ASCE STANDARD

ASCE/SEI
41–06

Seismic Rehabilitation of Existing Buildings

This document uses both the International System of Units (SI) and customary units

ASCE

SEI
Structural Engineering Institute

ASCE STANDARD ASCE/SEI 41-06

American Society of Civil Engineers

Seismic Rehabilitation of Existing Buildings

This document uses both the International System of Units (SI) and customary units.

ASCE

SEI
Structural Engineering Institute
of the American Society of Civil Engineers

Published by the American Society of Civil Engineers

Library of Congress Cataloging-in-Publication Data

Seismic rehabilitation of existing buildings.
p. cm.
"ASCE standard ASCE/SEI 41-06."
Includes bibliographical references and index.
ISBN-13: 978-0-7844-0884-1
ISBN-10: 0-7844-0884-X
1. Buildings—Repair and reconstruction—Standards. 2. Earthquake resistant design—Standards. 3. Buildings—Earthquake effects. I. American Society of Civil Engineers.

TH420.S43 2007
693.8'52—dc22

2007009080

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191
www.pubs.asce.org

ISBN 13: 978-0-7844-0884-1
ISBN 10: 0-7844-0884-X
Manufactured in the United States of America.

STANDARDS

In 2003, the Board of Direction approved the revision to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Society's Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee made up of Society members and nonmembers, balloting by the membership of the Society as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding five years.

The following standards have been issued:

ANSI/ASCE 1-82 N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures

ASCE/EWRI 2-06 Measurement of Oxygen Transfer in Clean Water

ANSI/ASCE 3-91 Standard for the Structural Design of Composite Slabs and ANSI/ASCE 9-91 Standard Practice for the Construction and Inspection of Composite Slabs

ASCE 4-98 Seismic Analysis of Safety-Related Nuclear Structures

Building Code Requirements for Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02) and Specifications for Masonry Structures (ACI 530.1-02/ASCE 6-02/TMS 602-02)

ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures

SEI/ASCE 8-02 Standard Specification for the Design of Cold-Formed Stainless Steel Structural Members

ANSI/ASCE 9-91 listed with ASCE 3-91

ASCE 10-97 Design of Latticed Steel Transmission Structures

SEI/ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings

ASCE/EWRI 12-05 Guideline for the Design of Urban Subsurface Drainage

ASCE/EWRI 13-05 Standard Guidelines for Installation of Urban Subsurface Drainage

ASCE/EWRI 14-05 Standard Guidelines for Operation and Maintenance of Urban Subsurface Drainage

ASCE 15-98 Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

ASCE 16-95 Standard for Load Resistance Factor Design (LRFD) of Engineered Wood Construction

ASCE 17-96 Air-Supported Structures

ASCE 18-96 Standard Guidelines for In-Process Oxygen Transfer Testing

ASCE 19-96 Structural Applications of Steel Cables for Buildings

ASCE 20-96 Standard Guidelines for the Design and Installation of Pile Foundations

ANSI/ASCE/T&DI 21-05 Automated People Mover Standards—Part 1

ASCE 21-98 Automated People Mover Standards—Part 2

ASCE 21-00 Automated People Mover Standards—Part 3

SEI/ASCE 23-97 Specification for Structural Steel Beams with Web Openings

ASCE/SEI 24-05 Flood Resistant Design and Construction

ASCE/SEI 25-06 Earthquake-Actuated Automatic Gas Shutoff Devices

ASCE 26-97 Standard Practice for Design of Buried Precast Concrete Box Sections

ASCE 27-00 Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction

ASCE 28-00 Standard Practice for Direct Design of Precast Concrete Box Sections for Jacking in Trenchless Construction

ASCE/SEI/SFPE 29-05 Standard Calculation Methods for Structural Fire Protection

SEI/ASCE 30-00 Guideline for Condition Assessment of the Building Envelope

SEI/ASCE 31-03 Seismic Evaluation of Existing Buildings

SEI/ASCE 32-01 Design and Construction of Frost-Protected Shallow Foundations

EWRI/ASCE 33-01 Comprehensive Transboundary International Water Quality Management Agreement

EWRI/ASCE 34-01 Standard Guidelines for Artificial Recharge of Ground Water

EWRI/ASCE 35-01 Guidelines for Quality Assurance of Installed Fine-Pore Aeration Equipment

CI/ASCE 36-01 Standard Construction Guidelines for Microtunneling

SEI/ASCE 37-02 Design Loads on Structures During Construction

CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data

EWRI/ASCE 39-03 Standard Practice for the Design and Operation of Hail Suppression Projects

ASCE/EWRI 40-03 Regulated Riparian Model Water Code

ASCE/SEI 41-06 Seismic Rehabilitation of Existing Buildings

ASCE/EWRI 42-04 Standard Practice for the Design and Operation of Precipitation Enhancement Projects

