May 12, 2016

MEMORANDUM TO: Sujit K. Samaddar, Chief
Structural Engineering Branch
Division of Engineering Infrastructure
and Advanced Reactors
Office of New Reactor

FROM: Tze-Jer Chuang, Senior Structural Engineer **/RA/**
Structural Engineering Branch
Division of Engineering, Infrastructure
and Advanced Reactors
Office of New Reactor

SUBJECT: JOINT TRIP REPORT FOR MARCH 2-4, 2016, AMERICAN SOCIETY OF CIVIL ENGINEERS STANDARD 67 TORNADO WIND SPEED ESTIMATIONS MAIN COMMITTEE MEETING

The main committee meeting of the American Society of Civil Engineers (ASCE) Standard 67 on Tornado Wind Speed Estimations was held in Norman, OK, during the week of March 2-4, 2016, at NOAA's Weather Service Center. The U.S. Nuclear Regulatory (NRC) staff members who participated in the main committee meetings covered in this report include Tze-Jer (Jerry) Chuang of Office of New Reactors and Joseph Kanney of Office of Nuclear Regulatory Research. Mr. Chuang attended in person while Mr. Kanney participated via webinar. The attached enclosure contains a summary of the major items discussed at the various meetings in which the aforementioned staffs participated. A copy of the NRC trip report for the participation in the main committee meetings of ASCE Standard 67 on Tornado Wind Speed Estimations is also included as an attachment to the enclosure.

Enclosure:
Trip Report

CONTACTS: Tze-Jer Chuang, NRO/DEIA
301-415-8586
Joseph F. Kanney, RES/DRA
301-415-1920

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Memo to Sujit K. Samaddar from Tze-Jer Chuang dated _____

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TRIP REPORT

AMERICAN SOCIETY OF CIVIL ENGINEERS
TORNADO WIND SPEED ESTIMATIONS STANDARD COMMITTEE MEETING

MARCH 2-4, 2016

NORMAN, OK

Abstract

This trip report contains the information obtained from participation in the third American Society of Civil Engineers (ASCE) Standard 67 Main Committee Meeting on Tornado Wind Speed Estimations held in Norman, OK, March 2-4, 2016. The status and progress of the Standard write-up, 8 chapters inclusive, are covered. U.S. Nuclear Regulatory (NRC) staff positions were proposed to working group (WG) 3 under the Subcommittee on enhanced Fujita (EF) Scale as a new damage indicator (DI) for the nuclear facilities to promote NRC's interest. NRC WG Action Items are highlighted at the end of the report.

INTRODUCTION

Concerning the design of the SSCs important to safety, the NRC currently recommends the COL applicants to follow Regulatory Guide (RG) 1.76 in defining the site-specific design-basis tornado wind loadings in Standard Review Plan (SRP) Section 3.3.2 (which is a deterministic approach[1]). The recommendation in RG 1.76 is based on EF scale tornado wind maps published by NUREG/CR-4461 based on data provided by National Oceanic and Atmospheric Administration (NOAA's) National Weather Service. However, recent violent EF-5 tornado outbreaks had a wind speed at 300 mph or more, far exceeding the EF-5 lower bound level of 200 mph. Use of the wind maps in EF-scale to define the tornado wind loads, for the purposes of design against tornado strikes for the structure, system and component (SSCs) important to safety may become un-conservative. Further, for a given tornado, the wind speed estimated by the different available techniques often yields inconsistent results. Recognizing those shortcomings, NOAA in conjunction with National Institute of Standards and Technology (NIST) proposed to establish a standard on tornado wind speed estimations, encompassing all available methodologies in an attempt to make all estimation results consistent. The proposal was submitted to ASCE and as a result, a new standard proposal, ASCE 67 on Tornado Wind Speed Estimations was approved in 2014. A Standards Committee consisting of 30 voting members was created in 2015, to develop the standard. The plan was to complete the draft by 2019, and publish the standard in 2022.

