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49-21

Wind Tunnel Testing for Buildings and Other Structures

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DEDICATION

The members of the Wind Tunnel Testing for Buildings and Other Structures Standards Committee of the Structural Engineering Institute respectfully dedicate this standard in the memory of Dr. Jon A. Peterka, P.E., who passed away on May 22, 2019.

Jon was a pioneer and community pillar of wind engineering. He was instrumental in the writing of the first version of ASCE 49 (and its antecedent, ASCE Manual of Practice 67), and was relied on for thoughtful guidance as the ASCE 7 wind load provisions evolved. This service to our profession was only the tip of the iceberg in his passion for his work. Jon's imprint can be found throughout this standard, certainly in the knowledge and methods he contributed, but also in the spirit in which we strive to provide the information necessary to improve the transparency, consistency, and quality of wind tunnel testing.

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PREFACE

Prepared by the Wind Tunnel Testing for Buildings and Other Structures Standards Committee of the Codes and Standards Activities Division of the Structural Engineering Institute of ASCE

Wind Tunnel Studies for Buildings and Other Structures, Standard ASCE/SEI 49-12, provides the minimum requirements for conducting and interpreting wind tunnel tests to determine wind loads on buildings and other structures. Wind tunnel tests are used to predict the wind loads and responses of a structure, structural components, and cladding to a variety of wind conditions. This standard includes commentary that elaborates on the background and application of the requirements.

Topics include simulation of wind in boundary-layer wind tunnels, local and area-averaged wind loads, overall wind effects, aeroelastically active structures, extreme wind climate, and snow load model studies.

New to this version are requirements for wind loads on products. Wind loads are a critical design consideration for many mass-produced products that are constructed or installed at many different sites and in many different situations. Such products can be building-mounted (sunshades, solar racking, HVAC units, screen walls) or freestanding (ground-mounted solar trackers, gazebos, fences, communication towers). In addition, commentary guidance is provided for determining wind loads on buildings and other structures in tornadoes, which is an area of current active research.

The requirements outlined in this standard satisfy requirements for wind tunnel testing set out in *Minimum Design Loads for Buildings and Other Structures*, Standard ASCE 7. The loads produced by these tests are suitable for use in building codes and standards.

The material presented in this standard has been prepared in accordance with recognized engineering principles. This standard should not be used without first securing competent advice with respect to its suitability for any given application. The publication of the material contained herein is not intended as a representation or warranty on the part of ASCE, or of any other person named herein, that this information is suitable for any general or particular use or promises freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability from such use.

This standard will be useful to those who design, conduct, and interpret wind tunnel tests for buildings, including structural engineers, architects, and building code officials.

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ACKNOWLEDGMENTS

ASCE acknowledges the work of the Wind Tunnel Testing for Buildings and Other Structures Standards Committee of the Codes and Standards Activities Division of the Structural Engineering Institute (SEI). This group comprises individuals from many backgrounds representing consumers, producers, and general interest individuals; included were wind engineers, consulting engineers, professors, and an insurance company representative. This standard was prepared through the consensus standards process by balloting in compliance with procedures of ASCE's Codes and Standards Committee.

The following individuals serve on the Wind Tunnel Testing Standards Committee:

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CHAPTER 1
GENERAL

1.1 SCOPE

This standard provides minimum requirements for wind tunnel tests to determine wind loads on, and responses of, buildings and other structures. Loads considered in this standard are wind loads for main wind-force-resisting systems (MWFRS) and for individual structural components and cladding (C&C) of buildings and other structures. Loads produced by tests meeting the specifications of this standard are suitable for use as design wind loads in applicable building codes and standards.

Provisions of this standard satisfy the requirements for wind tunnel testing of ASCE 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Wind tunnel testing has the capability to perform measurements beyond those specifically addressed in this standard, including pedestrian wind evaluations, dispersion of airborne pollutants, fugitive particulates, and wind energy siting studies. Although these studies are not included in the scope of this document, they shall be permitted to be included within the test report addressing wind loads.

The flowchart in Figure 1-1 illustrates the organization of this standard; it is intended to assist the user in navigating the relevant chapters and to identify the scoping considerations therein.

1.2 REPORT CONTENT

The wind tunnel test report (hereinafter referred to as the report) shall be prepared to document the wind tunnel test setup, procedure, and results.

The report, including any appendixes, shall be auditable and contain sufficient information that any party reviewing or performing a peer review of the wind tunnel tests can clearly understand all testing methods, assumptions, and results. At a minimum, the report shall include the following material directly or this information shall be documented and be made promptly available to the sponsor on request:

1. Description of the test setup, objectives, and test methodology, including
   (a) Similarity parameters for geometric (length), velocity, and time scaling;
   (b) Characteristics of the target upwind exposure, terrain, and proximity features;
   (c) Description of the measurement technique utilized; and
   (d) Any other basic characteristics of the test setup.
2. Description of the properties of the simulated wind field for each wind direction considered, including
   (a) Simulated and target mean velocity profiles,
   (b) Simulated and target longitudinal turbulence intensity profiles, and
   (c) Simulated and target turbulence spectra and longitudinal length scales.
3. Description of the development and application of the wind climate analysis, including
   (a) Basic wind climate characteristics and a description of data set(s) used, and
   (b) A description of the statistical method used to combine the climatological data with the aerodynamic response results.
4. Results of the tests
   (a) The specific type of test results to be included in the report and the format in which they are to be used shall be based on the agreement between the sponsor and the wind tunnel laboratory.
5. Quantification of the uncertainty
   (a) This shall include uncertainties associated with the testing process and techniques: structural property assumptions, the wind climate data, measurement devices, approach flow, and any other sources contributing to the overall uncertainty.

Time histories of the loads, pressures, and reference velocities shall be stored for future reference and quality control purposes.

Where wind tunnel test conditions vary from those specified in this standard, a justification for the variance shall be included in the report.

1.3 COORDINATE SYSTEMS

The following coordinate system with mean and fluctuating velocities is defined:

x, y, z = Right-hand coordinate axes, z is vertical;
U, V, W = Mean velocities in the x-, y-, and z-directions; and
u, v, w = Fluctuating portion of velocity vector in the x-, y-, and z-directions.

1.4 DEFINITIONS

Unless specified in this section, all terms used in this standard are consistent with definitions of the ASCE 7 wind load provisions.

Aeroelastic Feedback: Process by which motion of a body in the wind causes changes in applied wind pressures.

Aeroelastic Model: Model that simulates the stiffness, mass, and damping of the full-scale structure.

Aeroelastic Structure: Flexible building or other structure for which the aerodynamic forces are affected by the motion of the structure itself.

Approved: Acceptable to the Authority Having Jurisdiction.

Atmospheric Boundary Layer (ABL): Lower part of the atmosphere, typically 3,000 to 13,000 ft (1,000 to 4,000 m) thick