NIST GCR 11-917-12

Standards of Seismic Safety for Existing Federally Owned and Leased Buildings

ICSSC Recommended Practice 8 (RP 8)

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ICSSC Recommended Practice 8 (RP 8)

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The Interagency Committee on Seismic Safety in Construction (ICSSC) developed the 2011 edition of the *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings* (NIST GCR 11-917-12) as part of the continuing effort to achieve seismic safety in existing Federal buildings. The *Standards* document was drafted for the National Institute of Standards and Technology (NIST) on behalf of the ICSSC by a committee of experts organized by the Building Seismic Safety Council (BSSC) of the National Institute of Building Sciences (NIBS).

This edition of the *Standards* document is dedicated in the memory of Mr. Bela Palfalvi, who represented the General Services Administration on the ICSSC for many years and provided outstanding leadership in establishing sound seismic safety standards, not only for GSA but for all Federal agencies.

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PREFACE

In response to Public Law 101-614 and Executive Order 12941, the Interagency Committee on Seismic Safety in Construction (ICSSC) issued the first edition of *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings* in 1994 as Recommended Practice 4 (RP 4) and the second edition, in 2002, as RP 6. This edition, designated Recommended Practice 8 (RP 8), is a revision of RP 6.

The intent of this *Standards* document is to identify common minimum evaluation and mitigation measures for all Federal departments and agencies and to ensure that all Federal entities have balanced agency-conceived and -controlled seismic safety programs for their existing owned or leased buildings. Since the issuance of RP 6, several Federal Emergency Management Agency (FEMA) pre-standards have become national consensus standards issued by the American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI), some of which are being updated, and FEMA has continued to publish guidance documents related to the evaluation and retrofitting of existing buildings. These documents are referenced and cited throughout this 2011 edition of the *Standards* (RP 8).

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EXECUTIVE SUMMARY

In response to Public Law 101-614 and Executive Order 12941, the Interagency Committee on Seismic Safety in Construction (ICSSC) issued two editions of *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings* as Recommended Practice 4 and 6 (RP 4 and RP 6) in 1994 and 2002, respectively. Like the earlier reports, this 2011 edition, RP 8, provides Federal agencies with minimum and extended standards for the evaluation and mitigation of seismic risks posed by their building inventories.

The minimum acceptable performance objective for Federal buildings, when evaluation is triggered, is based on life safety in a large earthquake. This document also defines a higher occupancy-based objective for certain facilities and contemplates an operations-based objective for mission-critical facilities. ASCE/SEI 31-03, *Seismic Evaluation of Existing Buildings,* and ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings,* in conjunction with ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other Structures*, as modified by Part 1 of the 2009 *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* (FEMA P-750), provides the basis for defining these performance objectives, evaluation procedures, and, if necessary, mitigation criteria.

This edition of the Standards identifies situations that trigger application of the Standards, preliminary and detailed evaluation procedures, and mitigation requirements for the safety-based and occupancy-based performance levels – Life Safety and Immediate Occupancy.

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Chapter 1

INTRODUCTION

1.0 Intent and Reference Standards

The intent of the *Standards of Seismic Safety for Federally Owned and Leased* Buildings (hereinafter referred to as the *Standards*) is to provide Federal agencies with common minimum and higher standards for the evaluation and mitigation of seismic risks in their existing owned or leased buildings and in privately-owned buildings on Federal land to ensure that all agencies have balanced, agency-conceived and -controlled seismic safety programs. The *Standards* establishes procedures and criteria intended to provide a low risk of earthquake-related death or life-threatening injury. The *Standards* also provides criteria suitable for certain essential facilities for use by the agencies when they address such buildings in their inventories (see Section 1.1.2). The *Standards* builds upon previous efforts by the Interagency Committee on Seismic Safety in Construction (ICSSC) in support of the National Earthquake Hazards Reduction Program (NEHRP). The *Standards* (RP 8) supersedes RP 6, the ICSSC's previous guidance document.

The *Standards* document references the following national standards documents:

- ASCE/SEI 31-03, *Seismic Evaluation of Existing Buildings* (ASCE/SEI, 2003);
- ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE/SEI, 2006); and
- ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other Structures* (ASCE/SEI, 2005), as modified by Part 1 of P-750, *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* (FEMA, 2009).

This edition of the *Standards* document consists of this introduction and three additional chapters as follows:

- Chapter 2, Application of the *Standards*, identifies situations that trigger the application of the *Standards*, defines compliance with the *Standards*, and identifies additional measures that must be included in each agency's seismic safety responsibilities for existing buildings.
- Chapter 3, Evaluation Requirements, identifies building data needed to conduct a building evaluation and provides guidance on the application of ASCE/SEI 31 and ASCE/SEI 41 based on building type and other factors.
- Chapter 4, Mitigation Requirements, includes the requirements for mitigation of seismic risks; standards for retrofitting identified deficiencies; and guidance on incremental or

partial retrofitting, alternative mitigation methods; and retrofitting of historic buildings based on ASCE/SEI 41.

C1.0 Intent and Reference Standards

Risks are mitigated in various ways including demolition of dangerous buildings, changes of occupancy, and retrofit of gravity and lateral-load structural systems as well as nonstructural systems. The term "retrofit" is used in this document to refer to alterations or strengthening of existing systems or elements to meet or exceed minimum performance standards. In previous editions of the *Standards*, the term "rehabilitation" has been used in this context. It is now standard practice to call these retrofit procedures.

RP 4, published in 1994, was based on FEMA 178, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings*, which established criteria for evaluating buildings to a performance level of Substantial Life Safety.

FEMA 310, *Handbook for the Seismic Evaluation of Buildings, A Prestandard,* was published in 1998 and is based on FEMA 178.

In 1997, FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings,* and FEMA 274, *NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings* were published. A prestandard based on these documents was issued in November 2000 as *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 356).

RP 4 was updated as RP 6 in 2002 and incorporated FEMA 356 and FEMA 310.

