Residential Structures and Utility Damages after Hurricane IKE

Meng Liu and C. Vipulanandan, PhD., P. E.
Texas Hurricane Center for Innovative Technology (THC-IT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX 77204-4003
Tel: (713)743-4278
Email: mliu17@uh.edu, cvipulanandan@uh.edu

Abstract: In this study, failure rate of the residential structures and utilities (power and water) during hurricane IKE was investigated. A nonlinear mathematical model was developed to relate the frequency of degree of damage to structural and utilities to wind speed, distance from hurricane Ike path to each zip code and tree distribution.

1. Introduction

Our research is based on the survey (http://www.egr.uh.edu/hurricane/files/assessment.pdf) undertaken by the Texas Hurricane Center for Innovative Technology (THC-IT) to determine the damages to residential structures and utilities in the region. Over 550 responses were received so far on the Hurricane IKE survey. In this survey residential structures were categorized as wood, brick or concrete. Utilities investigated included water and power. The damages were grouped into three classes (minor, moderate and major) for analyses. From the response, reliability of the residential structures with different types of building materials was analyzed. A nonlinear mathematical model have been developed and verified with the collected data from the Hurricane IKE survey. The nonlinear model relates the degree of structural and utility damages with wind speed, distance from Hurricane IKE path to each zip code and density of trees.

2. Objectives

The objectives are as follows: (a) analyze the Hurricane IKE survey to quantify the failures; and (b) to develop a damage model (DM-THC) to represent the damages to residential structures and utilities.

3. Damage Analysis

The survey respondents were requested to categorize their structural and utility damages as follows: Category 1: None to minor damage; Category 2: Moderate damage/habitable/usable; and Category 3: Major damage/inhabitable/unusable. For the analyses, it was assumed that Categories 2 and 3 as failure. It must noted that the analyses were based on the residential structural type (wood, brick, concrete) as selected by the respondents. Based on the analyses, there was less than 20% structural failures of which 3% were category 3 (major damage). These failures were observed even when the hurricane wind speeds were below the design wind speeds of 90 mph and higher. It was clearly the power utility failure that dominated the reported failures (Fig. 1). Except for the apartments, the power utility failure in all types of structures were 70% or higher. The reported drinking water utility failure varied from 20 to 35% based on the residential structure type.

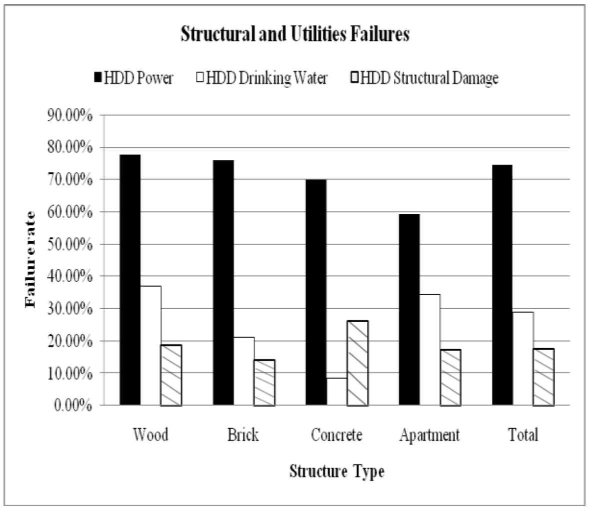

Figure 1. Structural and Utility Failure Rate for Different Structural Types

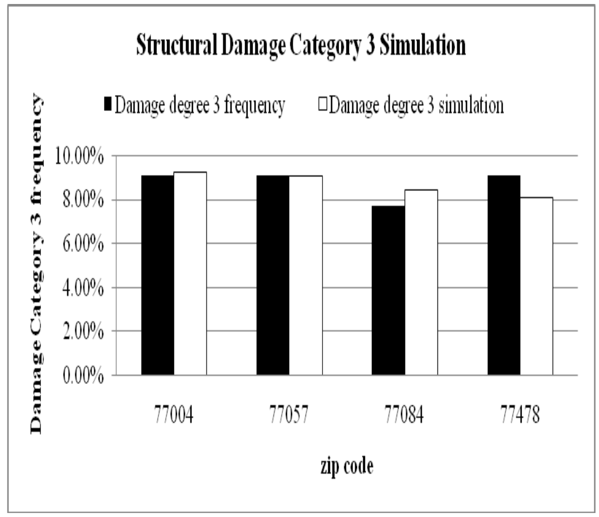

Figure 2. Actual and Predicted Structural Damage Category-3

4. Damage Model (DM-THC) for Structures and Utilities

During a hurricane the damage to the structures and utilities will not only depend on the wind speed, but also the trees around and the distance from the hurricane path. Using the data from survey, structural and utility damage category frequencies were related to the wind speed (V), distance to IKE path to each zip code (d) and tree distribution (T). Hence the damage model (DM-THC) relationship is as follows:

Frequency of Damage category = a[wind speed] m x [distance to hurricane path] n x [tree distribution] l,

$$[\text{FD Cat-1,2 or 3}] = a\,[V]^m \times [d]^n \times [T]^l \quad (1)$$

where parameters a, m, n and l will be determined based on the damage frequency and other data available.

For Residential Structure Damage (SD), Analyses showed that for category 3 (major damage) the wind speed and the distance from the hurricane path contributed. The relationship is as follows:

$$[\text{Frequency of SD-3}] = 306 \times 10^{-11} * [\text{wind speed}]^{3.7} * [\text{distance to IKE route}]^{0.08} \quad (2)$$

Hence wind velocity and distance are two important parameters. The predicted results using Eqn (2) are compared to the actual data in Fig. 2. The agreement is good.

The Damage Model also use in the simulation of Power Utility Damage and Water Damage.

6. Reference

Huang, Z., Rosowsky, D. V., and Sparks, P.R. (2001), Long-term hurricane risk assessment and expected damage to residential structures, Reliability Engineering and System Safety, 74, 239-249.

7. Acknowledge

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