After the standard is established, NOAA intends to develop a new set of tornado wind maps for the continental United States with wind speed data compiled by the standard methods. It is expected that this NOAA's effort should result in a publication of more precise and reliable tornado wind maps. Once the new maps are published by NOAA, NRC may need to revise RG 1.76 using the updated wind maps in compliance of general design criteria (GDC) 2, which depicts that combined operating license (COL) applicants shall design the SSCs important to safety against tornado effects with a design basis (cf. SRP Chapter 3 in deterministic approach)

[1] The design-basis wind speed is based on a probabilistic approach (i.e. the 1E-7 annual exceedance probability). Once that wind speed has been defined, the approach to estimate wind and missile loads is deterministic.

to reflect the most severe tornadoes that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. Accordingly, it is important that our NRC WG should help to shape the Standard promoting NRC's interest. On the other hand, the tornado hazard may be characterized by risks (cf. SRP Chapter 19 in probabilistic approach). Currently, NRC in SRP 3.3.2 endorses ASCE Standard 7-05 in which tornado design is not covered. Recognizing this shortcoming, an Ad-Hoc Committee on Tornado Resistant Design was created between ASCE 67 and ASCE 7. Meanwhile, a three-year research contract was awarded to Applied Research Associates, Inc., (ARA) by NIST to develop tornado/hurricane hazard maps in the United States. The objective was to develop a new chapter in ASCE 7-22 covering tornado design with those hazard maps developed by ARA attached as an appendix to the new chapter. Once the new version of ASCE 7 is finalized, the NRC should propose a tornado margin analysis methodology for beyond-design-bases tornado events using PRA approach based on ASCE 7 in SRP Chapter 19 (in contrast with the deterministic approach in SRP Chapter 3.5/8.3), similar to the case of seismic analysis (SRP 3.7 vs. 19.55). Accordingly, NRC WG should also participate in the AD HOC Committee as the new chapter in tornado resistant design in ASCE 7-22 will impact on SRP Chapter 3 and Chapter 19.

Third ASCE 67 Main Committee Meeting[1]

The third Main Committee Meeting of the ASCE Standard 67 on Tornado Wind Speed Estimations was held in Norman, OK, during the week of March 2-4, 2016 at the NOAA's Weather Service Center. The NRC staff members who participated in the meetings include Tze-Jer (Jerry) Chuang of Office of New Reactors and Joe Kanney of Office of Nuclear Regulatory Research. The following contains a summary of the major items discussed at the various meetings in which the staff participated.

Subcommittee on Remote Sensing of Tornado Damage (Chapter 6)

The Subcommittee Chair, Arn Womble led the discussion on finalizing the scope statement. There are two working groups to develop Chapter 6 of the Standard: (1) WG-1 on Small Scale was tasked to identify DIs' for which minimum remote sensing parameters will be specified; to develop methodology for assigning confidence intervals to DIs, Department of Defense (DODs) and remote-sensing parameters such as view angle, spectral resolution, spatial resolution, etc., and (2) WG-2 on Large Scale was tasked to identify critical measures (path length, width) on tornado path/track for which minimum remote sensing parameters will be specified; to assign minimum resolution and view angle for large-scale pattern determination, and to provide example images. Details of the sensing techniques were discussed, including passive imagery (e.g., observations of the visible or near-infrared portions of the electromagnetic spectrum) and active imagery (e.g., LiDAR or synthetic aperture radar). In this regard, it is noted that NOAA has announced a research funding in its VORTEX-SE Program at $3.3 M per annum on the development of innovative measurement technology on tornado wind speed.

Subcommittee on Tree Fall Pattern (Chapter 7)

The Subcommittee Chair (SC,) Chris Karstens led the discussion on finalizing the scope framework. Chapter 7 of the Standard will be consisted of three sections: (1) Tree fall vector digitization from observations including field surveys, aerial surveys and mapping; (2) Pattern matching including tree fall simulations, subjective methods and objective methods; and (3) Statistical techniques.

International Working Group

The International Working Group organized by Greg Kopp of Canada aims to define international approaches to tornado damage characterization and uses of the E-F Scale. Detailed objectives include: (1) to identify various approaches used to characterize tornadoes around the world; (2) to identify similarities/differences in the scale and approaches to damage characterization; (3) to identify common international DIs; and (4) to provide recommendation on how a common scale can be developed.

