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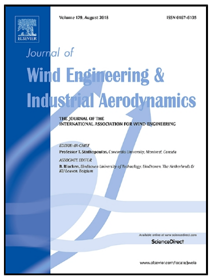

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Improved Near-surface Wind Speed Characterization Using Damage Patterns

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ABSTRACT: Tornadoes have caused significant damage and casualties in the past decades. These losses have spurred efforts toward tornado-based design, which require an accurate estimate of the tornadic near-surface wind speeds. Due to the difficulty of obtaining in-situ measurements and various issues regarding Enhance Fujita (EF) scale, a promising method of estimating near-surface wind speed based on damage inflicted is developed. The method utilizes fall directions of trees and other objects with distinct fall patterns to describe the characteristics of the tornado and other wind storms. The observed fall patterns are used to estimate Rankine vortex parameters and reproduce near-surface wind field. The wind field then can be compared to structural damage as an independent method. The near-surface wind speeds of different tornado cases were estimated using this method, one of which (Sidney, IL) exhibited 'crop-fall' patterns and yet another (Naplate, IL) caused damage to trees and other infrastructures such as street signs. Based on the damage to structures and estimated wind speeds from tree-fall analysis, empirical fragility curves are also developed, which allows to interpret the vulnerability to tornadoes. The entire process of wind speed, wind load, structural resistance and ultimately how to mitigate damage then can be better understood.

KEYWORDS: Tornado, Wind speeds, Tree-fall, Crops, Fragility

1. INTRODUCTION

During 1996–2017, the annual total loss from property and crop damage due to tornadoes reached nearly $1.5 billion (NOAA, 2018). As a result, tornado-based design for all structures, including residential and commercial structures, is gaining traction in the engineering community in order to minimize the structural damage (ASCE, 2016; Prevatt et al., 2012; van de Lindt et al., 2013). However, tornado-based design is particularly complicated because tornadoes induce more complex and extreme wind loading on buildings than straight-line winds (Amini and van de Lindt,