



DEVELOPMENT OF THE ASCE/SEI STANDARD FOR THE ESTIMATION OF TORNADO WIND SPEEDS

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ABSTRACT

Development of the new ASCE/SEI consensus standard for wind speed estimation in tornadoes began in 2014 and is currently underway. The intent of the new standard is to standardize the methods used to estimate the wind speeds in tornadoes including improvements and expansions for the damaged-based Enhanced Fujita Scale (EF Scale), with potential to extend the scope of the standard to include other windstorms. The standard will include sections on the EF Scale, radar measurements, tree fall pattern analysis, data archives, forensic engineering analysis, in-situ measurements (anemometry), and remote-sensing applications. Users of the standard will include wind, structural and forensic engineers, meteorologists, climatologists, forest biologists, risk analysts, hazards modellers, emergency managers, building and infrastructure designers, the insurance industry, and the media. The standard is intended for adoption by the National Weather Service and for use by storm study teams and researchers as a guide for conducting storm surveys and analysis of storm data. Development of the standard highlights the current state-of-the-art in wind speed estimation and also identifies areas where new research is needed. Development of the standard will include a public ballot period. The standard is scheduled to be completed in 2019.

1. ENHANCED FUJITA SCALE

The EF Scale subcommittee is exploring possible new Damage Indicators (DIs) for inclusion in the standard. These additions are particularly necessary for the estimation of wind speeds where no DIs are currently available, especially in rural areas. New research on wind damage modes to additional objects has been completed since the current EF Scale was released in 2006, and the standard will benefit from inclusion of new DIs. Further enhancements to the EF Scale include revision of existing DIs and DoDs to achieve better consistency in damage descriptions and wind speed estimates for buildings with similar construction types, rounding of wind speed values (to remove the unwarranted perception of precision), and emphasis on construction and assembly – rather than occupancy – of buildings for possible combination and simplification of existing DIs. The DIs and DoDs for trees

will also be updated based on recent research. Photographic guidance will also be provided for all DIs and DoDs to fill existing gaps.

2. FORENSIC ENGINEERING

Careful attention to detailed forensic engineering provisions in the standard includes probabilistic failure analysis emphasizing fragility functions for more common building types, identification of essential parameters of both tornado wind structure and characteristics of structures leading to wind damage, and protocols for collecting and analyzing field damage data to determine associated wind speeds.

3. REMOTE SENSING

Remote sensing provides an effective means of quickly acquiring and preserving damage data across a large area. Remote-sensing data of various spatial resolutions are helpful for a variety of damage data: satellite imagery in the range of 1 km to 1 m can be used to determine tornado paths; satellite and aerial imagery with resolutions finer than 1 m can be used to make overall condition assessments of damaged buildings; imagery with resolutions of 1 cm and finer (some aerial and UAV imaging as well as laser scanning) can be used to determine the size of structural members and to determine the extent of structural deformations (useful for detailed forensic studies). The ASCE standard will provide guidance on the use of imagery with various spatial resolutions for large-scale applications (tornado path characteristics) and small-scale applications (assessment of damages to DIs at the DOD level as well as forensic studies). Although continued research addresses the automation of wind damage assessment using remote-sensing imagery, practical implementation of remote-sensing imagery is heavily reliant on manual (visual) assessments of damage. The first edition of the ASCE standard will therefore concentrate on the necessary parameters of remote-sensing imagery (e.g. spatial and spectral resolutions) for various large-scale and small-scale applications conducted through manual (visual) analysis.

4. TREE FALL ANALYSIS

New research has focused on the production of wind speed estimates from analysis of tree-fall patterns (derived from aerial image analysis) from within tornado tracks. The method generates a spatial grid of maximum wind speeds as well as instantaneous wind vectors along a tornado path.

5. RADAR AND IN-SITU MEASUREMENTS

Although direct measurement of tornado wind speeds is relatively rare, the benefits of direct measurements are tremendous. The ASCE standard will provide specifications (e.g., anemometer siting and instrument characteristics) that must be met to ensure reliability of in-situ data. In conjunction with radar data, in-situ data can help to better determine the vertical profile of horizontal wind speeds in tornadoes and other wind events. In-situ measurements can also help to evaluate the use of barometry as a possibly proxy for estimation of tornado wind speeds.

6. INTERNATIONAL INTEREST

It is anticipated that the ASCE standard will serve as an international model for tornado wind speed estimation, and its development has attracted significant interest from international engineers and meteorologists. Around the world currently, only a handful of countries have formally adopted the EF-Scale, so a wide range of approaches are used. Having international agreement on standardized approaches for wind speed estimation would enhance the ability to gain a consistent understanding of tornado climatology from around the world. The ASCE standards committee has strong representation from Canada, Japan, and Europe, and the international working group is actively considering the inclusion of various worldwide approaches as a part of the standards document commentary with the vision of eventually harmonizing various approaches employed worldwide.