The following items suggested to be included in the International Standard were discussed: (1) Approaches to characterize tornado around the world including the rates used; how the damage is assessed; similarities and differences in scale used and how the damage survey is conducted; (2) E-F scale and its variations such as how many countries use E-F scale; what's their variations, and who are in charge of maintaining the scale (Table 3 lists E-F scale speeds set by various countries); (3) DIs and DODs describe DI/DODs in different countries; their commonalities and differences; the processes used to modify/develop new DI/DODs; and common international DIs; (4) Conclusions and Recommendations. To be included in the Appendix are: A- DIs in the World; B-Tornado damage scale references and C- Contacts responsible in various countries. Next Meeting is scheduled on 9/5-8/16 in Austria.

Yukio Tamaru presented an introduction on the Japanese Tornado Standard including a set of standard DI/DODs and standard EF ratings where wind speed will be specified in addition to the range of the rating.

Main Committee Meeting

Jim LaDue, the Committee Chair, presented the opening remarks including the summary of the second Committee Meeting in Texas; progress report; and meeting expectations. The number 4 and 5 Meetings will be skipped, using webinars. The next Main Committee Meeting will be held in Spring, 2017 at Norman, OK again.

Marc Levitan, the Co-Chair of the Committee, made a presentation on the frame work of the Standard Chapter 1 "General Requirements" which includes three main sections in the main body and a Commentary at the end: (1) Definition of common tornado wind parameters such as velocity profile, guest factor, correction for exposure (e.g., effect of terrain roughness), correction to topography, etc., (2) Common data, metadata and data archival requirements; (3) Other common requirements across multiple chapters. The Commentary Section will include (i) Consensus judgement of the committee; (ii) Interpretation and consideration for unusual circumstances; (iii) User's Guidance; and (iv) examples.

Darrel Kingfield of NOAA made a tech presentation on "A Comparison of Landsat-derived Disturbance Detection to NDVI for the Identification of Tornado Damage in Forests" which compares Disturbance Index (DI) with Normalized Difference Vegetation Index (NDVI) in space borne imagery for several tornadoes.

Larry Twisdale of ARA made a technical presentation ("Probabilistic Tornado Damage Modeling Update") which described finite element modeling of wind impacts on 3 types of wall: unreinforced masonry (URM), Tilt-up and bond beam were developed and verified with data.

The output is a set of fragility curves. Examples were given to demonstrate their applicability, using 3D Building Models for Walmart (in the case of RM walls) and Home Depot (in the case of tilt-up walls). A discussion followed which concluded that the APC (atmospheric pressure drop) effects on large buildings with few openings are significant for tornadoes as compared with straightline winds. Other influencing factors include: rotation, vertical velocity profile and size effects. Another idea proposed: Can we use component-level DI?

Subcommittee on Radar (Chapter 3)

Josh Wurman, the SC Chair led the discussion on the measuring methods by DOW, Mobile Mesonates and Weather Pods. Data obtained at low-levels from 1-50 m above ground level (AGL) tornadic winds: In-situ and Radar observation at Low levels (TWIRL) in the Great Plains. Specific devices used include: light detection and ranging (LIDAR,) sound detection and ranging (SoDAR) and other airborne radar (ARs). Criteria to be developed such as gate length, pulse length, pulse repetition time (PRT,) Dwell time, number of hits, beam width across tornado diameter, etc. by experts (Wakimoto, Atkins, Rasmussen, etc.)

Subcommittee on In-Situ (Chapter 2)

Chris Karstens made a tech presentation on “Near Ground Pressure and Wind Measurements in/near Tornadoes” in which in-situ data measurements for pressure deficit in/near a tornado are presented as a function of distance or time.

Frank Lombardo, the SC Chair presented in-situ data of the horizontal as well as vertical velocities as a function of height (AGL). Two critical parameters must be standardized: AGL (10m or 30m?) and gust factor (1 s or 3 s?). The SC continued to develop the framework of the Standard Chapter 2. The scope of Chapter 2 will covers measurement height AGL, average time, terrain conditions for all wind directions, instrument types, sampling rate, profile and geographic location.

Subcommittee on Forensic Engineering (Chapter 5)

William Coulbourne, the SC Chair discussed the scope and framework of the Standard Chapter 5 on Forensic Engineering. Important sections include: wind effects, probability of failure with associated range of wind speeds. When appropriate: special effects, static pressure drop, transient effect, debris loading. Building orientation and building geometry. Technical issues discussed include: (1) deterministic vs. probabilistic approaches; (2) Tornado wind structure; (3) Procedure of converting wind speed to pressure loading follows ASCE 7 on 3 s gust, although radar measurement using 1 s gust; (4) contribution to damage must consider wind-borne debris in addition to wind load/pressure.