In 2003, FEMA 310 was converted to a standard and published by the American Society of Civil Engineers as ASCE/SEI 31. In 2006, FEMA 356 was converted to a standard and published by the American Society of Civil Engineers as ASCE/SEI 41.

While FEMA 178 dealt only with the risk to life safety, ASCE/SEI 31 and ASCE/SEI 41 (and their predecessors FEMA 310 and FEMA 356) include procedures for evaluation and rehabilitation of buildings for Life Safety and Immediate Occupancy performance levels.

This document, RP 8, incorporates ASCE/SEI 31 and 41 and clarifies the specification of their standard performance levels. It also utilizes the Seismic Design Categories defined in ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*, to assign seismic performance requirements and define seismic hazard levels in various regions of the United States. ASCE/SEI 7 and other documents cited in Chapter 1 are updated on a regular basis. The *Standards* document references certain editions of the reference documents that are compatible. It is unlikely that later editions will be changed in such a way that references in this document will not be valid. Agencies may use later editions of the primary references after review to assure compatibility with RP 8.

1.1 Performance Objectives

A performance objective combines a desired performance level with a specified earthquake hazard. The *Standards* contemplates three performance levels and pairs them with appropriate hazards.

The primary objective of the *Standards* is to reduce the life-safety risk to occupants of Federal buildings and to the public. Thus, the safety-based objective defined in Section 1.1.1 is the minimum performance level appropriate whenever the *Standards* are invoked by Section 2.1, unless the agency has designated the building or the leased area for a higher objective.

In addition, the *Standards* defines an occupancy-based objective in Section 1.1.2, which is appropriate for facilities that pose special risks or that need to recover functionality quickly after an earthquake. Assignment of an occupancy-based objective is left to the discretion of each agency in accordance with Section 2.4.

The third and highest performance level is for mission-critical facilities requiring high reliability of operational performance during and immediately after the specified earthquake. Assignment of a mission-critical objective and specification of corresponding evaluation and rehabilitation criteria are left to the discretion of each agency in accordance with Section 2.4 and are not addressed in the *Standards*.

C1.1 Performance Objectives

RP 4 established Substantial Life-Safety as the minimum performance level for Federally owned and leased buildings. Executive Order 12941 directed Federal agencies to adopt RP 4 for use in assessing the seismic safety of their owned and leased buildings and in mitigating seismic risks in those buildings. Recent earthquakes have clearly illustrated the importance of the need for the immediate use of certain facilities after an earthquake. Recognizing this need, ASCE/SEI 31 (and FEMA 310 before it) provides for evaluation to a higher level of performance, Immediate Occupancy, in addition to Life Safety.

The *Standards* is not intended for use in judging the adequacy of past good-faith agency evaluation and mitigation efforts; rather, it is intended for use in establishing appropriate minimums for actions taken after the *Standards* is formally adopted by the ICSSC. In other words, the *Standards* is not intended to be applied retroactively. Regardless of the procedures or criteria employed in past agency efforts, the criteria of the *Standards* are intended to apply only as invoked by Section 2.1.

1.1.1 Safety-Based Objective

Unless the facility is designated for a higher objective, the minimum performance objective shall be the following safety-based objective, given in terms defined by ASCE/SEI 31 and ASCE/SEI 41:

- For evaluation, ASCE/SEI 31 Life Safety performance at the default ASCE/SEI 31 hazard level.

- For retrofitting, both parts of the ASCE/SEI 41 Basic Safety Objective (BSO) – Life Safety performance in the Basic Safety Earthquake-1 (BSE-1) ground shaking and Collapse Prevention performance in the Basic Safety Earthquake-2 (BSE-2) ground shaking. BSE-1 and BSE-2 are to be taken as defined in ASCE/SEI 41.

C1.1.1 Safety-Based Objective

Note that the defined objective, by referencing ASCE/SEI 31 and 41, includes consideration of nonstructural components, geologic site hazards, and adjacency hazards.

ASCE/SEI 31 defines worst-case acceptable Life Safety performance as "building performance that includes damage to both structural and nonstructural components during a design earthquake, such that: (a) partial or total structural collapse does not occur and (b) damage to nonstructural components is non-life-threatening." The ICSSC similarly understands Life-Safety deficiencies to include only those that would normally lead to life-threatening conditions under the specified earthquake hazard. RP 4 specified these to include only structural collapse, heavy falling hazards, blocked egress, or hazardous materials release. Refer to Section 3.2 of this *Standards* document.

1.1.2 Occupancy-Based Objective

Federal agencies may pursue objectives more stringent than Life Safety performance for those buildings where it is necessary to control damage or maintain function in the post-earthquake period. The *Standards* recommends the following occupancy-based objective, given in terms defined by ASCE/SEI 31 and ASCE/SEI 41:

- For evaluation, ASCE/SEI 31 Immediate Occupancy performance at the default ASCE/SEI 31 hazard level.

- For retrofitting, a two-part ASCE/SEI 41 objective – Immediate Occupancy performance in BSE-1 ground shaking and Life Safety performance in BSE-2 ground shaking.

This occupancy-based objective is not necessarily adequate for facilities that must remain fully operational during and following an earthquake. Assignment of a mission-critical objective and specification of corresponding evaluation, rehabilitation, and mitigation criteria are left to the discretion of each agency in accordance with Section 2.4 and are not addressed in the *Standards*.

C1.1.2 Occupancy-Based Objective:

Because objectives beyond safety are optional (i.e., to be assigned by each agency at its discretion), the *Standards* only recommends an appropriate application of ASCE/SEI 31 and 41.

ASCE/SEI 31 defines worst-case Immediate Occupancy performance as "building performance that includes damage to both structural and nonstructural components during a design earthquake such that: (a) the damage is not life-threatening, so as to permit immediate occupancy of the building after a design earthquake, and (b) damage is repairable while the building is occupied."

