SIMPLIFIED BUILDING DESIGN FOR WIND AND EARTHQUAKE FORCES

Second Edition

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PREFACE

This edition constitutes a considerable expansion of the topic over that presented in the first edition, which was published in 1980. Design examples have been extended to cover a wider range of building types and situations, more discussion of general building design issues has been added, and considerable new material on design of foundations for lateral loads has been included. Still, the general concept and basic style are the same as for the first edition. The book is intended primarily for persons with an interest in building design but who lack extensive training in engineering investigation and structural theory.

A major incentive for producing a new edition at this time was the publication of the 1988 edition of the *Uniform Building Code* (*UBC*). This edition of the *UBC* contains a major expansion and revision of requirements for seismic design, much of which is aimed at architectural design issues regarding materials and building form. Since an earlier edition of the *UBC* also made major changes in wind design requirements, the combination made much of the material in the first edition out of date. As the book has continued in use, the authors felt an obligation to produce a new edition.

Bringing the work into line with the new *UBC* is a major issue in the presentations in this edition. However, the *UBC* is not really the original source of the work on which its requirements are based, but simply reflects current directions in research, experiences gathered from recent major disasters (windstorms and earthquakes), and developments in design by leading professionals and firms. The presentations in this book, while intended to help explain some of the new *UBC* requirements, are really aimed at ideas of fundamental concern and general interest related to the topics of design for wind and seismic effects on buildings.

Both authors have experience in teach-

ing these subjects to architecture and engineering students and in working as structural designers with architects—the latter in many cases also representing a teaching involvement. This book is extensively illustrated and contains basic explanations of concepts and problems that are aimed specifically at persons with a general interest in building design. In many situations, equal time is given to discussions of general design concerns for the building, as well as to concerns for structural behavior.

A new section has been added to this edition containing study materials, which should be of special value to persons using the book in a self-study situation. Both authors have also had recent experience in helping to develop materials for the state board examinations for architectural registration, and feel that these study materials should be useful for preparation for those exams.

We are grateful to the International Conference of Building Officials, publishers of the *Uniform Building Code,* for their permission to reprint major portions of the 1988 *UBC* in Appendix C of this book. Reference to these materials is made repeatedly throughout this book, and the reader should thus be able to gain considerable familiarity with the code.

We are also grateful to the Masonry Institute of America for their permission to reprint the materials presented here in Appendix D. Use of these materials is demonstrated in design examples.

Finally—as always—we are grateful to the many students and fellow designers whose difficulties in dealing with these subjects has steadily developed our need and concern for explaining things in as simple and clear a manner as possible.

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INTRODUCTION

The purpose of this book is to provide a source of study and reference for the topics of wind and earthquake effects as they pertain to the design of building structures. The treatment of these subjects is aimed at persons not trained in structural engineering but who have some background experience in the analysis and design of simple structures. Material presented includes the development of background topics, such as basic aspects of wind and earthquake effects and fundamentals of dynamic behavior, as well as the pragmatic considerations of design of structures for real situations.

As implied by the title, the scope of the work is limited. This limitation is manifested in the level of complexity of the problems dealt with and in the techniques used, principally with regard to the degree of difficulty in mathematical analysis and the sophistication of design methods. In order to set these limits we have assumed some specific minimal preparation by the reader, and individual readers should orient themselves with regard to these assumptions. For those with some lack of preparation, the list of references following Chapter 6 may be useful for supplementary study. For the reader with a higher capability in mathematics or a more intensive background in applied mechanics and structural analysis, this work may serve as a springboard to more rigorous study of the topics.

The majority of the mathematical work, especially that in the applied design examples in Chapter 5, is limited to relatively simple algebra and geometry. In the treatment of the fundamentals of dynamics and in the explanation of some of the formulas used in analysis and design it is occasionally necessary to use relationships from trigonometry, vector analysis, and calculus. The reader with this level of mathematical background will more fully appreciate the rational basis for the formulas, although their practical application

will usually involve only simple algebra and arithmetic. Persons expecting to pursue the study of these topics beyond the scope of this book are advised to prepare themselves with work in mathematics that proceeds to the level of advanced calculus, partial differential equations, and matrix methods of analysis.

A minimal preparation in the topics of applied mechanics and structural analysis and design is assumed. This includes the topics of statics, elementary strength of materials, and the design of simple elements of wood, steel, and concrete structures for buildings. The general scope of the work in the design examples is limited to that developed in *Simplified Engineering for Architects and Builders* by Harry Parker and James Ambrose (Ref. 18). When some of the examples involve the analysis of indeterminate structures, the work presented is done with simplified, approximate methods that should be reasonably well understood by the reader with the previously described minimal background. For a more rigorous and exact analysis of such problems, or for the study of more complex problems, the reader is advised to pursue a general study of the analysis of indeterminate structures.

A third area of assumed background knowledge is that of the ordinary materials and methods of building construction as practiced in the United States. It is assumed that the reader has a general familiarity with the ordinary processes of building construction and with the codes, standards, and sources of general data for structures of wood, steel, masonry, and concrete.

A major reference used for this work is the 1988 edition of the *Uniform Building Code* (Ref. 1), hereinafter called the *UBC*. The design examples in this book use the general requirements, the analytical procedures, and some of the specific data from this reference. Much of the material from the *UBC* that relates directly to problems of wind and earthquakes is reprinted in Appendix C of this book. It is recommended, however, that the reader have a copy of the entire code available because it contains considerable additional material pertinent to the use of specific materials, to structural design requirements in general, and to various problems of building planning and construction.

In real design situations individual buildings generally fall under the jurisdiction of a particular local code. Most large cities, many counties, and some states have their own individual codes. In many cases these codes are based primarily on one of the so-called "model" codes, such as the *UBC*, with some adjustments and additions for specific local conditions and practices. The reader who expects to work in a particular area is advised to obtain a copy of the code with jurisdiction in that area and to compare its provisions with those of the *UBC* as they are used in this work.

Building codes, including the *UBC*, are occasionally updated to keep them abreast of current developments in research, building practices, analytical and design techniques, and so on. The publishers of the *UBC* have generally followed a practice of issuing a new edition every three years. For reference in any real design work the reader is advised to be sure that the code he is using is the one with proper jurisdiction and is the edition currently in force. This precaution regarding use of dated materials applies also to other reference sources, such as handbooks, industry brochures, detailing manuals, and so on.

Use of the word *simplified* does not mean to imply that all design for wind and earthquakes can be reduced to simple methods. On the contrary, many problems in this area represent highly complex, and as yet far from fully understood, situations