Subcommittee on Data and Archival Requirements (Chapter 8)

Brenton MacAloney, the SC Chair was to decide whether Chapter 8 is necessary. Depending on other SC’s request/results, those requirements could be included in Chapter 8 or spread through other chapters or be part of Chapter 1. Members responsible for the requirements in each chapter are: EF-Scale (B. Smith, J. LaDue), Forensic Engineering (D. Herseth, J. Kanney), In-situ (Marc Levitan), Radar (Melissa Faletra, D. Burgess), Remote Sensing (D. Liang, B. Smith), Tree Fall Pattern (J. Kanney, E. Ostyno).

Subcommittee on EF-Scale (Chapter 4)

Tanya Brown-Giammanco, the SC Chair reported the status of Chapter 4: the Chapter scope was completed; outlines were ongoing and definitions were in progress. There are five working groups. The status of the WG activities are listed below.

Working Group 2 on Update DI/DOD Photos (Chair: Brian Smith)

- Set-up Google Drive Folder
- Photo uploader stored to NWS Server (NOT in ASCE Standard; but electronically available)

Working Group 3 on New DI/DODs (Chair: Tom Smith)

- Draft list of potential new DIs with Champions identified
    - Tze-Jer (Jerry) Chuang representing NRC proposed Nuclear Facilities as DI No. 17:
        - DI 17.1 Reactor Containment Building
        - DI 17.2 Turbine Building
        - DI 17.3 Administration Building
        - DI 17.4 Switchyard
        - DI 17.5 ISFSI
        - DI 17.6 Fuel Handling Building
        - DI 17.7 Uranium Enrichment Facilities

- Develop criteria/ data requirements
- Set-up process to complete the work
    - DIs with no champions postpone to next version
    - Proposal template will be sent out by Tom Smith
    - Champions selected and send proposal (not include wind speeds associated with DODs) to Tom Smith by November 1, 2016
    - Tom will send the proposal to WG 3 members for comments
    - Upon consensus, the proposal will be sent to SC-EF Scale

Working Group 4 on Existing DI/DODs (Chair: Tim Marshall)

- Primary adjustments
- Adjust Wind Speeds
- Combine a few DIs of similar constructions
- Standardize DIs/DODs
- Correlate wind speed with research.

Working Group 5 on Tree DIs (Chair: Chris Peterson)

Melissa Faletra of ARA made a presentation on Statistical Analysis of DI Frequencies based on data collected from Storm and DAT database. Based on the results, the following 3 DIs occurred most frequent: Houses; Trees and Electrical Lines/towers of which WG4 and WG5 should focus efforts as a first priority.

NRC Working Group on Tornadoes Action Items

NRC has established an internal WG to address wind and missile hazards. Part of the WG charge is to support NRC participation in the ASCE Standard 67. As Tze-Jer (Jerry) Chuang proposed a set of new DIs to WG 3 of the SC-EF Scale based on our NRC staff position, and these new DIs had been labeled as DI No. 17, the following action items are needed from our NRC WG:

(1) Identify NRC staff members who can serve as Champion or Assistant Champion for the following new DIs:
- 17.1 Reactor Containment Building
- 17.2 Turbine building
- 17.3 Administration Building
- 17.4 Switchyard
- 17.5 ISFSI (Independent Spent Fuel Storage Installation)
- 17.6 Fuel Handling Building
- 17.7 Uranium Enrichment Facility

(2) Tze-Jer (Jerry) Chuang is to receive the template of the proposal from WG3 Chair, Tom Smith
(3) Each Champions and Associates to fill-out the proposal. Included are Justification, DI name, its DODs. The wind speeds need not be worked out.
(4) The deadline for submitting the proposal to Tom is November 1, 2016.
(5) Develop a strategy on how to deliver the staff position on EF-5 upper-bound to ASCE Committee on EF Scale.

There will be a meeting at ASCE HQs in Reston, VA on Friday, March 25, 2016 sponsored by Ad Hoc Committee on Tornado Resistant Design