Project Summary

Texas Department of Transportation

0-6063: Site Specific Wave Parameters for Texas Coastal Bridges

Background

In recent years, several devastating hurricanes have caused severe damage to coastal highway bridges along the U.S. coast of the Gulf of Mexico. Damage to these bridges hampered emergency response and other services, and caused tremendous economic loss. To prevent structural failure of coastal bridges, the magnitude of wave load on the bridges must be determined. The objective of this research was to determine site-specific design wave parameters (i.e., wave height and wave period) for selected bridges which are needed in computation of wave loads and evaluation of wave effects on coastal bridges.

What the Researchers Did

In order to determine site-specific wave parameters (i.e., wave height and wave period) at four bridges along the Texas coast, the researchers used two numerical models to simulate extreme wave and storm surge conditions during hurricanes. The following sections describe project activities.

- **Collect and Archive Historical Wave, Water Level, and Wind Data**
  Researchers collected wave, water level, and wind data along the Texas coast. Wave and water level data were used to validate the numerical models by comparing model results and measurements at the same locations. Wind data were used to provide input to numerical models.

- **Set Up the Models Swan and Adcirc for Wave and Water Level/Storm Surge Hindcast**
  SWAN (Simulating WAves Nearshore) model setup
  Researchers developed fine-grid coastal domains to cover the entire Texas coast. Three bridges were initially selected for evaluation in this project: San Luis Pass Bridge, Galveston Bay Causeway, and Lavaca Bay Causeway. After Hurricane Ike, Rollover Pass Bridge was added to the modeling work.

  ADCIRC (ADvanced CIRCulation) model setup
  The ADCIRC water level/storm surge model was set up on a high-power computer cluster consisting of 36 central processing units at the Department of Civil Engineering at Texas A&M University in College Station.

  After Hurricane Ike, researchers performed hindcast of wave and storm surge using historical wind field data. Wave simulation results were compared to wave data measured by National Data Buoy Center (NDBC) buoys.

Research Performed by:

Texas A&M University at Galveston (TAMUG)

Texas Transportation Institute (TTI),
The Texas A&M University System

Research Supervisor:
Jun Jin, TAMUG

Researchers:
Chankwon Jeong, TAMUG
Vijay G. Panchang, TAMUG
Chang, Kuang-An, TTI

Project Completed: 8-31-09

Storm surge simulation results were compared to high-water marks measured by U.S. Geological Survey (USGS) observation stations. Both models compare well with measured results.

- **Archive Wave and Storm Surge Hindcast and Data**

- **Perform Statistical Analyses**
  Researchers initially performed wave and water level/storm surge simulations using artificial hurricanes for three bridges: San Luis Pass Bridge, Galveston Bay Causeway, and Lavaca Bay Causeway. They scaled wind speed to different levels and updated water depths in wave simulations according to storm surge simulation results.

  Following Hurricane Ike, researchers added the Rollover Pass Bridge to the study and used the wind history of Hurricane Ike to hindcast wave and storm surge conditions during the hurricane. They scaled the wind speed to different levels and set water depths to different levels. Statistical analyses established extreme wave statistics corresponding to each wind speed and storm surge levels. Design wave parameters (wave height and period) associated with certain wind speeds were determined for each bridge site.

What They Found

Site-specific wave parameters (wave height and wave period) have been determined for four bridges along the Texas coast. These parameters were developed using results of numerical simulations of wave and storm surge performed at combinations of different hurricane wind and storm surge levels. Researchers observed how extreme wave heights at these four bridges increase with hurricane wind speed and storm surge level. At Rollover Pass Bridge, the wave heights were less sensitive to wind speed.

What This Means

In 2008, the American Association of State Highway and Transportation Officials (AASHTO) published *Guide Specifications for Bridges Vulnerable to Coastal Storms*, which provided equations for computation of wave forces on coastal bridges. The results obtained in this project will enable TxDOT to quickly implement the equations in AASHTO guidelines to determine wave forces on the four bridges studied in this project.

For More Information:
Research Engineer - Wade Odell, TxDOT, 512-465-7403
Project Director - Dacio Marin, TxDOT, 512-416-2223
Research Supervisor - Jun Jin, TAMUG, 409-741-7153

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Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-465-7403