Project Summary

Texas Department of Transportation

0-5516: Synthesis of Wave Load Design Methods for Coastal Bridges

Background

As population growth has increased in the Atlantic and Gulf of Mexico coastal areas, the risk of infrastructure damage due to hurricanes has increased. Over a period of years, several bridges have been seriously damaged. The bridges on U.S. Highway 90 across Biloxi Bay and St. Louis Bay were heavily damaged by Hurricane Camille in 1969. In 2004, Hurricane Ivan overturned several spans of Escambia Bay Bridge in Florida. Shortly after this research began, Hurricane Katrina severely damaged the bridge on U.S. Highway 90 across St. Louis Bay, Mississippi, the bridge on U.S. Highway 90 across Biloxi Bay, Mississippi, and the bridge on I-10 across Lake Pontchartrain in New Orleans, Louisiana.

A preliminary review of the existing design codes and guidelines for the design of bridge decks subjected to wave loads revealed that there is limited information available on the subject, and some of it is difficult to find or to interpret.

What the Researchers Did

This project summarized basic concepts about the formation of hurricanes, climatology, hurricane winds, and tides. A summary of basic concepts of water waves and wave statistics was also developed. The research also included an investigation of available design guidelines, research articles, and books that provide information related to the estimation of forces induced by waves on bridge decks. A set of parameters that could affect the design of bridge decks subjected to wave forces was defined in order to collect relevant meteorological and oceanographic information.

Next, the research team compiled a database of the design parameters. The database included data from the Texas Coastal Ocean Observatory Network, from a database called weather underground, and from a data buoy center. The information collected included items such as water level, wind speed, and barometric pressure recorded at short time intervals since 1988. The database also included a historical summary of hurricanes that developed in the Atlantic Ocean and the Gulf of Mexico between 1886 and 2005.

Researchers then devised a plan of action to develop design methodologies, and they estimated the safety and financial benefits of taking this project beyond the synthesis stage.

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What They Found

A review of the literature studied indicated that a hurricane would most likely induce a sea state that can only be approximated using non-linear wave theories. Vertical forces induced on bridge decks by the action of waves can be three times or greater than horizontal forces.

All of the experimental studies summarized in this research showed significant variability in the data obtained. Several methods proposed to estimate wave forces were evaluated approximately, showing considerable discrepancies in the vertical and horizontal wave forces predicted.

Worth mentioning is the recommendation of the Coastal Engineering Manual to consider the forces computed with the methods it proposes to be only preliminary estimates. The safety analysis concluded that no lives are expected to be lost due to a bridge collapse if the population follows evacuation plans.

The financial study implied the investment of 1 million dollars on research to develop a design methodology that would allow bridge decks to resist wave forces induced by hurricanes. The financial analysis concluded that investing in research could result in an annual savings of approximately 12 million dollars for 26 years for one bridge.

What This Means

A more detailed comparison of the various methods studied is recommended, since different methods based their predictions on different assumptions and specimen configuration. A verifiable method for design of the superstructure of coastal bridges that can withstand the action of wave forces is not currently available in the literature, and further studies are recommended.

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