Occupancy-based objectives are generally appropriate for what building codes call "essential facilities." The definition of what is "essential" needs to be determined by each individual agency. As a guide, Table 1-1 of ASCE/SEI 7-05 and Table 1604.5 of the 2009 *International Building Code* (ICC, 2009) identify the following, among others, as essential facilities:

- Fire, rescue, and police stations
- Hospitals
- Designated medical facilities having emergency treatment facilities
- Designated emergency preparedness centers
- Designated emergency operation centers
- Designated emergency shelters
- Power generating stations or other utilities required as emergency back-up facilities for other essential facilities
- Emergency vehicle garages and emergency aircraft hangars
- Designated communication centers
- Aviation control towers and air traffic control centers
- Structures containing certain quantities of toxic or explosive substances
- Water treatment facilities required to maintain water pressure for fire suppression

FEMA E-74, *Reducing the Risks of Nonstructural Earthquake Damage*, may be useful as an additional reference for scoping and prioritizing the protection of nonstructural components and contents for occupancy-based performance.

1.2 Items Not Addressed in the *Standards*

The *Standards* is not intended to cover stand-alone, nonbuilding structures such as bridges, transmission towers, industrial towers and equipment, piers and wharves, or hydraulic structures.

The *Standards* does not include means to evaluate or mitigate the effects of:

- Flooding,
- Fire,
- Wind,
- Blast,

- Tsunami, or
- Volcanic activity.

The *Standards* also does not address criteria for:

- Repair of deteriorated buildings, including damage caused by previous earthquakes,
- Preparation of post-earthquake preparedness plans, or
- Seismic instrumentation of Federal buildings.

C1.2 Items Not Addressed in the *Standards*

Nonbuilding structures can pose earthquake risks to safety and function just as buildings can. However, because the *Standards* rely on ASCE/SEI 31 and 41, which address only building structures, these and other nonbuilding structures must be addressed using other appropriate procedures and criteria. Similar nonbuilding structures that are not "stand-alone" but rather are attached to a subject building (e.g., such as a roof-mounted tower or an adjacent pedestrian bridge) are within the scope of the *Standards* and should be addressed as nonstructural components by applying engineering judgment and alternative criteria as appropriate.

Although there are obvious interactions between seismic hazards and other natural or man-caused threats to buildings, a multi-hazard approach is beyond the scope of this document. However, before mitigation measures are taken for seismic deficiencies, it is good practice to consider other potential hazards, particularly wind.

As shown in Section 2.1d, the *Standards* triggers seismic evaluation and, possibly, mitigation when certain damage levels are reached. The intent of Section 1.2 is not to conflict with Section 2.1 but rather to clarify that the *Standards* does not provide technical criteria for addressing material deterioration from such causes as corrosion, rot, fire charring, and termites. It is beyond the scope of the *Standards* document to address evaluation and mitigation criteria for damaged or deteriorated buildings, including those buildings damaged by earlier earthquakes. However, any agency conducting an evaluation of a building damaged in accordance with Section 2.1d must investigate the condition of both the gravity load and lateral-force resisting elements to ensure that these elements and systems can perform dependably during an earthquake.

Although seismic instrumentation of Federal buildings is not addressed by the *Standards*, agencies are encouraged to instrument a number of buildings representative of their inventory to record their responses during seismic events in order to validate and/or improve their expected performance and more accurately target mitigation goals.

1.3 Exemptions

The following buildings are exempt from the *Standards*:

a. All buildings located where $S_{DS} < 0.167$ g and $S_{D1} < 0.067$ g; where S_{DS} and S_{D1} are the Design Earthquake Spectral Response Acceleration Parameters at short periods and at a 1 second period, respectively, as defined in ASCE-7.

b. All buildings located where $S_{DS} < 0.330$ g and $S_{D1} < 0.133$ g unless designated for an occupancy-based performance objective;

c. Detached one- and two-family dwellings located where $S_{DS} < 0.4$ g unless designated for an occupancy-based performance objective;

d. Building structures that are intended only for incidental human occupancy or that are occupied by persons for a total of less than 2 hours a day, unless designated for an occupancy-based performance objective;

e. One-story buildings of steel light frame or wood construction with areas less than 280 m^2 (3000 ft^2), unless designated for an occupancy-based performance objective;

f. Buildings scheduled for demolition;

g. Buildings in foreclosure;

h. Non-Federally owned buildings leased by the Federal Government with temporary short-term leases;

i. Non-Federally owned buildings containing a total area leased by the Federal Government of less than 930 m^2 (10,000 ft^2) where $S_{DS} < 0.50$ g and $S_{D1} < 0.20$ g; or,

j. Buildings designated by the agency as having a remaining useful life of, or fulfilling an agency need for, less than five years.

C1.3 Exemptions

S_{DS} and S_{D1} are spectral accelerations that are measures of shaking intensity at a site. The value of S_{DS} is more applicable to short stiff buildings and S_{D1} is more applicable to taller, more flexible buildings. Spectral accelerations are the parameters used in presenting seismic maps for the United States.

Buildings that are not expected to pose a significant safety risk are exempted from the *Standards* procedures. The list of exempt buildings was developed based on ICSSC member judgment and on precedents from various building codes and standards. Most of the exemption criteria can be applied without knowledge of earthquake engineering principles, but *Item a* through *Item c* and *Item i* require the involvement of structural engineering professionals.

Item a addresses buildings that would be assigned to Seismic Design Category (SDC) A by ASCE/SEI 7-05 covering the design of new buildings. No systematic seismic design is required for new buildings in this category because the values of the Design Earthquake Spectral Response Acceleration Parameters are low, based on the earthquake hazard and building response periods, so active mitigation of existing buildings in this category is not warranted.

Item b generally covers buildings that would be assigned by ASCE/SEI 7-05 to SDC B, which is the next higher seismic design category. If every building that ASCE/SEI 7-05 assigned to Occupancy Category IV were also designated by its agency for an occupancy-based performance objective, the match would be exact, and Item b could be written as a blanket exemption for all of SDC B. However, because the *Standards* allows for agency discretion in assigning performance objectives, the exemption is written specifically in terms of seismic demand and performance objective, not in terms of SDC.

