Assessing the Vulnerability of Delaware’s Coastal Bridges to Hurricane Forces

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Overview

- Need to analyze bridges for hurricane forces
- Delaware’s bridge inventory risk
- Analyze a bridge in Delaware
- Mitigation and recovery techniques
Background on Previous Bridge Disasters

- Hurricane Ivan in Florida
  - Damaged I-10 Bridge over Escambia Bay

- Hurricane Katrina in Louisiana and Mississippi
  - Damaged I-10 Bridge over Lake Pontchartrain and US-90
Need for New Guidelines

- AASHTO LRFD Bridge Design Specifications provides little guidance on hurricane wave forces.
- Force effects due to water loads are available, but specific information for bridges is not provided.
Purpose of Analyzing Delaware

- Florida DOT has sponsored research at University of Florida and Ocean Engineering Associates, Inc.
- Efforts have been made to adapt the work done in Florida to the Gulf and Atlantic Coasts
- Need to determine validity of work already accomplished
Hurricane Forces

- Hurricane hazards come from:
  - Storm surge, high wind, tornadoes, and flooding
  - Winds between 74 and 200 mph and storm surge up to 20 ft
  - Winds and storm surge cause waves that can reach bridges
History of Delaware Hurricanes

- No tropical cyclone has struck while maintaining hurricane intensity
- Hurricanes passing near by have caused Delaware to experience high winds and storm surge
What makes bridges vulnerable to hurricane forces?

- Low clearance above water
- Close to the coastline
- Be in an area where waves can form
Bridge Selection

- Indian River Inlet Bridge
  - Good location for waves to form
  - Bad height of the bridge above water and superstructure type

- Fenwick Island Bridge
  - Decent location for waves to form
  - Good low clearance and superstructure type
Fenwick Island Bridge

- Carries SR 54 over Little Assawoman Bay
- 440 ft long with 11 simply supported pre-stressed concrete spans, 39 wide ft superstructure
Fenwick Island Bridge
Fenwick Island Bridge
Wave Analysis

- Wave geometry is dependent on:
  - Storm surge
  - Wind speed
  - Fetch length
  - Bathymetry
- Category 3 wave height is 5.509 ft
Wave Force Analysis

- Vertical and Horizontal Forces
  - $F_{v-max}=0.0899$ kips/ft
  - $F_{h-max}=38.53$ kips/ft
Bridge Resistance Analysis

- Dead load of superstructure resists vertical uplift force
  - Dead Load is 10.84 kips/ft
- Friction between bearing pads and the girders resists horizontal force
  - Frictional force is 0.542 kips/ft
- Resists vertical force, but not horizontal
Mitigation Techniques

- For vertical force
  - Vent cells that could potentially trap air
  - Use anchorage tie downs
- For horizontal force
  - Open or sacrificial parapets
  - Use a continuous superstructure
  - Concrete keeper blocks
Recovery

- If DelDOT decides not to mitigate, they need to understand how to recover a bridge after a hurricane.
- Many spans that have shifted off of their bearings and into the water can be raised back into place with minimal repairs.
Conclusion

- We discussed
  - Need to analyze bridges
  - Risk to Delaware
  - Fenwick Island Bridge analysis
  - Mitigation and recovery techniques
Conclusion

- In a Category Three Hurricane there is a high risk to the Fenwick Island Bridge and mitigation techniques should be used.
- This study validates that bridges have not been previously been designed for hurricane forces.
Questions???