# Chapter 1

# Introduction

The American Society of Civil Engineers (ASCE) publication, ASCE/SEI Standard 7-10, *Minimum Design Loads for Buildings and Other Structures*, is a consensus standard. It originated in 1972 when the American National Standards Institute (ANSI) published a standard with the same title (ANSI A58.1-1972). That 1972 standard was revised 10 years later, containing an innovative approach to wind loads for components and cladding (C&C) of buildings (ANSI A58.1-1982). Wind load criteria were based on the understanding of aerodynamics of wind pressures in building corners, eaves, and ridge areas, as well as the effects of area averaging on pressures.

In the mid-1980s, ASCE assumed responsibility for the Minimum Design Loads for Buildings and Other Structures Standards Committee, which establishes design loads. The document published by ASCE (ASCE 7-88) contained design load criteria for live loads, snow loads, wind loads, earthquake loads, and other environmental loads, as well as load combinations. The ASCE 7 Standards Committee consists of voting membership representing all aspects of the building construction industry. The criteria for each of the environmental loads are developed by respective subcommittees.

The wind load criteria of ASCE 7-88 (ASCE, 1990) were essentially the same as ANSI A58.1-1982. In 1996, ASCE published ASCE 7-95 (ASCE, 1996). This version contained major changes in wind load criteria: the basic wind speed averaging time was changed from fastest-mile to 3-second gust. This in turn necessitated significant changes in boundary-layer profile parameters, gust effect factor, and some pressure coefficients. A *Guide to the Use of the Wind Load Provisions of ASCE 7-95* (Mehta and Marshall, 1997) was published by ASCE to assist practicing professionals in the use of wind load provisions of ASCE 7-95.

In 2001, ASCE published a revision of ASCE 7-95 with updated wind load provisions. The document is termed ASCE 7-98 and has the same title (ASCE, 2001). The International Building Code (ICC 2000) adopted the wind load criteria of ASCE 7-98 by reference. This was a major milestone since it had the potential to establish a single wind load criterion for design of all buildings and structures for the entire United States. A *Guide to the Use of the Wind Load Provisions of ASCE 7-98* (Kishor and Perry, 2001) was published soon after publication of ASCE 7-98. After each revision of the ASCE/SEI standard in 2002 and 2005 *Guide to the Use of the Wind*

*Load Provisions* are published by ASCE (Mehta and Delahay, 2003, Mehta and Coulbourne, 2010).

A revised standard, ASCE/SEI 7-10, was published by ASCE (ASCE, 2010). This version of the standard contains significant changes in wind speed maps, load factors, and format of the wind load provisions. This document, *Wind Loads: Guide to the Wind Load Provisions of ASCE 7-10*, contains explanations and guidance to the changes in the wind load provisions. Two items in the previous guides were well received by practitioners: Examples and Frequently Asked Questions; these items are revised and retained in this updated guide.

## 1.1 Objective of the Guide

The objective of this guide is to provide direction in the use of wind load provisions of ASCE 7-10 (referred to as "the Standard"). The Commentary of ASCE 7-10 (chapters C26 through C31) contains a good background and discussion of the wind load criteria; that information is not repeated in this document.

**Chapters 4 through 13** of this guide contain 14 worked examples. Various examples illustrate different methods of obtaining wind loads given in the Standard. Sufficient details of calculation of wind loads are provided to help the reader properly interpret the wind load provisions of the Standard. Sections of the Standard, as well as the figures and tables of the Standard, are cited liberally in the examples. The equation numbers given in the examples are from the Standard to allow users to track steps of the Standard. ***It is necessary to have a copy of ASCE 7-10 to follow the examples and work with this Guide.*** A copy of ASCE 7-10 can be ordered by calling 1-800-548-ASCE or ordered on-line at http://www.asce.org/bookstore.

## 1.2 Significant Changes and Additions

The wind load provisions of ASCE 7-10 appear completely different from the previous versions of the Standard because of a major change in the format. Wind load provisions contained in one chapter (chapter 6) in previous versions are expanded into chapters 26 through 31. This expansion is designed to make provisions more user-friendly. The provisions are organized by the type of building or structure under consideration, and equations and tables are repeated to provide all necessary items in one location or chapter.

In addition to format, other significant changes include wind speed maps that are related to limit state loads, an addition of a simplified procedure for enclosed buildings with roof height equal to or less than 160 ft, and clarifications/modifications of exposure categories, debris zones, and minimum loads. The basic approach to assessing wind loading has not changed. Major changes in format are listed as follows by each chapter.

Chapter 26 contains general requirements for wind load determination. General requirements for all buildings and structures include wind speed, wind directionality, exposure category, topographic effect, gust effect factor, enclosure classification, wind-borne debris regions, internal pressure coefficient, symbols, and definitions. Decisions regarding these requirements can be made prior to obtaining wind loads for surfaces of buildings and structures.