Item c is similar (though not identical) to the exemption for new buildings found in 2009 *International Building Code* Section 1613.1. Note that the exemption is based solely on the Design Earthquake Spectral Response Acceleration Parameter, S_{DS}, and applies regardless of structural and nonstructural response periods or geologic conditions.

Item d is similar to the exemption for new buildings found in 2009 *International Building Code* Section 1613.1. The 2-hour criterion has been added here.

Item h refers to leases that may be necessary for surge space during renovation, for extra space during emergencies, or other short-term use. Some agencies have internal guidance that simplifies other leasing requirements in such situations and it would be logical to use the same criteria for seismic requirements.

Item i is intended to exempt small leases in buildings that would be assigned to SDC C by ASCE/SEI 7-05. This exception is not intended to cover multiple small leases totaling over 930 m^2 (10,000 ft^2) in a single building.

Other exemptions found in RP 6 Section 1.3 based on compliance with certain older guidelines or RP documents have been replaced by revisions to benchmark rules given in Section 1.3.1. For many buildings, the result will be the same, but relief from the requirements of RP 8 appears in the evaluation section.

1.3.1 Benchmark Buildings

In addition to the full-building exemptions in Section 1.3, buildings – both those incorporating seismic provisions in their original design and those that have been seismically retrofitted – that qualify as Benchmark Buildings per Table 1-1 are deemed to comply with the structural evaluation and retrofitting provisions of the *Standards*. The criteria in Table 1-1 shall be applied as in ASCE/SEI 31 Section 3.2, with Table 1-1 in its entirety replacing ASCE/SEI 31 Table 3-1 in its entirety. It is the intention of the ICSSC that *Standards* Table 1-1 shall be superseded by the corresponding benchmark buildings table in the forthcoming revision of ASCE/SEI 31.

Table 1-1 Benchmark Buildings

Building Type[1, 2]	Model Building Seismic Design Provisions				FEMA 178[10]	FEMA 310/ ASCE 31[10, 11]	FEMA 356/ ASCE 41[7,8,10,11]
	NBC[10] SBC[10]	UBC[10]	IBC/ IRC[10]	NEHRP[10]			
Wood Frame, Wood Shear Panels (Type W1 & W2)	1993	1976	2000	1985	*	1998	2000
Wood Frame, Wood Shear Panels (Type W1A)	*	1997	2000	1997	*	1998	2000
Steel Moment-Resisting Frame (Type S1 & S1A)	*	1994[4]	2000	1997	*	1998	2000
Steel Braced Frame (Type S2 & S2A)	*	1997	2000	*	*	1998	2006
Light Metal Frame (Type S3)	*	*	2000	*	1992	1998	2000
Steel Frame w/ Concrete Shear Walls (Type S4)	1993	1994[9]	2000	1985	*	1998	2000
Steel Frame with URM Infill (Type S5, S5A)	*	*	2000	*	*	1998	2000
Reinforced Concrete Moment-Resisting Frame (Type C1)[3]	1993	1994	2000	1997	*	1998	2000
Reinforced Concrete Shear Walls (Type C2 & C2A)	1993	1994[9]	2000	1985	*	1998	2000
Concrete Frame with URM Infill (Type C3 & C3A)	*	*	2000	*	*	1998	2000
Tilt-up Concrete (Type PC1 & PC1A)	*	1997	2000	*	*	1998	2000
Precast Concrete Frame (Type PC2 & PC2A)	*	*	2000	*	1992	1998	2000
Reinforced Masonry (Type RM1)	*	1997	2000	*	*	1998	2000
Reinforced Masonry (Type RM2)	1993	1994[9]	2000	1985	*	1998	2000
Unreinforced Masonry (Type URM)[5]	*	1991[6]	2000	*	1992	1998	2000
Unreinforced Masonry (Type URMA)	*	*	2000	*	*	1998	2000

[1] "Building Type" refers to one of the Common Building Types defined in ASCE/SEI 31 Table 2-2.
[2] Buildings on hillside sites shall not be considered benchmark buildings.
[3] Flat slab concrete moment frames shall not be considered benchmark buildings.
[4] Steel moment-resisting frames shall comply with the 1994 UBC Emergency Provisions, published September/October 1994, or subsequent requirements.

[5] URM buildings evaluated using the ABK Methodology (ABK, 1984) may be considered benchmark buildings.
[6] Refers to the *Guidelines for the Seismic Retrofit of Existing Buildings* (GSREB) or its predecessor, the *Uniform Code of Building Conservation* (UCBC).
[7] S-3 Structural Performance Level for the 10%/50-yr ground motion or Simplified Rehabilitation Method.
[8] S-1 Structural Performance Level for the 10%/50-yr ground motion.
[9] For buildings six stories or less, the benchmark year may be taken as 1976.
[10] Only buildings designed and constructed or evaluated in accordance with these documents and being evaluated to the Life-Safety (LS) performance level may be considered benchmark buildings.
[11] Buildings designed and constructed or evaluated in accordance with these documents and being evaluated to the Immediate-Occupancy (IO) performance level may be considered benchmark buildings.
* No benchmark year; buildings shall be evaluated in accordance with the *Standards*.

Note that NBC = *National Building Code* (BOCA, 1993); SBC = *Standard Building Code* (SBCC, 1994); UBC = *Uniform Building Code* (ICBO, 1997); GSREB = *Guidelines for Seismic Retrofit of Existing Buildings* (ICBO, 2001); IBC = *International Building Code* (ICC, 2000); IRC = *International Residential Code* (ICC, 2000); NEHRP = FEMA 368 and 369, *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings and Other Structures* (FEMA, 2000); FEMA 178 = *NEHRP Handbook for the Seismic Evaluation of existing Buildings* (FEMA, 1992a); FEMA 310 = *Handbook for the Seismic Evaluation of Buildings – A Prestandard* (FEMA, 1998); FEMA 356 = *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA, 2000); ASCE/SEI 31-03 = *Seismic Evaluation of Existing Buildings* (ASCE/SEI, 2003); ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE/SEI, 2006).

