

CHAPTER 1

OVERVIEW

The purpose of this book is to provide structural engineers with the knowledge and tools required for the proficient design of buildings for wind loads. The book is concerned with both ordinary and special structures.

Ordinary structures are typically designed by using standard provisions for wind loads. Owing in part to their development by successive and more or less disorderly accretions, the wind loading provisions of the ASCE 7 Standard have become increasingly difficult to apply. In an effort to respond to the demand for a clearer document, the ASCE 7-10 version of the Standard has been substantially expanded and revised. Nevertheless, difficulties remain. A main objective of this book is to provide clear and detailed guidance to the use of the ASCE 7-10 Standard, including information on the fact that alternative procedures specified in the Standard for buildings of the same type may yield significantly different results.

The design of special structures typically requires the use of aerodynamic data obtained in ad hoc tests conducted in wind tunnel and/or large-scale testing facilities, and of extreme wind speed data. The requisite aerodynamic and wind speed data are reflected in wind engineering consultant reports. However, such reports do not—or do not yet—have to conform to uniform standards of practice. For this reason, response estimates for the same building can differ by more than 40%, depending upon the wind engineering laboratories providing them. It is therefore in the structural engineers' interest to be able to scrutinize and evaluate consultant reports effectively. This book provides the wind engineering knowledge and tools required to do so. The book also enables structural engineers to perform, independently, detailed estimates of wind-induced response for both strength and serviceability, much as structural engineers do for seismic response. The estimates must use extreme wind speed

data and aerodynamic or aeroelastic data provided in standardized formats by wind engineering consultants. The data are first applied to a preliminary structural design. Iterations of the calculations are then performed until the design is satisfactory. Such calculations, based on clear and transparent algorithms, can be performed routinely and efficiently by using public domain software referenced in the book.

Response calculations must allow for appropriate safety margins that reflect uncertainties in the parameters governing the wind-induced demand. These safety margins were provided in earlier versions of the Standard in the form of wind load factors. The book documents the limitations and shortcomings of the Load and Resistance Factor Design (LRFD) approach, in which wind load factors are used. In the ASCE 7-10 Standard, wind load factors are nominally equal to unity; however, values larger than unity are implicit in design wind speeds with mean recurrence intervals longer than those specified in the Standard's earlier versions. However, for some special structures, those mean recurrence intervals may not be adequate. This is the case if the uncertainties in the parameters affecting the demand are larger than the typical uncertainties inherent in the Standard provisions for ordinary, rigid structures. In particular, if uncertainties in the dynamic effects are significant, a calibration procedure is needed to calculate safe mean recurrence intervals of the design wind effects. Such a procedure was developed at the express request of structural engineering practitioners (see Appendix A5), and is discussed in the book's chapter on structural reliability.

Part II of this book is devoted to the ASCE 7-10 Standard, and is divided into eight chapters (Chapters 2 through 9) concerned with (1) general requirements (i.e., risk categories, basic design wind speeds, terrain exposure, enclosure classification, directional factors, topographic factors), and (2) the determination of wind effects on main wind force resisting systems and on components and cladding, by regular or simplified approaches. Part II illustrates the Standard provisions by means of a large number of calculation examples.

Part III is devoted to fundamentals. Chapter 10 is concerned with atmospheric circulations and the features of various types of storm. Chapter 11 provides descriptions of the atmospheric boundary layer, including the description of the wind velocity dependence on height above the surface, and of the turbulence within the atmospheric surface layer. Chapter 12 considers extreme wind speeds and extreme wind effects, their statistical estimation by parametric and non-parametric methods, estimation errors, wind speed simulations, and the dependence of wind effects on wind directionality. Chapter 13 provides fundamental notions of bluff body aerodynamics, and discusses modeling laws and aerodynamic measurements in the wind tunnel and large-scale aerodynamic testing facilities. Chapter 14 presents fundamentals of structural dynamics under stochastic loads for the general case of buildings with non-coincident mass and elastic centers. Chapter 15 is concerned with aeroelastic

effects. Chapter 16 presents (1) a critique of conventional structural reliability approaches known as Load and Resistance Factor Design, (2) material on mean recurrence intervals calibrations as functions of parameter uncertainties, (3) an introduction to strength reserves in a wind engineering context, and (4) an innovative approach to multi-hazard design, which shows that ASCE Standard provisions on the design of structures in regions with strong earthquakes and wind storms can be unsafe. Chapter 17 is an introduction to wind-induced loss estimation.

Part IV is concerned with the determination of wind effects on rigid and flexible buildings (Chapters 18 and 19, respectively), and discusses database-assisted design (DAD) concepts and procedures. Pressure records can be used for the calculation of wind loads, or can be part of the more elaborate DAD approach, which allows combinations of wind effects to be developed conveniently and rigorously, and provides integrated loading and design calculations in one fell swoop.

Part V contains appendixes. Appendix A1 concerns fundamentals of the theory of stochastic processes. Appendix A2 presents elements of the theory of mean wind profiles in the atmospheric boundary layer. Appendix A3 presents elements of the theory of turbulence in the atmospheric boundary layer. Appendix A4 provides a description and critique of two commonly used but typically unsatisfactory approaches to the wind directionality problem. Appendix A5 provides an authoritative view by a prominent structural engineering firm on some important aspects of the state of the art in wind engineering.

