DESIGN AND PERFORMANCE OF TALL BUILDINGS FOR WIND

ASCE MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 143

EDITED BY PREETAM BISWAS
JOHN PERONTO

TASK COMMITTEE FOR THE DESIGN AND PERFORMANCE OF TALL BUILDINGS FOR WIND

ASCE

SEI STRUCTURAL ENGINEERING INSTITUTE

ASCE Manuals and Reports on Engineering Practice No. 143

Design and Performance of Tall Buildings for Wind

Edited by Preetam Biswas and John Peronto

Prepared by
Task Committee for the Design and Performance of Tall Buildings for Wind of the Structural Engineering Institute of the American Society of Civil Engineers

ASCE

SEI ASCE STRUCTURAL ENGINEERING INSTITUTE

Published by the American Society of Civil Engineers

Library of Congress Cataloging-in-Publication Data

Names: Biswas, Preetam, editor. | Peronto, John, editor. | Task Committee for the Design and Performance of Tall Buildings in Wind author.
Title: Design and performance of tall buildings for wind / prepared by Task Committee for the Design and Performance of Tall Buildings in Wind; edited by Preetam Biswas, P.E., and John (Sp.) - Peronto.
Description: Reston, Virginia : American Society of Civil Engineers, [2020] | Series: ASCE manuals and reports on engineering practice ; no. 143 | Includes bibliographical references and index. | Summary: “Design and Performance of Tall Buildings for Wind, MOP 143 provides a framework for the design of tall buildings for wind, based on the current state-of-practice in tall building structural design and wind tunnel testing”– Provided by publisher.
Identifiers: LCCN 2020033269 | ISBN 9780784415658 (paperback) | ISBN 9780784483121 (adobe pdf)
Subjects: LCSH: Tall buildings–Aerodynamics. | Wind resistant design.
Classification: LCC TH891 .D37 2020 | DDC 690/.21–dc23
LC record available at https://lccn.loc.gov/2020033269

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191-4382
www.asce.org/bookstore | ascelibrary.org

Errata. Errata, if any, can be found at http://dx.doi.org/10.1061/9780784415658.

ISBN 978-0-7844-1565-8 (soft cover)
ISBN 978-0-7844-8312-1 (PDF)

Manufactured in the United States of America.
25 24 23 22 21 20 1 2 3 4 5

MANUALS AND REPORTS ON ENGINEERING PRACTICE

(As developed by the ASCE Technical Procedures Committee, July 1930, and revised March 1935, February 1962, and April 1982)

A manual or report in this series consists of an orderly presentation of facts on a particular subject, supplemented by an analysis of limitations and applications of these facts. It contains information useful to the average engineer in his or her everyday work, rather than findings that may be useful only occasionally or rarely. It is not in any sense a "standard," however, nor is it so elementary or so conclusive as to provide a "rule of thumb" for nonengineers.

Furthermore, material in this series, in distinction from a paper (which expresses only one person's observations or opinions), is the work of a committee or group selected to assemble and express information on a specific topic. As often as practicable the committee is under the direction of one or more of the Technical Divisions and Councils, and the product evolved has been subjected to review by the Executive Committee of the Division or Council. As a step in the process of this review, proposed manuscripts are often brought before the members of the Technical Divisions and Councils for comment, which may serve as the basis for improvement. When published, each manual shows the names of the committees by which it was compiled and indicates clearly the several processes through which it has passed in review, so that its merit may be definitely understood.

In February 1962 (and revised in April 1982), the Board of Direction voted to establish a series titled "Manuals and Reports on Engineering Practice," to include the manuals published and authorized to date, future Manuals of Professional Practice, and Reports on Engineering Practice. All such manual or report material of the Society would have been refereed in a manner approved by the Board Committee on Publications and would be bound, with applicable discussion, in books similar to past manuals. Numbering would be consecutive and would be a continuation of present manual numbers. In some cases of joint committee reports, bypassing of journal publications may be authorized.

A list of available Manuals of Practice can be found at https://www.asce.org/bookstore.

This page intentionally left blank

AUTHORS

Preetam Biswas, Skidmore, Owings & Merrill
Preetam Biswas is a director of structural engineering at Skidmore, Owings & Merrill (SOM). He has led the design of multiple tall buildings, airports, stadiums, and convention centers around the globe. He has authored many technical papers focusing on tall buildings and other structural system innovations and served as the chair for the task committee that authored this Manual of Practice.

John Peronto, Thornton Tomasetti, Inc
John Peronto is a senior principal at Thornton Tomasetti and has led the design of many tall-to-megatall buildings, as well as unique and iconic structures around the world. He is highly published and a leader in professional organizations such as ASCE, ACI, IStructE, ICE, CTBUH, CCHRB, and has served as the chair for the Tall Buildings Committee of SEI since 2016.

Kevin Aswegan, Magnusson Klemencic Associates
Kevin Aswegan is an associate with Magnusson Klemencic Associates (MKA) in Seattle where his design experience focuses on tall buildings in areas of high wind and seismicity in the United States and around the world. He is actively involved in wind-related research, has authored many articles on performance-based wind design, and is an active member of the Standard ASCE 7 update process.

Roy Denoon, CPP Wind Engineering
Dr. Roy Denoon is vice president of CPP Wind Engineering and has been involved in wind tunnel testing for 30 years, during which time he has worked on many globally iconic buildings and structures. He is a member of the ASCE 7 Wind Load Subcommittee, a contributing author to the *ASCE/SEI Prestandard for Performance-Based Wind Design*, a co-author of

the *CTBUH Technical Guide on Wind Tunnel Testing of High-Rise Buildings* and is a CTBUH Fellow.