C1.3.1 Benchmark Buildings

A "benchmark building" is one that was designed and built, or retrofitted, in accordance with seismic provisions deemed suitable to the performance objective of interest. The determination of benchmark buildings, as described in ASCE/SEI 31 Section 3.2, is complex and varies with building location, age, structural system, and governing building code.

Table 1-1 is an updated version of both Table 1-1 in RP 6 and Table 3-1 in ASCE/SEI 31-03. It is based on progress through June 2011 by the ASCE/SEI Standards Committee on Seismic Rehabilitation and is expected to reflect the version of the table that will appear in the next edition of ASCE/SEI 31 and ASCE/SEI 41 (scheduled to be published in 2013 as a single standard designated ASCE/SEI 41-13).

As in ASCE/SEI 31, benchmarking by Table 1-1 addresses only the structural scope of work. Unless otherwise exempt, nonstructural components and geologic site hazards must still be considered even for buildings shown as benchmarked in Table 1-1. Further, as provided in ASCE/SEI 31 Section 3.2, use of the benchmark building provisions must be supported by consideration of changes to site seismicity since original construction and by confirmation that the building was designed and constructed according to the appropriate code, as indicated in Table 1-1, and available design documents.

1.3.2 Leased Buildings

The *Standards* shall apply to non-Federally owned buildings leased by an agency unless exempt under the provisions of Section 1.3.

The following provisions also shall apply:

a. No new leases or lease renewals/extensions shall be made in buildings that do not comply with the *Standards*.

   Exception: If no seismically conforming space is available, otherwise acceptable space with the best available seismic resistance shall be pursued.

b. The building owner shall obtain certification by a qualified registered professional engineer that the building conforms to the *Standards* (see Section 2.3).

c. In leased buildings, nonstructural components whose damage would not affect the required performance of the leased area (which includes safe egress from the leased area) need not be evaluated or retrofitted.

1.3.2 Leased Buildings

Non-Federally owned buildings in which an agency leases space are subject to the *Standards* unless exempt per Section 1.3. In particular, see Section 1.3 *Item h* and *Item i*.

1.3.3 Privately Owned Buildings on Federal Land

The *Standards* applies to privately owned buildings located on Federal land. Application of the *Standards* to evaluation and mitigation of seismic risks is the responsibility of the building owner.

C1.3.3 Privately Owned Buildings on Federal Land

Privately owned buildings on Federal land (e.g., concessionaire buildings in National Parks, schools on military bases, and buildings constructed and owned by private contractors with long-term exclusive relationships with Federal agencies) were exempted by RP 4. However, the ICSSC recommends that these buildings be evaluated and that unacceptable seismic risks be mitigated. As a result, the *Standards* applies to all privately owned buildings located on Federal land.

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Chapter 2

APPLICATION OF THE STANDARDS

2.0 Scope

This chapter defines those situations that trigger a seismic evaluation and, if necessary, seismic retrofitting of a Federal building.

2.1 Situations Requiring Evaluation and Potential Mitigation

At a minimum, a building shall be evaluated and any unacceptable risks posed by the building shall be mitigated when any of the following occur:

a. A change in the building's function that results in an increase, as determined by the agency, in the building's level of use, importance, or occupancy;

b. For buildings assigned to Seismic Design Category (SDC) C (as defined by ASCE 7), a project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 50 percent of the replacement value of the building;

c. For a building assigned to SDC D, E or F (as defined by ASCE 7), a project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 30 percent of the replacement value of the building;

d. The building or part of the building has been damaged as a result of fire, wind, earthquake, or another cause to the extent that, in the judgment of the agency based on evaluations performed by qualified registered professional engineers (see Section 2.3), significant structural degradation of the building's vertical- or lateral-load-carrying systems has occurred;

e. The building is designated by the agency to pose an exceptionally high risk to occupants or to the public at large; or

f. The building is added to the Federal inventory through purchase or donation after adoption of the *Standards*.

C2.1 Situations Requiring Evaluation and Mitigation

Seismic risk mitigation programs consist of both "active" and "passive" components. "Active" components of a seismic risk mitigation program specifically require some action (e.g., inventory, evaluation, planning for retrofitting, or retrofitting) to be taken.

The focus of the "passive" components or "triggers" is on changes to the building that will increase its life or value (e.g., extensive renovation) or that will increase the risk level of the

building (e.g., a change in occupancy). The philosophy of the use of triggers is to achieve seismic safety in older buildings similar to that in new buildings at times when decisions have been made that significantly extend the life of the building or the agency's reliance on it. Such triggers also serve to gradually reduce the overall seismic risk presented by the existing building stock. In addition, when such triggered improvements will be done concurrently with significant non-seismic work, the cost and disruption attributable to the seismic retrofitting is minimized.

The mitigation policy defined in the *Standards* varies with the seismic risk presented by the building as defined by the building's ASCE/SEI 7 Seismic Design Category (SDC), which is a measure of both potential shaking intensity and the consequences of damage to the building. The *Standards* exempts existing buildings in areas of very low seismicity (see Section 1.3b) – SDC B – even though new buildings in those regions require seismic design. The trigger for evaluation and possible mitigation for buildings in SDC C, the next higher level of seismicity, is intended to apply in cases where renovations will extend an existing building's life so that it is similar to that of a new building, although the measure, for simplicity, is taken as the ratio of construction cost to replacement cost. In high seismic zones (SDC D or greater), the expenditure trigger is set relatively low (30 percent of replacement cost) to force serious consideration of the value of making significant non-seismic improvements to buildings with potentially high seismic risk. "Replacement cost" shall be defined by each agency; however, it should be taken to mean the cost to build a building of identical size and quality that is intended for the same use. Adding a wing that is separated from the main building normally will not trigger evaluation of the main building unless extensive renovations are associated with the addition.

The basic triggers listed in this section encourage consistent application of the "renovation" philosophy discussed above. Because of the efficiency of combining seismic retrofit with other work, the establishment of additional triggers may be advantageous for an agency depending upon the specific characteristics of its program.

