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Modeling of hurricane damage for Hawaii residential construction

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Abstract

Past information on Hurricane Iniki damage to Hawaii buildings of residential, commercial, and resort occupancies has been gathered and geo-referenced on GIS. Comprehensive reconstruction cost documentation has been combined with post-hurricane aerial photography and linked to a robust property tax database of construction type attributes and property valuation. Using the data available in the property tax records to define construction attributes, residential building fragilities and loss functions have been developed along with risk relativity factors. *The resultant Damage Curves estimate hurricane damage to a wide variety of Hawaii building types as a function of peak gust windspeed.*

Keywords: Hurricane; Building damage; GIS; Hawaii

1. Introduction

Past information on wind damage to buildings of residential, commercial, and resort occupancies has been gathered and geo-referenced on GIS. These reconstruction cost estimates have then been combined with post-hurricane aerial photography imaging and robust databases of construction type, foundation, age, and roof design parameters. The wind speed-up results were used with a hurricane windfield model

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developed by a concurrent project, *Wind Speed Mapping of Hawaii and Pacific Insular States by Monte Carlo Simulation*, and a topographic effects model developed earlier in this project [1] to define wind speed regions of Hurricane Iniki to further segregate the data. Multivariate regressions of wind speed-defined building inventories subsequently were performed to develop building fragility, risk relativity, and expected wind loss functions for prototypical buildings reflecting the performance of Hawaii-specific construction features.

2. Hurricane Iniki

Hurricane Iniki was the most destructive storm to hit Hawaii in recorded history. The system initially formed from tropical depression 18E on September 5, 1992 near 12°N, 135°W. On September 7 at 5 p.m., it was upgraded to Tropical Storm Iniki near 12°N, 144.5°W. Iniki followed a westward track embedded in an easterly flow along the southern edge of the seasonal subtropical high pressure ridge that historically had carried most hurricanes south of the Hawaiian Islands. Iniki became a hurricane with estimated central pressure of 992 mb on September 8 at 11 p.m. Hawaii Standard Time when its position was at 13°N 152°W, and soon began translating west-northwest (See Fig. 1).

On September 10, as Iniki approached the weakening western edge of the subtropical high pressure ridge, a large low pressure area at 30°N and cold trough located east of the International Dateline created southwesterly upper level flow and southerly low level flow. As a result, when located near 15°N 159°W Iniki started to ''recurve'' northward while continuing to intensify (951 mb). At 2:00 p.m. Thursday afternoon, September 10, 1992, the National Weather Service had issued a bulletin indicating that Iniki would bypass the Hawaiian Islands. However, by 5:30 p.m., a Hurricane Watch was issued for Kaua'i with the center of the storm near 16°N 160°W. At 8:30 p.m., a Hurricane Warning was issued for Kaua'i. Located 210 km south-southwest of Lihue, Kaua'i on September 11, at 11 a.m., Iniki's central barometric pressure of 938 mb was the lowest ever recorded in a central Pacific hurricane, and Iniki was classified as a Category 4 hurricane with flight-level sustained winds of 65 m/s (145 mph) and gusts of 78 m/s (175 mph).

The hurricane made landfall at 3:30 p.m. Hawaii Standard Time at Category 3–4 intensity (945–950 mb) and quickly passed over the island by 4:10 p.m. (See Fig. 2). Iniki was a relatively small and compact storm with a radius to maximum winds of about 15 km, with sustained winds in open terrain of approximately 55 m/s (125 mph) and peak gusts of 72 m/s (160 mph) or more, subject to further increases caused by topographic speed-up. The peak gusts of 64 m/s (143 mph) recorded at Makahuena Point, located at the southeast corner of the island about 20 km distant from the center of the storm, and 58 m/s (130 mph) recorded at Lihue, about 25 km from the center, are considered representative surface windspeeds at landfall to the east of the eyewall in the right forward quadrant of the hurricane, that are also relatively free of major topographic effects [2].