Bridge Damage and Repair Cost Estimates after a Hurricane

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Abstract: Hurricanes causes significant damage to the transportation systems, and the overall cost to repair or replace the bridges damaged during hurricanes has to be estimated. This study describes the observed damage patterns to bridges, as well as repair cost estimation used for the bridges and transportation system.

1. Introduction

Highway bridges are the most important components of the transportation systems, and their damage threatens the emergency response and recovery efforts which results in severe economic losses of the region. Many studies have focused on the response and behavior of bridges subjected to other hazards, such as earthquakes, blast or impact but there is very limited information in the literature about the hurricane damages to bridges caused by storm surge. Repair costs or replacement costs have to be estimated for the various types and levels of damage sustained by bridges. The overall cost to repair or replace the bridges damaged during Hurricane Katrina, including emergency repairs, was estimated at over $1 billion based on damage inspection reports and bid estimates (TCLEE 2006).

2. Objectives

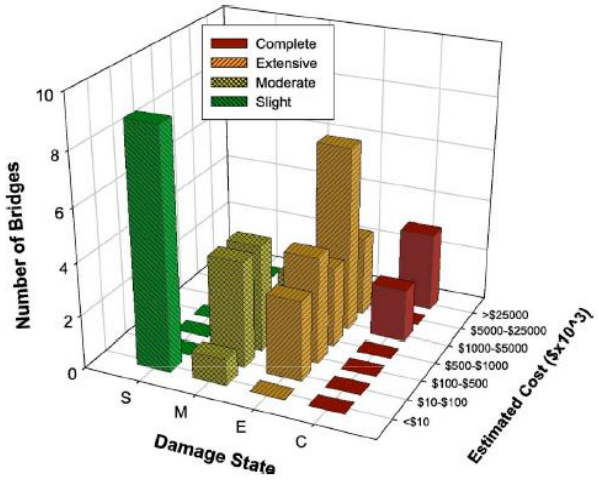
The objective of this study was to describe the observed damage patterns to bridges and to give a general understanding about repair cost estimation used for the bridges and transportation systems.

3. Summary of Bridge Damage due to Hurricanes

Hurricanes cause primarily damage to above ground structures. Some of the damages are due to storm surge-induced loading, coastal scour, damage due to water inundation, and wind damage. Hurricane generated storm surge and waves have damaged a number of major bridges, with mass of water moved onto land by winds and forward motion of hurricane. Damages are also caused by impact of water on structures and erosion of soil supporting the structure. Damages to bridges include the I-10 Bridges over Escambia Bay near Pensacola, Florida during Hurricane Ivan in 2004 (Category 3), the US 90 Bridges over Biloxi and Saint Louis Bays in Mississippi and the I-10 Bridges over Lake Pontchartrain in Louisiana during Hurricane Katrina in 2005 (Category 3) (Martin,2009). Failure modes associated with surge-induced damage occurred in both traditional fixed-type bridges having continuous and simply supported spans, as well as in movable bridges having a swing, lift, or bascule (Padgett, 2008). Impact damage is caused by drifting oil drilling platforms, tug boats, and other types of debris. Bridge scour is the removal of sediment such as sand and rocks from around bridge piers. Bridge scour is one of the three main causes of bridge failure. It is the most common bridge failure in the United States (Kattell, 1998). Water inundation affects bridges by damaging electrically and mechanically-dependent systems. Movable bridges mostly damaged due to water inundation which results in delays of marine traffic and transport of goods for disaster relief and recovery. The high winds from the Hurricane may contribute to the other modes of failure by increasing the potential for impact and debris, and facilitating large surges, waves, and horizontal pounding (Padgett, 2008).

4. Repair Costs

Estimating the cost of bridges repair and maintenance is crucial and needed to provide an accurate estimate to assist project managers to choose adequate alternatives. Estimates of downtime and repair cost are important factors for loss calculation of natural disasters. As indicated by Comario (2006), documentation of empirical data regarding repair and recovery along with associated costs is essential to refine loss models to assess the consequences and impacts of natural hazard events to communities and regions. The most important aim of emergency repairs is to provide quick restoration of functionality which results in higher costs. Cost and design data can be used for training and testing neural network models to estimate the total cost of repairing bridges (Boubaz, 2008). Several researchers have used neural networks as a tool to estimate costs with a high accuracy. Fig. 1 shows a plot of the number of bridges in each damage state that fell into a given range of estimated repair or replacement cost for Hurricane Katrina. This plot indicates that all of the slightly damaged bridges had repair costs of less than $10,000.



		Damage State			
		Slight (S)	*Moderate (M)*	*Extensive (E)*	*Complete (C)*
Estimated Cost ($ × 10^3)	*<$10*	9	1	-	-
	$10-$100	-	4	3	-
	$100-$500	-	4	4	-
	$500-$1000	-	-	4	-
	$1000-$5000	-	-	6	2
	$5000-$25000	-	1	3	-
	>$25000	-	-	-	3
	Total # of Bridges	9	10	20	5

Figure1 - Distribution of damaged bridges by damage state and estimated repair cost in Hurricane Katrina

5. Conclusions

The combination of high winds, rain, and storm surge during hurricanes causes significant damage to highway bridges. Five different typical modes of failure are presented. Repair costs varies according to damage state of bridges however use of neural network gives accurate results to estimate the repair costs which requires sufficient amount of data.

6 Acknowledgements

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7 References

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