Policies for the repair of damaged buildings are continuously evolving and also vary according to the local seismicity. The cost for repair as compared to the value of the building presents issues similar to those associated with renovations and similar rules could be applied. An additional consideration is whether earthquake ground shaking has damaged a building in a manner that clearly identifies the building as a poor performer, which would indicate repair without strengthening would not be cost effective. The circumstances that would identify such a building depend on the level of shaking and the extent of damage. The term "significant structural degradation" used in *Item d* can be compared to "substantial structural damage" as used in Chapter 34 of the International Building Code (ICC, 2009). Rules contained in Chapter 34 for determination of "substantial structural damage" are deemed to comply with the *Standards* although they should not be considered to set minimum standards.

The term "exceptionally high risk" has been previously defined in association with collection of the Federal inventory (ICSSC RP 5, 1995) and varies from agency to agency but is based on consideration of one or more of the following factors: seismicity of the building site, structural system, number of occupants, date of construction, number of stories, occupancy type, size (square footage), structural irregularities, unusual building geometry or characteristics, and importance of the building to the agency mission.

A building presenting such an exceptionally high risk may be discovered at any time (e.g., in a systematic evaluation process or by review of the building for other purposes). A plan to reduce such high risks should be developed immediately. One or more of the mitigation measures listed in Section 4.1 should be considered.

Item f is intended to prevent unsafe buildings from being permanently added to the Federal inventory by triggering a seismic evaluation and, if necessary, mitigation, when they are acquired. It is not intended to apply to buildings temporarily under Federal ownership such as those in the assets of failed banks placed under Federal guardianship (see Exemption 1.3g).

2.2 Compliance

A building is considered to be in compliance with the *Standards* if it is:

a. Exempt from the *Standards* in accordance with Section 1.3,
b. Determined by evaluation to be in compliance with the *Standards* in accordance with Section 1.3.1 or Chapter 3, or
c. Retrofitted or otherwise subject to mitigation measures in accordance with Chapter 4.

Compliance with the *Standards* should result in a minimum performance level of the Basic Safety Objective of ASCE/SEI 41 or conformance with a performance objective selected in accordance with Section 1.1. The *Standards* also provides for the evaluation of buildings and mitigation of seismic risks to meet the higher performance level of Immediate Occupancy where this level of performance is required to meet the agency's mission.

2.3 Qualifications of Evaluators, Designers, and Reviewers

In general, all evaluation, development of mitigation approaches, and design of retrofit work shall be prepared by a registered professional engineer with experience in the type of work being considered. For independent peer reviews of alternative or innovative evaluation methods, analysis techniques, or retrofit concepts required by the *Standards*, an individual highly qualified in the field of earthquake engineering or a panel of such individuals should be selected by the agency. ASCE/SEI 31 Tier 2 and or Tier 3 evaluations regarding potential foundation deficiencies or geologic site hazards should be conducted by a geotechnical engineer or engineering geologist qualified to perform the work by registration and/or experience.

C2.3 Qualifications of Evaluators, Designers, and Reviewers

Registered professional engineers should be used to evaluate seismic risks for a specific building and to plan mitigation schemes. The experience and qualifications of the individuals should match the scope and complexity of the assignment. Registration as a professional engineer is intended to ensure that an individual possesses at least a familiarity with design and analysis of buildings

for dynamic lateral loads. In addition, training and experience in seismic investigations should be required because ASCE/SEI 31 and 41 use concepts, terminology, and procedures different from those used for new building design

Those with a minimum amount of such background experience may be qualified for relatively small and simple buildings. Highly qualified individuals are required for complex buildings or for peer review. Such persons likely will have academic credentials far beyond the bachelor level with courses in structural dynamics, inelastic analysis, and other topics in advanced earthquake engineering. They may have published technical articles on seismic issues related to existing structures or be active in relevant professional organizations. Their project experience should relate specifically to seismic investigations of structures. They should be capable of providing personal references attesting to their successful completion of projects similar to that contemplated by the agency.

A specialist in geology or geotechnical engineering should be used for evaluation of foundation deficiencies and geologic site hazards.

2.4 Additional Requirements

As part of each agency's seismic safety responsibilities for existing buildings, the following measures shall be implemented as appropriate:

a. Designation of certain facilities for performance objectives higher than the safety-based objective defined in Section 1.1.1;

b. Designation of certain facilities for mission-critical performance objectives and development of standards for such objectives;

c. Development and dissemination of agency-specific policies consistent with all provisions of the *Standards* including consideration of past policies and their current applicability;

d. Assurance that consistent measures of quality control are included in such policies and applied to all phases of evaluation, design, and construction in a manner consistent with ASCE/SEI 31 and 41; and

e. Designation of certain facilities as being of exceptionally high risk consistent with Section 2.1e.

C2.4 Additional Requirements

Item c, policies, is intended to enable efficient and acceptable use of "grandfathering" buildings previously evaluated or retrofitted. It is not the intent of the Standards to rewrite agency procedures but rather to set common minimum standards for use by all Federal agencies. Once the

Standards document is formally adopted for Federal use, each agency should be able to demonstrate which of its existing and/or past programs meet or exceed the Standards and which may not as well as to identify specific areas of potential deficiency.

Item d, quality control, must not be overlooked in a seismic hazard mitigation project. All phases of a project, including evaluation, design and construction, must be monitored and evaluated to be successful. Guidance from documents like the *Standards*, ASCE/SEI 31 and 41, and commentaries like FEMA 357 is needed in order to consistently identify and improve seismically hazardous buildings. However, earthquake engineering is not an exact science. Codes are constantly developing in an attempt to incorporate new research results and to balance safety, building performance, and cost. Considerable engineering judgment is required to properly apply the *Standards* to existing buildings. Reviews of evaluations for consistency, of construction documents for adequacy, and of construction itself for compliance with drawings and construction standards are all essential to maximize effectiveness of the project.