ASCE/SEI 43-05 Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities

ASCE/EWRI 44-05 Standard Practice for the Design and Operation of Supercooled Fog Dispersal Projects

ASCE/EWRI 45-05 Standard Guidelines for the Design of Urban Stormwater Systems

ASCE/EWRI 46-05 Standard Guidelines for the Installation of Urban Stormwater Systems

ASCE/EWRI 47-05 Standard Guidelines for the Operation and Maintenance of Urban Stormwater Systems

ASCE/SEI 48-05 Design of Steel Transmission Pole Structures

This page intentionally left blank

FOREWORD

In 2003, the Board of Direction approved the revision to the ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Society's Codes and Standards Committee (CSC). The consensus process includes balloting by a balanced standards committee made up of Society members and nonmembers, balloting by the membership of the Society as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding five years.

The material presented in this Standard has been prepared in accordance with recognized engineering principles. This Standard should not be used without first securing competent advice with respect to its suitability for any given application. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Society of Civil Engineers, or of any other person named herein, that this information is suitable for any general or particular use or promises freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability from such use.

This page intentionally left blank

ACKNOWLEDGMENTS

The Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) acknowledges the devoted efforts of the membership of the Seismic Rehabilitation of Existing Buildings Standards Committee of the Codes and Activities Division of SEI. This group comprises individuals from many backgrounds, including consulting engineering, research, construction industry, education, government, design, and private practice.

Balloting for this standard began with FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, prepared by ASCE for the Federal Emergency Management Agency (FEMA). FEMA 356 was developed from FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*, developed for FEMA by the Applied Technology Council (ATC). ASCE acknowledges and is grateful for the over ten years of support provided by FEMA to the development of a new generation rehabilitation standard, and particularly for their support during this final step, the development of this consensus standard.

This standard was prepared through the consensus standards process in compliance with the procedures established by the ASCE Codes and Standards Committee and accredited by the American National Standards Institute (ANSI). Those individuals who served on the standards committee are:

Bechara Elias Abboud, Ph.D., P.E., M.ASCE
Michael D. Blakely, P.E., M.ASCE
David Clare Breiholz, P.E., F.ASCE
James Brown, P.E., L.S., F.ASCE
Thomas Marvin Bykonen, P.E., M.ASCE
Hashu H. Chandwaney, P.E., F.ASCE
Chang Chen, Ph.D., P.E., M.ASCE
Kevin C. K. Cheung V, Ph.D., P.E., M.ASCE
James Hamilton Collins, M.ASCE
W. Gene Corley, Ph.D., P.E., Hon.M.ASCE
Mark W. Fantozzi, P.E., M.ASCE
Hans Gesund, Ph.D., P.E., F.ASCE
Satyendra K. Ghosh, M.ASCE
Sergio Gonzalez-Karg, P.E., F.ASCE
Phillip Gould, P.E., F.ASCE
Melvyn Green, P.E., F.ASCE
D. Kirk Harman, P.E., S.E., M.ASCE
John R. Hayes, Jr., PhD, PE, M.ASCE
Jon A. Heintz, P.E., M.ASCE
Richard L. Hess, P.E., F.ASCE
Darrick Bryan Hom, P.E., M.ASCE
Jen-Kan Hsiao, Ph.D., P.E., S.E., M.ASCE
Tom Chi-Tong Hui, P.E., M.ASCE
Roy J. Hunt, P.E., M.ASCE
Mohammad Iqbal, Ph.D., P.E., F.ASCE
Robert C. Jackson, P.E., M.ASCE
Wen-Chen Jau, Ph.D., A.M.ASCE
Martin W. Johnson, P.E., M.ASCE
John C. Kariotis, P.E., M.ASCE
Brian Edward Kehoe, S.E., F.ASCE
Patrick J. Lama, P.E., M.ASCE
Jim Eugene Lapping, P.E., M.ASCE
Feng-Bao Lin, M.ASCE
Philip Line, M.ASCE
Roy F. Lobo, P.E., M.ASCE
Charles R. Magadini, P.E., L.S., F.ASCE
Ayaz H. Malik, P.E., M.ASCE
Rusk Masih, Ph.D., P.E., Aff.M.ASCE
Vicki Vance May, P.E., A.M.ASCE
Bruce Herman McCracken, P.E., M.ASCE
Richard McConnell, Ph.D., P.E., M.ASCE
Thomas Harold Miller, P.E., M.ASCE
Andy Hess Milligan, P.E., M.ASCE
Andrew Douglass Mitchell, P.E., M.ASCE
Myles A. Murray, P.E., M.ASCE
Joseph F. Neussendorfer, Aff.M.ASCE
Glen John Pappas, Ph.D., M.ASCE
James C. Parker, P.E., M.ASCE
Celina Ugarte Penalba, M.ASCE
Mark Allan Pickett, Ph.D., P.E., M.ASCE
Chris Donald Poland, M.ASCE
Daniel E. Pradel, Ph.D., P.E., F.ASCE
Timothy Edward Roecker, M.ASCE
Charles W. Roeder, Ph.D., P.E., M.ASCE
Abdulreza A. Sadjadi, P.E., M.ASCE
Ashvin A. Shah, P.E., F.ASCE
Richard Lee Silva, P.E., M.ASCE
Thomas David Skaggs, P.E., M.ASCE
Glenn R. Smith, Jr., Ph.D., P.E., M.ASCE
Eric Christian Stovner, P.E., M.ASCE
Donald R. Strand, P.E., F.ASCE
Peter Tian, P.E., A.M.ASCE
Frederick Michael Turner, S.E., M.ASCE
Michael T. Valley, P.E., M.ASCE
Thomas George Williamson, P.E., F.ASCE
Lyle L. Wilson, F.ASCE
Lisa A. Wipplinger, P.E., M.ASCE
Tom Chuan Xia, P.E., M.ASCE
Wade Wesley Younie, P.E., M.ASCE

