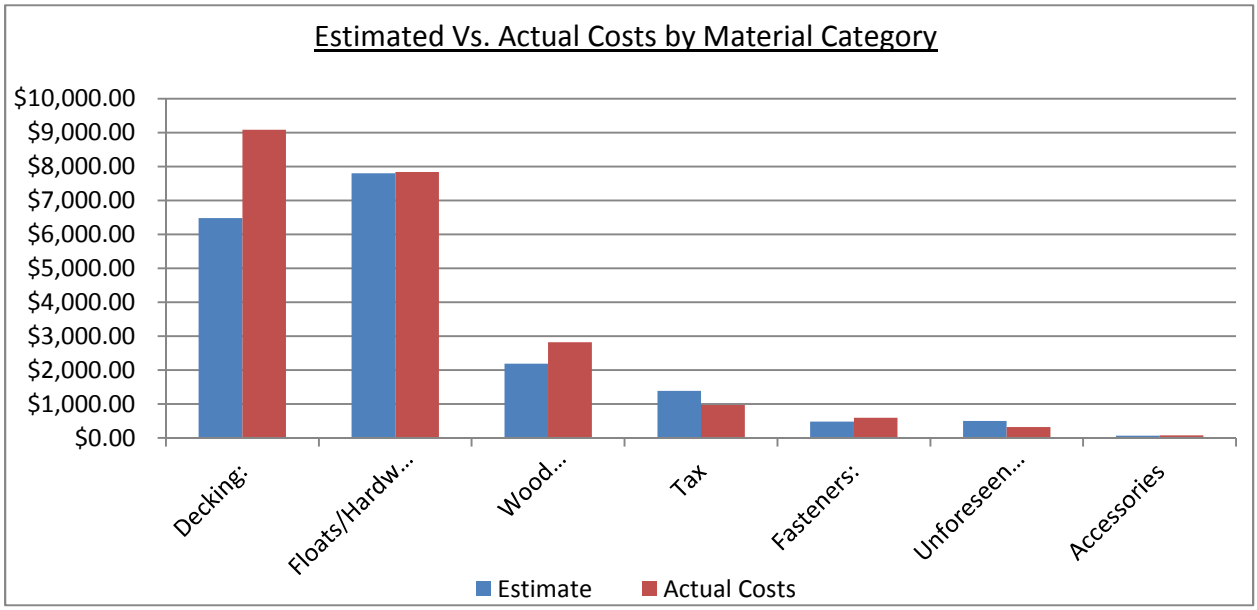

Figure 2 - Estimated Vs. Actual Costs by Material Category

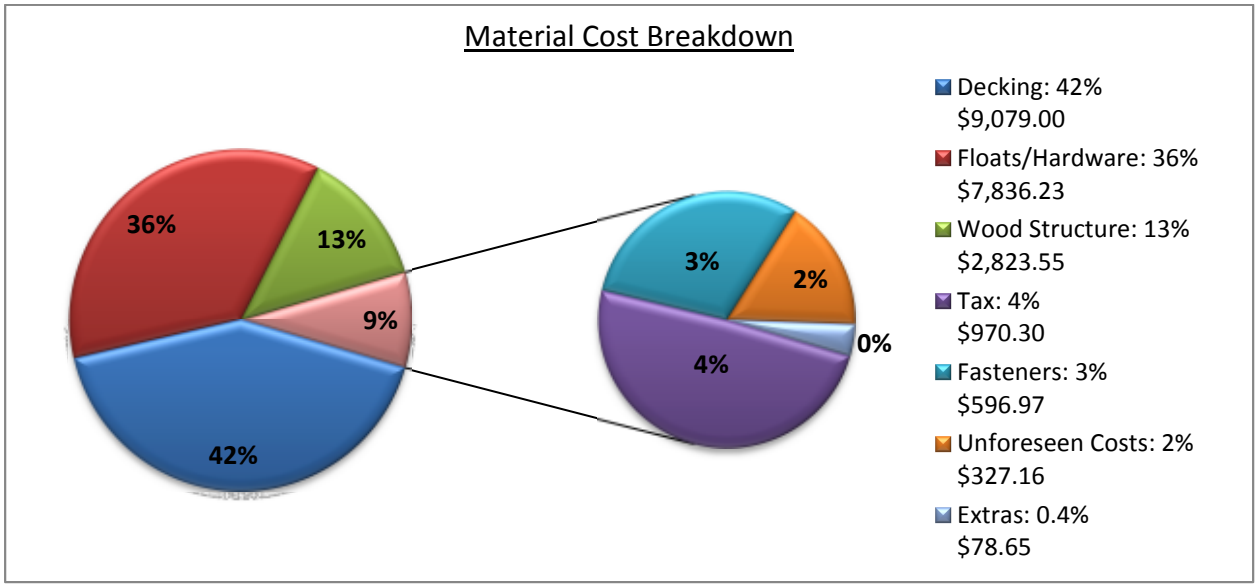

Figure 3 - Material Cost Breakdown

Construction

Brian Woods graciously allowed us to build the dock sections in his garage at Heritage Ranch and also obtained access to the Heritage Ranch launch ramp for floating and assembling the dock sections. The build plan was to construct the main structure upside down in Brian's garage and attach all floats while still assembled. We would then remove two of the side beams and split the section at the cross bracing into four segments that consisted of 3 floats each. (See Sheet 1.A-1) Both sections would be built this way the first weekend and then we would float, re-assemble the structure and install the joists and decking the second weekend. Simultaneously, the old section of dock would be retrieved from the course, demolished at the launch ramp and hauled out. Once the sections were floated and completed we would attach them to the remaining sections of the existing structure.