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Chapter 3

EVALUATION REQUIREMENTS

3.0 Scope

The purpose of the evaluation described in this chapter is to determine whether a building meets the Life Safety or Immediate Occupancy performance levels as required by the agency-selected performance objective. ASCE/SEI 31 provides a seismic evaluation process for existing buildings in any region of seismicity, considering either the Life Safety or Immediate Occupancy performance level. Note also that an agency may determine, through an evaluation and risk assessment, that the level of risk is sufficiently low that mitigation is not required.

3.1 Evaluation Requirements

Seismic evaluation of a building for a specific performance level shall be carried out as needed to ensure compliance with the *Standards* in accordance with Section 2.2. The performance objective for the evaluation shall be established by the agency having jurisdiction over the building, subject to the minimum acceptable requirements given in Section 1.1. Recall, however, that the minimum acceptable performance objective for Federal buildings is based on life safety in a large earthquake.

Any buildings that do not meet the exemption criteria defined in Section 1.3 and that are in a triggering situation described in Section 2.1 shall be evaluated using the procedures set forth in ASCE/SEI 31 for the stipulated seismic demands that are based on the Maximum Considered Earthquake (MCE) ground motions as defined in that document. The evaluation must include consideration of the structural, nonstructural, foundation, and geologic site hazard conditions as prescribed by the ASCE/SEI 31 "Tier 1" checklists (see Section C3.1). Buildings complying with the intent of all the requirements of ASCE/SEI 31 shall be deemed to meet the specified performance level, either Life Safety or Immediate Occupancy.

Buildings may be evaluated for higher levels of performance than Life Safety and Immediate Occupancy by other well-established procedures based on engineering analysis.

C3.1 Evaluation Requirements

ASCE/SEI 31 provides a three-tier process for seismic evaluation of existing buildings. The procedures allow buildings to be evaluated to either the Life Safety or Immediate Occupancy level for a seismic demand based on the MCE ground motions. The MCE represents ground motions with a 2 percent probability of exceedance in 50 years with deterministic-based maximum values near known fault sources and is the same basis used for the design of new buildings.

The seismic evaluation begins with a Tier 1 evaluation that is required for non-exempt buildings in accordance with the requirements of Chapter 3 of ASCE/SEI 31. Through the use of checklists, the lateral-force-resisting system's potential deficiencies are identified. Potential deficiencies are eligible for further evaluation under the Tier 2 procedures that provide detailed reconsideration of the potential deficiencies. Any remaining deficiencies after the Tier 2 process should be investigated to determine their effect on desired performance or, if appropriate, evaluated under a Tier 3 evaluation using a lateral-force procedure or a displacement-based analysis. In some conditions, a displacement-based analysis will show that the remaining potential deficiencies are not significant.

It is important to note that ASCE/SEI 31 is intended to serve as a guideline reference for evaluation of buildings, but strict adherence to the letter of the document may not be appropriate at all times. Engineering judgment must be applied in situations where ASCE/SEI 31 is silent or not applicable. What is important is that agencies meet the intent of ASCE/SEI 31 (i.e., to provide substantial life safety to occupants and to the public) and determine if their buildings meet the performance goal desired.

3.2 Nonstructural Evaluation Final Assessment

For an evaluation at the Life Safety performance level, each item found non-compliant (NC) by the Tier 1 nonstructural checklist statement shall be carefully assessed by the engineer and those that pose significant threats to life safety or that could totally block an anticipated egress route should be listed for mitigation.

For an evaluation at the Immediate Occupancy performance level, each item found "NC" by the Tier 1 nonstructural check list shall be carefully reviewed and recommended for mitigation.

C3.2 Nonstructural Evaluation Final Assessment

The ASCE/SEI 31 nonstructural checklists include a large number of components that could represent serious threats to occupant safety, depending on their size, location, and vulnerability. Past earthquakes have shown that significant loss of life occurs when a large portion of a building or the entire building collapses. Falling panelized ceilings and light fixtures, dislodged walls, broken pipes, and shifted equipment most often render a building unusable but not inherently unsafe. Life Safety performance assumes that occupants will take proper care to protect themselves during the earthquake ("drop, cover, and hold") and will be able to exit the building on their own through disturbed, but not blocked, egress routes and in spite of the injuries that they may experience. The engineer doing the assessment needs to visualize what is expected to happen for each potential nonstructural deficiency and determine if a hazard exists that could seriously harm or kill an occupant or block their ability to exit the building. FEMA publication E-74, *Reducing the Risks of Nonstructural Earthquake Damage*, provides information on the relative risks posed by nonstructural elements, as well as appropriate mitigation techniques. Future editions of ASCE/SEI 31 are expected to focus directly on the Life Safety performance level, significantly revise the Life Safety nonstructural checklist, and provide specific guidance for making the final assessment.

Chapter 4

MITIGATION REQUIREMENTS

4.0 Scope

This chapter presents the requirements for mitigation of seismic risks; standards for retrofitting identified deficiencies; and guidance on incremental or partial retrofitting, alternative mitigation methods; and retrofitting of historic buildings based on ASCE/SEI 41.

4.1 Requirements

Retrofit of buildings shall be performed in accordance with ASCE/SEI 41 or other methods that are consistent with and achieve the selected performance objective, subject to the minimum acceptable requirements of Section 1.1. Alternatives to retrofitting include but are not limited to the following:

a. Removal of the building from an agency inventory by termination of a lease agreement or sale,

b. Demolition or permanent evacuation of the building, or

c. Change in occupancy of the building such that it becomes exempt in accordance with Section 1.3.

C4.1 Requirements

The *Standards,* when mitigation is triggered, require reducing the risk of loss of life as well as meeting any other agency-specified performance objective in the earthquake ground motions specified in the referenced standards. Mitigation measures may or may not include retrofitting of the building itself. In some cases, the nature or extent of necessary retrofitting can be so extensive that abandonment and relocation is a cost effective alternative.