This page intentionally left blank

CONTENTS

The Structural Engineering Institute (SEI) of the American Society of Civil Engineers is committed to providing accurate, up-to-date information to its readers. To that end, SEI maintains a listing of errata at http://www.seinstitute.org/publications/errata.cfm.

Seismic Rehabilitation of Existing Buildings

1.0 REHABILITATION REQUIREMENTS

1.1 SCOPE

This standard for the *Seismic Rehabilitation of Existing Buildings*, referred to herein as "this standard," specifies nationally applicable provisions for the seismic rehabilitation of buildings. Seismic rehabilitation is defined as improving the seismic performance of structural and/or nonstructural components of a building by correcting deficiencies identified in a seismic evaluation. Seismic evaluation is defined as an approved process or methodology of evaluating deficiencies in a building, which prevent the building from achieving a selected Rehabilitation Objective. Seismic evaluation using ASCE 31 (ASCE 2002), the procedures and criteria of this standard, or other procedures and criteria approved by the authority having jurisdiction is permitted.

Seismic rehabilitation of existing buildings shall comply with requirements of this standard for selecting a Rehabilitation Objective and conducting the seismic rehabilitation process to achieve the selected Rehabilitation Objective. This standard does not preclude a building from being rehabilitated by other procedures approved by the authority having jurisdiction.

Symbols, acronyms, definitions, and references used throughout this standard are cited separately in sections located at the end of this standard.

C1.1 SCOPE

This standard is intended to serve as a nationally applicable tool for design professionals, code officials, and building owners undertaking the seismic rehabilitation of existing buildings. In jurisdictionally mandated seismic rehabilitation programs, the code official serves as the authority having jurisdiction. In voluntary seismic rehabilitation programs, the building owner, or the owner's designated agent, serves as the authority having jurisdiction.

This standard consists of two parts: Provisions, which contain the technical requirements, and Commentary, intended to explain the provisions. Commentary for a given section is located immediately following the section and is identified by the same section number preceded by the letter C.

It is expected that most buildings rehabilitated in accordance with this standard would perform within the desired levels when subjected to the design earthquakes. However, compliance with this standard does not guarantee such performance; rather, it represents the current standard of practice in designing to attain this performance. The practice of earthquake engineering is rapidly evolving, and both our understanding of the behavior of buildings subjected to strong earthquakes and our ability to predict this behavior are advancing. In the future, new knowledge and technology will improve the reliability of accomplishing these goals.

The procedures contained in this standard are specifically applicable to the rehabilitation of existing buildings and, in general, are more appropriate for that purpose than are new building codes. New building codes are primarily intended to regulate the design and construction of new buildings; as such, they include many provisions that encourage or require the development of designs with features important for good seismic performance, including regular configuration, structural continuity, ductile detailing, and materials of appropriate quality. Many existing buildings were designed and constructed without these features and contain characteristics such as unfavorable configuration and poor detailing that preclude application of building code provisions for their seismic rehabilitation.

Although it is intended to be used as a follow-up to a previous seismic evaluation, this standard can also be used as an evaluation tool to ascertain compliance with a selected rehabilitation objective. An ASCE 31, Tier 3 evaluation is an example of this use. It should be noted, however, that an evaluation using this standard may be more stringent than other evaluation methodologies because the provisions have been calibrated for use in design. Historically, criteria for evaluation have been set lower than those for design to minimize the need to strengthen buildings that would otherwise have only modest deficiencies.

The expertise of the design professional in earthquake engineering is an important prerequisite for the appropriate use of this standard in assisting a building owner to select voluntary seismic criteria or to design and analyze seismic rehabilitation projects, whether voluntary or required. The analytical work required by this standard must be performed under the responsible charge of a licensed professional engineer; however, that does not preclude a design professional without a professional engineering license, but with responsible charge, from leading a seismic rehabilitation project. For example, an architect with responsible charge can