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MULTI-PLATFORM TORNADO DAMAGE SCENE PRESERVATION

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ABSTRACT

A severe tornado system produced damage to engineered metal buildings at an industrial facility outside Pampa, TX and toppled several nearby center-pivot irrigation structures. Rapid remote-sensing preservation of this overall damage scene was of particular necessity: access to the industrial facility was prohibited, and the overall size of the center-pivot irrigation system disallowed rapid direct measurement of member displacements. Engineers and architects from West Texas A&M University, University of Nebraska-Lincoln, and Texas Tech University collaborated to acquire and preserve the damage scene for future study, using a suite of existing and emerging platforms: including 3D point clouds derived from aerial FoDAR, aerial drone imaging, terrestrial laser scanning, and terrestrial digital photogrammetry as well as two-dimensional, four-band satellite imaging. Data collection using these various platforms offers guidance for the future remote-sensing preservation of damage scenes, the validation of estimated wind speeds currently employed in the Enhanced Fujita Scale of tornado intensity, and the further development of techniques for automated remote-sensing-based wind damage assessments.

1. BACKGROUND

A rare November tornado outbreak produced at least 17 tornadoes across portions of Texas, Oklahoma, and Kansas on November 16-17, 2015. The most intense of these tornadoes severely damaged a group of engineered buildings at the Halliburton Oilfield Services facility at Pampa, TX. The National Weather Service has rated the intensity of this tornado as EF3 (estimated 158 mph wind speed), based on damage to buildings at this facility. This facility contained multiple types of engineered structures for which structural resistances can be estimated, thereby enabling the verification of the estimated wind speeds required to cause the observed damage. The tornado also overturned several nearby engineered center-pivot irrigation systems.

2. NEED FOR REMOTE SENSING

Facility owners made immediate plans to demolish the damaged buildings and prohibited access to the site due for safety and security liability reasons. Investigators were therefore not able to make direct measurements of structural member sizes and deformations to assist with resistance calculations. Investigators were, however, able to acquire laser scan data from the property line. As structural steel members of the pre-engineered metal buildings were visible, measurements of the member sizes could be utilized in structural analysis models to validate or correct the wind speed estimates for damage to pre-engineered buildings in the current EF Scale. Laser scanning from the property line as well as aerial and drone (UAV) imaging provided effective solutions for rapidly and accurately preserving damage data for subsequent detailed forensic analysis. Although access to the nearby center-pivot irrigation systems was possible, measurements of the overall structure (approx. ¼ mile long) and deformations were most readily accomplished by laser scanning and drone imaging.

3. DATA ACQUISITION

In the weeks following the tornado, a collaborative team of investigators from West Texas A&M University, the University of Nebraska-Lincoln, the National Wind Institute of Texas Tech University, and the Texas Tech University School of Architecture conducted a multi-platform remote-sensing investigation of the Halliburton facility and surroundings to capture data for further analysis. The various remote-sensing platforms included UAV (drone) imaging, 3D laser (LiDAR) scanning 3D photogrammetric modeling based on a suite of 2D digital images, 3D FoDAR imaging based on third-party aerial imaging, and high-resolution satellite imaging.

4. ADVANTAGE OF DATA PRESERVATION

These data have provided the opportunity to demonstrate new and existing platforms available for reality capture for damage scenes. Long-term preservation of such damage scenes will be valuable for wind engineering researchers and insurance modellers for decades to come. An archive of such damage scenes is being made available for use by researchers through the NHERI DesignSafe-ci.org Cyberinfrastructure data repository at the University of Texas at Austin. The data in this repository can assist hazards researchers in countless future analyses, including validation of damage models. This event is one of the first new events to be preserved in this new archive. Preservation of 3D damage scenes, including damaged structures and related debris fields, enables researchers to validate new wind-damage prediction models, via physical (wind-tunnel) modeling, computer modeling (computational fluid dynamics) and other predictive damage modeling (e.g., loss estimation and risk assessment models). Such perseverations of data minimize collection times, costs, and efforts and also facilitate forensic structural engineering investigations whenever access is limited due to safety and/or security concerns.

5. OPPORTUNITIES FOR APPLICATION OF DATA

Preservation of 3D damage scenes enables researchers to validate new wind-damage prediction models, via physical modeling, computer modeling, and other predictive damage modeling (e.g., loss estimation and risk assessment models). Such perseveration of data minimizes collection times, costs, and efforts and also facilitate forensic structural engineering investigations whenever access is limited due to safety and/or security concerns. The data are valuable to wind-hazard researchers, structural engineers, and atmospheric scientists because the performance of these structures under the extreme tornado-induced loads help to validate the wind speed estimates for the EF Scale. Due to the scarcity of direct measurements, tornado wind speeds remain largely unknown; the EF Scale has thus necessarily relied upon wind speeds estimates based on common damage indicators (e.g., trees, signs, light poles, and buildings). By nature, the vast majority of these damage indicators are found in urban or forested areas, while damage indicators in rural areas remain scarce. For accurate populating of the national tornado database (relied upon for risk assessments for engineering design and insurance modeling), it is necessary to obtain intensity information for all tornadoes: including both urban and rural settings. Damage information for new damage indicators can be readily obtained using the above-mentioned platforms.

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