4.2 Minimum Standards and Scope for Mitigation

Where compliance with the *Standards* is to be achieved through mitigation, the retrofit performance objective shall be selected in accordance with Section 1.1. If shown by evaluation that the desired performance level is not obtained, the retrofit of the building and/or site to attain the Basic Safety Objective and/or the Immediate Occupancy level, shall satisfy the requirement of ASCE/SEI 41. Additional performance objectives may be defined by the agency, but the Basic Safety Objective of ASCE/SEI 41 is the minimum objective for buildings under the requirements of this chapter.

4.3 Incremental/Partial Retrofitting

Risk reduction by incremental or partial retrofitting of a building is acceptable as an interim step in a complete seismic mitigation process. It shall be permitted ***only*** if the partial retrofitting is designed and constructed in accordance with ASCE/SEI 41 and accounts for the future completion of the mitigation plans. In addition, such partial retrofitting shall comply with the following conditions:

a. The retrofitting measures shall not result in a reduction in the performance level of the existing building,

b. The retrofitting measures shall not create a new structural irregularity or make an existing structural irregularity more severe, and

c. All new or retrofitted structural components and elements shall be detailed and connected to the existing structure in compliance with the requirements of ASCE/SEI 41.

C4.3 Incremental/Partial Retrofitting

For a variety of reasons, it may be necessary to complete a mitigation project in several phases. This practice is acceptable as long as retrofitting measures do not reduce the performance level of the existing structure at any time, except during actual construction, and the retrofit has a reasonable plan for completion. The requirement demands careful consideration of the performance of the structure after each increment of retrofitting as recommenced in FEMA P-420, *Engineering Guidelines for Incremental Seismic Rehabilitation*. Additional guidance is given in FEMA publications 395, 396, 397, 398, and 399.

4.4 Strategies for Mitigation

The *Standards* does not limit the strategies that can be used for seismic mitigation.

C4.4 Strategies for Mitigation

Adding strength and stiffness to a building is the most conventional strategy for improving seismic performance. However, in many cases, it may be impractical or uneconomical to add sufficient strength to achieve the desired performance, particularly in structural components that are not part of the seismic-force-resisting system (e.g., gravity columns in older concrete buildings). Techniques that improve the drift tolerance of such components are available for use alone or in conjunction with strengthening to meet objectives. In addition, configuration irregularities can be eliminated, damping can be added, or all or part of the building can be seismically isolated to reduce displacement demand. Further guidance on strategies for retrofitting is contained in FEMA 547, *Techniques for the Seismic Rehabilitation of Existing Buildings*.

4.4.1 Local Modification of Components

Local modification of deficient components shall be permitted as an applicable retrofitting measure if the resultant building conforms to ASCE/SEI 41.

C4.4.1 Local Modification of Components

Some existing buildings have substantial strength and stiffness, but their gravity systems may not have adequate strength, toughness, or deformation capacity to satisfy the mitigation objectives. An appropriate retrofitting measure for such structures may be to perform local modifications of components that are inadequate while retaining the basic configuration of the building's lateral-force-resisting system.

4.4.2 Removal or Lessening of Existing Irregularities

Elimination or lessening of existing structural irregularities or removal of mass shall be permitted as an applicable mitigation measure, provided the completed work conforms to ASCE/SEI 41.

4.4.3 Nontraditional Mitigation Methods

Nontraditional mitigation methods (e.g., adding damping or seismic isolation) or innovative methods that are beyond the scope of the requirements of ASCE/SEI 41 shall be permitted, provided an analytical procedure acceptable to the agency shows that the required performance objective is attained. When such techniques are proposed for a specific building, a peer review panel, acceptable to the agency, shall determine the adequacy of the techniques (see Section 2.3.).

C4.4.3 Nontraditional Mitigation Methods

New materials and structural systems or other techniques not specifically covered by standards are generally allowed by building codes, subject to some form of review and approval. Generally, the alternative methods must conform to the intent of the prevailing standard. This allowance is particularly important for the seismic retrofit of existing buildings due to the large number of special conditions that inevitably arise. Many private and public institutions have established procedures for peer review. Some have standing panels; others hire reviewers for specific projects when the need arises. Agencies should establish policies to ensure the independence and qualifications of the reviewers. The policy also should cover the general procedures to be followed by the engineer and the reviewers.

4.4.4 Mitigation of Nonstructural Mechanical and Electrical Equipment

Buildings that are mitigated for the Immediate Occupancy performance level of ASCE/SEI 41 may include nonstructural mechanical and electrical equipment required to remain functional following an earthquake. Unified Facilities Criteria UFC 3-310-04, *Seismic Design for Buildings with Change 1* (Department of Defense 2007) identifies this equipment as "Designated Seismic Systems" and provides guidance on satisfying the post-earthquake functionality requirements.

4.5 Historic Buildings

Historic buildings shall not be exempted from the *Standards* and, depending upon their use, may be required to meet the same performance objectives as other buildings in the Federal inventory. Many codes covering historic buildings allow some flexibility in required performance depending on the effect of retrofit on important historic features. In some cases, it may be appropriate to retrofit an historic building to the Damage Control Structural Performance Range per ASCE/SEI 41 to ensure that the architectural fabric survives earthquakes expected in the region.

In preserving the historic fabric of these buildings, publications such as *The Secretary of the Interior's Standards for the Treatment of Historic Properties* and *Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (1995) shall be used. Alternative methods of mitigation of seismic risks for historic buildings shall be permitted subject to the requirements of Section 4.4.3.

C4.5 Historic Buildings

Mitigation of seismic risks in historic buildings is a sensitive process. The design professionals must take care to protect the historical character and fabric of the building as much as possible. This reduces the flexibility and freedom to make alterations to the structure. In the development of mitigation strategies, consideration must be given to the architectural and historic value of the building. Many codes covering historic buildings allow some amount of flexibility in required performance, depending upon the effect of retrofitting on important historic features. The intent of the *Standards* is to provide essentially the same level of seismic performance objectives as for nonhistoric buildings without unreasonable impediment to the historic preservation process. Consequently, alternative mitigation methods (see Section 4.4) are allowed and encouraged when they can lessen the impact of the structural strengthening.

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