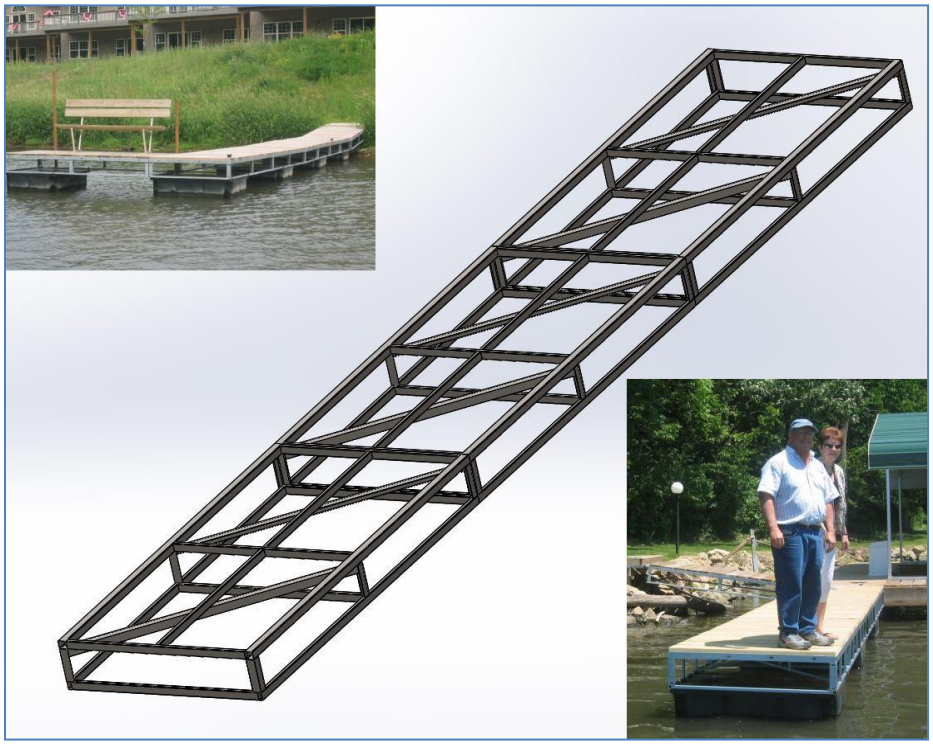
PIER GENIUS ANTI-SWAY FLOATING DOCK FRAME ANALYSIS

WODEN, IOWA



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AMI Project 121194

WODEN, IOWA

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Purpose

AMI Consulting Engineers, P.A. (AMI) was contacted by Pier Genius to model their anti-sway floating dock frame, as well as a dock frame representative of their competitors' frame to compare their performance.

FIE Model Overview

The frames were modeled in Solidworks 2013 using weldments made of structural members. The member sizes and the framing dimensions were provided by Pier Genius, with the Pier Genius frame incorporating a diagonal member under the decking.

Each dock was made of three 4 foot by 8 foot frames joined together to create a dock 4 feet wide and 24 feet long. The model was supported by a hinge connection at the shore end to allow it to pivot vertically. A spring connection was added to the 4 foot by 4 foot bay furthest from the shore on each 4 foot by 8 foot frame section to replicate the buoyancy forces of the floats. Each spring connection was given a spring constant of 78.116 pounds per inch of displacement to replicate the buoyancy forces of the floats used by Pier Genius. The analysis also included the weight of the frames so spring preload was used to level the dock frames when under a no load condition.

All steel framing components are constructed with A513 material, but were modeled with A36 material. This variance will not affect the analysis output since both materials have the same Young's Modulus of Elasticity as A513 steel. Decking materials and mooring lines or posts were not included in the analysis.

Analysis

A finite element analysis was conducted for various loading scenarios. The design guidelines used were from the "ASCE planning and Guidelines for Small Craft Harbor" which are regularly used as design criteria for DNR projects.

