

# Seismic Evaluation and Retrofit of Existing Buildings

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

**American Society of Civil Engineers**

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## STANDARDS

In 2006, 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 530-13/ASCE 5-13/TMS 402-13) and Specifications for Masonry Structures (ACI 530.1-13/ASCE 6-13/TMS 602-13)
- ASCE/SEI 7-10 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 12-13 Standard Guidelines for the Design of Urban Subsurface Drainage
- ASCE/EWRI 13-13 Standard Guidelines for the Installation of Urban Subsurface Drainage
- ASCE/EWRI 14-13 Standard Guidelines for the 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 19-10 Structural Applications of Steel Cables for Buildings
- ASCE 20-96 Standard Guidelines for the Design and Installation of Pipe Foundations
- ANSI/ASCE T&DI 1-13 Automated People Mover Standards
- 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 33-09 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 Surface Utility Data
- EWRI/ASCE 39-03 Standard Practice for the Design and Operation of Hail Suppression Projects
- ASCE/EWRI 40-06 Regulated Riparian Model Water Code
- ASCE/SEI 41-06 Seismic Rehabilitation of Existing Buildings
- ASCE/EWRI 42-04 Standard Practice for the Design and Construction 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 48-11 Design of Steel Transmission Pole Structures
- ASCE/SEI 49-12 Wind Tunnel Testing for Buildings and Other Structures
- ASCE/EWRI 50-08 Standard Guideline for Fitting Saturated Hydraulic Conductivity Using Probability Density Functions
- ASCE/EWRI 51-08 Standard Guideline for Calculating the Effective Saturated Hydraulic Conductivity
- ASCE/SEI 52-10 Design of Fiberglass-Reinforced Plastic (FRP) Stacks
- ASCE/G-I 53-10 Compaction Grouting Consensus Guide
- ASCE/EWRI 54-10 Standard Guideline for Geostatistical Estimation and Block-Averaging of Homogeneous and Isotropic Saturated Hydraulic Conductivity
- ASCE/SEI 55-10 Tensile Membrane Structures
- ANSI/ASCE/EWRI 56-10 Guidelines for the Physical Security of Water Utilities
- ANSI/ASCE/EWRI 57-10 Guidelines for the Physical Security of Wastewater/Stormwater Utilities
- ASCE/T&DI/ICPI 58-10 Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways
- ASCE/SEI 59-11 Blast Protection of Buildings
- ASCE/EWRI 60-12 Guidelines for Development of Effective Water Sharing Agreement

## FOREWORD

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.

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Throughout this text, a gray bar appears in the margins to indicate that the adjacent text is commentary provided for clarification. The commentary is not part of the mandatory standard.

The checklists that appear in Appendix C may be obtained in PDF format from <http://dx.doi.org/10.1061/9780784412855>. A complete listing of known errata is available at <http://www.asce.org/sei/errata>.

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focused studies and administrative efforts have made this standard possible.

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## UNIT CONVERSIONS

<i>Measurement</i>	<i>SI Units</i>	<i>Customary Units</i>
Abbreviations	m = meter (SI base unit of length) cm = centimeter km = kilometer ha = hectare L = liter (SI base unit of volume) mL = milliliters kg = kilogram (SI base unit of mass) g = gram N = Newton ( $\text{mkg s}^{-2}$ ) Pa = Pascals ( $\text{N/m}^2$ ) kPa = kilopascals J = Joule W = watt kW = kilowatt s = second (SI base unit of time) min = minute h = hour day °C = degrees Celsius ppm = parts per million	yd = yard in. = inch mi = mile acre gal = gallon qt = quart lb = pound oz = ounce lbf = pound-force (lb/ft) psi = pounds per square inch atm = atmosphere ft·lbf = feet per pound-force Btu = British thermal unit hp = horsepower s = second min = minute h = hour day °F = degrees Fahrenheit ppm = parts per million
Length	1 m = 3.2808 ft = 1.0936 yd 1 cm = 0.3937 in. 1 km = 0.6214 mile	1 ft = 0.3048 m 1 in. = 2.54 cm 1 mile = 1.6093 km
Area	1 m <sup>2</sup> = 10.7643 ft <sup>2</sup> 1 km <sup>2</sup> = 0.3861 mi <sup>2</sup> 1 ha = 2.4710 acre	1 ft <sup>2</sup> = 0.0929 m <sup>2</sup> 1 mi <sup>2</sup> = 2.59 km <sup>2</sup> 1 acre = 43,560 ft <sup>2</sup> = 0.4047 ha
Volume	1 L = 0.2642 gal 1 ml = 1 cm <sup>3</sup>	1 gal = 4 qt = 3.7854 L 1 ft <sup>3</sup> = 7.481 gal = 28.32 L
Mass	1 g = 0.0353 oz 1 kg = 2.2046 lb	1 oz = 28.3495 g 1 lb = 0.4536 kg
Force	1 N = 0.2248 lbf/ft	1 lbf = 4.4482 N
Density	1 kg/m <sup>3</sup> = 0.2048 lb/ft <sup>3</sup> 1 kg/m <sup>3</sup> = 6.2428 lb/ft <sup>3</sup>	1 lb/ft <sup>3</sup> = 4.882 kg/m <sup>3</sup> 1 lb/ft <sup>3</sup> = 16.018 kg/m <sup>3</sup>
Pressure	1 kPa = 0.1450 psi	1 psi = 6.8948 kPa 1 atm = 14.7 psi = 101.35 kPa
Energy and Power	1 ft·lbf = 1.3558 J 1 Btu = 0.2778 W·h = 0.948 Btu 1 W = 0.7376 ft·lbf/s = 3.4122 Btu/h 1 kW = 1,3410 hp	1 ft·lbf = 1.3558 J 1 Btu = 1.0551 kJ 1 ft·lbf/s = 1.3558 W 1 hp = 550 ft·lbf/s = 0.7457 kW
Flow	1 L/s = 15.85 gal/min = 2.119 ft <sup>3</sup> /min	1 gal/min = 0.1337 ft <sup>3</sup> /min = 0.0631 L/s
Concentration	mg/L = ppm <sub>m</sub> (in dilute solutions)	
Temperature	°C = (°F - 32) × 5/9	°F = (°C × 9/5) + 32
Fundamental Constants and Relationships	Acceleration of gravity Density of water (at 4 °C) = Specific weight of water (15 °C) = Weight of water	32.2 ft/s <sup>2</sup> = 9.81 m/s <sup>2</sup> 1,000 kg/m <sup>3</sup> = 1 g/cm <sup>3</sup> 62.4 lb/ft <sup>3</sup> = 9,810 N/m <sup>3</sup> 1 gal = 8.345 lbs = 3.7854 kg

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11.11.2	Bookcases	13.8.2	Contents	
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11.11.4	Hazardous Material Storage	13.8.4	Hazardous Material Storage	
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