We began on the weekend of February 27-28, 2016 with all materials for both sections inside Brian's garage inventoried and laid out. It was our logic that a smaller, more talented crew would be more efficient so we compiled a crew of seven Far West members all who were talented in the trades and worked well together. We started by assigning three people to cutting the 4x14 perimeter beams to length while others cleaned the workplace and laid out brackets. As most of us worked on assembling the outer perimeter a few worked on cutting the 4x6 stringers to length. As the perimeter was completed we pulled the structure into square and held it there using come-alongs to connect the corners diagonally. I had pulled the layout for the 4x6 stringers while the crew was finishing the perimeter and we began installing the stringers as soon as the perimeter was squared. As we were installing the stringers, the cutters were measuring, cutting and laying out the cross bracing which we began installing as we finished the stringers. The first section took most of Saturday to construct, breakdown into four segments and stack. We then cleaned the workspace and laid out the perimeter to begin the second section on Sunday. The second section went much faster and we finished assembly in four to five hours. We then stacked the first section on top of the second in the garage to store until the second weekend of construction.

On the weekend of March 12-13, 2016 we started by pulling the segments out, loading them (two at a time) onto a trailer and floating them at the launch ramp. This weekend we had a much larger crew of Far West and Cal Poly Water Ski members totaling roughly twenty-five people with varying skill levels. As the segments made it to the launch ramp, we floated them into position and tied them together until all four were aligned and ready to receive the end beams which we lifted into place. Once all members were in place, we tightened all connections and began dropping joists into joist hanger we had installed the first weekend. Once the joists were laid out we braced them and attached the twist ties on the second and fifth stringer. The joists went quite quickly as they were all precut and easy to drop into place. Once a section had the joists installed we began installing the deck boards. It was useful to have many hands while installing the decking and it went relatively quickly. After finishing the first section, we floated the original section with the awning over to the new section and transferred the awning. The original section was then demolished and loaded into a dump trailer. While this was happening, we had a crew installing the joists and decking on the second section. After removing the original section from the area, we attached the two new sections together creating a 20'x40' section and began towing it to the slalom course.

All in all, the project took roughly 320 man hours over two weekends to construct, disassemble, transport, float, assemble, finish and install the two new dock segments.

Please see the references tab for a photo sequence of construction.

Lessons Learned

The practical construction knowledge I took away from this experience, along with skills developed through working with professionals on the design and procurement of the dock are the capstones of this project. During the design and procurement of this project I was using ArchiCAD, Blubeam Revu and Excel extensively which provided me with many skills applicable to real world processes. Working with Brian Woods and Steve Cramer to design and redesign the dock multiple times was definitely one of the most frustrating, but educating and beneficial phases of the project. Procuring the materials required balancing classes and working on my project during east coast business hours, which taught good time management. Also having to cold call so many people for getting information on dock design, material information and pricing was very beneficial as that is something I wasn't completely comfortable with until the end of the project. The relatively strict budget for the project was an aspect in every decision and made me work harder to find the best prices on materials. Throughout the project many hours were spent considering constructability aspects, mainly focusing on how to build and float the structure without heavy equipment. The solution was to prefabricate the docks in such a way we were able to disassemble each section into movable segments, which eliminated the need for any lifting equipment. It should be noted that it was possible to move the individual segments by hand, but lifting equipment would have been useful. One of the unique lessons learned was buoyancy calculations, which I had never been exposed to but was simple to complete. Working with Brian Woods to determine the final build plan was one of the most valuable experiences in my opinion. Many of his ideas were completely different than mine which created an environment of great diversity in thoughts and fostered effective collaboration. Managing people and the overall project on the days of construction was also a very valuable experience as I learned how to be agile with my decisions and adapt quickly to issues that arose in order to keep everyone busy. This project was a lot more work than I was expecting which may have been the most valuable lesson learned of all and was definitely the most rewarding.

Conclusion

Over the year it took to design, procure and construct this project I accomplished many things but learned even more. The lessons learned span over the entire duration of the project from conception to final completion and vary from analytical skills to people skills and computer skills to physical construction skills. The project developed a deep sense of pride for a job done right and taught many valuable lessons to navigate the construction industry upon graduation. I'd like to extend a huge thank you to the Far West Water Ski Club for making this project possible, to Steve Cramer, and to the entire Woods Family especially Brian for putting in so much hard work throughout this process.

References:

Monterey County Water Resources Agency Ordinance No. 04065