Vertical End Loading

Guideline: "When a 400 pound load is applied in the center of a finger dock, 2 foot from the outer end, there shall be no more than 4 inches loss of freeboard at the end of the dock."

Results: When loaded with 400 pounds as specified the total loss of freeboard at the end of both the Pier Genius dock and the competitors dock was 3.8 inches.

Comparison: The two docks performed similarly in this test. The main contributing factor to the results of this loading scenario is the performance of the float. For this analysis both docks were modeled with identical floats which are based on the float used by Pier Genius.

Vertical Corner Loading

Guideline: “When a 200 pound load is applied to one outer corner of a finger, there shall be no more than 2 inches of difference in freeboard across the end of a 3 foot wide finger, and proportionally more on wider fingers and end of mainwalks.” With a 4 foot wide dock the allowable freeboard difference becomes 2.7 inches.

Results: The software reported a difference in height between the dock ends of 1.1 inches for the Pier Genius dock, and 1.8 inches. for the competitors dock frame.

Comparison: The competitors frame deflected 70.8% more than the Pier Genius frame under the corner load. This deflection is what Pier Genius refers to as “sway” in their dock design.

Horizontal Wind Load

The ASCE guideline does not provide specific guidelines on wind loading, but instead provides some recommendations to allow the engineer to determine how to analyze a floating dock based on the location and use of the dock. The analysis performed by AMI was not for a specific location so a wind speed of 75 mph. was chosen for the analysis. Using the formula provided in the ASCE manual a load of 15 pounds per square foot was calculated. This wind load was projected on a boat the full length of the pier and 7 feet above the water line. The height of 7 feet was chosen as a representative estimate of the height for a typical boat using this type of dock, and using the full pier length was given as one method by the ASCE manual. A total wind load of 2520 pounds was calculated. The modeling software only allowed for this force to be applied at the intersection nodes of the frame so fourteen 180 pound forces were applied, one to the top member and one to the bottom member, every 4 feet across the length of one side of the dock.

Results: The wind loading scenario resulted in a lateral displacement of 0.9 inches at the end of the Pier Genius dock and 4.3 inches at the end of the competitors dock.

Comparison: The analysis showed that the Pier Genius frame was substantially stiffer laterally then the competitors frame. The deflection of the competitors frame is 363% more than the deflection of the Pier Genius frame. This number is conservative because the software analysis makes the assumption that the frames will continue to behave elastically. In reality the steel will only allow elastic behavior up to the yield point of the material, after which the material will deform permanently, possibly to the point of failure of the structure. The high peak stresses shown in the competitors frame indicate that under a similar load an actual dock of this design would most likely sustain permanent damage, possibly failing entirely.

Summary

The simulations showed that the Pier Genius dock met the ASCE guidelines for corner loading and end loading. The simulation also showed that the Pier Genius dock provided a substantially stiffer dock then the competitors dock in both the wind loading scenario and the corner loading, or "sway" scenario. Additionally the Pier Genius dock offered a considerable weight reduction with the competitors frame weighting 15.9% more than the Pier Genius frame.

Dock Section Comparison (1,3,5)					
	Wind Load (2)		Corner Load (200lb.)	End Load (400 lb.)	Weight
	Lateral Displacement At End of Dock (in.)	Peak Stress (PSI) (4)	Lateral Displacement (in.)	Vertical Displacement (in.)	Per 8' Section (lbs)
Pier Genius Frame	0.9	43,907	1.1	3.8	138
Competitors Frame	4.3	192,999	1.8	3.8	160
% difference ((Comp.-P.G.)/P.G.)	363%	340%	70.8%	0.0%	15.9%

1. Calculations based on frame only, no decking included in analysis
2. Wind load based on 15 psf x height (7 ft) x length of dock (24 ft) = 2520 lbf distributed along length of dock
3. Analysis assumes fully welded joints
4. Peak stress as reported by FEA software
5. Effects of local buckling an plastic behavior not considered in analysis

Please feel free to contact me with any questions you may have.

Respectfully Submitted,

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Reviewed By,

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