PREDICTING COASTAL ROADWAY DAMAGE USING MODIFIED DISPERSION FUNCTIONS

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ROADWAY DAMAGE PREDICTIVE FUNCTIONS

Empirical dispersion functions appear to reasonably predict damage risks for coastal roadways subjected to coastal storm surge and wave hazards. County Road 257 (CR 257) in Brazoria County, Texas had significant damage at various locations during Hurricane Ike in September 2008. Cumulative peak hourly water surface elevation, wave period, and current velocity output from a hindcast ADCIRC+SWAN model was assessed using modified celerity dispersion functions relative to measured distance between roadway and shoreline. These intensity measures provide a strongly correlated model for predicting likelihood of roadway damage.

COASTAL MODELING DATA

The model includes the Atlantic, Caribbean, and Gulf of Mexico basins and extends into the back bays of Galveston and Chambers counties, as well as portions of Brazoria, Harris, and Jefferson counties (see Figure 1). Results for low and high resolution hindcast simulations were output in two different formats: maximum intensities and time series. Data sets included wind fields, currents, storm surge elevations, flooding depths, and wave characteristics. Storm surge water levels and waves were well predicted as verified with model-data comparisons. Model output data were extracted along CR 257 between Galveston and Surfside, Texas. Data were evaluated for multiple variables assessing significance and correlation.

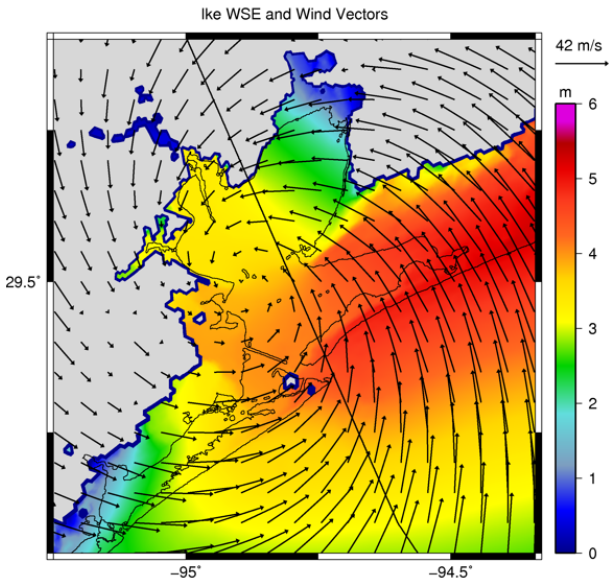

Figure 1 - Coastal Hindcast Model

CORRELATED RANDOM VARIABLES

Initial correlation analyses compared various intensity measure (IM) data from the coastal model to other measured and modeled attributes of the storm event, roadway, and beach transects. Analyses focused on damage and no-damage points along CR 257 confirmed by reviewing post-event field inspections and roadway damage repair drawings. Horizontal distance from the road to the shoreline is strongly correlated to damage potential. Significant damage potentially occurs with road alignments sited within 150 m of the shoreline.

MODIFIED CELERITY DISPERSION FUNCTIONS

Modified gravity wave celerity dispersion functions using cumulative water surface elevation and cumulative wave period hourly peak IMs for overtopping flows are strongly correlated in predicting roadway damage as shown in Figure 2. Cumulative current velocity accounts for velocity head of overtopping flow. The resultant value is reported as dispersion frequency per meter of distance measured between road and shoreline.

Cumulative rates for dispersion functions converge to approximately the same final value over the storm's duration as shown in Figure 2. Comparing the cumulative dispersion function progression for the event assists with validating the likely damage failure mode. The critical threshold value for predicting likely damage along CR 257 is cumulative dispersion value less than 0.025 s/m or cumulative dispersion frequency greater than 40 Hz/m.

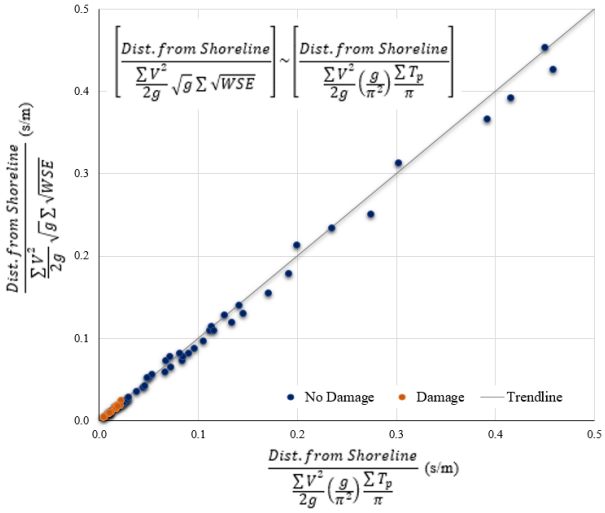

Figure 2 - Roadway Damage Dispersion Functions

Cumulative dispersion values were compared to current velocity vector directions to assess whether damage occurred with initial storm surge overwash or receding storm surge backflow into the Gulf of Mexico. Data show that critical cumulative damage values are realized soon after current velocity vectors reverse direction as storm surge recedes. This suggests that significant damage occurs with backflow over roads with saturated subsoils, effectively creating broad-crested weir scour conditions.

Research is ongoing to further develop and validate these closely correlated modified dispersion functions by evaluating similar events at different locations.