

NEHRP Seismic Design Technical Brief No. 10



Seismic Design of Wood Light-Frame Structural Diaphragm Systems

A Guide for Practicing Engineers

Kelly E. Cobeen J. Daniel Dolan Douglas Thompson John W. van de Lindt



NEHRP Seismic Design Technical Briefs

National Earthquake Hazards Reduction Program (NEHRP) Technical Briefs are published by the National Institute of Standards and Technology (NIST) as aids to the efficient transfer of NEHRP and other research into practice, thereby helping to reduce the nation's losses resulting from earthquakes.

NGT National Institute of Standards and Technology

NIST is a federal technology agency within the U.S. Department of Commerce that promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST is the lead agency of NEHRP. Dr. John (Jack) R. Hayes, Jr., is the Director, and Dr. Steven L. McCabe is the Deputy Director of NEHRP within NIST's Engineering Laboratory.

Applied Technology Council

The Applied Technology Council (ATC) is a nonprofit corporation advancing engineering applications for hazard mitigation. This publication is a product of Task Order 13-486 under Contract SB134113CQ0009 between the ATC and NIST. Jon A. Heintz serves as the Program Manager for work conducted under this contract.

Consortium of Universities for Research in Earthquake Engineering

The Consortium of Universities for Research in Earthquake Engineering (CUREE) is a nonprofit organization advancing earthquake engineering research, education, and implementation. This publication was produced under a cooperative agreement between ATC and CUREE. Robert Reitherman served as Associate Program Manager overseeing production. Reed Helgens and Darryl Wong served as report production and report preparation consultants for this work.

About The Authors

Kelly E. Cobeen, S.E., is an Associate Principal at Wiss, Janney, Elstner Associates, Inc. in Emeryville, California. Ms. Cobeen has 30 years of experience in structural design, working on a wide range of project types, sizes, and construction materials. She has been involved in code development, research, and educational activities, including the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings*, and International Building Code (IBC) and International Residential Code development. She has taught wood design at University of California at Berkeley, coauthored *The Design of Wood Structures* textbook, and co-authored the *Recommendations for Earthquake Resistance in the Design and Construction of Woodframe Buildings*, a guideline developed for the CUREE-Caltech Woodframe Project. J. Daniel Dolan is a Professor of Civil and Environmental Engineering and Director of Codes and Standards for the Composite Materials and Engineering Center at Washington State University. Dr. Dolan has been involved in development of several of the building codes and design standards used in the United States, as well as France and Canada. He holds positions on the Building Seismic Safety Council and IBC Technical Update Committee for the Structures Section. He has conducted extensive research in the area of the dynamic response of timber structures, especially their response to earthquakes and hurricanes. He has published over 300 technical publications and has given over 500 technical presentations dealing with these topics.

Douglas Thompson, P.E., S.E., SECB, is president of STB Structural Engineers, Inc. in Lake Forest, California, and he is also the 2013-2014 president of the Structural Engineers Association of Southern California. He has authored several articles and publications, including the light-frame design examples in the *Seismic Design Manuals*, the *Guide to the Design of Diaphragms, Chords and Collectors*, and *Four-story/Five-story Wood-frame Structure over Podium Slab*. He has been involved with code changes to the Uniform Building Code and IBC for over 25 years and is a voting member of the American Wood Council's Wind & Seismic Task Committee.

Dr. John W. van de Lindt is the George T. Abell Distinguished Professor in Infrastructure in the Department of Civil and Environmental Engineering at Colorado State University. He has led more than 30 research projects, with many focused on seismic performance of wood structures, with 275 technical publications to his credit. While serving as the Project Director for the NEESWood Project from 2005-2009, he led the research on the full-scale six-story building tested on the E-Defense shake table in Miki, Japan and recently served as the Project Director for the Natioanl Science Foundation-funded project Seismic Risk Reduction for Soft-Story Woodframe Buildings. He is an Associate Editor for the Journal of Structural Engineering for wood topics and past Technical Administrative Chair for the American Society of Civil Engineers Structural Engineering Institute Committee on Wood.

About the Review Panel

(see inside back cover.)



Applied Technology Council (ATC)

201 Redwood Shores Parkway - Suite 240 Redwood City, California 94065 (650) 595-1542 www.atcouncil.org



Consortium of Universities for Research in Earthquake Engineering (CUREE) 1301 South 46th Street - Building 420 Richmond, CA 94804 (510) 665-3529 www.curee.org

Seismic Design of Wood Light-Frame Structural Diaphragm Systems

A Guide for Practicing Engineers

Prepared for

U.S. Department of Commerce National Institute of Standards and Technology Engineering Laboratory Gaithersburg, MD 20899-8600

> By Applied Technology Council

In association with Consortium of Universities for Research in Earthquake Engineering

> and Kelly E. Cobeen J. Daniel Dolan Douglas Thompson John W. van de Lindt

> > September 2014



U.S. Department of Commerce Penny Pritzker, Secretary

National Institute of Standards and Technology Willie E. May, Acting Under Secretary of Commerce for Standards and Technology and Acting Director

Contents	
1. Introduction	1
2. The Roles of Diaphragms	4
3. Diaphragm Components	5
4. Diaphragm Behavior and Design Principles	12
5. Diaphragm Seismic Design Forces	20
6. Modeling and Analysis Guidance	25
7. Design Guidance	29
8. Detailing and Constructability Issues	32
9. References	
10. Notations and Abbreviations	
11. Credits	41

Disclaimers

This Technical Brief was prepared for the Engineering Laboratory of the National Institute of Standards and Technology (NIST) under the National Earthquake Hazards Reduction Program (NEHRP) Earthquake Structural and Engineering Research Contract SB134113CQ0009, Task Order 13-486. The contents of this publication do not necessarily reflect the views and policies of NIST or the U.S. Government.

This report was produced by the Applied Technology Council (ATC) in association with the Consortium of Universities for Research in Earthquake Engineering (CUREE). While endeavoring to provide practical and accurate information, ATC, CUREE, the authors, and the reviewers assume no liability for, nor express or imply any warranty with regard to, the information contained herein. Users of information contained in this report assume all liability arising from such use.

Unless otherwise noted, photos, figures, and data presented in this report have been developed or provided by ATC staff, CUREE staff, or consultants engaged under contract to provide information as works for hire. Any similarity with other published information is coincidental. Photos and figures cited from outside sources have been reproduced in this report with permission. Any other use requires additional permission from the copyright owners.

Certain commercial software, equipment, instruments, or materials may have been used in the preparation of information contributing to this report. Identification in this report is not intended to imply recommendation or endorsement by NIST, nor is it intended to imply that such software, equipment, instruments, or materials are necessarily the best available for the purpose.

NIST policy is to use the International System of Units (metric units) in all its publications. In this report, however, information is presented in U.S. Customary Units (e.g., inch and pound), because this is the preferred system of units in the U.S. earthquake engineering industry.

Cover photo. Construction of a five-story, wood-frame apartment building.

How to Cite This Publication

NIST (2014). Seismic design of wood light-frame structural diaphragm systems: A guide for practicing engineers, NIST GCR 14-917-32, prepared by the Applied Technology Council for the National Institute of Standards and Technology, Gaithersburg, MD.