John Kilpatrick, RWDI

John Kilpatrick is a principal at RWDI. John is currently Wind Engineering Practice Leader at RWDI, a former chair of the UK Wind Engineering Society, and is a contributing author to the *ASCE/SEI Prestandard for Performance-Based Wind Design* and *ASCE 49 Standard for Wind Tunnel Testing for Buildings and Other Structures.*

Sami Matar, LERA Consulting Structural Engineers

Sami S. Matar is an associate partner with LERA Consulting Structural Engineers (LERA). Since joining LERA in 1995, he has built extensive experience in a variety of projects and has participated in or led the design of several of the firm's high-rise building projects.

Brian McElhatten, Arup

Brian McElhatten is an associate principal in Arup's Chicago office and leads the structural engineering group there. He has extensive knowledge of tall building systems, analysis, and design. During his time at both Arup and SOM, he has worked on and led the structural design of numerous tall and supertall buildings around the world. In addition to the Tall Buildings Committee of SEI, he is actively involved in CTBUH.

Patrick Ragan, WSP

Patrick Ragan is an associate with WSP in Chicago. His design experience includes towers in the United States, China, and the Middle East, with a primary focus on the lateral system design and optimization of high-rise structures. He has authored papers on various subjects including statistical methods for estimating wind turbine design loads, form-finding analysis of shell-shaped roof structures, and fluid viscous damper alternatives to conventional steel brace outrigger systems.

CONTRIBUTOR

Alexander W. Jordan, Skidmore, Owings & Merrill

Alex Jordan is an Associate at Skidmore, Owings & Merrill (SOM). He has experience in the design of tall buildings and airports, and he specializes in digital design practices.

CONTENTS

PREFACE

The Tall Buildings Committee of the Structural Engineering Institute of the American Society of Civil Engineers comprises senior leaders active in the field of tall buildings from both industry-leading professional consulting firms and academic institutions. The goal of this committee is to publish an industry consensus manual of practice that provides guidelines on the design and performance of tall buildings for wind effects. This publication provides recommendations and guidance on tall building design industry standard practice and approaches to complement current literature, model codes, and other standards. This publication should be used in conjunction with local building codes and considered a current consensus document developed by industry leaders for the design and performance of tall buildings for wind effects. However, it is the opinion of the committee that this consensus will evolve over time and as the industry advances.

Preetam Biswas, P.E., LEED
Director of Structural Engineering
Skidmore, Owings & Merrill
Task Committee Chair—Design and Performance of Tall Buildings for Wind

John Peronto, P.E., S.E., C.Eng, EUR ING, FIStructE, FICE, SECB, LEED AP
Senior Principal
Thornton Tomasetti, Inc.
Technical Activities Division Chair—Tall Buildings

This page intentionally left blank

ACKNOWLEDGMENTS

To all the individuals who contributed to the discussion on content:

Maryam Asghari Mooneghi
Andrew Bartolini
Audrey Bentz
Manotapa Bhaumik
Melissa Burton
Finley Charney
Jon Galsworthy
Mike Gibbons
Ramon Gilsanz
Jennifer Goupil
Jeremy Hasselbauer
Johnn Judd
Hessam Kazemzadeh
Tracy Kijewski-Correa
Jordan Komp
Michael Montgomery
Deepak Pant
Viral Patel
Karl Rubenacker
Rob Smith
Seymour Spence
John Tessem
May Thu Nwe Nwe
Un Yeong Jeong

To members of institutes and firms that contributed to the discussion on content:

Arup
ASCE/SEI
BCE
CPP
DCI
GMS
Gradient Wind
JHU
Kinetica
LERA
McNamara Salvia
MKA
Rad Urban
RWDI
SOM
TT
University of Michigan
University of Notre Dame
University of Wyoming
Virginia Tech
Walter P Moore
WSP

A special acknowledgement to the members of the Blue Ribbon Panel for their thorough and detailed review of the contents of this manual:

Abbas Aminmansour, Ph.D.
William F. Baker, P.E., S.E., F.ASCE
Daryl Boggs, Ph.D., P.E.
David Farnsworth, P.E.
William Faschan, P.E., S.E., F.ASCE

Robert A. Halvorson, P.E., S.E.
Peter Irwin, Ph.D., P.Eng.
Ahsan Kareem, Ph.D., Dist.M.ASCE
Ron Klemencic, P.E., S.E.
Robert Sinn, P.E., S.E.

CHAPTER 1
INTRODUCTION

1.1 PURPOSE

This Manual of Practice is intended to provide best-practice guidelines for the design of tall buildings for wind. Current building codes and design standards focus primarily on strength design for ultimate wind loads, offering little guidance related to the evaluation and establishment of acceptance criteria for tall building performance under varying levels of wind effects. As such, current design practice varies widely across the industry. The goal of this document is to promote consistency and best practices within the industry for the design of tall buildings for wind. It is envisioned to apply to buildings with height greater than 120 m (400 ft) and/or a height to width aspect ratio greater than 5:1.

1.2 SCOPE

The design recommendations provided in this manual are primarily focused on the wind design of building structures that are especially tall, slender, and/or prone to wind-induced movement. A discussion of both static and dynamic approaches to wind design are presented in subsequent chapters. Wind design performance objectives are achieved by

- Ensuring structural integrity under ultimate loads;
- Limiting lateral deflections under service loads to prevent permanent deformations, damage to nonstructural elements, or adverse effects on the serviceability of the building's services and vertical transportation systems;