Florida Department of Transportation
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INVESTIGATION OF FENDER SYSTEMS FOR VESSEL IMPACT

PROBLEM STATEMENT

In 1988, due to the increasing number of shipping accidents with bridges, a pool-funded research project sponsored by 11 states and the FHWA was initiated to establish design specifications for ship impact with bridges. The findings were adopted by AASHTO, and are presented in the Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges (AASHTO 1991). These guidelines provide two alternatives for bridge design: (1) to design bridge elements to withstand ship impact force, and (2) to design pier protection systems.

A variety of bridge pier protection systems have been used. The most common forms include large-diameter dolphins, and protective islands placed around the most vulnerable piers. Additional protective measures include the use of electronic navigational aids and motorist warning systems to interrupt traffic on the bridge (in case of an accident).

Fender systems are currently placed between channel piers of bridges crossing navigable waterways to guide vessels through the navigational channels. These structures are composed of prestressed concrete piles and treated timber wales. Fender systems have not been designed to withstand any lateral load. Because they are part of the U.S. Coast Guard requirements, however, it would be convenient and economically advantageous to adapt them to act as pier protection systems.

Figure 1.1. Fender Systems Currently Used by FDOT

OBJECTIVES

The objective of this research was to investigate the adaptability of the existing bridge fender systems as pier protection elements against vessel impact, including (1) a static analysis using the equivalent force equation from AASHTO (1991) and performed with ANSYS, version 5.5, and (2) a dynamic analysis which includes a model of the barge, performed with LS-DYNA, version 950.

FINDINGS AND CONCLUSIONS

Research demonstrated that the current Florida Department of Transportation (FDOT) fender configuration is very weak, and unable to support any significant barge impacts. Failure occurred at the cables connecting piles in the fender system. Bridge fenders have a potential, however, to be used as an energy absorbing system for errant barges, and their crashworthiness can be improved by retrofitting them.

Behavior of the fender system during ship impact largely depends on the pile connections. Stiffer connections provide better energy transfer between adjacent piles, which results in improved crash energy distribution throughout the system.

The concrete head seems to be more suitable for new fender systems than for existing structures. Some elements can be precast; tightening the concrete head to the pile can provide a customized solution. Plastic lumbers can be used to replace timber wales; their durability, corrosion resistance, and reusability after an impact make them attractive for the corrosive environment in Florida.

A retrofit scheme with steel plates connecting the piles showed limited success in barge impact resistance. However, corrosion concerns may preclude the use of this retrofit. Another retrofit scheme utilizes concrete wedges between piles. This solution was more effective in substantial energy absorption, but less effective for absorbing an equivalent static force.

A retrofitted fender is capable of absorbing up to 70% of the kinetic energy of the barge impacting with the assumed collision velocity (3.8 knots, the maximum current prediction for reference stations in Florida, since accidents involving barges and bridges are more likely to occur when barges are detached from towboats). For an initial impact angle 30 degrees or less, it is capable of redirecting the barge and saving the bridge pier.

Neither the modified nor the original structures contribute to essential reduction of the design equivalent static force applied to the bridge pier (up to 10%). However, analysis showed that the modified fender is capable of resisting less severe collisions. There is also a significant possibility that a barge impacting with a smaller impact velocity would be essentially slowed down by the modified fender, which would reduce potential damage to the protected pier. These benefits are worth considering, particularly since most collisions that take place are not as extreme as those considered in this study.

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