Chapter 27 contains wind load criteria for the main wind force-resisting system (MWFRS) of buildings using the directional approach. This approach is the traditional approach used since ANSI A58.1-1972. Wind loads criteria in Part 1 are applicable to enclosed, partially enclosed, or open buildings of any height. Criteria of Part 1 are necessary if wind loads are to be determined for windward, leeward, and side walls and roof including internal pressures for the MWFRS. Part 2 is a new simplified procedure for buildings with roof height equal to or less than 160 ft; the procedure is restricted to enclosed buildings with simple diaphragms. Simplification in Part 2 constitutes a tabular form of pressure values. There are other restrictions for use of the simplified procedure of Part 2; these are shown in **Chapter 2** of this guide.

Chapter 28 contains wind loads criteria for the MWFRS of low-rise buildings (envelope approach for buildings with roof height *h* less than or equal to 60 ft). Part 1 of the chapter gives equations for velocity pressures and design pressures for windward, leeward, and side walls and roof of the building. Part 2 is a simplified procedure in which horizontal and vertical design pressures are given in tabular form.

Chapter 29 contains wind loads criteria for the MWFRS of other structures and building appurtenances. Structures include chimneys, signs, walls, towers, and others. Building appurtenances are limited to rooftop equipment. Wind loads on parapets and overhangs are referred to in appropriate sections in other chapters. This cross referencing of sections where loading criteria can be found is designed to make the standard more user-friendly.

Chapter 30 contains wind loads criteria for components and cladding (C&C). Because wind loads on C&C of different buildings are given in various formats, the chapter is divided into six parts:

- Part 1 is applicable to low-rise buildings.
- Part 2 is a simplified approach for low-rise buildings.
- Part 3 is applicable to buildings of any height.
- Part 4 is a simplified approach and is applicable to buildings with roof height equal to or less than 160 ft.
- Part 5 is applicable to open buildings.
- Part 6 is applicable to building appurtenances, such as rooftop equipment, roof overhangs, and parapets.

Chapter 31 contains the criteria for the wind tunnel procedure. The criteria include wind tunnel test conditions and limitations on wind loads.

As noted, the basic methodology of the Standard remains the same as in ASCE 7-05. Additional significant changes in the standard are listed as follows.

- Three wind speed maps are given. Each map is related to the risk category of building specified in Table 1.5-1 of the Standard. Specification of three wind speed maps eliminates the need for Importance Factors used in previous versions of the Standard.

- Wind Speeds in the maps are related to limit state strength design. The load factors in load combinations of Sections 2.3 and 2.4 of the Standard are associated with these wind speeds.
- State of Hawaii is designated as a special wind region; basic wind speed will be in accordance with local jurisdictions.
- Exposure Category D is applicable to water surfaces including hurricane prone regions.
- New simplified procedures to obtain wind loads for MWFRS and C&C of enclosed buildings with roof height equal to or less than 160 ft are added. These procedures provide wind loads in tabular form.
- Provisions for calculations of natural frequency for building frames to determine gust effect factor are added.
- Minimum design loads for MWFRS are revised; horizontal loads on wall surfaces are increased to 16 psf to make them consistent with strength design. On vertical projection of roof, horizontal loads are specified as one-half of minimum loads on walls.
- Wind-borne debris regions are revised to relate to building risk categories.
- Lower limits of wind loads obtained from wind tunnel procedures are specified in the Standard.

The aforementioned changes are reflected in the example problems of this guide. A new chapter 3 is added to this guide to explain wind speed maps as they relate to risk categories of buildings and structures and load factors in load combinations.

## 1.3 Limitations of the Standard

Successful use of the Standard is dependent on knowledge of parameters and factors used in the algorithms that define the wind loads for design applications. Limitations of some of the significant parameters are given as follows.

### *Assessment of Wind Climate*

The current edition of the Standard provides a more realistic description of wind speeds than did the previous editions. Perhaps the most serious limitations are that design speeds are not referenced to direction, and potential wind speed anomalies are defined only in terms of special wind regions. These special wind regions include mountain ranges, gorges, and river valleys. Unusual winds may be encountered in these regions because of topographic effects or because of the channeling of wind. The Standard permits climatological studies using regional climatic data and consultation with a wind engineer or a meteorologist.

Tornado winds are not included in development of the basic wind speed maps (Fig. 26.5-1 of the Standard) because of their relatively rare occurrence at a given location. Intense tornadoes can have ground level wind speeds in the range of 150–200 mph; however, the annual probability of exceedance of this range of wind speeds may be less than $1 \times 10^{-5}$ (mean recurrence interval exceeding 100,000 years). Special structures and storm shelters can be designed to resist tornado winds if required.

## Limitations in Evaluating Structural Response

Given that the majority of buildings and other structures can be treated as rigid structures, the gust effect factor specified in the Standard is adequate. For dynamically sensitive buildings and other structures, a gust effect factor, $G_f$, is given. The formulation of gust effect factor, $G_f$, is primarily for buildings; it is not always applicable to other structures. It should be noted that the gust effect factor, $G_f$, is based on along-wind buffeting response.

Vortex shedding can be present with bluff-shaped cylindrical bodies. It can become a problem when the frequency of shedding is close to, or equal to, the frequency of the first or second transverse modes of the structure. The intensity of excitation increases with aspect ratio (height-to-width or length-to-breadth) and decreases with increasing structural damping. Structures with low damping and with an aspect ratio of 8 or more could be prone to damaging vortex excitation. If across-wind or torsional excitation appears to be a possibility, expert advice should be obtained.

Even though the standard does not specify limiting values for serviceability, a discussion of serviceability is given in the Commentary Appendix C of the Standard. The user of the Standard is encouraged to review this appendix to obtain guidelines for drift of walls and frames and vibrations.

## Limitations in Shapes of Buildings and Other Structures

The pressure and force coefficients given in the Standard are limited. Many of the building shapes (e.g., "Y," "T," and "L" shapes) or buildings with stepped elevations are not included (except as shown in Fig. 30.4-3). Fortunately, this information may be found in other sources (see **Table G1-1**).

When coefficients for a specific shape are not given in the Standard, the designer is encouraged to use values through interpretation of the intent of the Standard (see **Chapter 8** for L-shape, **Chapter 9** for U-shape, and **Chapter 12** for oddly shaped buildings). Pressure coefficients that are available in the literature also can be used. However, the use of prudent judgment is advised, and the following caveats should be addressed:

1. The coefficients should be obtained from proper turbulent boundary layer wind tunnel (BLWT) tests.
2. The averaging time used should necessarily be considered in order to determine whether the coefficients are directly applicable to the evaluation of design loads or whether they need to be modified.
3. The reference wind speed (fastest-mile, hourly mean, 10-min mean, 3-s gust, etc.) and exposure category under which the data are generated must be established in order to properly compute the velocity pressure, $q$.

**Table G1-1** Technical Literature

| Subject | *Selected Reference Material (see References Section of this guide)* |
|---|---|
| Wind effects on buildings and structures | Newberry and Eaton (1974); Lawson, vols. 1 and 2 (1980); Cook, parts 1 and 2 (1985); Holmes, Melbourne, and Walker (1990); Liu (1991); Simiu and Scanlan (1996); Dyrbye and Hansen (1997); Holmes (2007) |
| Codes and standards | NRCC (2010); British Standard BS 6399 (1997); Eurocode 1 (2005); ISO (1997); Australian/New Zealand Standard AS/NZS 1170.2 (2002); Stafford (2010) |
| Wind tunnel testing | Reinhold (1982); ASCE (2012 ) |
| General wind research | ASCE (1961); Cermak (1977); Davenport, Surry, and Stathopoulos (1977, 1978); Simiu (1981) |
| Pressure and force coefficients | ASCE (1961, 1997); Hoerner (1965) |
| Tornadoes, shelter design | Minor, McDonald, and Mehta (1993); FEMA TR83-A (1980); Minor (1982); McDonald (1983); Coulbourne, Tezak, and McAllister (2002); FEMA 320 (2008); FEMA 361 (2008); ICC 500 (2008) |
| Impact resistance protocol | SBCCI (1999); ASTM E1886-05 (2005), ASTM E1996-09 (2009); Miami/Dade County Building Code Compliance Office Protocol PA 201-94 and PA 203-94 (1994) |

4. If an envelope approach is used, the coefficients should be appropriate for all wind directions. If, however, a directional approach is indicated, then the applicability of the coefficients as a function of wind direction needs to be ascertained. A limitation in the use of directional coefficients is that their adequacy for other than normal wind directions may not have been verified.

## 1.4 Technical Literature

There has been a vast amount of literature published on wind engineering during the past four decades. Most of it is in the form of research papers in the *Journal of Wind Engineering and Industrial Aerodynamics, Journal of Structural Engineering, Proceedings of the International Conferences on Wind Engineering* (a total of 13), *Proceedings of the Americas Conferences on Wind Engineering* (11), *Proceedings of the Asia-Pacific Conferences on Wind Engineering* (6) and *Proceedings of the European-African Conferences on Wind*

*Engineering* (5). The literature is extensive and scholarly; however, it is not always in a format that can be used by practicing professionals.

Several textbooks, handbooks, standards and codes, reports, and papers contain material that can be used to determine wind loads. Selected items are identified in **Table G1-1**. The items are listed by subject matter for easy identification. Detailed references for some of these items are given in the citations in References of this guide.